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2022
EIUSRC

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INTRODUCTION

Eastern International University (EIU) was founded by Binh Duong province-headquartered Becamex IDC Corporation with the mission of training high-quality human resources to effectively meet the urgent need for manpower for sustainable socio-economic development in Binh Duong. In addition, EIU aims to become a scientific research hub for technology transfers and applications which will help drive socio-economic development not only within the southern key economic region but for the entire of Vietnam.

As a corporate-founded university, EIU is particularly interested in interdisciplinary research cooperations and research projects which focus on solving real-life problems of the community and businesses as part of the Smart City Project, Binh Duong Innovation region, and the surrounding areas. Additionally, EIU is also interested to foster and improve the scientific research capacity of lecturers and students of EIU, helping our lecturers, staff members, and students become excellent researchers and develop potential research groups. To achieve the above goals, EIU has successfully organized the Eastern International University Scientific Research Conference 2022 (EIUSRC 2022) on December 14th, 2022 with the topic "From academic research at universities to practical innovation application". EIUSRC 2022 was a forum for academic exchange and sharing of the latest scientific research and contributed to promoting a community of scientists and experts working together on projects and feasibility studies that can support the development of EIU, Binh Duong province as well as Vietnam.

Despite being held for the first time, EIUSRC 2022 has received the participation of more than 200 researchers, lecturers, and students from EIU and other universities. More than 70 authors have contributed 33 research works from multiple disciplines to our conference and all submissions were carefully reviewed by our scientific committee. We selected 29 papers to edit into conference proceedings. The papers in the proceedings are organized into four main groups of issues including Economics & Business Management, Engineering, Information Technology, and Health Science. It can be said that EIUSRC 2022 has been a successful start for the organizers and will certainly be a great source of motivation for us to hold better conferences in the near future.

Lastly, thank you to all the researchers, lecturers, and students who have contributed to the success of EIUSRC 2022. We hope all participants have had a great experience with EIUSRC 2022 and would greatly appreciate your feedback, suggestions, and enthusiastic participation in the next coming research activities of Eastern International University.

Thank you very much!

The Organizing Committee

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PART I

ECONOMICS & BUSINESS MANAGEMENT

HISTORY OF THE CREATION OF DIGITAL ECONOMIC CONCEPT AND DEFINITION IN THE WORLD

Doan Thi Anh Ngoc[1]
[1]*Science and Technology Department, Binh Duong, Viet Nam*
ngoc.anh.hungyen90@gmail.com

Abstract: The digital economy is a concern today, especially in the context that Vietnam and Asian countries are trying to avoid the middle-income trap. Going from a traditional economy to a digital economy is a process of innovation and digital transformation. However, the concept and definition of the digital economy in Vietnam still have many different views. The article will describe the formation of the ideas of the digital economy in different periods, thereby providing a comprehensive and macro perspective on this economy and creating a premise for research next steps (in terms of characteristics, core elements, evolution, ...).

Keywords: *digital economy, concept, definition*

I. INTRODUCTION

The dominant nature of an economic field is often used to name it. In the development history of the world, the explosion of the Internet and information technology from the third industrial revolution has created quite a lot of economic concepts (which are associated with the birth of a new scientific field).

In the 70s of the last century, the world's significant factories began to move into the post-industrial era. There has been a shift from the production of goods to a service economy, where people study and decision-making relies heavily on information evaluation; from here comes the concept: Information Economy. This time is also when computer science and information technology (Information Technology) developed strongly and began to create personalized computers; the embryonic period for the next two decades has the appearance and explosion of the Internet (Daniel Bell, 1974) [1].

In 1986, the NSFnet network (The network of the National Science Foundation of the United States) was officially established to replace the ARPANET (the network of the Advanced Research Projects Agency of the US Department of Defense - which is dedicated mainly to military purposes and national security). It marked the birth of the "net". Email and file transfers started to be used by people. In 1991, the Internet explosion occurred when Tim Berners Lee (CERN, the European Organization for Nuclear Research) invented the World Wide Web (WWW). Since then, the world has added a new economic concept: the Internet Economy, which is mainly based on the Internet connection to carry out socio-economic activities. (Manuel Castells, 1996)[2].

Communication, networking, data, and computing technologies born and developed rapidly in the 1970s continue to collaborate

with the content industry. In 1996, Don Tapscott [3] called it the convergence of three focus areas: computing, communication, and content, creating a new economic field: Digital Economy. He has known worldwide as the first person to raise the notion of the digital economy in the US [4]. His idea began to be gradually accepted. And its existence is recognized in many parts of the world.

Thus, the digital economy is not the first economic concept associated with the field of science and technology. The history of the world's economic formation has shown that many economic sectors go along with the development of computer science, information, and communication technology (ICT) as the Information economy, Internet economy,... These concepts have scope in the overall economy based on crucial operating protocols. However, when it comes to the digital economy, the world had begun to witness the confluence of many industries and technologies, culminating in the fourth industrial revolution (recognized when the German government launched the industry 4.0 initiative, 2011). From there, the digitization process (which existed when the computer storage system developed) began to transform powerfully into digital transformation and took place on a large scale, gradually entering various stages that were not previously possible for humans to transfer to computers and AI (Artificial Intelligence). The concept of the digital economy has followed this stormy development and exploded many ideas with various interpretations. Both the US and Europe are constantly having new perceptions and images about the digital economy and spreading to Asia.

Until recent years, many economists have had views on rediscovering the true nature of the digital economy because it is vital to measure, direct and let the economies of developing countries enter in nice time and right place because the digital economy has existed in major powers since the 1990s, nearly 30 years ago and has undergone many changes and different appearances.

The article aims to fix the digital economy's understanding by synthesizing theoretical studies on concepts (from socio-economic scientists) and practical conclusions (from economic and policy consulting organizations) since 1996 (when just formed), through changing milestones, and until now, before COVID-19 spread and caused significant impacts on the world economy. That more or less affects the digital economy and the orientation of countries that the article has not mentioned in depth in the research framework.

II. THE EARLY DIGITAL ECONOMY: WHEN IT JUST FORMED IN THE US

People applicated the outstanding efficiency and features of computers and the Internet in economic activities. The digital economy also has a new element that Don Tapscott has found to be different from the two concepts of the information economy. And before the Internet economy, it was the involvement of content production behind which people connected to each other online. [3] Although people continually participate in economic sectors through the improvement of the tools of production: computers and telecommunications. Nevertheless, the direct involvement of people interacting

with each other through the web and the increasing number of new features emerging is what creates markets and drives needs, and emotions found right on the computer screen. The invention of the Word Wide Web was the first basis for content to be transmitted and expanded without limits. From that, it promotes the development of content production on the Internet (it can exist in the text as writing, images, audio or video clips,...). Initially, the content is copyright protected and published in the traditional form (books, movies, music, ...) and then digitized to put on the Internet. Gradually, there appeared free and online production content from users through the web and chat messages... [5]. Since then, there have been circulating cash flows, the exchange, sale, and production of digital products (which only exist on the network and computers), and virtualization have begun to take place, changes the business model, changes the company structure ... [3].

In the interplay between technologies, Tapscott pointed out that people are at each link (Figure 1) and that an essential connection is connecting people, not just computers. The digital economy is a new economy characterized by networked (human) intelligence [3]. From there, the social characteristics of this economy highlighted: innovation and human knowledge, connection, and globalization,...

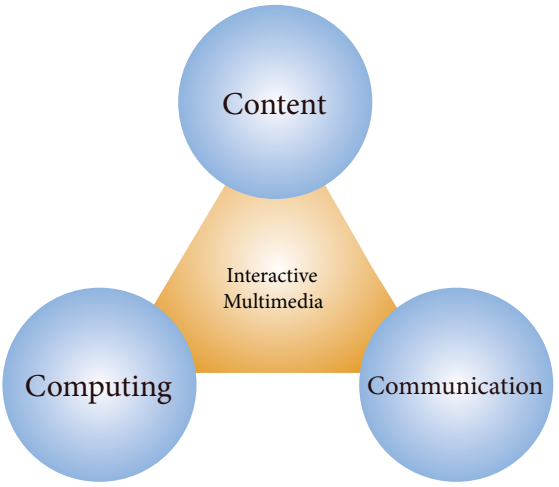

Figure 1. Converging Technologies

(Source: © New Paradigm Learning Corporation, 1996) [3]

III. THE CONCEPT OF THE DIGITAL ECONOMY BEFORE THE EXPLOSION OF THE FOURTH INDUSTRIAL REVOLUTION

Tapscott's work [3] paved the way for the conceptual understanding of the digital economy in the US. Buvvhkt and Heek (2018) [6] briefly reported on some concepts:

In 1999, Lane, science and technology assistant of the United States president, stated the definition of the digital economy: "The convergence of informatics and information technology on the Internet and the resulting technology and information, which has ignited all of e-commerce and the profound change in how it organized."

In the same year, Margherio et al. (US Department of Commerce) [7] introduced the concept of the digital economy based on four main points: (1) Built from the Internet, (2) E-commerce between different ways of doing business, (3) Digital distribution of goods and services and (4) Retail sale of tangible goods.

By 2000, Kling & Lamb's [8] definition of the digital economy (but more clearly what goods are in the digital economy): "Includes goods and services whose development, production, sale, and supply are highly dependent on digital technology". Divide the digital economy into four parts: "(1) Highly digital goods and services... (2) Digital blended goods and services... (3) Goods and services are produced with strong IT intensity and (4) IT industry".

The common feature of these definitions is that there is still a great deal of interest in digital technology, the Internet, and information communication. As for the content and data factors, Tapscott (at the time when the digital economy was just formed) mentioned more.

Brynjolfsson and Kahin (2000) [9] emphasize understanding the digital economy from different angles: Macroeconomics, competition, labor, and organizational change and have commented: The digital economy has only happened recently, and there is still no clear, major transformation in the economic sectors created from the digitization of information to enhance computer capabilities.

In 2001, the definition of the digital economy was again systematized by Mesenbourg [10] in order to focus on measuring e-business and e-commerce: "Digital economy is three basic components":

"E-business infrastructure is the share of the overall electronic infrastructure (common infrastructure) that is used to support the e-business process and control e-commerce."

"Electronic business (e-business) is any process that an economic organization conducts through intermediate computer networks."

"Electronic commerce (e-commerce) is the value of goods and services sold through an intermediary computer network."

In addition to Bukht and Heek's set of definitions, in 2007, Atkinson and McKay [11] found that 70% of microprocessors do not go into computers but into cars, airplanes, HDTVs, etc., and allow connections to connect their digital functions via wifi. The digital economy is more expanded:

"The digital economy represents the widespread use of IT (hardware, software, applications, and telecommunications) in all aspects of the economy, including the internal operations of organizations. (business, government, and non-profit); transactions between organizations; and transactions between individuals, as consumers, citizens and institutions... The underlying technologies of the digital economy also extend beyond the Internet and personal computers. It is embedded in a wide range of products, not just technology products such as cell phones, GPS devices, PDAs, MP3 players, and digital cameras. It is in everyday consumer products like washing machines, cars, credit cards, and industrial products like machine tools, lasers, and computer-controlled robots."

This is the rapid and diversified development of terminal devices thanks to the development and improvement of semiconductor technology (used in chip manufacturing). The phenomenon "The number of transistors per square inch will double every 24 months" [12] was recorded by Moore (Founder of Intel chip manufacturing

corporation) in an article from 1965 and was discovered and expressed as a law afterward. It explains why production costs are always low while hardware performance increases rapidly. Continuously improved chips have fueled the development of microprocessor-attached physical devices that have become increasingly intelligent and common to the masses. Moore's law continues to exist more than 50 years later and is the foundation for organizations to constantly find new and expanded uses for IT, along with the development of wireless network (wifi) applications. Mobile technology has covered almost all areas of life. However, agriculture, fishery, low-wage occupations, and rural areas in underdeveloped countries still lack access to digital technologies.

Based on their studies, Edward J. Macleki and Bruno Moriset (2008) [13] have presented the image of the digital economy as a 4-story pyramid (Figure 2), with the top - "spike" being the industry sector. Silicon foundry and semiconductor chip manufacturing – This is essentially a conventional physical manufacturing industry, but its products become the core of an increasingly wide range of devices: from consumer electronics to cell automobiles and industrial machinery to heating and air conditioning systems. Major distribution chain Wal-Mart has tagged smart tags (RFIDs or radio frequency identification devices) on packages of basic goods sold in supermarkets. Computers and telecommunications (both manufacturing and services) are seen as the core of the digital economy (and just below the "spike") because they rely on chips to operate and allow the lower part (of the pyramid) to work. The body part is the central scope of the digital economy, including (1) IT-enabled services and (2) Advanced manufacturing.

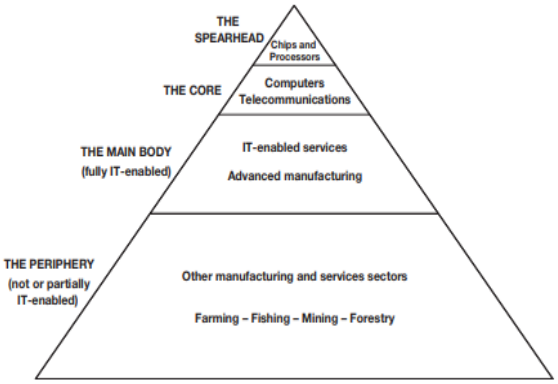

Figure 2. The Pyramid of the Digital Economy

(Source: Edward J. Malecki and Bruno Morisset, 2008) [13]

For services: E-commerce, media, entertainment, IT-enabled business services (such as call centers and shared service centers), and financial services.

For manufacturing: IT-intensive sectors where the "product lifecycle" is driven entirely or in part by IT, such as the automotive or aircraft industries.

The bottom part, temporarily, is the areas that IT applications have not touched or have very little existence. That is the case for much of the crop industry, especially in developing countries. In household and consumer services, as well as in public services, many people almost never use the computer, such as housekeepers, cleaner, hairdressers, and garbage collectors (Time of the year 2008). However, along with Moore's law and the innovation and improvement of human production, these fields are also gradually being penetrated more deeply by it. Particularly this bottom is the periphery of the digital economy. It is only increasingly

digitized but does not satisfy the characteristics of the digital economy.

Through the analysis of Edward J. Malecki and Bruno Morisset at the time of 2008, it can be seen that the digital economy at this time is only the digital economy (and can be extended inference backward) by this time. The world has not yet emerged with 4.0 industrial networks and complex digital transformation. An economy based primarily on ICT devices, computers (and the microprocessor devices of industries), along with human economic activity. A bold digital nature, a clear line between digital and non-digital, a high level of ICT not being used, and not yet widespread digital transformation are the features of the digital economy. Because the word "digital", when translated into Vietnamese, can be understood as "kỹ thuật số" or "số", Vietnam has used "digital economy" to understand it briefly. The word "digital economy" is appropriate today because the world has had a high level of scientific and technical development, and almost every organization and every field are digitalizing; all data has been digitized. Therefore, today's "digital economy" is much more complicated and actually is "digital economy" because the "digital" content is very high and dense, and universal.

IV. THE FOURTH INDUSTRIAL REVOLUTION AND THE MODERN DIGITAL ECONOMY

The fourth industrial revolution, with the rise of new technologies, has pushed countries to carry out technological transformations, change the environment and business models, and create new ways of production. The digital economy has grown and impressively contributes to the GDP in many countries (8% of value added to the US GDP from 2006 to 2016 [14]; 33% of China's GDP in 2017 - 27.2 trillion yuan [15]; 87% of Dutch GDP in 2015 [16]). A series of policies to catch up with the 4.0 trend and accelerate the application of achievements of science and technology to promote the economy and digital economy. For example, USA: AMP Program (1.0 and 2.0) to maintain the leadership of the manufacturing industry; Germany: strategy "Industrie 4.0"; Korea: Manufacturing Innovation 3.0 strategy (mainly supporting SMEs, creating smart production processes); China: "Made in China 2025" initiative with ten key areas; Taiwan: Productivity 4.0 strategy targets seven key areas and enhances national competitiveness;... [17].

Starting from 2020 until now, the world has continuously appeared with new definitions of the digital economy and come from many regions as countries have recognized the opportunities and challenges in this new phenomenon in the United States. Organizations discussing the definition of the digital economy are not outside the purpose of guiding national economic development strategies and international cooperation. Bukit and Heek [6] further expand the list of definitions gathered:

In 2010, the London Economic Intelligence Unit [18] expanded the scope of the study worldwide. It ranked digital economies in countries based on: "The quality of a country's ICT infrastructure and the ability that consumers, businesses, and governments countries can use ICT to their benefit." At this point, the US has focused on the foundation

of creating a digital economy rather than just talking about it with measurement: (1) Technology infrastructure and connectivity, (2) Business environment, (3) Socio-cultural environment Society, (4) Country Vision and Policy, (5) Customers and (6) Business Acceptance.

In 2013:

OECD [19] definition: "Digital economy enables and carries out commercial activities of goods and services through e-commerce on the Internet."

Australian Department of Broadband, Communications, and Digital Economy (DBCDE) [20]: "Global economic networks and social activities enabled by digital technologies, such as the internet and mobile networks."

European Commission 2013 [21]: (Digital economy is) "…an economy based on digital technologies (sometimes called the internet economy)". Identify the characteristics of digital economy companies:

- Innovation through new sources of financing (venture capital);
- The importance of intangible assets;
- New business models based on network effects;
- Cross-border e-commerce;
- European Parliament (2015) [22]: "A complex structure of arrays, interconnected layers that are almost endless and always increasing in the number of nodes. Stacked platforms allow polyline to reach end users and make it difficult to eliminate certain players, i.e., competitors.

In 2016:

G20 Summit [23]: (Digital economy is) "… a broad range of economic activities including the use of digitized information and knowledge as a key element of a product, modern information networks as a space where important activities take place, and the effective use of information and communication technology (ICT) as a key driver of productivity growth and structural optimization of the economy".

Another concept from the Middle East is: Digital economy with three attributes: "creating value at a new frontier of the business world, optimizing the execution of a vision of customer experience, and building foundational capabilities to support the entire structure" (Elmasry et al., 2016) [24].

Balh (2016) [25] when it comes to the digital economy in the Asia Pacific, there is a comparison between "is" and "does" the digital economy. The author offers advice for transitioning from doing to being digital: "Businesses need to inject digital at the core of what they do and how they interact and communicate with customers, partners, and employees. This means digitizing processes to generate abundant profits and super profits."

Also, in 2016, Knickrehm et al. [26] began to include digital technologies and supporting platforms in the definition:

"The digital economy is the amalgamation of several universal technologies (GPTs) and a range of socio-economic activities carried out by people everywhere on the Internet and related technologies. It encompasses the physical infrastructure on which digital technology is based (broadband lines,

routers), the set of devices used to access it (computers, smartphones), applications that these devices provide (Google, Salesforce), and the functions they provide (IoT, data analytics, cloud computing)".

Deloitte's net document [27] wrote: (Digital Economy is) "…economic activity that results from billions of people online every day, connecting people, businesses, devices, data, and processes. The backbone of the digital economy is hyper-connectivity (developing the connection of people, organizations, and machines together). This hyperconnectivity is the result of the Internet, mobile technology, and the Internet of Things (IoT).

In general, these modern phase definitions have added a lot of new terms, mainly due to new technologies produced in the 4.0 industry era and the close cohesion of organizations and people in the "digital" world that the digital economy in the early days did not have. In addition to providing definitions (approached from many different perspectives and coming from many cultures), Bukht and Heeks developed a conceptual framework that today's countries and many scientists have adopted and used this framework to lay the groundwork for moving towards digital economic measurement.

V. WIDELY ACCEPTED DIGITAL ECONOMY CONCEPTUAL FRAMEWORK

Bukht and Heeks [28] propose three levels in the digital economy, which are widely accepted as (1) The core is information technology and information and communication technology, (2) The true digital economy is narrow-scale, and (3) The economy is digitized or broad-scale. Based on that, it is possible to give three dimensions of influence of the digital economy:

(1) Core: here only includes the ICT sector. The key areas here are hardware manufacturing, information and communication services, and software and information technology consulting. Thus, this core has not yet described the extent of the widespread influence of digital technology leading to the formation of new economic models.

(2) Digital economy: expanded from the core, full of the true nature of the digital economy, including fields with business models closely related to digital technology. The main areas here include the core sector above, with the addition of digital services, the underlying infrastructure economy, the sharing economy, and the loosely coupled economy (also known as the self-employment economy).

To better explain the concepts [29], it can be understood that a platform economy is a type in which economic activities take place on digital platforms, such as Uber and Grab...; sharing economy is an economy in which shared assets or services are shared between individuals; a gig economy is one in which workers work in temporary and flexible positions, i.e., self-employed, and companies hire freelancers instead of employees. These are the current three typical types of the digital economy in the digital environment.

(3) Digitalized economy: this is the next development of the digital economy, which is a trend of the era of the fourth industrial

revolution. Including the digital economy, the digitized economy also involves the digitization of traditional industries. The main areas will have all the areas of the core part, of the digital economy, with the addition of e-business, e-commerce, industry 4.0, precision agriculture, and algorithmic economy.

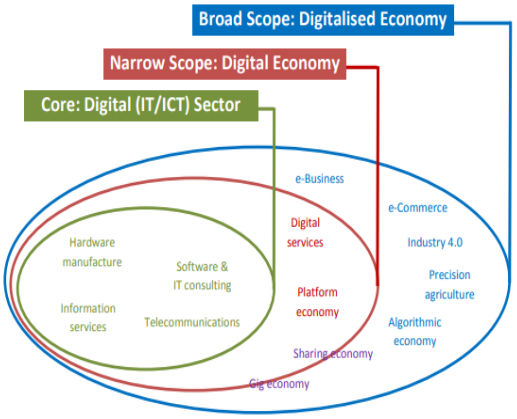

Figure 3. The sphere of influence of the digital economy

(Source: Bukht & Heeks, 2018) [30]

Bukht and Heek's conceptual framework once again shows how far the field of the digital economy (previously the pyramid of Edward J. Malecki and Bruno Morisset) is in a modern economy that is continuously being rapidly digitized quickly. Through this, it will be clearly shown how the impact of technology policies will spread and in what areas need more attention than other stimulus forces such as human, natural science, biomedical, social sciences, education, and training... (i.e., fields where digital is not the main thing).

Today, in the first years of the new decade, economic researchers want to be more explicit about which production sectors fall under the digital economy and, in fact, the economic practice shows signs of data (information digitized information and user parameters on the internet) was segregated into a new economic sector like this is separate from computer hardware and software. Software and data are evolving independently [31] and rapidly surpassing hardware production in value-added due to their non-stop innovation and no physical limitations (as stated by Moore's law).

2020, Tim Jordan [32] also commented: Are Microsoft and Apple companies in the field of the digital economy? They are very different from Google and Facebook company. Microsoft has to produce computers, and revenue comes from computers and Windows operating systems; Apple has to make the iPhone and other electronic devices: Ipad, Macbook, … and revenue comes mainly from selling products. While Google and Facebook do not produce, and revenue comes from, the creation, storage, analysis, and sale of information. Suppose hardware production is separated without creating added value and helpful software. In that case, these products will not meet consumer needs, and now these two companies are no different from Ford, a car production company. That is one of the examples of digital economy practice and a sign that there is a new economy (entirely online) that has separated from the conventional physical-digital economy. The GDP of countries created from the digital economy is also clearly analyzed from which areas of the digital economy come so that appropriate economic policy can be developed. The data economy is completely based on human creativity, innovation, and knowledge, although it is still dependent on digital devices.

VI. CURRENT STATUS OF DIGITAL ECONOMY RESEARCH IN SOME ASIAN COUNTRIES AND VIETNAM

Asian countries with reasonable GDP growth rates have had many in-depth studies on the digital economy, such as Japan, China, India, etc.

- Japan has incorporated digital economy concepts into the Ministry of Information and Communications strategies in the white paper on Information and Communication of Japan.
- India: Research institutes and scholars in this country have also done much research on the digital economy. According to Nayak, Tapan Kumar, and Manish Agarwal [33]:

"A digital economy is one in which all the transactions are done using cards or digital means. The circulation of physical currency is minimal. India uses too much cash for transactions. The ratio of cash to gross domestic product is one of the highest in the world—12.42% in 2014, compared with 9.47% in China or 4% in Brazil. Less than 5% of all payments happen electronically. The number of currency notes in circulation is also far higher than in other large economies. India had 76.47 billion currency notes in circulation in 2012-13 compared with 34.5 billion in the US."

India focuses on cashless transactions and is interested in a digital transaction economy to avoid tax evasion and inflation and reduce economic costs [34].

- From China, Xiaoming Zhu [34] published his research on the "1+10" framework of the digital economy:

The vigorous development of technologies: Big data, cloud computing, platform technology, mobile Internet, and IoT (Internet of Things) has laid a solid foundation for the sharing economy, prosumer economy, long tail economy, inclusive economy, cooperative economy, and smart economy (Xiaoming Zhu, 2019). It can be seen that the digital economy, starting from the continuous innovation and invention of information and communication technologies, has promoted the development of 4 basic (core) economies: (1) Economic Data Economy, (2) Service Economy, (3) Platform Economy, and (4) Internet of Things Economy. From here, the harmony and convergence of these four major technologies, along with changes and combinations of other factors, have created six new economic models: (5A) Sharing economy, (6) Prosumer Economy, (7) Long Tail Economy, (8) Inclusive Economy, (9) Cooperative Economy and (10) Smart Economy.

Many Western researchers have also published many research papers on the current state of the digital economy in Southeast Asian countries, such as Thailand. Authors Bukht and Heeks have also done research on digital economy in Thailand: Digital Economy Policy: The Case Example of Thailand, a working paper (2018) on https://diodeweb.files.wordpress.com/2018/05/thai-digital-economy-policy-diode-paper1.pdf.

It can be seen that the level of development of information and communication technology and science and technology in Asian countries is different. Some countries have implemented digital transformation very early and have a modern digital economy.

Their economy has high technology content and advanced science and technology, which has deeply interfered in production and service provision. Other countries with labor-intensive manufacturing have also quickly entered the digital transformation period and highly valued digital transformation to avoid lagging and keep up with the world's development.

In Vietnam and many countries around the world, the digital economy concept of Bukht and Heeks is quite popular among scientists and politicians. According to Decision No. 411/QD-TTg, dated March 31, 2022, of the Prime Minister on approving the National Strategy to develop digital economy and digital society to 2025, with orientation to 2030, business The number is defined as follows:

"A digital economy is an economic activity that takes digital technology, and digital data as the main input takes the digital environment as the primary operating space, uses ICT to increase labor productivity, innovate business models, and optimize the economic structure.

Includes:

Digital economy ICT: the information technology industry and telecommunication services.

Digital platform economy is economic activity of digital platforms, online systems connecting supply and demand, and online services.

Sector digital economy is digital economic activities in industries and fields."

This division of the digital economy is quite similar to the conceptual framework and scope of the digital economy of Bukht and Heeks. Also according to the Ministry of Information and Communication Technology, "developing the digital platform economy focusing on national digital platforms is the driving force for developing the digital economy of all sectors and fields."

VII. CONCLUSION

The fourth industrial revolution, with three major scientific trends: physics, information technology, and biology, has brought human history to a new level. The digital economy - the field that has inherited almost all of the achievements of physical science and ICT has grown tremendously and brought into full play its maximum strength. Besides, we cannot deny that the development of all other scientific fields contributes to each country's socio-economic development. Like other economic fields, the digital economy is an inevitable development of society, with science and technology increasingly invested and developed with the purpose of development. The new economy that humanity has not yet reached that point. Therefore, all the critical factors for socio-economic development must be considered and adequately recognized for their role and importance. The drivers of economic growth, especially green and sustainable growth, still need to be focused on daily. In this crucial period of society, the digital economy has emerged as a significant phenomenon and promises to change the world and the fate of countries and regions. However, it will have a bit of willpower (Idealism) if we place the entire economic development based on

"digital". What are the characteristics of this economy, the core factors, and the key to success that needs to continue to be studied based on facts and scientific arguments? The wisdom in decision-making now, in the face of the industrial revolution and the challenge of the global pandemic, COVID-19 is deciding the future of more than 90 million people in Vietnam, and it is necessary to follow the objective law of motion advocacy. Respect and move forward with the world. There have been many successful lessons that Vietnam will follow. The potential risks will be eliminated by drawing on the practical experience of previous countries; Vietnam can learn and make optimal use of it to do better.

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SUPPLY CHAIN RISK MANAGEMENT: A REVIEW OF EXISTING LITERATURE

Ngoc Bich Tram Nguyen[1], Vinh Quang Le[1]
[1]*Becamex Business School, Eastern International University, Binh Duong, Vietnam*
tram.nguyenngoc.bbs18@eiu.edu.vn, quang.le@eiu.edu.vn

Abstract: Globalization and extraordinary global issues (e.g., pandemics, political turmoil, economic instability, catastrophic events, etc.) have triggered serious risk occurrences, making the supply chain more vulnerable and unstable. Supply Chain Risk Management (SCRM) has continuously been a crucial component of the supply chain and is still a top research priority in the modern era. Numerous scholars and practitioners in many countries have studied SCRM. Nevertheless, few studies of SCRM adopt a holistic, systems thinking approach in order to provide an integrated perspective that could reveal the risk complexities and dynamics within the supply network system. Academics in Vietnam similarly have paid attention to SCRM research, but the number of publications is limited. This paper reviews the existing literature and identifies some future research objectives for SCRM in Vietnam.

Keywords: *supply chain risks, supply chain risk management, literature review*

I. INTRODUCTION

A supply chain is a network of companies that collaborate to transform inputs into valuable outputs and deliver them to final customers [1], [2]. In the context of globalization, supply chains have grown increasingly interdependent [2], and their operations have become highly complex [1]. Attempting to maintain competitive advantages, businesses have engaged in "supply chain competition" [2]. In this competition, organizations of every size and in every industry must rethink their approaches to achieve effective supply chain management. However, when numerous businesses strive to increase competitive advantages, they also catalyze the business environment to become more sophisticated and complicated. It has posed new concerns and challenges for the entire supply chain and economy [2]. Consequently, Supply Chain Management has captivated a substantial amount of attention from organizations, scholars, and practitioners [3], especially in today's economic environment [4]. Although a substantial amount of research has been conducted in the SCRM field, several knowledge gaps still existed. It has resulted mostly from the absence of generalized concepts, inconsistent definitions of SCR and SCRM, lack of cohesive methodology between scholars and practitioners, and incomplete coverage of the entire SCRM process [5]–[9].

Vietnam is becoming increasingly cognizant of the significance of SCRM. Particularly, many companies recognize the need for effective SCRM approaches to identify, assess and mitigate risk and its effects.

Simultaneously, there has been an increase in scholarly research on SCRM principles in a range of industries such as agriculture, fishery, garment and others. Nevertheless, the concepts of SCRM in Vietnam are still infancy and need to develop more in future.

Based on the literature views and experiences expressed by supply chain academics, this study's main goals are to

(1) review the literature from the previous two decades;

(2) propose some recommendations for future SCRM research.

II. METHODOLOGY

In this review, we focused on the extant literature on the SCRM domain. Next, we searched for the online database with simple keywords: risks, supply chain risk, and supply chain management. Journal articles were collected from reliable databases such as Emerald, ProQuest, ScienceDirect, Taylor & Francis, and Wiley. Non-filtered articles were excluded. Fourthly, the reference lists were examined to ensure that no pertinent publications were overlooked. Each article's content was thoroughly evaluated to make sure that it was related to SCRM and covered at least one SCRM topic.

III. DEFINITIONS

A. Risks

There are several definitions of risks. In the past, authors defined risk as "the potential for unexpected negative results that are driven by events or activities" [10]. Risk is also explained as the "probability" that an event happens [11] or as disruption, susceptibility, ambiguity, catastrophe, threat, and hazard [12]. Risk and its consequences can happen to anyone, anywhere and at any time [13]. Whenever risks happen, it will cause disruptions and vulnerability, especially in the supply chain. Therefore, risks generally may be understood as negative occurrences and results. For example, Covid-19 has triggered supply risks which make entire supply chain under pressure, manufacturers faced a shortage of materials and resistance to international trade.

B. Supply Chain Risks (SCR)

SCR also witnessed the inconsistency in definitions. Several academics proposed definitions for a specific supply chain function or component, but not for the full supply chain [14], [15] specifically identified SCR as the supply risk. In contrast, [16] characterized it as the risk of information flow, the danger of material flow, and the risk of product flow. While [17] and other authors referred to these as general risks. Encompassing all of these previous explanations of supply chain risk, [3] defined supply chain risk as the potential and influence of unwanted macro- and/or micro-level occurrences or situations that negatively cause breakdowns or abnormalities at the all levels of a supply chain.

Consequently, it is imperative to establish a precise comprehension of supply chain risk. It will enhance interaction between scholars and practitioners and access to empirical studies.

C. Supply Chain Risk Management (SCRM)

SCRM is a multi-aspect concept. In our paper, we will provide the three

SCRM definitions that have been approved and developed over previous years. [18] developed the SCRM definition based on collaborative relationships among supply chain participants. Several authors argued that SCRM definitions should be described as an inter-organizational collaborative effort to discover, analyze, mitigate, and monitor unanticipated macro- and micro-level events or conditions that have an adverse influence on any element of a supply chain [3]. But the subsequent scholars were able to come up with a more accurate definition of SCRM that applies tools, techniques and strategies to the SCRM process to maintain competitive advantage coupled with profitability [19].

Still, the Fan and Stevenson definition only converged on the financial performance indicators. Therefore, our contribution is that SCRM should concern with a competitive advantage to create profitability and long-term growth while enhancing non-financial performance indicators (i.e. enhancing customer satisfaction, resource utilization, flexibility, technological innovation and product design) [20].

IV. RESULTS OF LITERATURE REVIEWS

In the examination of the relevant literature, we briefly discuss the various SCRM resources available, including the number of papers published and the most reputable publications in which they have appeared. This is aimed to help young researchers, particularly in Vietnam, go direct to online sources quickly when they intend to do research in the SCRM field. For the overview, we referred to previous literature reviews that have been published and cited most. It will help us to summarize more information effectively.

A. Overview of SCRM Literature

According to [4], the top five journals publishing SCRM are:

- International Journal of Production Research,
- European Journal of Operation Research,
- Supply Chain Management: An International Journal,
- The International Journal of Physical Distribution & Logistics Management,
- The International Journal of Production Economics.

These publications feature Q1 papers that are pertinent to the most recent and serious SCRM topics. They are the most important academic works that set the foundation and evidence for further research.

Secondly, in the review of [19], they concluded that the number of articles published annually on SCRM was out of 354 papers since 2000. It shows that researchers have increasingly discussed a multitude of SCRM approaches and methods, which provide more extensive literature for this field. As a result, the following scholars will have various references to find and fill in knowledge gaps, aiming to perfect the SCRM principle, process, and practice.

Finally, Vietnamese academics have attempted to study the SCRM process in several industries. Research's scope refers to the effect of risks on operational, logistical and supply chain performance [21]–[25]. The majority of the research was published

on Uncertain Supply Chain Management, which was Q3 journal from 2019. It means the scholarly articles have not yet been eligible for international publication.

B. Results

The results will provide several key parts including the industry and places that have been studied; the research methodology that has been used; and the SCRM process. In this part, we focus on listing SCRM literature's key conclusion, expecting to provide some directions or ideas for further research.

a) Research Methodology

There are numerous research techniques. Case studies are utilized by some researchers to gain valuable insight because they facilitate the analysis of a variety of issues and their interrelationships with risk profiles and tools [26], [27]. Modeling or mathematical modeling is another technique which broadly applied to emphasize the significance of risk quantification and to establish the relationships between objectives and risk metrics to mitigate potential risk [26] (Ozlem, 2018). In terms of risk evaluation and perspective, the Analytical Hierarchy Process (AHP) is also a useful tool for assessing inbound supply chain risk [26]. Authors also emphasized that academics used ISM to better comprehend "the interrelationships among risk mitigation enablers." [26].

Practitioners rely on simple and well-established methods, such as the Ishikawa diagram, value stream mapping, and cause-and-effect diagram, to measure supply chain performance [19]. These methods provide organizations with quantifiable metrics for monitoring the performance of their supply chains and making the necessary adjustments to increase efficiency and reduce costs.

Consequently, researchers should propose simpler approaches to consolidate the research-to-practice gap.

b) The SCRM Domain

The SCRM process has four stages, namely risk identification, assessment, treatment (or mitigation) and monitoring. Strategic risk management focuses on detecting and evaluating the likelihood and effects of risks, and adopting effective risk strategies to lower the likelihood of losses due to unfavorable occurrences [28]. In this part, we will provide overall information on the SCRM and the strategies applied in each stage of the process.

1. Risk Identification

The identification of risk aims to find all pertinent risks and anticipate future uncertainty; thus, the risks can be recognized and proactively managed [19]. SCR might be divided into supply risks, demand risks, process risks, financial risks, macro-environmental risks and security risks [28], see Table 1.

Table 1. Risk sources

Risks sources	Description
Supply risks	The irregularities and instability in supplier performance and relationships that constitute a threat to the performance of the acquiring company and expose it to increased risk [17]. Supply risk can present itself in a variety of ways, such as inconsistent delivery schedules, inadequate quality control, or escalating costs, which trigger a negative influence on the buying firms.

Risks sources	Description
Demand risks	Outbound flow events, such as changes in economic cycles, consumer preferences, competitive offerings, and new product introductions [28] that could change the probability of customers placing orders with a
Demain risks	focal enterprise as well as customer volume and assortment preferences, which could affect the demand for the firm's products. well as customer volume and assortment preferences.
Process risks	Process risk is the probability of deviating from the intended quality and quantity at the appropriate leadtime [29] due to delays, missed deadlines, errors, insufficient planning and communication, lack of resources, unclear objectives, or other performance issues.
Financial risks	The threat posed by information systems, physical infrastructure, and freight to individuals, businesses, and the supply chain by terrorism, vandalism, crime, and sabotage [28].

2. Risk Assessment

Not every risk is a problem for every supply chain. Some risks can affect a supply chain, while other risks cannot affect it. Reviewing the 2004 paper by [19], [32] firm size, debt-equity ratio and timing demonstrated that a SCRM is effective as it necessitates a holistic, swift, and cost-effective evaluation of SCRs. The risk assessment's objectives are to determine whether the level of risk is high or low, so managers can make informed decisions about which risks should be addressed initially and prepare proactive strategies for unanticipated issues. However, risk assessments should consider losses, intangible and unregulated outcomes, such as flexibility, agility, and brand reputation. In addition, there should be more and stronger techniques and approaches to assist with risk assessment at the supply chain level, not solely at the company level [19].

3. Risk Treatment

It seems that risk treatment does not have specific guidelines or states to act when the risk happens. This is because not all risk occurs at the same time in the same way and in the same way. Therefore, researchers and practitioners have found and applied flexible approaches to assess risk by themselves. Table 4 is one of the pieces of evidence conducted by [19].

In real-time business, the process may go against risk mitigation to risk acceptance. We noticed that risk mitigation was studied in an early stage when SCRM had just started to emerge. It shows that both academic and business levels highly emphasize and concentrate on investigating solutions to reduce the effects of risks on the supply chain. After that, they recognized the importance of "collaborative advantage" when they began to share risk with relationships. Followed by risk transfer, risk avoidance and finally risk acceptance.

4. Risk Monitoring

Despite being a crucial part of SCRM, risk monitoring has received less attention than other SCRM aspects because of its perceived complexity and lack of a defined structure [19]. There are less than 100 papers studies on risk monitoring and most work has been done only in a developed country context [19]. Further work has significantly needed to be researched to provide ongoing directions for the future.

V. CONCLUSION

This study highlights many incisive SCRM field knowledge. In this paper, we have conducted and recorded a significant number of journal articles studying SCRM. We further contribute to SCRM definitions for non-financial performance outcomes. Thirdly, providing some domain on the SCRM process allows subsequent researchers and practitioners to focus insights into the content of SCRM.

In addition, it has been demonstrated that a substantial number of manufacturing companies in the Western nations and the United States have adopted SCRM to reduce the risk associated with their supply chains; meanwhile, numerous studies on the implementation of SCRM have been completed in the countries of these nations [33]. In contrast, the usage of multi-dimensional risk evaluation and its effects on performance in Asia's developing nations is still quite constrained [34].

Particularly in Vietnam, SCRM research is rarely available now. SCRM is adopted by a small number of businesses, and there has been little significant research undertaken in this area. Therefore, we recommend that academics and practitioners in Vietnam focus on the first stage of SCRM — risk identification. It attempts to improve understanding and classification of risk sources, as well as the link between them and their consequences on organizational performance in Vietnam. Since SCRM's aims, tactics, and procedures are extraordinarily complex.

However, successful risk management is only possible if risks are accurately identified, regardless of whether the issue is safety, quality, shortage of supply, lawsuits, or natural disasters [35]. Regardless of the risk management strategy employed, [1] noted that end-to-end SCR must be comprehended and managed entirely. According to the preceding principles, investigating the primary role of SCRM to identify potential risk sources is appropriate for the Vietnamese context. Importantly, academic institutions and businesses will have greater confidence in establishing risk mitigation and resilience strategies if they appreciate the identification phase.

This paper still has many limitations. Firstly, our literature is mainly based on previous reviews therefore the information was quite out-of-date. Lastly, the expectation to review existing literature was only in the listing stage and lack of analysis.

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SUPPLIER INTEGRATION AND ITS INFLUENCING FACTORS: AN EMPIRICAL STUDY IN BINH DUONG

Nguyen Cao To Linh[1], Kieu Manh Kha[1]
[1]*Becamex Business School, Eastern International University, Binh Duong, Vietnam*
linh.nguyencao.bbs18@eiu.edu.vn; kha.kieu@eiu.edu.vn

Abstract: The benefits of supply chain integration (SCI) on organizational performance have been grounded in the current body of knowledge. Although previous studies have identified and confirmed various SCI drivers, there is a lack of rigorous study into the sub-domains of SCI, especially supplier integration (SI). This research aims to assess how relationship quality (RQ), which includes supply uncertainty, technology uncertainty, and anticipation of benefits influences SI. A cross-sectional survey was developed to collect the responses from consumers in Binh Duong, Vietnam to empirically test the developed theoretical model. The findings of this study close the knowledge gap in the SCI domain by specifying the different impacts of drivers on SI. This research provides insights into SI which create a foundation for future research in this supply chain domain. Provide useful information for companies to build better supplier strategies. Practical implications are drawn from this research to assist industry practitioners to make better supply chain decisions.

Keywords: *supply chain, supplier integration, relationship, quality*

I. INTRODUCTION

Integration is the process of merging separate components into a single, coherent whole. The more systems involved, the harder it is to integrate them, hence businesses frequently prefer to outsource some or all of the system development process to outside contractors. Businesses that have an integrated supply chain are better equipped to react swiftly to changes in the market, consumer expectations, and competition activity. They lessen spending and waste as well. Essentially, having an integrated supply chain gives them an advantage over the competitors, and the whole business benefits. The normal practice is to use a strategy of short-term, ad hoc targets that gradually work towards complete integration by connecting multiple subsystems when appropriate because integration is difficult to achieve all at once [6]. The literature is concentrating more and more on the connection between external supply chain integration as the advantages of internal integration are more generally recognized. Prior research claimed that a company's capacity to integrate its supplier might enhance business success [50]. For the aforementioned reasons, we are quite eager to start working on this research to examine the elements influencing supplier integration.

In turbulent and complex environments, companies are working harder than ever to improve supply chain cooperation [8]. In order to create seamless processes and solid supply chains that are hard for competitors to

imitate, supplier integration tries to increase the efficiency and efficacy of information and physical flows between a manufacturer and suppliers [25]. Because it enables suppliers to share with the business their experience with innovations, supplier integration has a good impact on new product flexibility. Additionally, supplier integration makes it easier to create new product flexibility by easing internal complexities and resolving issues with projects to create new product flexibility [74]. Strong supplier collaboration has long been seen as crucial to business success [43]. Due to just-in-time initiatives, vendor-managed inventory programs at Wal-Mart and Dell Computer, and just-in-time programs generally, the industry has been leading supplier integration activities. Projects to integrate suppliers, like third-party logistics, are also on the rise. In these initiatives, networks of businesses, possibly from various industries, work together to achieve cost savings through scale. Therefore, higher levels of performance ought to be attained as a result of increased expenditures on supplier integration [56]. In many industries, there is a growing interest in supplier-customer interactions, but there are currently few complete conceptual frameworks available. There is a need for procedures that make it possible to comprehend suppliers' integration in supply chains in detail and systemically [9].

Businesses are already dealing with more supply chain interruptions, which might affect how they build their supply bases. Studies examining how these decisions impact other supplier management strategies, such as supplier integration, are few, nevertheless [7]. The supply chain management theory has recognized suppliers as a crucial part of the supply chain. Companies must interact effectively and swiftly with their suppliers to promptly offer customized items to clients. For businesses, this frequently requires a considerable attitude change where they no longer see the supplier as a rival but as a partner [69]. Supplier integration emphasizes the importance of having a connection with a significant supplier that includes information exchange, teamwork during planning, and cooperative product creation while navigating organizational barriers. It helps businesses to collaborate more successfully with a select group of significant suppliers who are ready to share accountability for the goods' success. In order to collaboratively increase service capabilities and reduce supply chain costs, the essential skills, and capacities of suppliers and customers are brought into alignment through supplier integration [49]. The increased connection among suppliers enables them to better understand the demands of the organization and meet those needs by providing the appropriate supplies [44]. Due to its enormous improvements in the areas of generating top standard goods, providing value, reducing cycle times, and lowering costs and production lead times, integration of suppliers has become crucial to corporate success [36].

1. How can the concept of supplier integration be described?
2. What are the drivers of supplier integration and how it be defined?
3. How has supplier integration been impacted by the drivers?

This study specifically aims to:

1. Reveal supplier integration-related discoveries that provide the groundwork for further supply chain-related research.

2. Evaluate the drivers affecting supplier integration.
3. Provide practical implications to help business professionals improve their supply chain.

In order to help the research paper be completed effectively and make it easier for the readers to understand, this research paper will consist of 5 sections. The thesis statement, which is only a summary of the goals of the research project, was to be presented at the beginning of the research paper. The theoretical framework that was developed throughout the research is then presented in the literature review. The methodology section details the precise procedures utilized during the study process later on. Next, section 4 summarizes the problem throughout the course of the research and the outcomes. Finally, reiterate the thesis statement, and the results of the analysis by bringing all of these factors together and forming conclusions.

II. LITERATURE REVIEW AND HYPOTHESES

1. Supplier Integration

Integration is motivated by the recognition of interdependency. Getting different functional groups of a corporation to cooperate to achieve corporate goals was an issue in previous, more vertically integrated periods. Companies must combine partner and supply chain operations to efficiently deliver items to the market as growing amounts of the product value are partitioned to entities outside the business [71]. There has been increasing consensus during the previous ten years that integrating suppliers, manufacturers, and consumers are crucial from a strategic perspective [70]. Of these, supplier integration is the focus of this research. Many scholars have recognized the multifaceted aspects of supplier integration, which may include information exchange, developing long-term relationships with suppliers, including suppliers in the creation of new products, integrating products, and integrating processes [34], [36]. In order to meet customer expectations, a manufacturer collaborates with its suppliers to plan activities and make choices by exchanging information and involving suppliers in internal operations [50]. Supply chain success is positively and significantly correlated with supplier integration on both the tangible and intangible fronts [33]. Supplier integration is a condition of syncretism between an organization's manufacturing, buying, and supplier elements [69]. The techniques of collaborating with suppliers to pool materials, establishing inter-organizational norms and behaviors, and creating contemporary capacities to meet consumer demands are collectively referred to as supplier integration [50]. Supplier integration aims to create collaborative, coordinated, and well-controllable integration methods, practices, processes, and behaviors. Sustainable competitive advantages may be created by combining a company's resources with the skills of its supplier and executing cooperative operations. In the context of Industry 4.0, the reduction of product development and life cycle times as well as the related quick, flexible, and effective production processes raise the significance of supplier integration [24], [52]. Integrating suppliers well is a crucial tactic for businesses looking to get an advantage over their competitors [34]. A manufacturer can acquire important and

limited information and resources through exchanges, collaboration, and cooperation with suppliers [50]. Many businesses continue to struggle with supplier integration (SI), and issues with supplier relationship management may potentially endanger shareholders' assets [35]. For instance, while incorporating suppliers in their new product development initiatives, Boeing and Airbus encountered considerable issues that resulted in significant disruptions and cash requirements [36]. The implementation of the supplier integration plan is challenging, and the results are complex [57]. The outcomes of supplier integration might not be universal but instead depend on environmental and firm-specific factors [37]. Given the complexity of supplier integration, greater knowledge about how and when supplier integration improves performance is needed [32]. Due to rising global competitiveness, several businesses all over the world are forming cooperative, win-win relationships with supply chain partners. On-time delivery is a persistent issue for small and medium-sized businesses. SMEs may communicate order and inventory information with suppliers by integrating with their suppliers. Additionally, supplier integration, which entails effective communication, information exchange, and collaboration with suppliers, helps lessen upstream complexity. Integration of suppliers improves responsiveness, flexibility, and time efficiency. Through the reduction of uncertainty and the lowering of production costs, supplier integration also contributes to the reduction of transaction costs. Consequently, supplier integration has a favorable effect on the operational effectiveness of a firm [24], [23]. Integration of suppliers also fosters innovation [38].

2. Drivers of supplier integration

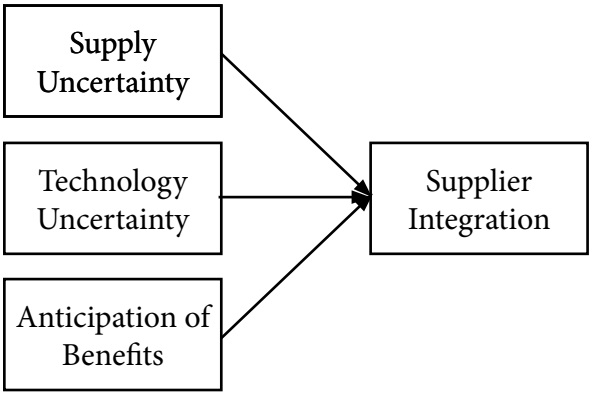

Figure 1. Research model of drivers impacting supplier integration

As seen in Figure 1, a variety of goals must be taken into account in order to understand the drivers of supplier integration. In order to determine how relationship quality, which comprises supply uncertainty, technological uncertainty, and expectation of benefits, impacts supplier integration, this research was developed. In order to pinpoint the factors that influence supplier integration, the research offers a summary of the essential ideas that the entire article would be built around. Additionally, it has been established that there are interdependencies between suppliers and purchasers, necessitating strong and reliable ties between the parties to the transaction [58]. Considering the mentioned gaps, the present study contributes to understanding supplier integration and lays the groundwork for future research in this area of the supply chain. It also has practical implications for helping businesses make better supply chain decisions.

2.1. Supply uncertainty

Uncertainty in supply networks refers to shifts in fulfillment and profitability brought

on by unforeseen occurrences as well as the difficulty in making decisions when there is a lack of clarity in the chain, which means we have no way of understanding the situation and effects of potential actions [2]. Uncertainty is given in an economy that is growing and going global. Uncertainty is unexplained and uncontrollable, in contrast to disruptions, which refer to unfavorable occurrences that really occurred. The main way that uncertainty affects how businesses behave is by impairing judgment and making it difficult to understand the purpose and benefit of business conduct [59]. The reconfiguration of physical resources, like inventories and supply chain resources, to make one more resilient to the detrimental consequences of supply chain disruptions is frequently the subject of supply chain uncertainty research. For instance, demonstrate how organizational structure and manufacture of products may be combined to generate harmony with the surrounding environment, and the negative effects of supply chain uncertainty may be minimized [50]. Other writers emphasize the use of impalpable assets in reducing the judgemental consequences of supply chain breakdowns. These include influencing politicians and finding fresh commercial opportunities, as well as developing internal cultural power to increase adaptability achieved through a business's human capital [45], [51], [19]. Supply uncertainty refers to the unpredictable and variable nature of changes in and the overall character of a firm's supply chain as a significant component of the uncertainty in a firm's environment [60]. One of the frequent supply chain issues is supply uncertainty, when the quantity provided by the provider may differ from the initial request. Such losses may result from strikes, product misplacement, or improper shipping amounts on the part of the supplier [1]. Uncertainty in the supply chain alters assessments of the level of outsourcing and raises the demand for vertical integration [61]. For many businesses, overcoming supply instability is a major concern. Markets are becoming more volatile, and manufacturing and logistical procedures are becoming more vulnerable as a result. Supply chain management has acknowledged managing uncertainty as a crucial responsibility. High supply unpredictability in supply networks necessitates flexibility to handle unforeseen changes in company operations [62]. Demand and supply uncertainty coexist in reality, and the best course of action should be chosen by taking into account the combination of these two uncertainties. We show that, if a business doesn't plan for uncertainty, the cost under a particular degree of supply uncertainty is higher than the cost under a comparable amount of demand uncertainty. The cost of unreliability is higher under supply uncertainty than under demand uncertainty. This indicates that it is important to plan for supply volatility [3]. Businesses working in uncertain conditions may choose somewhat conservative strategies like buffering and bridging [47]. As a result, in highly uncertain circumstances, the expected beneficial impact of any strategic behavior or capacity, including innovation, may be reduced [4].

H1: Supply uncertainty has a positive impact on supplier integration

2.2. Technology uncertainty

Businesses lose sight of their potential future in uncertain conditions, and the results of their strategy and efforts are unclear. Therefore, given the volatility and uncertainty

in the structure and behavior of the firm's external environment, companies are likely to pursue more conservative and cautious methods and make fewer unconventional decisions [73]. Technology uncertainty is undoubtedly several of the most crucial issues for enterprises among these several kinds of environmental uncertainty [48], [21]. Technical ambiguity has two facets. One is the unpredictability of innovation, including its R & D efficiency, interoperability among several systems, ability to commercialize accomplishments, et.; this means that it is not entirely clear whether applying technology will have the desired economic effect. The second type of technological uncertainty is the technological cognition unclear. Regulatory environment circumstances, shorter product development cycles, technology that ages quickly, and the standstill of technology intellect caused by the conventional stagnation cause an organization's understanding and opinions of updated and iterative technology to diverge, causing the organization to make different decisions that have a significant impact on the detailed integrated for double creativity [41]. Technology uncertainty is the inability to know or predict if a certain result or target can be attained or how to do so based on commonly accepted technological knowledge or experience [63]. Manufacturers face major hurdles as a result of technology uncertainty because quick changes to the product and/or process standards and specifications can impede the efficient flow of materials in long supply chains [5]. Technology uncertainty is concerned with modifications to the requirements for items and procedures that are essential to a company's sector of the market [53]. Technology uncertainty raises the need for additional help from suppliers in the design of, and adjustments to, goods and processes because it lowers the capacity of manufacturers in a chain to regulate the component's makeup and imposes adaption challenges [53]. Where technology is new or changing quickly, there is a lot of technological uncertainty [64]. One of the most significant examples of technological uncertainty is environmental uncertainty. It is typically characterized as the totality and unpredictable nature of technology developments in the sector that affect products or services [40]. According to research, technology uncertainty has an impact on business-to-business relationships. Growing technology uncertainty prompts collaborations between companies to develop new products [65], boosts interfirm information sharing [54], and may lead to a supply chain performance improvement learning process [46]. A growing body of research suggests that integrating suppliers in the improvement of products and processes might assist manufacturers to manage technological uncertainty [55]. In-depth studies between Japanese and American manufacturers, for contrast, revealed with "ensure that the customers engagement on creating new products groups and increased usage of knowledge sharing might alleviate the challenges associated with technological uncertainty" [66]. Uncertainty in technology is one of the common signs of a dynamic environment in the information economy era. When technology uncertainty is high, businesses are compelled to keep continuous communication with the outside technological environment, utilize knowledge management techniques to unceasingly transnational level explicit and implicit knowledge, and modify new understanding following internal degradation and conversion. This is because

it is challenging for businesses to predict research equipment change demographic changes and seize innovation capabilities. There will be a greater requirement for knowledge of innovative activities as technology uncertainty increases since the organization will have a smaller absolute knowledge reserve [42]. The predictability of technology utility declines as a result of the instability in the technological environment, thus businesses must deploy incremental innovation to preserve a brief competitive edge. Enterprises must simultaneously update their technology and put ground-breaking ideas into practice if they want to preserve their long-term competitiveness in a world of technological unpredictability. Because of this, technological uncertainty compels businesses to adopt flexible invention tactics that can meet international environmental conditions and are essential for controlling active learning and dual creativity [39]. Given how quickly technology is developing, industrial equipment that is purchased today can become obsolete shortly. The balance between the expenses involved in investing in alternative processing technologies under technological developments must thus be kept in mind by decision-makers in order to mitigate risks associated with technology uncertainty and sustain competitive advantages. In this situation, replacing the existing technology with a new one is one option. However, there are potential hazards associated with this move due to the payback period and the unpredictability of technological advancements. For instance, a more sophisticated technology than the one that has already been released may soon be made available. Due to this circumstance, existing technology becomes fast and out of date. Furthermore, the adoption of new technologies is made more difficult by the existence of unpredictable demands. In order to optimize a firm's profit, the best technology portfolio should be chosen rather than fully replacing the present ones. This means that the best technology portfolio should be formed while taking into account the aforementioned uncertainties. A rigorous modeling and solution methodology is required to accomplish this, especially in high-tech manufacturing companies [18].

H2: Technology uncertainty has a positive impact on supplier integration

2.3. Anticipation of benefits

When there are significant interruptions, supply chain (SC) networks become more complicated and there is confusion about how to balance demand with supply [22], [26], [27]. The analytical model will be improved to better capture the optimal decision-making processes in a multi-tier supply chain environment with the help of the empirical study of retail behaviors in anticipation of supply interruption [13]. Almost every part of a company's strategic management involves judgments about the future, from long-term plans to produce wholly new products or construct new factories to calculations of the production of items adjusted for seasonal changes. In contrast, all of finance is predicated on expectations [14]. Many academics from numerous areas and fields have studied anticipation throughout the past century. Different forms of anticipation exist, such as explicit vs implicit anticipation. Additionally, many forms of anticipation may be active simultaneously, blissfully coexisting, or interfering with one another

[17]. Within the context of professions, risk often refers to a mostly calculable future that can be projected from the past; it presupposes predicted continuities based on recognized causal pathways [28]. It is also closely linked to the notion of the supply chain as a system for planning anticipation. Throughout the whole new product development process, the marketing division may predict the results. Businesses should focus more on the future to improve the efficacy of the anticipating process [67]. Individual qualities and expertise of the company, those participating in the anticipatory phase, as well as the sectors and partners that businesses work in, affected and altered their anticipatory approach [29]. Future studies can give improved anticipation with the use of more financial statements [16]. Future market anticipation looks at how customers perceive producers' efforts to meet consumers' expectations and requirements in relation to design, cost, manpower, resource, rivalry, and ASEAN anticipation [31]. The extra effort, market performance, and customer value all improved as a result of the expectation for the future [15]. Future expectation focuses on how customers view a business' actions to address their requirements and wants in the future [30]. Customers will be able to determine whether and to what degree their suppliers have an anticipated capacity once they have more knowledge about the product categories and consumption experiences. Customers can find out information about new items through the internet or social media, especially in the twenty-first century, even before businesses introduce their new products. Customers already see Apple's skill at foreseeing their changing wants, for instance, after the company introduces successive iterations of the iPhone. Customers' perceptions of the target brand might be influenced by this unique emotion [12]. The customer may experience a loss of utility if their order cannot be filled within a certain time frame due to a supply shortfall. To avoid this, the customer might stockpile by buying more than they need when the supply is accessible in anticipation of a supply shortfall [13]. In life, anticipation plays a significant role. It may energize us and serve as a strong motivator to help us cope with life's ups and downs [10]. For instance, a network structural design in advance of a pandemic is preferable to other operational recovery measures being implemented during the epidemic when they are deployed [11].

H3: Anticipation of benefits has a positive impact on supplier integration

The knowledge gained from this study about supplier integration lays the groundwork for more investigation into this area of supply chains. The study's findings outline the various effects of factors on SI in order to help professionals in the field make more informed judgments about the supply network. The hypotheses in the research come from the research gap and have an important influence on SI. Therefore, the authors will send a survey to gather input and conduct empirical testing to verify the hypothesis.

III. METHODOLOGY

A statistical program for the analysis of quantitative data is the main feature of SPSS. The objective of this study is to gather customer feedback from Binh Duong, Vietnam, in order to experimentally evaluate the created theoretical model. In order to answer a research question, non-probability

sampling is a sampling technique that considers factors other than randomness, such as the accessibility, closeness to a certain location, or level of expertise of the people you wish to interview [75]. Despite the drawbacks, the cost of collecting survey data has increased considerably in recent years, leading many academics and polling organizations to forego costly probability-based samples in favor of less expensive non-probability techniques [76]. Samples are taken from the population closest to the researcher as part of convenience sampling. Because the researcher might employ respondents who are easily accessible at the researcher's reach, it is also known as incidental sampling, opportunity sampling, or grab sampling. Convenience sampling is used by researchers when collecting samples from the entire community is not feasible. The method of sampling is simple, quick to provide results, practical, and inexpensive. The sample comprises individuals who are in close vicinity to the researcher, such as at their place of employment, school, club, apartment complex, etc [77]. Customers who reside in Binh Duong and are undergraduates are the subject of the study. We utilized the Statistical Package for Social Sciences Version 26 to analyze and validate the primary data (SPSS26). To analyze and assess the data for this study, IBM's SPSS (Statistical Package for the Social Sciences) will be used. Additionally, it allows for the determination of whether the goals established have been achieved and provides feedback for decision-making. Descriptive analysis, a sort of data analysis, aids in properly describing, presenting, or summarizing data points so that patterns can emerge that fully satisfy the objectives of the data. It summarizes the data distribution, assists in identifying mistakes and outliers, and enables the identification of similarities across elements, setting its framework for further statistical research [79]. Low results may also be caused by poorly connected test questions or by assessing more than one hidden variable [68]. One of the first structural models is factor analysis, which Spearman created in 1904. He attempted to explain the relationships (correlations) between a series of test results and proposed that these results might be produced by a model with a single common component, which he dubbed "intelligence," plus a different factor for each test. When factor analysis is used to evaluate questionnaires, it gives decision-makers highly useful information that helps them concentrate on a small number of key variables rather than a huge number of aspects [78].

To gauge how closely two variables are related to one another, correlation coefficients are utilized. The calculations produce a number that ranges from -1 to 1, where:

- 1 indicates a strong positive relationship.
- -1 indicates a strong negative relationship.
- A result of zero indicates no relationship at all.

(Glen, n.d)

Using multiple regression analysis, researchers may assess the strength of the association between a result (the dependent variable) and various forecast factors (the independent variables) as well as the importance of every indicator to the connection [81]. Multiple regression analysis makes use of independent variables whose values are known in order to predict the value of the single dependent quantity.

IV. RESULT

To verify the predicted correlations, we used hierarchical regression analysis. Before calculating the interaction term, the independent variable and moderator were mean-centered to minimize the potential impact of multicollinearity [37]. The findings are consistent with the theory; supplier integration boosts a company's competitive advantage [80]. Prior to internal operational capabilities, the advantages of external integration must be translated [20].

V. CONCLUSION

Motivated by the fact that supplier integration (SI) is a crucial, current, and resource-intensive problem in the industry [72]. The degree of SI rises together with an enterprise's financial performance and lessens the financial crisis's negative effects. In order to build trust and create shared goals, businesses should initially integrate with suppliers with whom they aim to have a long-term relationship. They have to create a platform so they can communicate more effectively about their tasks and anticipated outcomes. SI increases supply chain flexibility and visibility while also generating competitive benefits that are essential to businesses for accurate forecasting, planning, and uncertainty reduction [69]. Depending on how they operate, businesses should have several SI techniques to increase performance. Improve the effectiveness of the company's operations by including its suppliers in continuity planning, cooperative decision-making, inventory management, and resource and risk sharing. This is especially important in the wake of the financial tsunami. Given that a high level of supplier integration (SI) may greatly reduce the negative effects of the financial crisis, businesses should adopt more SI methods to deal with difficult economic conditions. Last but not least, businesses should integrate with their suppliers gradually because a high degree of SI needs a lot of expenditure, which might be a development barrier [72].

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THE EFFECTS OF FOREIGN OWNERSHIP ON FIRM FINANCIAL PERFORMANCE: EVIDENCE FROM VIETNAM

Nhung Thi Hong Dang[1], Phuong Thanh Bui[1]
[1]*Becamex Business School, Eastern International University, Binh Duong, Vietnam*
nhung.dang.bbs18@eiu.edu.vn, phuong.buithanh@eiu.edu.vn

Abstract: Vietnam has witnessed notable growth in foreign capital inflow and an increased portion of foreign ownership in Vietnamese firms. This research examines the effects of foreign ownership on firm financial performance in various states of the economy. Pooled ordinary least squares (POLS), feasible generalized least squares (FGLS), and panel-corrected standard errors (PCSE) are employed to analyze panel data for non-financial companies listed on Ho Chi Minh Stock Exchange (HOSE) and Hanoi Stock Exchange (HNX) over (2009-2013) and (2014-2018). The study found that foreign ownership positively affects firm financial performance metrics return on asset (ROA), return on equity (ROE) from 2009 to 2013, and return on equity (ROE) between 2014 and 2018. However, from 2014 to 2018, foreign ownership had an inverted U-shaped relationship with a firm's return on assets (ROA), with an optimal level of foreign ownership of 21.94%. The findings indicated that foreign ownership has a different impact on firm financial performance in different states of the economy, contributing to practical implications for corporate managers and policymakers, and theoretical implications to the extent of foreign ownership literature for investigators in developing countries.

Keywords: *Foreign ownership, firm financial performance, states of the economy, ROA, ROE, Vietnam*

I. INTRODUCTION

Some foreign capital benefits consist of the attraction of innovative technologies, integration in international commerce, formation of human capital, and a competitive business environment, all of which result in economic growth, poverty eradication, and improved social and environmental conditions in host countries [1]. From a macroeconomic perspective, Vietnam is an emerging and small transition economy country with inadequate domestic savings, a lack of sufficient financial instruments, supporting policies and guidance for firms to seek a suitable capital structure [2, 3] needed to facilitate production investment to boost economic growth. Thus, sources of external finance such as Foreign Portfolio Investment (FPI) and Foreign Direct Investment (FDI) are considered the most crucially vital capital inflows to elevate economic growth [4].

From the enterprises' point of view, firms need to raise capital to finance their operation, expand production scale, extend into new markets, or invest in new projects [5]. The stock market capitalization in Vietnam was

reported at 57.2% of the GDP in 2019, and 68.6% of the GDP in 2020 [6], which depicts a significant impact of corporations on the Vietnamese economy. Notably, Vietnam witnessed a remarkable growth in international capital flows from US$371.8 million in 1988 to US$31.15 billion in 2021 [7].

In the context of the Vietnamese economy, from 2001 to 2007, the average real GDP growth of Vietnam was 7.25%, the highest in Asia. The Global Financial Crisis (GFC) made Vietnamese average annual GDP growth rate drop to 5.5% from 2009 to 2014 with a high level of macroeconomic instability and experienced two bouts of high inflation (in 2008 and 2011) booms and busts in equity and real estate markets and episodes of large capital inflows and outflows [8]. Seven years after the GFC of 2008, thanks to effective fiscal and monetary policies, the Vietnamese economy has shifted from short-term issues regarding inflation and payment imbalances to longer-term prospects for economic growth [9]. Vietnam's economy grew 6.68% in 2015, exceeding Prime Minister Nguyen Tan Dung's 6.55% forecast, the highest over a five-year period, thanks to rapid industrialization and FDI [10]. Meanwhile, the 2015 rate "represents a five-year achievement rather than the result of a single year's efforts" hence, Vietnam has been in a booming economy since 2014 Nguyen Bich Lam, the General Statistics Office (GSO) head, told a media conference [10]. Vietnam was top 10 fastest-growing economies [11, 12].

Diversification of capital structure is one of the critical successes of a business associated with costs versus benefits, and implied risks indicate a firm's prospects [13]. Several studies have been undertaken to understand better the impact of foreign ownership (FO) on firm financial performance (FFP) [14]. However, these studies do not have consistent implications, for example, a positive linear relationship [15, 16, 17, 18], a negative linear relationship [19], a non-linear U-shaped relationship [20], an inverted U-shaped relationship [21, 22], and even no relationship [23] between FO and FFP. Notably, there is an increased portion of FO in Vietnamese firms. In Vietnam, research on the impact of FO on FFP has been insufficient and has not yet converged on a conclusion for instance an inverted U-shaped relationship [24, 25, 26], or a U-shaped relationship [27].

Although the topic of the effects of FO on FFP is studied extendedly in the context of the Vietnamese economy, there is no paper distinguishing the impact on different states of the economy or evaluating the degree of the effects of FO on FFP in the bust economy (2009-2013), and the booming economy (2014-2018) in Vietnam. A lack of studies has looked at the effects of FO on FFP of different sizes, while most Vietnamese enterprises are small and medium. Hence, there is necessary to suggest FO policies by size.

A theoretical framework was developed (as presented in Fig. 1) to answer three questions: RQ1: How does FO affect FFP? RQ2: What is the optimal level of FO if the relationship between FO and FFP is nonlinear?? RQ3: Is the degree of the effects of FO on FFP by states of the economy different and by firm's sizes different?

II. METHODOLOGY

Foreign ownership (FO)

FO occurs when individuals who are not citizens of the country own or control a company, or when firms or institutions with headquarters outside the country [28, 29]. It can occur when a foreign individual acquires or purchases domestic property or shares. According to [30], defined FO is complete or majority ownership or control of a business in a country by companies whose headquarters are not in that country.

Firm's financial performance (FFP)

Firm performance depicts the efficiency and effectiveness of using business means in the process of business operations of enterprises [31] and reflects a firm's ability to achieve the firm's goals [32]. Financial and productivity measures can be utilized to assess firm performance [33]. The paper focuses on studying the impact of FO on FFP, financial metrics such as return on assets (ROA) and return on equity (ROE) are commonly used to examine FFP. FFP is used as a tool to measure an organization's current development and potential growth [34]. FFP is a subjective measure of how well a firm can use assets from its primary mode of business and generate revenues [35].

Agency theory

One of the most prevalent theoretical frameworks, agency theory, governs the relationship between ownership and management structure [36, 37]. Agency problems exist when there is a conflict of interest from the separation between the management and ownership, and the management pursues its own goals, not acting in the stockholders' best interests.

Agency costs include three major components to eliminate conflicts of interest between shareholders and company management or to build a supervisory system that acts in the best interests of the shareholders. (1) Monitoring costs are incurred when the owners of a business establish participation to orient and monitor the actions and performance of management; (2) Residual loss are the costs that arise when the managers make decisions in their own interest, not in the best interest of the stockholders; (3) Bonding costs are incurred to incentive managers act in the interests of the shareholders [36].

According to [38], the ownership structure affects the agency's costs. Since foreign investors participate in a firm, they facilitate corporate governance mechanisms, supervise, recommend, and participate in the firm's decision-making process and avoid any business decision that negatively affects the firm's value [39]. Regulations, corporate governance, and transparency might be relatively weak in the emerging stock markets, when FO increases to be major shareholders, who have the incentive to monitor a manager's activities [40] and set high standards of corporate governance [36], thereby mitigating the issue of agency and tending to maximize firm's value.

In contrast, major international investors may charge expropriations that adversely impact a company's value and are likely serious in developing nations with insufficient shareholder protection mechanisms [24].

Resource-based theory

Resource-Based Theory, resources that are valuable, rare, difficult to imitate, and non-substitutable, can provide the foundation to develop firm capabilities that can gain more competitive advantages, and lead to superior performance over time [15, 41].

Foreign-financial shareholders have an abundance of capital to support enterprise's production. However, they only focus on short-term investments and liquidity, aiming to boost the stock's market value [42; 43], which has only a minor impact on firm performance.

In contrast, foreign strategic investors use their shares' power to advance their strategic interests. Accordingly, they use their superior technical, corporate governance practices and tangible and intangible resources to assist domestic firms [44]. As a result, strategic foreign shareholders have a more significant positive impact on business performance than foreign financial shareholders.

The positive relationship between FO and FFP

The most common result is the positive relationship between FO and FFP. [45] showed a positive relationship between FO and firm performance in Norway and Sweden from 1996 to 1998, firms benefit from better governance and improve corporate value when it has FO. [46] proved a positive impact on plant productivity companies in Indonesia. [47] stated that FO helps companies overcome budgetary pressures and access foreign investment in Korea. [48] argued that foreign shareholders can assist technology, finance, and contribute on expertise, and experience, to make optimal decisions that increase credibility over domestic investors. FO helps to improve the monitoring mechanism, and the rise in R&D expenditures contributes to the long-term viability and competitiveness of the Japanese market [20].

However, some research shows that there is a negative relationship between FO and FFP. [49] found a negative relationship between FO and the productivity of wholly domestically owned firms in the same industry over 4,000 Venezuelan plants from 1976 to 1989. [50] discovered the inverted relationship in the real estate industry in Vietnam.

According to Resource-Based Theory, if a firm use valuable, rare, difficult to imitate, and non-substitutable resources, it can superiorly perform [51]. Meanwhile, foreign strategic investors help domestic firms gain more competitive advantages such as access to new markets, supplement capital, improve corporate governance practices and minimize production costs [44]. Thus, the first hypothesis is:

H1: FO level is significantly and positively associated with FFP.

While the paper uses the two financial ratios to measure FFP, which may have different results. Hence the two sub-hypotheses of this study are stated as follows:

H1a: The FO level is significantly and positively associated with ROA.

H1b: The FO level is significantly and positively associated with ROE.

The inverted U-shaped relationship between FO and FFP

FO has an inverted U-shaped relationship with a FFP according to agency and resource-based theories. [26] found an inverted U-shaped relationship between FO and firm performance, with an increase in firm performance reaching a turning point of 36.26% and then declining in 288 non-financial listed Vietnamese firms (2015-2019). Major foreign investors may charge expropriations that adversely impact a company's value and are likely serious in developing nations with insufficient shareholder protection system [24]. [52] showed an inverted-U relationship between FO and FFP in China, the FFP increased when FO ratio increased from 47% to 64%, and then decreased. [53] used Tobin's Q to conduct a study of 945 industrial firms in the first section of the Tokyo Stock Exchange and discovered that Tobin's Q rises until foreign ownership reaches approximately 40% to 45%, then falls back. Thus, the second hypothesis is:

H2: FO has an inverted U-shaped relationship with FFP.

While the paper uses the two financial ratios to measure FFP, which may have different results. Hence the two sub-hypotheses of this study are stated as follows:

H2a: FO has an inverted U-shaped relationship with ROA.

H2b: FO has an inverted U-shaped relationship with ROE.

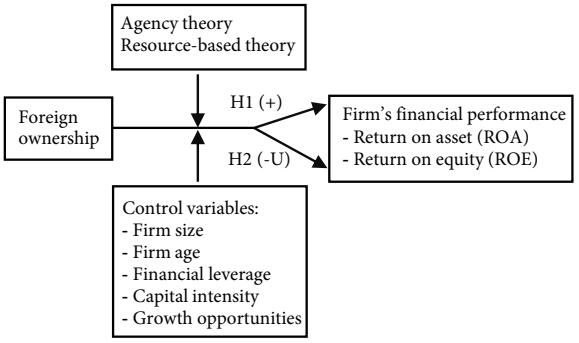

Figure 1. Conceptual framework

The research adopted a quantitative approach to examine a panel data to test the effect of FO on FFP. To analyze the dataset, STATA tool version 17 is conducted for this research.

In 2022, there are 410 listed companies on Ho Chi Minh Stock Exchange (HOSE), and 348 listed companies on Hanoi Stock Exchange (HNX); hence Vietnam currently has a total of 758 listed companies. The research samples are selected based on four criteria, as follows (1) they are listed companies on Ho Chi Minh Stock Exchange (HOSE), and Hanoi Stock Exchange (HNX); (2) they are non-financial listed firms, because financial institutions tend to have a different capital structure or follow different accounting and reporting standards to others; (3) they are listed at least before 2009 and have available audited, and annual reports in the study period from 2009 to 2018; (4) the study focuses on the information about FO; hence the samples must have the information of FO disclosed in the corporate reporting or FO in their ownership structure from 2009 to 2018. By using stratified sampling, this study consists of 73 samples. The information about FO, ROA, ROE, firm size, age, leverage, capital intensity, and growth opportunities

are collected from the firms' annual reports and cafef.vn.

Before running the panel data regression models, some tests were applied to test the independent variables, dependent variables, control variables, and the assumptions of linear/non-linear regression. Including multicollinearity through Variance Inflation Factor (VIF), Hausman test, and autocorrelation by Wooldridge test.

[54] confirmed that in the presence of heteroscedasticity, Pooled Ordinary Least Square (POLS) estimates are unbiased, but the usual tests of significance are generally inappropriate and their use can lead to incorrect inferences. POLS are not appropriate if heteroscedasticity is present in research data [55].

The fixed-effect model (FEM) assumes that there is one true effect size, while the random-effects model (REM) assumes the true effect could vary from study to study [56]. The Hausman test is then used to determine whether FEM or REM is appropriate when heterogeneity or autocorrelation exists in POLS [57].

When heteroscedasticity and autocorrelation exist in FEM/REM, feasible generalized least squares (FGLS) [58] and panel-corrected standard errors (PCSE) proposed by [59] methods are applied to eliminate the effects of these issues. To test for non-linearity between FO and FFP and to find the optimal FO ratio in firms, a quadratic test and Sasabuchi-Lind-Mehlum (SLM) test are used.

A non-linear relationship is measured using a basic linear regression with a quadratic term (λ) [60] as follows:

$$PERP_{i,t} = \beta 0 + \beta 1*Fopercent_{i,t} + \lambda*FopercentS_{i,t} + \beta 2*Lnage_{i,t} + \beta 3*Lnsize_{i,t} + \beta 4*Leverage_{i,t} + \beta 5*Capint_{i,t} + \beta 6*Invest_{i,t} + \varepsilon_{i,t}$$

III. RESULTS

A. Descriptive data

FO greater than 49% accounts for only 5% of the sample's observations. In the period 2009-2013, FO on a Vietnamese listed firm was limited to around 49%, but since 2015 thanks to the Decree No. 60/2015/ND-CP (Decree 60) of June 26th, 2015 [61], which allows 100% FO instead of 49% FO of a firm's shares as before, the maximum FO on a listed firm in Vietnam increase to 76.9% (2014-2018).

B. Research findings and discussion

This study explores the relationship between FO and FFP in (2009-2013) and (2014-2018).

Table 1. Summary regression results 2009-2013

Variable	ROA				ROE			
Model	POLS	FEM	FGLS	PCSE	POLS	FEM	FGLS	PCSE
Fopercent	0.0529**	0.115**	0.0600***	0.0683***	0.0772*	0.223*	0.0955***	0.0803***
Lnage	0.0238***	-0.114***	0.0105***	0.0233***	0.0389***	-0.247***	0.0208***	0.0323***
Lnsize	0.0100***	-0.0168	0.00637***	0.00818**	0.0177***	-0.0456	0.0206***	0.0255**
Leverage	-0.228***	-0.184***	-0.184***	-0.188***	-0.133***	-0.0997	-0.112***	-0.103***
Capint	-0.0521***	-0.0354	-0.0393***	-0.0517**	-0.0997***	-0.0144	-0.0901***	-0.0928**
Invest	0.0640***	0.0331***	0.0311***	0.0413***	0.152***	0.0884***	0.0912***	0.106***
_cons	-0.162**	0.985***	-0.0429	-0.129	-0.396***	2.201***	-0.425***	-0.602**

*Notes: * p<0.1, ** p<0.05, *** p<0.01*

Table 2. Summary regression results 2014-2018

Variable	ROA				ROE
Model	POLS	FEM	FGLS	PCSE	POLS
Fopercent	0.0529**	0.115**	0.0600***	0.0683***	0.0772*
Lnage	0.0238***	-0.114***	0.0105***	0.0233***	0.0389***
Lnsize	0.0100***	-0.0168	0.00637***	0.00818**	0.0177***

Leverage	-0.228***	-0.184***	-0.184***	-0.188***	-0.133***
Capint	-0.0521***	-0.0354	-0.0393***	-0.0517**	-0.0997***
Invest	0.0640***	0.0331***	0.0311***	0.0413***	0.152***
_cons	-0.162**	0.985***	-0.0429	-0.129	-0.396***

*Notes: * p<0.1, ** p<0.05, *** p<0.01*

Table 3. U-test regression results of the SLM Test

Period	2009-2013		2014-2018		
Variables	ROA	ROE	ROE	ROA	
				SMEs	Large enterprises
Extreme point	Outside interval - trivial failure to reject H0: Monotone or Inverse U shape/U shape		.219379	.3698291	.0650488

The results indicate that H1 is accepted. Particularly, FO is significantly and positively associated with two financial metrics of FFP (ROA, and ROE) from 2009 to 2013, and ROE from 2014 to 2018. This finding is consistent with the findings in previous studies [15, 16, 17, 18]. This demonstrates foreign investors enhance FFP since they have incentives to synchronize managers' activities with the goals of shareholders [33]. Foreign shareholders support firms in the capital, technologies, training, and management techniques, which is pivotal in improving performance [21, 26]. The recent corporate failures in emerging and developing markets, such as the case of South Africa, Turkey, China, and Vietnam blamed on irregular reporting and a lack of strategic planning of weak corporate governance practices [33]. As a result, FO's integration of enhanced corporate governance measures led to an increase in FFP [45, 62].

The results indicate that H2 is accepted. Particularly, FO has an inverted U-shaped relationship with ROA (2014-2018), which is consistent with H2a but rejects H2b. This finding is consistent with previous studies [21, 22, 25, 26], but contradicts [27]. This depicts that when the economy is bust, firms need more and more foreign finances to maintain and improve their operations, but in the booming economy, the efficiency and effectiveness in operation by using optimal financial strategy are more crucially vital to perform better and grow. Nonetheless, when FO exceeds a certain level, major foreign shareholders adversely affect FFP by pursuing their own interests at the expense of minority shareholders, such as higher short-term capital gains and dividend yield as an entrenchment effect [62, 63, 64]. Moreover, large international investors may charge expropriations that adversely impact a company's value and are likely serious in developing nations with insufficient shareholder protection procedures [24]. Consequently, the effect of FO on FFP thus becomes negative [52]. Moreover, domestic-owned firms may benefit from familiarizing themselves with the domestic business environment, including procedures, corporate practices, and legal and regulatory frameworks, which highly concentrated foreign-owned firms cannot achieve (liability of foreignness) [21, 33]. As a result, the decline in FFP after FO exceeds 21.94%. Thus, to maximize FFP, Vietnamese listed firms should have at least 80% domestic investors of total shareholdings, which helps prevent negative influence from foreign investors' power in ways that benefit FFP [62].

When a firm's size is not considered, the optimal level of FO is 21.94%, while most Vietnamese enterprises are small and medium enterprises (SMEs). Hence, there are necessary to suggest policies of FO by size. To evaluate whether there is a different level of the optimal ratio of FO and FFP, panel data for the period 2014-2018, were separated into two different panel data including SMEs, and large enterprises. The optimal level of FO

in SMEs is 36.98%, which is consistent with previous findings by [26]. In large enterprises, the optimal level of FO is 6.5%. Most SMEs are not satisfied with requesting capital from financial institutions, thus large enterprises have greater access to finance [65]. Moreover, the diversification of components in the capital structure helps businesses be more proactive in financing business operations, decreasing risks, and reducing mobilization costs [66]. Therefore, large firms that take advantage of easily accessing various financial sources to minimize risks and costs and maximize the firm's profit, which results in a need to raise funds from FO, are insignificant. In contrast, the availability of finance has been highlighted as a significant factor in SMEs' development, growth, and success [67, 68]. Still, various constraints such as collateral and complex application processes from financial institutions make few SMEs that could gain access to finance [65]. While the level of FO is high, these firms usually have access to diverse financing channels compared to others [69], which results in a lower requirement for external financing.

IV. CONCLUSION

The research used ROA and ROE as dependent variables, proportion of FO, and the square of the rate of FO in firms as independent variables, and firm age, size, age, leverage, capital intensity, and growth opportunity as five control variables in POLS, FGLS, and PCSE to study the relationship between FO and FFP in Vietnam in two different periods (2009-2013) and (2014-2018). The findings show that FO had a significant and positive impact on both ROA and ROE in Vietnamese listed non-financial firms from 2009 to 2013, while FO significantly and positively influenced ROE from 2014 to 2018. However, FO has an inverted U-shaped relationship with ROA from 2014 to 2018, with the optimal level of 21.94% of FO when the firm's size is not taken into account but increases to 36.98% for SMEs, and decreases to 6.5% for large enterprises.

These research outcomes also contribute to practices such as policy implications and orientation to assist managers and investors in assessing the impact of FO on FFP. Firstly, since leverage negatively affects FFP, more than domestic shareholders are needed to fund the firm's operations. Foreign investor participation improves FFP in terms of capital and governance. For policymakers, Vietnamese listed companies should be continued to consider easing restrictions on foreign investors, which will result in an increase in FO in domestic firms, which benefits from attracting foreign capital flows, improving performance, and achieving potential profit growth. Interestingly, the research results also show an inverted U-shaped relationship between FO and FFP. FO will be detrimental to FFP if it exceeds a certain limit as a cost of entrenchment and/or foreignness liability. Therefore, the optimal economic structure is crucial for FFP. The research result recommends managers should identify the optimal mix of firm's financial structures to gain better growth and minimize risks and costs. However, the different results in the different study periods (2009-2013) and (2014-2018) emphasize the impact of FO and FFP in different periods will be different with different optimal levels of FO ratio in firms by firm size. Thus, to develop an effective business strategy for raising funds, domestic

managers' professional qualifications should be enhanced in conjunction with the firm's financial mix and foreign investment potential. Moreover, to deal with entrenchment and foreignness liability effect, business executives, including both foreigners and domestic members, will be advantageous to the specialized management capacity industry and better understand local cultural identity. Lastly, these research outcomes also provide appropriate orientation to assist investors in assessing the impact of the FO to build an effective investment strategy.

The research has some limitations as others. Firstly, the study focuses on Vietnamese listed companies from different industries, not considering any particular sectors. In fact, various industries require dissimilar capital inflows, resulting in different optimal FO ratios in firms. Thus, future research should consider industrial characteristics to get insight into the impact of FO and FFP in Vietnam. Secondly, our results pointed out different relationships between FO and the FFP of Vietnamese listed firms when using different FFP metrics (ROA and ROE). Therefore, other financial metrics, such as Tobin's Q, and profit margin, are recommended for further studies.

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DISCRETE-EVENT SIMULATION AS A GUIDING TOOL FOR QUALITY IMPROVEMENT (QI) AT BECAMEX INTERNATIONAL HOSPITAL IN BINH DUONG, VIETNAM

Phat Nguyen Tien[1, 2], Thao Nguyen Ngoc[2], Tri Le Minh[2], Tien Nguyen Minh[2]

[1]Becamex Business School, Eastern International University, Binh Duong, Vietnam

[2]Operations Department, Becamex International Hospital, Binh Duong, Vietnam

phat.nguyent@bih.vn

Abstract: In healthcare, the use of discrete-event simulation (DES) has increased in popularity in recent years due to its ability to enhance operational efficiency, help with system design and reconfiguration, and assess resource needs. However, there have been few reported cases of successful implementation of DES models in the healthcare industry [1], with a lack of participation from stakeholders being a major hindrance [2]. DES was implemented to improve quality at Becamex International Hospital in Vietnam. The simulation results allowed hospital staff to gain a thorough comprehension of the present challenges and helped to correct misinterpretations about addressing fundamental causes. One trial using DES led to a 40% reduction in patient waiting time and increased staff engagement in and commitment to changes informed by DES, as opposed to the standard top-down approach.

Keywords: *discrete-event simulation, healthcare analytics, healthcare operations, healthcare modeling*

I. INTRODUCTION

Simulation modeling is frequently utilized in the healthcare industry due to its ability to simulate real-world systems with random variables, providing insight and evidence that may not be attainable through mathematical models alone [3]. It allows for the exploration of system changes and testing of scenarios that may not be feasible in real life due to financial or safety constraints [4]. These simulations can be applied to various aspects of healthcare, including patient care, operational efficiency, and management aspects. The most commonly used simulation modeling techniques in healthcare are discrete-event simulation, Monte Carlo simulation, agent-based simulation, and hybrid simulation.

DES is a popular method used in operational research, especially in healthcare. It is effective at modeling systems that require a lot of detail, particularly those involving the flow of individual items, like queuing systems. DES has demonstrated its value in healthcare systems where there is competition for resources and priority options have to be decided. The inclusion of randomness elements in DES also makes it well-suited for systems with loads of uncertainty. In healthcare, DES is often applied to improve patient flow, manage beds, and schedule resources [5]. This method is beneficial when the modeler wants to include patient characteristics, such as gender, age, and disease group, in the assessment. This allows for the application of sophisticated logical rules to determine an individual patient's journey through a series

of steps. Other mathematical models such as non-linear or convex optimization might introduce unnecessary complexities and fail to replicate real-life elements.

The project was carried out at Becamex International Hospital (BIH), Binh Duong, Vietnam. Outpatient flow is a crucial but heavily congested system at Becamex International Hospital (BIH). On a typical day, the hospital sees around 1,000 outpatient visits, which puts a lot of pressure on medical staff in terms of service delivery and management in terms of safety and scalability. BIH, is different from its competitors in the sense that we aim to deliver quality care for the patient with less cost. As a result, this motivates us to plan for improvements.

One issue with our quality improvement (QI) method has been that the tools we use, like Plan-Do-Study-Act (PDSA), are not being utilized in the way they were intended. QI is often led by department heads, with front-line staff in charge having minimal involvement in the planning phase. Change ideas are often simplistic and untested, based on managers' hunches, leading to a lack of complete consensus and less successful implementation of changes due to low engagement.

This led us to seek ways to increase stakeholder engagement in the early planning stages of QI. Our goal in this project is to use simulation modeling to gain the support of multiple stakeholders and quickly test ideas virtually in order to inform the planning stage of PDSA cycles. Simulation modeling is a technique that involves creating computer models of real-world systems to replicate their behavior, measure performance, and forecast the consequences of changes. This enables users to conveniently carry out "what-if" analyses and tests without disrupting the actual systems. This project employs simulation modeling to inform quality improvement initiatives in the outpatient department and assess the hypotheses and preconceived notions of managers.

The research questions addressed in this project, which used simulation experimentation with the participation of outpatient staff, are:

1. What are the current obstacles or challenges in the outpatient flow system?
2. What is the effect of certain potential interventions on the current process on overall system performance?
3. How does simulation modeling with staff affect their commitment to changes?

The paper is organised as follows:

- Planning and collecting data;
- Consolidating the conceptual model;
- Evaluation of current system performance;
- Building and validating the base model;
- Experimentation with proposed interventions to the system based on the validated model;
- Evaluation of changes and conclusion;

II. DATA AND METHODOLOGY

Descriptions of data

The project implements Simul8, a visual process simulation software to model the outpatient department operations. Most of the data used in simulation modeling is obtained from the hospital information system (HIS). However, several data parts, such as processing times at several stations,

are not recorded in the HIS. This data must be gathered through direct observation and modified using domain knowledge from the process manager.

We used Python to handle the data before putting it into the model:

- Combining and integrating datasets using patient IDs;
- Cleaning and transforming the data to prepare it for analysis;
- Conducting explanatory data analysis for a preliminary overview of the system;

Previous paper suggests a standard process for a successful simulation project [6]. The process of creating a conceptual model from a real-world problem involves creating a computer model using specialized software. Once the computer model is developed and validated, it can be used to conduct experiments and gain a deeper understanding of real-world issues, as well as identify opportunities for improvement.

Conceptual model

Fig. 1 shows a high-level map of the current patient outpatient flow process. The main goal of the project is to enhance system comprehension, demonstrate principles, and achieve mutual agreements on targets and the direction of the QI project. As a result, the system complexity is made simpler in order to illustrate principles. For example, the imaging department, which offers a variety of services (e.g., X-ray, ultrasound, MRI, CT), is represented as a single entity. The validity of the process was ensured by department heads of related services. The simplified flow has been approved by related stakeholders that it contains sufficient information for the scope of this project. The latter steps from data collection, modelling and analysis are guided by the conceptual model.

Current system performance

Data was gathered from the hospital database over a period of four weeks. The outpatient division receives between 700 and 1000 visits daily, with the most visits occurring on Tuesdays and Saturdays, with the latter typically exceeding 1000 visits (Fig. 2). The number of patients coming to the department rises to its highest level at the start of the two sessions, and diminishes as the sessions progress, with a lunch break from 12:00 – 13:00 (Fig. 3). The same trend is seen in the outpatient system throughout the week.

The initial data analyses show that there are periods of high demand throughout the day that cause maximum usage in various areas of the system, leading to bottlenecks at:

- Check-in counters and exams when the sessions start;
- Diagnostic imaging services after morning rush hour, around 9:00 AM;
- Dispensing medication after 09:30 AM;

The data from Fig. 4 indicates that there are major delays at station for registration for non-appointment patients, Examination and Diagnosis Imaging, with patients having to wait approximately 40 to 50 minutes on average to be served. A significant amount of the total waiting time is comprised of these queues that do not provide any benefit to the patients.

A basic calculation shows that most workstations were at risk of disruption due to high utilisation levels (Table 1).

Building the base model

A simulation model of the outpatient pathway is created using Simul8—a Discrete Event Simulation (DES) software—based on the descriptions provided, presented in Fig. 5. The base model is the representation of the conceptual model discussed in Fig. 1. It basically summarises the steps that the patients need to pass through. Each station is input with parameters to ensure it replicates real-life operations. The input parameters are presented in Table 2.

The main performance metrics (KPIs) can be classified as:

- On average, how long does a patient stay in the system (ATIS) in minutes?
- ATIS for walk-in patients and those with appointments
- Average waiting time at key stations (such as the examination room, imaging center, and check-in counter) in minutes
- Utilisation rate at key stations workstations, such as imaging services or exam rooms

The goal of the simulation is to help hospital staff understand the logic of the system and perceive any potential problems or solutions. Specifically, the simulation aims to:

- To evaluate the current level of performance and determine the underlying causes of any problems
- To assess the potential effect of staff improvement suggestions on system performance.
- To enhance the team's commitment to participating in an improvement program.

Input parameters

To ensure accurate data is entered into the model, a series of steps are followed. These steps include:

- Retrieving data from the HIS, totaling 200 observations. Only processing times at the examination and imaging stations are present.
- Verifying input consistency and handling any abnormal data that might interfere the modelling process.
- Processing times for other steps, including registrations, cashiers, laboratory, and pharmacy, were gathered through observations through camera system. 200 samples were collected for each station.
- Finally, the collected data is reviewed and validated with input from staff in charge of each area to ensure its relevance to the general flows.

We fit a theoretical probability distribution to the processing times of each workstation by utilizing Anderson-Darling (AD) statistical tests and the graphical method.

The Anderson-Darling test was conducted on the input data for Imaging service time using Minitab, with the sample result shown in Fig. 6.

The AD test shows that none of the commonly used distributions adequately describe the service duration. Given the large sample size of 200, it is reasonable to anticipate this result on the Anderson-Darling test. If the sample size was smaller, it is unlikely that any candidate distribution would be rejected by the goodness-of-fit test. When a large sample size is taken into consideration, most distributions are rejected [7]. If the empirical

data deviated even slightly from the expected distribution, the AD test would likely reject it.

Hence, we also examine the data graphically through the histogram. The histogram shapes in Fig. 7 indicate that the Lognormal distribution is suitable for modelling the service duration of the workstations being studied.

The model's input data analysis is summarised in Table 2.

Base model validation

From the conceptual model, the base model undergoes a series of validation steps to ensure it replicates the real-world systems.

A thorough assessment of both the conceptual model and the agreed flowchart is conducted to validate the model and make sure it accurately reflects the outpatient flow at BIH. The computer simulation is then evaluated.

White-box validation is performed to check if the characteristics of entities flowing through the system and the logic flow represent the actual operations. The classification of patients and arrival rate from the base model demonstrates similar patterns as of the collected data, summarized in Table 3.

Black-box validation:

The black-box validation is conducted to assess the general performance of the simulation model. Multiple aspects of the simulation outcomes are taken into consideration. Multiple simulated results are cross-checked with actual data to ensure the accuracy of the base model. The following two-sample t-tests are performed:

Number of walk-in patients:

- H_0: $\mu_1 = \mu_2$ (The average amount of patients is the same)
- H_α: $\mu_1 \neq \mu_2$ (The average amount of patients is not the same)

Number of appointment patients:

- H_0: $\mu_1 = \mu_2$ (The average amount of patients is the same)
- H_α: $\mu_1 \neq \mu_2$ (The average amount of patients is not the same)

Average time in system (ATIS) of patients:

- H_0: $\mu_1 = \mu_2$ (The ATIS is the same)
- H_α: $\mu_1 \neq \mu_2$ (The ATIS is not the same)

At $\alpha = 0.05$, the data does not provide sufficient evidence to reject the null hypothesis (p-value > 0.05). for all three tests. The model's simulated numbers mirror the real data.

Fig. 8 presents a graphical comparison of the real data and the modelling outcomes for the amount of booked and non-booked patients, as well as the average time in the system, with a 95% confidence interval.

Fig. 9 demonstrates that similarity between the actual data and simulation results. An exception to this is that the model is not able to accurately predict extreme data on the right side. Nevertheless, this is satisfactory due to the fact that such abnormal cases are not central to our project.

The base model has been validated and is suitable for experimentation and further analysis.

III. RESULTS

Experimentation

Variations and high utilization at workstations pose severe risks to the overall operations of the department. Therefore, we want to test scenarios proposed by the staff in charge with the aim to mitigate variability in service delivery and balance out the high utilization.

An iterative process is used to develop and analyze testing scenarios, with feedback loops from those running the outpatient system. Additionally, the scenarios are compared to the goals the hospital has set for the outpatient department, as outlined in Table 4.

The following are the test scenarios:

- **Scenario 1:** Increasing the number of imaging physicians by one.
- **Scenario 2:** Increasing the number of doctors in the Exam Room by one.
- **Scenario 3:** Raising personnel numbers to achieve the target queuing time detailed in Table 4.
- **Scenario 4:** Raising the number of appointment patients by 30%.
- **Scenario 5:** Boosting the number of booked patients by 30% and relocating those slots to the afternoon.
- **Scenario 6:** The implementation of prepaid card for biling services.

Simulation results and insights

From the validated base model, parameters of the system were adjusted to suit the testing scenarios. The main KPIs of the system including ATIS overall, ATIS for appointment and walk-in patients, queuing time at Imaging and Exam rooms are taken into consideration.

Each scenario demonstrate various changes to the KPIs being monitored. The most suggested change idea from staff is about increasing more headcounts (scenarios 1, 2, 3). Interestingly, the simulation illustrates that the effect of adding extra staff is rather limited. Realizing the cost and relatively limited impact the change they had hoped for would have on the system performance, the team, particularly the staff in charge, was able to determine that it would not be beneficial.

Scenario 5, which involves calming demand and decreasing variability across the system, demonstrated a much more significant improvement. In this situation, the system was assessed by adding 50% more appointment patients as in scenario 4, then transferring 30% of morning peak arrivals to the afternoon. This scenario evaluates the combined influence of more scheduled patients and a more even distribution of walk-in arrivals. Fig. 10 compares the current arrival schedule to its potential.

By doing this, the system is able to even out highs and lows, leading to a steadier volume. The problems with bottlenecks are taken care of. The revised arrival schedule has resulted in a more balanced demand, as demonstrated in Fig. 11. Simulation results in Fig. 12 indicate a clear enhancement in all workstations, particularly with the amount of time spent in the system decreasing by more than 44%.

The results presented in Fig. 13 demonstrate that scenario 5 is the most favorable for meeting the objectives set by the

general director for the outpatient department. This is further supported by the VUT (Variation x Utilisation x Time) relationship established in [8], which implies that variation and utilization of available resources affect the waiting time in healthcare systems.

The results from various simulations (seeds 150, 199, 205, 410, 999) demonstrated that the adjustments made in case 5 decrease the variance in the average amount of time patients spend, resulting in a greater proportion of patients finishing their visits within the target time frame of 130 minutes. This is highlighted in Fig. 14, which shows the comparison from a single simulation run (seed 150).

IV. CONCLUSION

From the analysis, we come up with answers to the research questions stated:

1. The most severe bottlenecks appear at check-in counters, exam room and imaging services.
2. DES helps greatly with testing certain interventions and validating the effects of these changes. For example, balancing out loads at workstations reduce more than 40% patient's waiting time, while adding more headcount might not be as beneficial.
3. We noticed that staff are much more engaged and committed to change initiatives when using DES as a tool to facilitate QI projects as compared to our previous approaches such as PDSA.

The simulation results indicated that smoothing out demand and variability in the system was the most effective change. Variation and utilisation are paramount when dealing with a sophisticated healthcare system such as outpatient services. By doing so, the overall time in system improved by over 44%. By failing to acknowledge these factors, the staff may request an excessive number of staff, leading to unrealistic staffing, as seen in Scenario 3.

Discrete-event simulation (DES) is an impactful tool for healthcare leaders and on-site personnel to attain a precise comprehension of the system. This tool provides a constructive and economical solution to direct the procedure and promote betterment for the hospital system. Employees are able to present their ideas and views and see if they make a difference through projects like this. The employees expressed that they have faith in the potential results of their ideas, leading to a greater sense of loyalty towards constructing and carrying out the improvement scheme.

The project has demonstrated that DES can be an effective tool for engaging stakeholders and increasing commitment to QI implementation, thus bridging the gap in simulation literature which has not adequately addressed the role of simulation experiments in practical QI directions. This is significant in healthcare operations, as one of the key obstacles is the difficulty of persuading people to accept change due to the range of opinions and objectives held by stakeholders.

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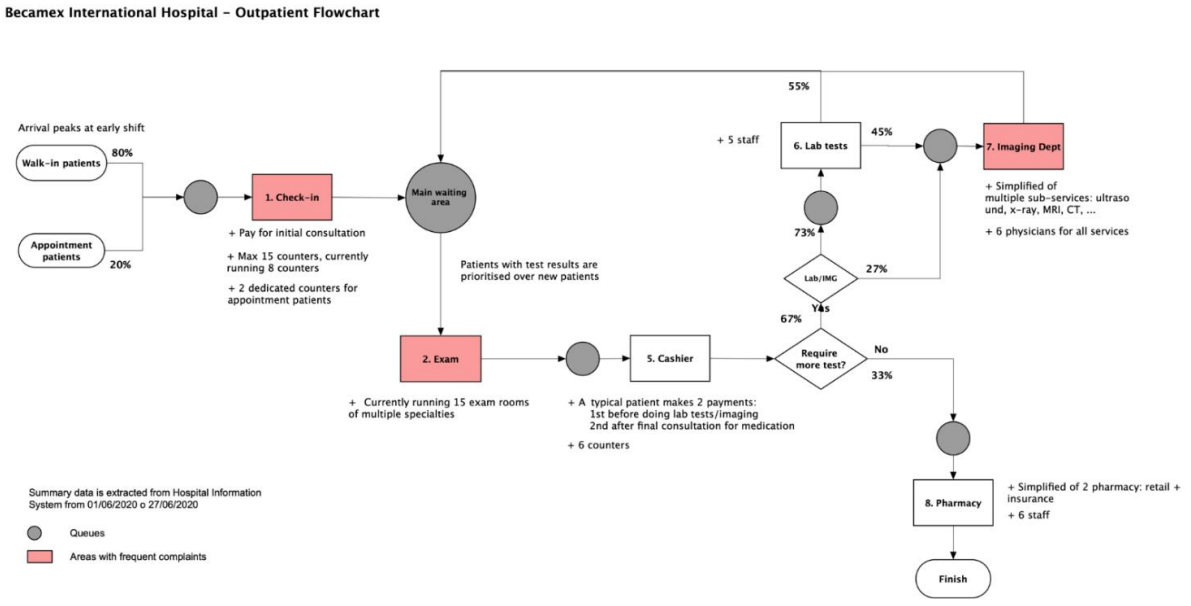


Figure 1. A conceptual framework for understanding the process of patient visits at BIH Outpatient Department

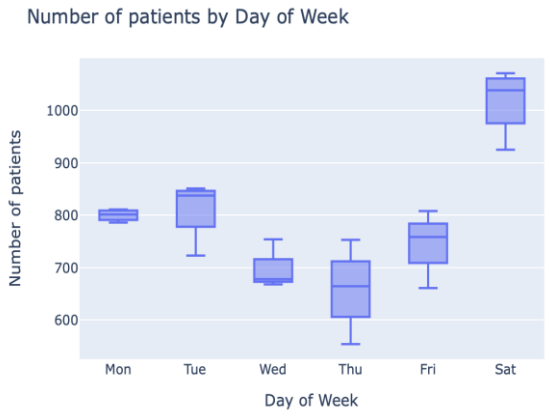


Figure 2. Number of patients per day of the week (n=4 weeks)

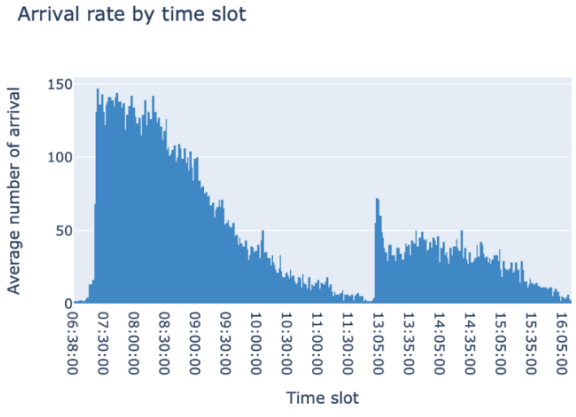


Figure 3. Average number of patients seen per time slot per day over a four-week period

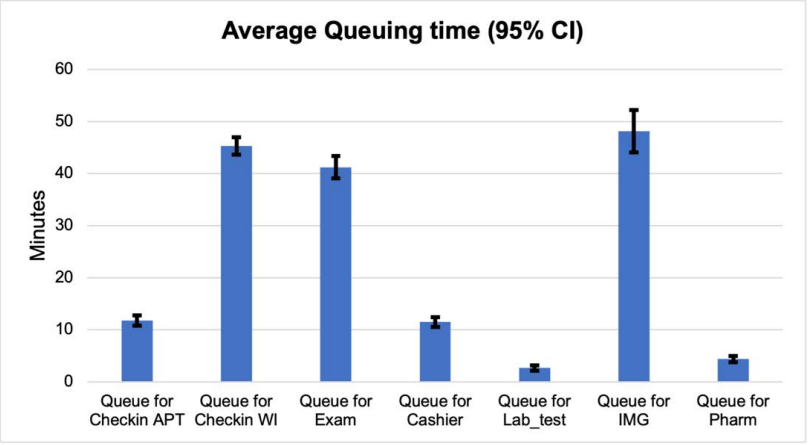


Figure 4. Average Queuing time at all workstations

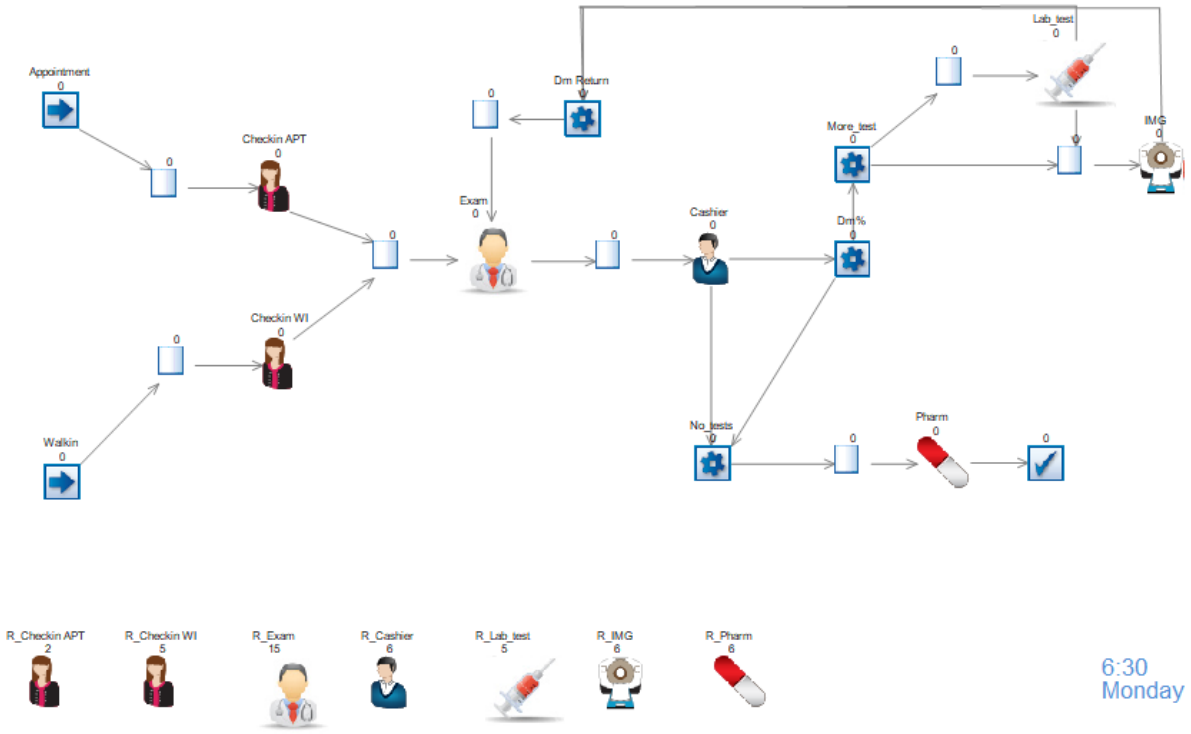


Figure 5. Base model on Simul8 software

Descriptive Statistics

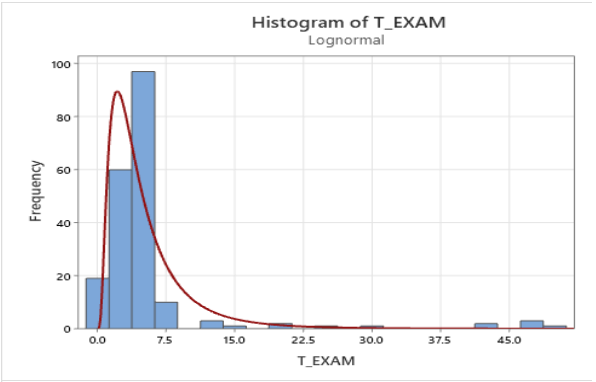
N	N*	Mean	StDev	Median	Minimum	Maximum	Skewness	Kurtosis
200	0	19.88	39.2612	10	1	221	3.89268	13.9170

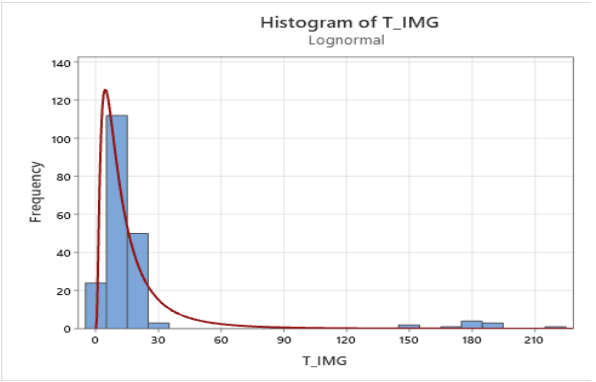
Box-Cox transformation: λ = -0.231251

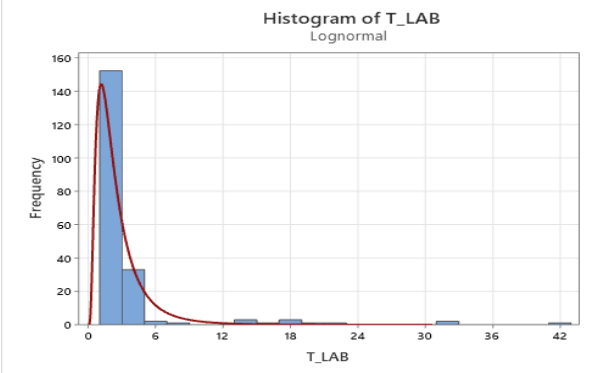
Goodness of Fit Test

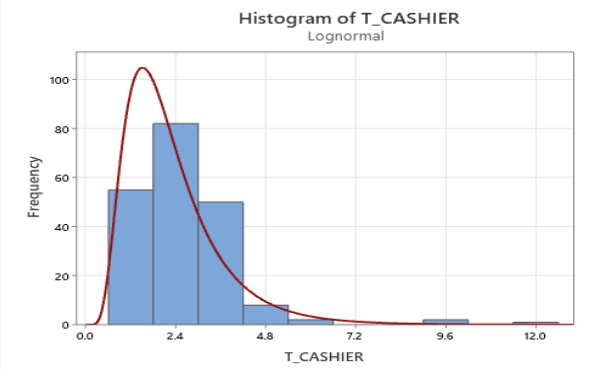
Distribution	AD	P	LRT P
Normal	49.881	<0.005	
Box-Cox Transformation	3.964	<0.005	
Lognormal	6.256	<0.005	
3-Parameter Lognormal	5.944	*	0.054
Exponential	21.100	<0.003	
2-Parameter Exponential	20.971	<0.010	0.000
Weibull	17.865	<0.010	
3-Parameter Weibull	15.083	<0.005	0.000
Smallest Extreme Value	55.141	<0.010	
Largest Extreme Value	25.758	<0.010	
Gamma	20.261	<0.005	
3-Parameter Gamma	17.895	*	0.000
Logistic	30.001	<0.005	
Loglogistic	2.640	<0.005	
3-Parameter Loglogistic	2.660	*	0.108

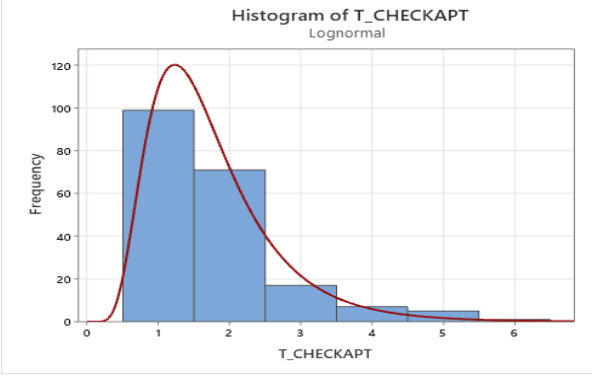
Figure 6. The result of a goodness-of-fit test for Imaging

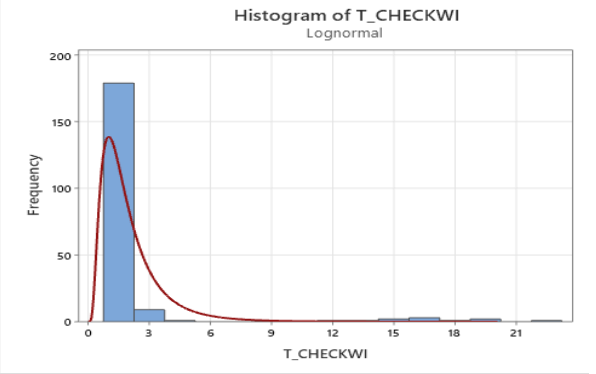


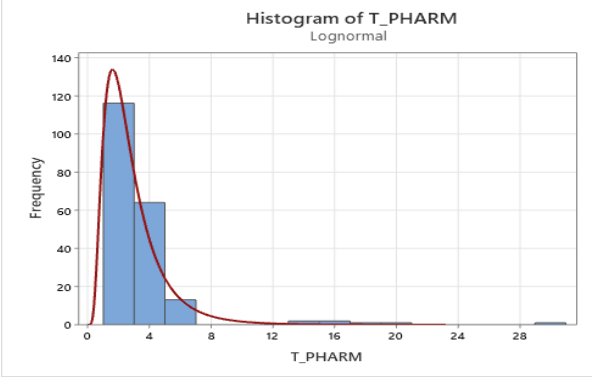












The visual representation of service times for each workstation, including Check-in, Exam, Cashier, Laboratory, Imaging, and Pharmacy.

Figure 7. Histograms of service durations for each station

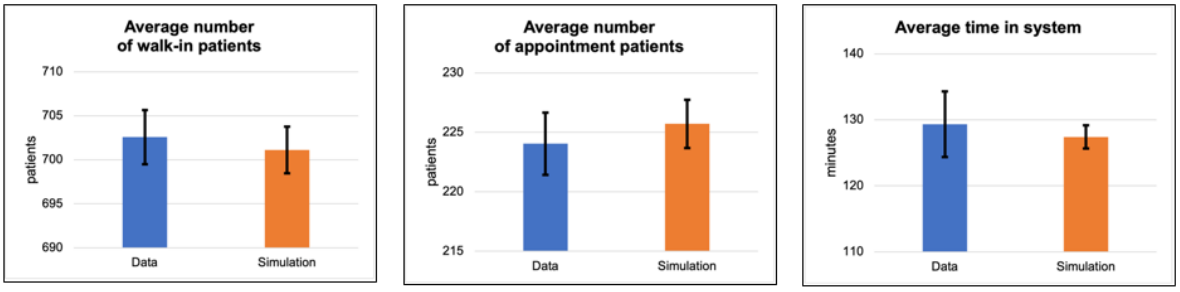


Figure 8. Actual data vs simulated results within a 95% confidence interval

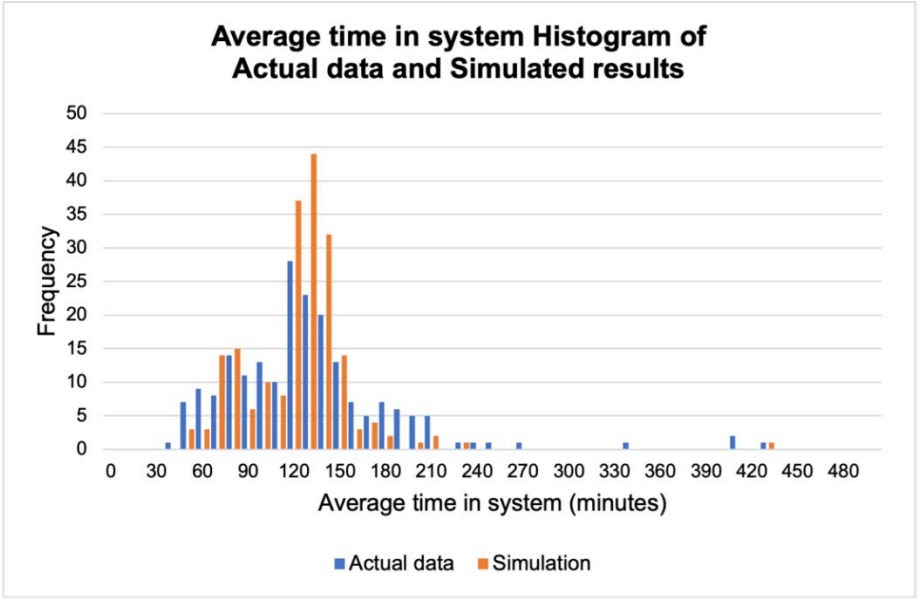


Figure 9. ATIS of Actual data vs Simulated results

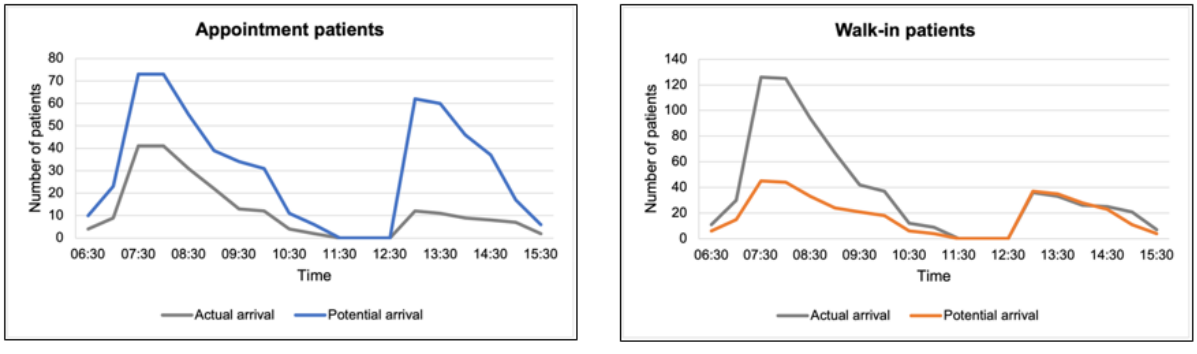


Figure 10. Current arrival vs Potential arrival

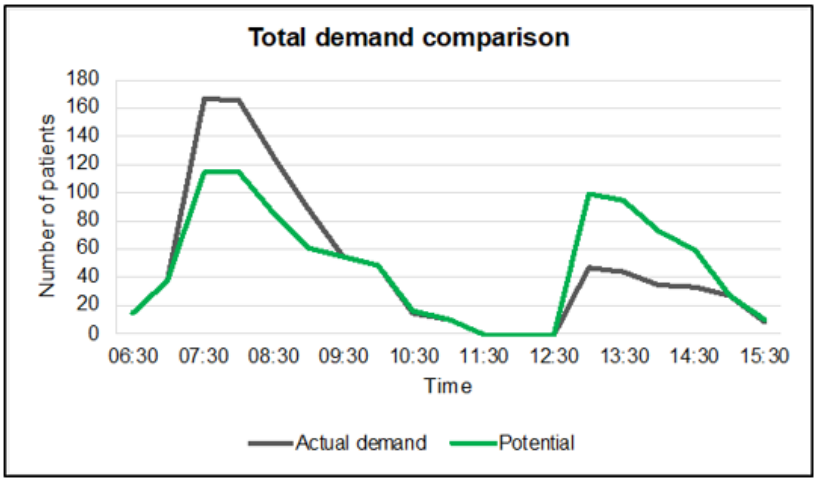


Figure 11. Total actual demand vs potential soothing demand

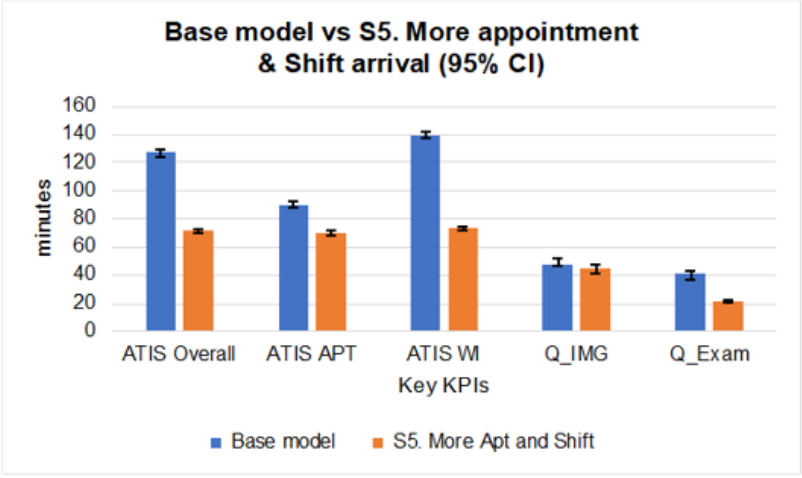


Figure 12. Base model vs S5. More appointment and Shift arrival

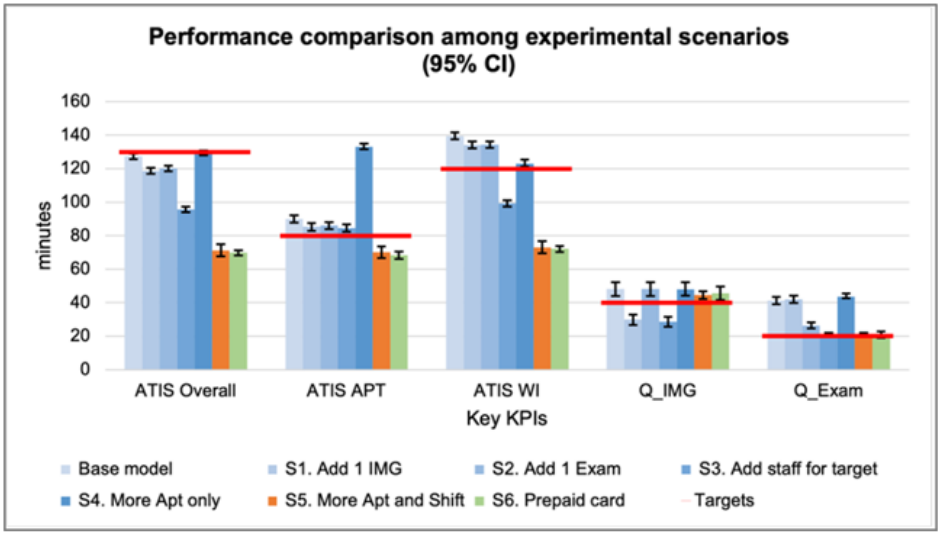


Figure 13. Performance comparison among testing scenarios

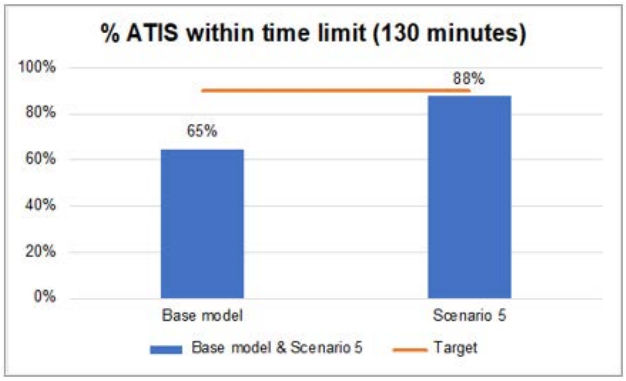


Figure 14. Percentage of patients with ATIS under 130 minutes

Table 1. Back-of-the-envelope capacity calculation

	Total patients served/day (1)	Average unit time (minutes) (2)	Average total time (minutes) (3)	Maximum capacity (minutes) (4) = (3)*60	Estimated utilisation (5) = (3) / (4)	Notes
Check-in WI	800	2.5	2,000	2,325	86.02%	
Check-in APT	200	2.0	400	555	72.07%	
Cashier	1,200	2.5	3,000	3,060	98.04%	Most patients make 2 payments/visit
Exam	1,330	5.5	7,315	8,445	86.62%	33% patients require more test, so have to return to consultation
Imaging	164	20.0	3,280	3,525	93.05%	Around 50% requires Imaging
Lab	213	3.0	639	1,305	48.97%	Around 65% requires Lab test
Pharmacy	897	3.0	2,691	3,060	87.94%	

Table 2. Summary of input probability distribution parameters

	Probability distribution	Estimated parameters (minutes)	Data source
Arrival rate (walk-in and appointment)	Empirical	Day Planner function	HIS
Check-in walk-in	Lognormal	$\mu = 2.345$ std = 3.658	Observation & Expert opinion
Check-in appointment	Lognormal	$\mu = 1.749$ std = 0.991	Observation & Expert opinion
Exam	Lognormal	$\mu = 5.648$ std =7.931	HIS
Cashier	Lognormal	$\mu = 2.309$ std = 1.485	Observation & Expert opinion
Lab specimen collection	Lognormal	$\mu = 2.993$ std = 5.126	Observation & Expert opinion
Imaging unit	Lognormal	$\mu = 19.865$ std = 39.401	HIS
Pharmacy	Lognormal	$\mu = 2.981$ std = 3.192	Observation & Expert opinion

Table 3. Classification of patients by types

Patient types	Percentage
Patient arrival types	100.00%
Appointment patients	18.92%
Walk-in patients	81.08%
Patient complexity types	100.00%
Patients with no test required	67.09%
Patients with more tests required	32.91%
With only lab tests	22.98%
With only imaging tests	27.42%
With both lab and imaging tests	44.60%

Table 4. Target queuing time at BIH's workstations

	Check-in APT	Check-in WI	Exam	Cashier	Imaging	Lab	Pharmacy
Target queue time (minutes)	10.00	20.00	25.00	15.00	40.00	10.00	10.00

	Overall ATIS		ATIS Walk-in		ATIS Appointment	
Target average time in system	Target (min)	% within limit	Target (min)	% within limit	Target (min)	% within limit
	130	90%	80	90%	120	90%

ENTERPRISE RISK MANAGEMENT: A LITERATURE REVIEW AND RESEARCH IMPLICATIONS FOR VIETNAM

Mai Nguyen[1], Quang Le[1]
[1]*Becamex Business School, Eastern International University, Binh Duong, Vietnam*
Mai.nguyen.bbs18@eiu.edu.vn, Quang.le@eiu.edu.vn

Abstract: Today's business environment has created numerous challenges for businesses to survive and thrive, especially when confronted with an unprecedented global crisis (e.g., financial crisis, war, trade war, pandemic, catastrophe, etc.). Attempting to manage uncertain and unexpected events is a top priority for any business. These risks must be addressed holistically rather than separately, and the management system must align corporate governance and strategy with risk management. Therefore, Enterprise risk management (ERM) is a comprehensive risk management method that has emerged as a substantial source of concern. The role of enterprise risk management has evolved significantly over time. However, most academic reviews on ERM are in finance and accounting, which are statistically calculated based on numbers rather than managing risk for the enterprise from multiple perspectives. There have been very few studies on ERM in developing countries, particularly Vietnam. As the majority of Vietnam is experiencing difficulties due to the current stressful economic, political, and environmental situation, this holistic review framework could assist researchers in identifying areas for future investigations and practitioners dealing with uncertainties to sustain their business operations.

Keywords: *Enterprise risk management, corporate risk management, business risk management, holistic risk management, strategic risk management, integrated risk management*

I. INTRODUCTION

Today's business climate has created several challenges for businesses to survive and flourish, particularly when presented with an unprecedented global crisis. Managing risk for the organization as a whole is critical in any company's strategy. Enterprise risk management (ERM) is a key element of current corporate governance reforms, with many concepts, guidelines, and benchmarks [9]. The majority of academic evaluations on ERM are in finance and accounting, which are statistically computed based on statistics rather than managing business risk from multiple viewpoints.

Various academic research has mostly focused on accounting and finance periodicals, with a few outliers in management journals. Finance and accounting research focuses on methodologies that solve the risks based on the statistical data. Furthermore, the approaches accessible in finance and accounting research are usually technically challenging, too hard to apply for most managers. Much of the study on international management risk focuses on

political or monetary factors. The literature on finance and insurance highlights uncertainty for which hedging or insurance instruments may be devised to limit company risks, but it misses critical strategic management uncertainties. The concentration on single uncertainties rather than multidimensional management of uncertainty is a major weakness in much of the current risk and uncertainty literature.

Otherwise, very little research on ERM has been conducted in developing nations, specifically none in Vietnam at a time when the majority of the country is enduring challenges as a result of the present strained economic, political, and environmental circumstances. This study will conduct a thorough review on the former literature about enterprise risk management, risk classifications, the effectiveness of ERM implementation worldwide and the studies about ERM in Vietnam to assist researchers in identifying areas for future research and practitioners dealing with uncertainties to sustain their business operations.

II. METHODOLOGY

In recent years, the number of papers concentrating on ERM has steadily increased. As a result, we examined journal papers published between 2000 and 2022. The search keywords were first defined. The search terms used were 'enterprise risk management' and 'enterprise risk.' Secondly, academic databases such as Google scholars, EBSCOhost, Emerald, Taylor and Francis, ScienceDirect, Wiley, ProQuest, and Springer were used to find journal articles. Peer-reviewed, quantitative and qualitative publications written in English and published in international journals were chosen to reach the best degree of knowledge coverage. Third, the reference lists of the nominated papers were thoroughly reviewed to verify that no other relevant publications were overlooked throughout the search. Finally, each article's content was extensively examined to verify that it fits into the context of ERM and analyzes at least one of its elements.

III. RESULTS

A. Concepts of enterprise risk management (ERM)

a) Enterprise risk management:

Corporate risk management, business risk management, holistic risk management, strategic risk management, and integrated risk management are all synonyms for this word of ERM. Although there is a little difference between these terms because of the context at the time each term was established, the basis is similar [6]. While conventional risk management is primarily concerned with protecting an organization from the adverse monetary impacts from risks, ERM helps businesses to make better decisions on ways to confront risks protecting shareholders' advantages and benefits [8].

According to [4] enterprise risk management (ERM) developed from the original risk management foundations established by visionary insurance academics Robert I. Mehr and Bob Hedges. Risk management strives to maximize company productivity and efficiency, and risks should be managed rather than insured. The role of risk management in organizations has shifted dramatically during the last two

decades. Twenty years ago, managing risks was often the task of the low-level positions that were mostly solved by buying insurance packages. However, during the last 10 years, the considerable development of corporate risk management has gone beyond the border of just insurance and finance, to become enterprise risk management which comprises all types of risks most notably operational risk, reputational risk, and, most recently, strategic risk [12].

The Committee of Sponsoring Organizations of the Treadway Commission (COSO) defined Enterprise risk management as the process used in strategy setting and across the enterprise under the management of a board of directors, strategic planning, and other upper-level personnel to identify potential incidents and thereby provide prompt assurance [3]. Agreeing with the definition of COSO [3], [15] emphasizes that the current approach to ERM provides benefits to businesses as an integrated method to manage risk, shifting the focus of the risk management function from primarily defensive to increasingly aggressive and strategic.

Otherwise, the Casualty Actuarial Society Committee (CAS) defined ERM as the discipline by which a company in industry analyses, regulates, exploits, budgets, and tracks threats from all sources in order to increase the company's short- and long-term value to its stakeholders [6].

In 2013, the study by Mike & Kaplan produced a more comprehensive definition of ERM based on the contingency theory of management accounting of [13], [9]. It focuses on the procedures that are active and obtrusive able to confront the current internal and external assumptions surrounding the company by using the distinct tools like risk mapping, stress testing, and scenarios emulating to solve the unaddressed gaps that other functions have left and make reasonable adjustments into the existing management practices.

All of these definitions place a high emphasis on the process of controlling risk by internal resources. However, there are some distinctions. The Cosco placed a high value on senior management and their ability to build procedures that are tailored to the company's needs. Meanwhile, CAS's concept of ERM emphasizes all personnel's joint obligation to analyze, control, exploit, fund, and monitor risks. Cosco prioritizes attaining the enterprise's ultimate goals, whereas CAS prioritizes benefits for all stakeholders. The definition of [9] gave a more well-rounded and rigid meaning, mentioning that the specific process and objectives cultivate insight each step. In general, ERM is thus intended to give a complete framework for the risk management process, giving the organization both resilience and opportunity, allowing it to fulfil its objectives in the face of uncertainty.

b) Enterprise risk categories:

This systematic review of a wide variety of literature on uncertainty and risk management was used to discover the specific uncertain components contained in this typology.

Table 1. Enterprise categories

Authors	Risk types
[11]	General environmental uncertainties, industry uncertainties, firm uncertainties.
[4]	Hazard risks, financial risks, operational risks, strategic risks.

[13]	Operational risk, reputational risk, and, most recently, strategic risk.
[16], [1]	Strategic market risks, operation risks, finance risks, human capital risks, it risks, legal risks, reputation risks.
[3]	Strategic, operations, reporting, compliance.
[9]	External risks, preventable risks, strategy execution risks.

B. Contingency theory

[9] has carried out a 10-year research obtaining more than 250 surveys with the upper-level risk officers, and three case studies. They proposed a contingency theory of ERM, revealing design factors contribute to the explained variance in firms' "ERM mix" together with the adding of factor so-called "the kind of risk an ERM practice addresses". They proposed a "minimum essential contingency framework" for empirical researchers to test hypotheses regarding "fit" between contingent variables like risk classes and ERM mix and outcomes like organizational performance [9].

The availability of risk management approaches, concepts, and technology has made it an enticing topic for academic research. Using the contingency theory in organizational and business managerial control research, academic studies on ERM have explored the link between ERM performance results and organisational environment [1], [9].

[6] based on contingency theory to study ERM and firm performance. They interviewed 112 US-based companies that declare their ERM efforts with the US Securities and Exchange Commission. Five factors from firms were confirmed to impact ERM performance are (1) environmental risks, (2) competition in the industry, (3) the complexity of operation, (4) firm's size, and (5) BOD' management. They have based on the COSO's objectives to develop the Enterprise Risk Management Index (ERMI) to measure a firm's level of effectiveness in adopting ERM scoring strategy, operatioin, reporting, and compliance. Their findings claimed that the relationship between ERM and company performance is dependent on an adequate match between ERM and the five influencing elements impacting a firm: environmental unpredictability, industry competition, firm size, firm complexity, and board of directors monitoring.

C. Factors affecting ERM adoption

According to [6] there are 5 internal factors from the firm that have impact on the ERM adoption including (1) environmental uncertainty, (2) industry competition, (3) firm complexity, (4) firm size, and (5) board of directors' monitoring. Meanwhile, [5] claimed that effectiveness of ERM implementation for a company depends on A range of external and internal factors.

Recent developments in computer capacity have enabled the development of strong modeling tools required to do extensive risk assessments for hazard hazards. Furthermore, large available database in finance and other historical recorded information facilitates users to figure out trends, correlations and relationships among features [4]. The fast and wide-spread changing of the world like globalization, industry consolidation, deregulation, increased regulatory attention to corporate governance. and technological progress that enables better risk quantification and analysis are the primary external managements that

have pushed organizations to move toward risk management in a logical and holistic way. Internal considerations are critical for shareholder wealth optimization. ERM supporters suggest that an integrated strategy increases business value by decreasing ineffectiveness in the traditional approaches, stabilizing the earnings, enhancing capital efficiency, and lowering the projected costs incurred of external finance and changes in regulations [15].

The present wave of acquisitions and mergers has resulted in increasingly sophisticated financial institutions, and the nature of risks confronting financial organizations has shifted. Financial corporations offer a diverse range of financial services with potentially linked obligations which are accompanied by certain types of risks. Generally, the rising competition has transformed the role of risk management from a defensive position to an offensive and strategic position [15].

Risk maps derived from risk assessment and identification techniques, stress tests based on statistical analysis and data collection and scenario analyses based on scenario envisionment and planning can all be valuable components of any company's ERM planning mix [11]. According to a former COSO chairman, any enterprise risk management approach must include three components: (1) a strategic activity that articulates "possible risks" that threaten organizational strategic goals, (2) governance activities involving participation and supervision at multiple management levels, and (3) a monitoring activity based on the supervision ideal reality context, measurement, and reporting [9]. All three ERM components are subject to change. Some organizations concentrate on circumstances that are monetarily, insurable, or quantifiably dangerous [10]. Others focus on qualitative issues [10], [17]. Some organizations have a quantification-oriented calculative culture and support statistics-based measurement and oversight [11], whereas others, skeptical of the validity and utility of risk indicators, encourage questioning and learning from statistics (Mikes 2011). Some businesses assess risk because their dangers are real and tangible.

D. Efficiency and downside of applying ERM

An increasing number of scholars view ERM as the fundamental paradigm for managing the portfolio of risks confronting organisations [1], [9], [7], 12]. Driving this trend is the belief that ERM offers companies a more comprehensive approach toward risk management than the traditional silo-based risk management perspective. By adopting a systematic and consistent approach (or process) to managing all of the risks confronting an organisation, ERM is presumed to lower a firm's over- all risk of failure and thus increase the performance and the value of the organisation. The study of [18] indicates that enterprise risk management (ERM) has emerged as a construct that purportedly helps to overcome the shortcomings of silo-based traditional risk management (TRM) and there is a positive association between growing levels of ERM capacity and company value, but there is no extra value rise for businesses reaching a higher ERM rating.

Businesses can no longer tolerate unpredictable occurrences at their own faulty

risks, nor can they afford to keep undiscovered regions of risk nameless. To mention a few risks, the modern economy has huge currency fluctuations, diminishing distribution lines, human resources in other nations, corporate governance, and an unrivaled reliance on technology. Few businesses are constrained by Enterprise Risk Management developments and require a comparable collateral plan for risk assessment, measurement, and treatment. By using this proactive risk management technique, organizations may transition from a "silo" management model to a more integrated integration of their different activities [15].

Firms that adopt ERM interpret the collective risk inherent in various business decisions. This provides an objective stance for resource allocation, boosting capital efficiency and return on equity. Organizations with a diverse variety of investment choices would likely profit from the ability to pick investments that rely on a more realistic risk-adjusted rate.

While individual risk management efforts may minimize profits volatility by lowering the likelihood of catastrophic losses, significant cross-risk interdependencies exist between activities that may go unreported in the standard risk management paradigm. ERM is designed for risk management operations that are based on an integrated framework that aids in the discovery of such mutualities. Individual risk management actions might therefore reduce profits volatility from a single source (hazard risk, interest rate risk, etc.), but an ERM approach reduces volatility by preventing risk aggregation across several sources [8], [15].

According to [15], Most businesses adopt a more comprehensive approach, utilising Enterprise Risk Management as a strategic business tool. Although most CEOs mention developing ERM processes, only a small percentage have finished its implementation. Executives from a variety of sectors in North America and Europe reveal that the majority of the panel of boards of directors and senior management personnel agree that ERM compliance is becoming increasingly important. Survey respondents of Subhani & Osman's study, whose companies have already implemented ERM, say it has added significantly more value than those who are still in the implementation process, and ERM-implemented organizations are superior in enhancing organizational practices like strategic planning. Corporations strive to improve their understanding of significant risks in order to hold the tactical and operation decisions that a company must make in order to assess business returns on a consistent basis [15].

The historical crisis including the September 11th attack (USA), the recent Earthquake and Tsunami in Japan in March 2011, the world economic recession in 2008, has alerted the world about the importance of ERM. On September 11, the world experienced a terrible loss; governmental and private sector icons were damaged, and whole businesses were destroyed. All industry interruption and third-party responsibility claims are mature, therefore insured losses surpassed $35 billion to $55 billion. 3 years later, Japan experienced a natural disaster in March 2011 and until now, it is still recovering, which may take a decade. In these cases, researchers and managerial experts have figured out that ERM

can be useful for planning for (1) extreme event risk, (2) managing capital, (3) managing exposure, (4) responding to disaster, and (5) managing stakeholder relationships. Many disputes and risks are undoubtedly beyond human comprehension; nonetheless, ERM can aid in imagining and planning for the unpredictable [15].

Leslie Lamb of Cisco stated, "Companies make money by taking risks and lose money by mismanaging them" [3]. Cisco aspires to evolve from a strong company with improved business continuity plans and flexible and agile business processes to an adaptable company with real-time data monitoring and a self-deciding, self-optimizing, and self-correcting organization. Adele Martz, General Motors' corporate risk manager, concurred. A GM assembly plant in Oklahoma was devastated by a hurricane in 2004. Early evacuation preparations saved the lives of 1,200 individuals. Weather-monitoring systems, preemptive evacuation procedures, and backup supply networks are all part of GM's Business Continuity Planning. To lessen uncertainty, GM's planning strategy at the time included investments in future technology. For successful risk management, both Cisco Systems and General Motors require a systematic methodology, top leadership support, and an integrated effort at all levels of the business. Relief organizations have not developed such risk management methods, but they have expressed a desire. Thousands of lives could be saved if emergency managers can develop more effective risk management systems, as evidenced by the 2005 Pakistan earthquake and Hurricane Katrina. Similarly, ERM awareness is expanding in developing countries like as Pakistan. Pakistan is trying everything possible to promote its outstanding offshore advantages, which include 17 million English speakers, a highly educated population with IT skills, and earnings equivalent to those in India. The country is working hard to address major difficulties such as a poor security image and a scarcity of skilled IT employees. Many organizations are organizing for growth and vigilance in order to migrate to ERM as a competitive advantage, such as United Bank Limited in Pakistan, which has embraced risk-management techniques. The risk management system of Bank Alfalah Limited analyses dangers in banking operations and systems and selects risk-mitigation alternatives [13], [16]. Swedish firms are the keenest to implement ERM among industrialized nations, while underdeveloped nations have a relatively low score. These finding stresses that firms in underdeveloped countries are only marginally involved in ERM practice, and Pakistan's score was determined to be the lowest among all nations bar a few, such as Nigeria [16].

According to a recent study of a group of Vietnamese researchers on the effects of ERM on firm value, they found that the value of firm will increase 0.14 times to the firm adapting ERM in their planning and operation more than the non-ERM firm. This finding supports prior research by [7]. Businesses that practice financial risk management will help to control investment risk. This has a favorable influence on the company's performance and worth.

However, despite various risk management tools and methodologies, many firms are unhappy with their own and others' efforts. In September 2008 research of CFOs, 62% of respondents mentioned inadequate or lax risk management at financial institutions.

72 percent of respondents were worried about their businesses' risk management methods [9]. A poll of more than 400 ERM process executives, including 20% respondents coming from financial services enterprises [1] found that most were dissatisfied with their risk supervision procedures; 42% described it as "immature" or "minimally mature" and only 3% as "extremely developed".

During the expansionary era of 2002-2006, almost all of the Wall Street financial institutions had built their own risk management departments and CROs. However, some of these businesses collapsed during the ensuing crisis, whereas others fared well. The presence of an ERM unit and a chief risk officer indicates virtually little about the quality, depth, and effect of a company's risk management operations [9].

The efficacy of risk management is ultimately determined by those who structure, coordinate, and make a significant contribution to risk management procedures, rather than the guiding framework. People, not frameworks, will be the ones who take responsibility for identifying, interpreting, and putting into action all of the risk information. Frequently, the actions of all personnel of a company will follow the permission from the CEO and board. As a result, various organizational and cultural situations in organizations that utilize the same ERM framework might result in diverse risk management framework implementation and use.

E. Researching ERM in Vietnam

Company Law or Corporate forms did not exist in Vietnam before the late 19th century French colonialism. The National Assembly of Vietnam passed the Enterprise Law 2005 on July 1, 2006, updating the Enterprise Law of 1999 to improve Vietnam's business climate. The Enterprise Law 2005 is Vietnam's most important corporate governance law. Vietnam, a transition economy, is expanding quickly due to major privatization and FDI [12]. As Vietnam adapts to global markets, enterprises confront increasing competitive challenges in both domestic and international markets. To survive and compete, firms must strategically manage business risks and improve corporate governance.

In 2020, a group of Vietnamese researchers carried out a study on how ERM affects firm value. 77 Vietnamese industrial listed companies were interviewed. They indicated that ERM application contributed a significant improvement to firm value during this period when Vietnamese enterprises were facing challenges due to international economic integration, especially the increasingly sophisticated financial risks. These companies indicate that when their company conducts risk management, they will have the business value increased by 0.14 times rather than not. Otherwise, if the company conducts financial risk management, it contributes greatly to the control of financial risk and strategic plan. The interviewed investors are not even attracted by the firm size to make investment decisions. Therefore, the wide enterprise risk management is undoubtedly proven to have a really positive impact on the performance and effectiveness of the enterprise operations and values regardless of firm size [15].

Though Vietnam had witnessed tremendous economic development as a result of major privatization and FDI inflows, this growth moderated in 2009. Vietnam,

like other emerging/transition countries, needs to enhance its institutional capabilities (e.g., legal and market infrastructure) to enable economic growth. [18] indicated that ERM implementation has great benefits for the Vietnam market. However, ERM implementation is such a hard task for Vietnamese enterprises due to the high cost. The increasing applications of risk management strategies aid organizations in achieving their goals and improving the market value of the company.

IV. DISCUSSION, CONCLUSION & IMPLICATION FOR VIETNAM

Enterprise Risk Management is a broad concept. This study demonstrates that organizations are shifting from a silo strategy (traditional risk management) to an enterprise-wide risk management (ERM), particularly in industrialized countries. Enterprise risk management is the 21st century's risk analysis and strategy. These tactics and analyses are, in many situations, diametrically opposed to standard methodologies. ERM is challenging at first, but the return is well worth the effort.

The above literature review has shown ERM scores for developed and developing nations were researched and assessed, and it was discovered that the ERM as a whole is used more frequently by firms in developed nations rather than developing nations. The cases of Cisco or General Motors in developed countries have shown how big businesses have survived after crises and disasters thanks to ERM. The Cisco company transferred itself from continuity plans and agile business processes to an adaptive corporation with real-time data monitoring and a self-deciding, self-optimizing, and self-correcting organization. Meanwhile, General Motors with an ERM of investments in future technology to reduce uncertainty, which includes weather-monitoring systems, preemptive evacuation processes, and backup supply networks have survived 1,200 humans from being wounded. It indicates great positive impacts of ERM in surviving business through crisis unpredictable events.

There have been many developing nations adopting ERM to a certain extent in the financial service industry and outsourcing including Pakistan, India, and Nepal. Actually, ERM is simple conceptually, but difficult to implement. Employees must understand how ERM offers value in order to properly implement it. It is not an academic exercise, but rather an essential tool for carrying out the firm's strategy. ERM must be "purchased" at all organizational levels. Management performance evaluation and incentives must be well-thought-out in order for the entire organization to support it [13].

In summary, ERM research in Vietnam is still at its infancy. Most of them are studies of financial risk management and there is hardly any paper indicating exact cases of ERM practice in Vietnam. Therefore, future research should fill in this gap.

In conclusion, this paper investigates the review of the previous literature on ERM and different events triggered in the history that require ERM to help companies survive. It could be seen that in the developed nations, ERM is one of the indispensable parts of every company. The bigger company would have a more complex system of risk management. Meanwhile, enterprise risk management is not considered serious in developing countries.

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PART II

ENGINEERING

SENSOR FUSION ALGORITHM FOR MOBILE ROBOT LOCALIZATION IMPLEMENTED BY ROS PLATFORM

Duy Nhat Tran[1]

[1]*EIU Fablab Center, Eastern International University, Binh Duong, Viet Nam*

nhat.tran.set15@eiu.edu.vn

Abstract: Robot localization is the method of knowing the current position in its environment; this is at the core of various fields such as robotics, autonomous vehicles or aerospace. This paper aims to present the estimated odometry data based on the encoder and inertial measurement unit data when moving a mobile robot in its environment. This estimation method will use an Extended Kalman Filter algorithm integrated into the robot_localization package of the ROS platform for fusing pose data from different sensors (Encoder pose and IMU pose) to improve the pose estimation of robot localization. Experimental results are visualized on the RVIZ tool by combining the advantages of multiple sensors, which will get better results instead of just using an encoder sensor; the application of this fusion method will improve the odometry data which will be used to build a 2D MAP environment from SLAM algorithm and navigate an autonomous mobile robot in the following plans.

Keywords: *Odometric Localization, ROS Platform, Extended Kalman Filter (EKF), Autonomous Mobile robot*

I. INTRODUCTION

A big problem for all mobile robot systems is the ability to know where the environment is [1]; the answer to this question can be obtained through sensor signals mounted in the robot, such as encoders, IMUs, Laser scans, etc. However, we know all too well that no single sensor can provide all the data a robot needs to perceive and navigate its environment (sensors are not correct, and their measurements are prone to errors [2]). For instance, if only using single sensors like wheel encoders, IMUs, or even laser scan sensor to measure odometry information, this could bring about a large error accumulation as each small error is added to the previous because of the drift physics of the sensors (noise sensor) over time and have an adverse bearing on localization a mobile robot in 2D Mapping or navigation stack. According to T. Moore et al. [2], by merging data from other sensor signals, we can get an overall position estimate.

In this paper, firstly, we will calculate odometry data from wheel encoders and read data (acceleration and velocity) from the BNO055 Absolute Orientation IMU sensor. Secondly, we use a software package, *robot_localization,* for the Robot Operating System (ROS) [4] to merge the odometry information from the above sensor signals. *Robot_localization* package was developed by Thom Moore et al. The main goal of this package is to provide accurate data about where the robot is and what it's doing based on the input of as many sensors. An Extended Kalman Filter

algorithm plays a pivotal role in this package and is the backbone of many sensors' fusion algorithms. All this data processing is done on an actual mobile robot that includes sensors, a mainboard controller attached to the mobile robot, and an embedded device, Jetson Nano, for running the ROS platform.

II. METHODOLOGY

Odometry is the act of using sensor data to estimate the position of our robot by measuring and adding up small changes – continuously, many times per second. Odometry could be gauged from wheel encoders, IMU, laser scans, camera sensors, etc. This is the oldest method of keeping track of a robot's location and is still one of the most popular standards today. In this part, we will introduce about specifications of the mobile robot, get odometry from the wheel encoder and the IMUs, and merge two types of odometry data based on the Extended Kalman Filter algorithm.

A. Specifications of mobile robot

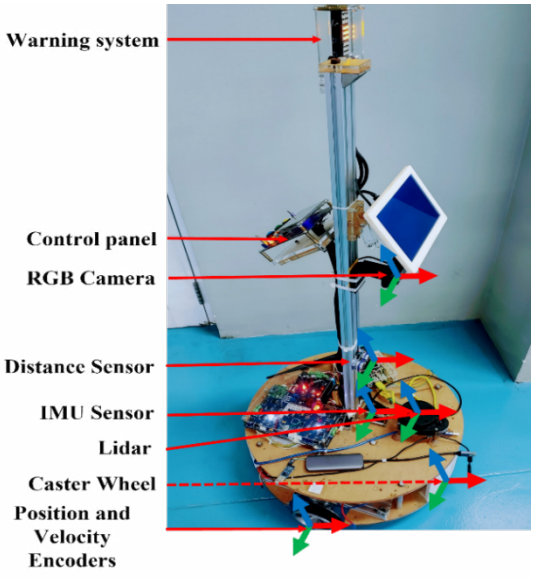

Figure 1. Mobile robot platform

Figure 1 shows the mobile robot developed at EIU Fablab for learning and research purpose, which attached sensors and an embedded device like wheel encoders, laser scan, IMUs sensors, RGB camera, and NVIDIA Jetson nano, respectively. Meanwhile, Figure 2 describes the process of subscribing and publishing data between nodes through ROS to perform robot motion and receive data from sensors.

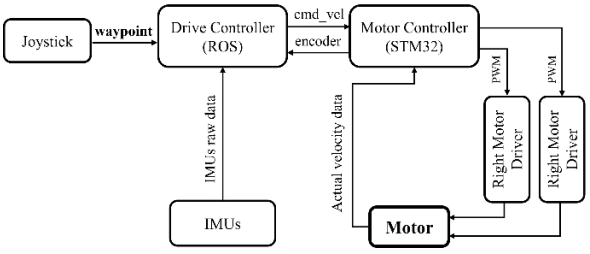

Figure 2. Mobile robot motion

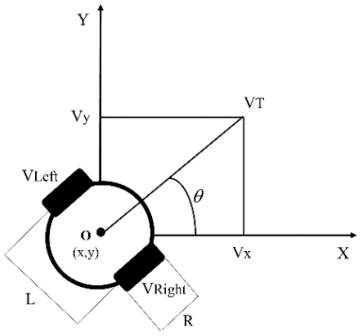

Figure 3. Unicycle Differential Drive kinematics

v_{left}, v_{right} – Rotational speed of wheels

l = 0.45 m – Wheels base

r = 0.1 m – Wheel radius

$o_{(x,y)}$ – Robot center position

θ – Robot orientation

v_t – Linear velocity

This project aims to estimate the robot's precise pose while moving in its environment. Figure 3 describes the motion of the mobile robot as equivalent to translating and rotating which depends on the rotational speed of

v_{left} and v_{right}. The differential drive forward kinematics of robot can be expressed as [5]

$$\begin{cases} v_l = x - \frac{\omega l}{2} \\ v_r = x + \frac{\omega l}{2} \end{cases} \quad (1)$$

Where:
x : linear velocity of robot (m/s)
y : angular velocity of robot (rad/s)

B. Odometry data

Wheel odometry

To track a robot's movement with the wheel encoder, we turn to the encoders by counting the pulse from encoders as the motor shaft turns and divide the number of pulses by the known number of ticks per meter.

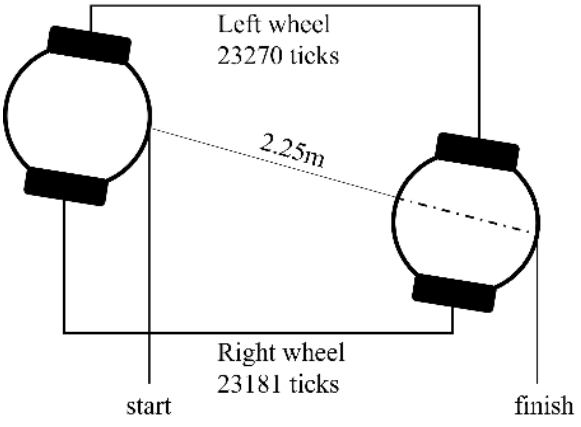

Figure 4. Measuring the ticks per meter

$$\text{Tick\_Per\_M} = \frac{\left(\frac{2370 + 23181}{2}\right)}{2.25} \quad (2)$$

Calculating the distance traveled for each wheel could be expressed:

$$\text{D} = 2 * \pi * \text{r} * \frac{\Delta_{tick}}{tick\_per\_M} \quad (3)$$

Calculating the total distance the robot has traveled

$$\text{DC} = \frac{(right + left)}{2.0} \quad (4)$$

With right and left variables are the distance traveled of each wheel based on formula (3).

Calculate the change in heading angle

$$\phi = \frac{(right - left)}{wheel\_base} \quad (5)$$

In general, we can describe the position of a robot capable of moving in a particular direction by integrating velocities as (6) equation:

$$\begin{cases} x_{new} = x_{old} + DC * cos(\phi) \\ y_{new} = y_{old} + DC * \sin(\phi) \\ \theta_{new} = \theta_{old} + \phi \end{cases} \quad (6)$$

IMUs odometry

In addition to wheel encoder-based odometry, we can use acceleration data, angular velocity data, or the Earth's magnetic field measurements to help track a robot's position and orientation. This project is utilized an absolute IMU, which has integrated the fusion inside of it to give highly accurate values.

The accelerometers measure linear acceleration in either milli*G-force* or meters / sec^2 [6].

$$\begin{cases} linear_{acc\,x} = \dfrac{rawdata}{100} \\ linear_{acc\,y} = \dfrac{rawdata}{100} \\ linear_{acc\,z} = \dfrac{rawdata}{100} \end{cases} \quad (7)$$

As opposed to linear acceleration, a gyroscope measures angular velocity – the rate at which the device turns – in either degree per second or radians per second. The apparent use of gyroscope data is to keep track of the orientation, which is excellent because wheel-encoder-only odometry heading calculations are wrong, and the angular velocity is described as an 8 equation [6].

$$\begin{cases} \theta_x = \left(\dfrac{rawdata}{900}\right) \\ \theta_y = \left(\dfrac{rawdata}{900}\right) \\ \theta_z = \left(\dfrac{rawdata}{900}\right) \end{cases} \quad (8)$$

C. Converting Euler angles to quaternions

Quaternions are one of several mathematical ways to represent the angles in three-dimensional space. Quaternions are the default method of representing rotation in ROS, adding a fourth variable to the orientation part of the pose data and usually notating with a w value (x, y, z, w). In mathematics, the quaternions are a numbers system that extends the complex numbers; they were first described by the Irish mathematicians William Rowan Hamilton in 1843 and applied to mechanics in three-dimensional space. The quaternion is the combination of the four numbers where three represent the coordinate of a vector, and the fourth one is a scalar.

$$q = w + xi + yj + zk \quad (9)$$

Where:

- w is a scalar value that represents an angle of rotation
- x, y, z Correspond to an axis of rotation about which the angle of rotation is performed. Fig. 5 shows a description between the Euler angle and quaternion.

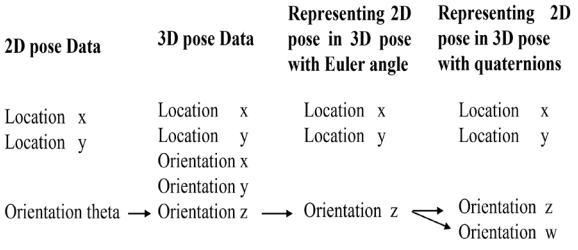

Figure 5. 2D pose and 3D pose with Euler and quaternions

The orientation within odometry data is described as Euler angles; we can also obtain the quaternion from Euler angles using the following conversion:

$$q_{1B} = \begin{bmatrix} cos(\psi/2) \\ 0 \\ 0 \\ sin(\psi/2) \end{bmatrix} \begin{bmatrix} cos(\theta/2) \\ 0 \\ sin(\theta/2) \\ 0 \end{bmatrix} \begin{bmatrix} cos(\phi/2) \\ sin(\phi/2) \\ 0 \\ 0 \end{bmatrix} \quad (10)$$

D. Transformation Matrix

In real-world robotic applications, the robot must know its location in the environment concerning the world frame. Therefore, the robot needs to observe objects to determine their location to objects. We need to choose the relation between the pose in the robot frame and the object frame using the transformation matrix shown in equation (10), which combines translation and rotation in Figure 6.

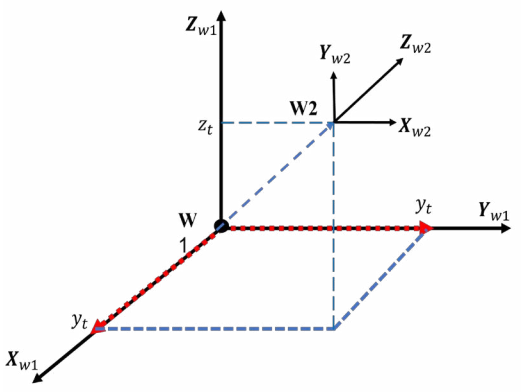

Figure 6. The coordinate frames in overtime

$$\begin{bmatrix} W1_x \\ W1_y \\ W1_z \\ 1 \end{bmatrix} = \begin{bmatrix} r11 & r12 & r13 & x_t \\ r21 & r22 & r23 & y \\ r31 & r32 & r33 & z_t \\ 0 & 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} W2_x \\ W2_y \\ W2_z \\ 1 \end{bmatrix} \quad (10)$$

Rotation Matrix (**R**) | Translation vector

With $\mathbf{R} = \mathbf{R}_z(\alpha)\,\mathbf{R}_y(\beta)\,\mathbf{R}_z(\gamma)$ [11]

E. Extended Kalman Filter

When working with robots in real-life scenarios, sometimes we must deal with sensor data that is not very accurate. If we want to perform a good localization for our robot, we need to have the most precise sensor data possible. For this purpose, one of the solutions is to merge data from different sensors. The better robot will be able to sense the world around it and the *robot_localization* package in ROS used in this situation. One advantage this package provides is merging data from many sensors. We could combine data from infinite sensors. To fuse the sensor data, it uses an Extended Kalman Filter algorithm.

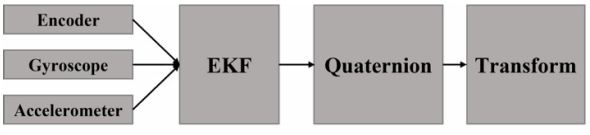

Figure 7. The proposed approach for sensor fusion

The Extended Kalman Filter was used to combine both types of positioning sensors. The Kalman filter could make an optimal estimate of the state variable even with the noisy nonlinearity of a mobile robot kinematic model. EKF requires system and measurement models, respectively, are shown by [8]:

$$\beta_k = f(\beta_{k-1}) + w_{k-1} \quad (12)$$

$$z_k = h(\beta_k) + v_k \quad (13)$$

Where:

β_k is the robot's system state, and the f and h represent the nonlinear system and measurement models, respectively. More specifically, most mobile robot models are constrained by velocity and acceleration limits (for our application, f is a standard differential drive mobile robot), while measurement models are described by measuring sensors in our system; the encoder estimates the wheel's velocity. IMU measures the angular velocity and acceleration rate in the gyroscope and accelerometer, respectively.

z_k is the measurement at time k, h is a nonlinear sensor model that maps the state into measurement noise, and

v_k is the customarily distributed measurement noise.

w_{k-1} is the process noise, which is assumed to be normally distributed.

The dynamic system noise, and measurement noise, are both zero mean Gaussian noise with associated covariance matrices:

$$w_{k\sim} N(0, Q_k), v_{k\sim} N(0, R_k) \quad (14)$$

Take the Jacobeans of f and h at the operating point during each time step. These matrices are:

$$F_{k-1} = \frac{\delta f(\beta)}{\delta \beta} \mid \hat{\beta}_{\bar{k}-1} \tag{15}$$

$$F_k = \begin{bmatrix} 1 & 0 & -V_k \Delta t \sin\theta_k & \Delta t \cos\theta_k & 0 \\ 0 & 1 & V_k \Delta t \cos\theta_k & \Delta t \sin\theta & 0 \\ 0 & 0 & 1 & 0 & \Delta t \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{16}$$

Prediction:

$$\hat{\beta}_{\bar{k}} = f(\hat{\beta}^{+}_{k-1}, u_k) \tag{17}$$

$$\mathrm{P_k} = \mathrm{F_k P_{k-1} F_k^{\,T}} + \mathrm{Q_k} \tag{18}$$

Update:

$$K_k = P_{\bar{k}} H_k^{\,T} (H_k P_{\bar{k}} + R_k)^{-1} \tag{19}$$

$$\hat{\beta}^{+}_{k} = \hat{\beta}^{-} + K_k (z_k - h(\hat{\beta}_{\bar{k}})) \tag{20}$$

$$P^{+}_{k} = P_{\bar{k}} - K_k H_k P_{\bar{k}} \tag{21}$$

III. RESULTS

The results were tested and shown on the RVIZ tool within the ROS platform. Fig. 8 and Fig. 10 show the information of odometry data, which converted from Euler angles to quaternion with the transformation between links to update new frames. For Odom data, we moved the mobile robot. Then the message showed the positionorientation with quaternion (z = - 0.48, w = 0.0), and transformation between the base_link and Odom are visualized when the robot moves. For IMUs data, we also pictured roll, pitch, and yaw angles on the RVIZ tool, which has the same description as Odom data. Fig. 9 and Fig. 11 visualize the transformation between links (Odom to base link to imu link).

Sensor fusion algorithm has also been applied and visualized on the RVIZ tool. Through fusion, if our robot is only using odometry from the wheel encoder then in some cases, like robot gets stuck or has some problem, the robot could not move while the wheel is spinning, which leads to a misalignment of coordinates. However, if we add an IMU sensor, this aids in better coordinate estimation.

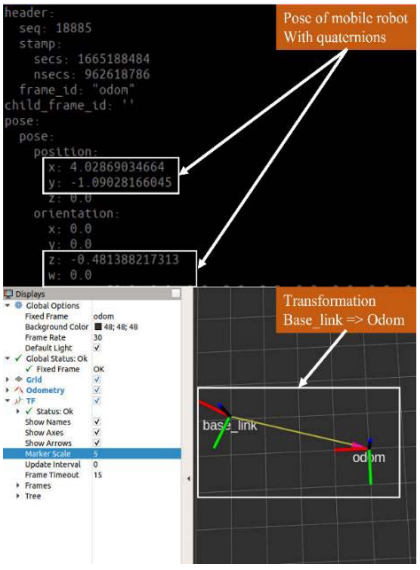

Figure 8. Show odometry data from encoder

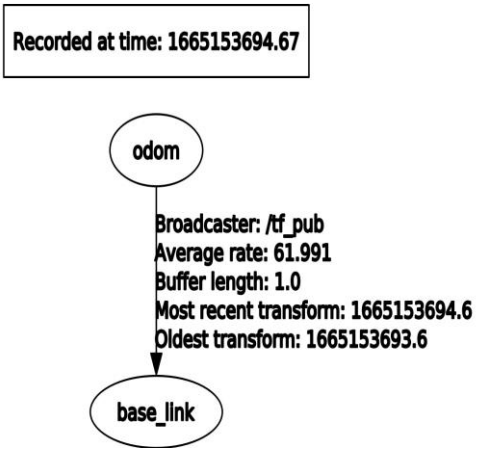

Figure 9. The diagram transformation between odom and base_link

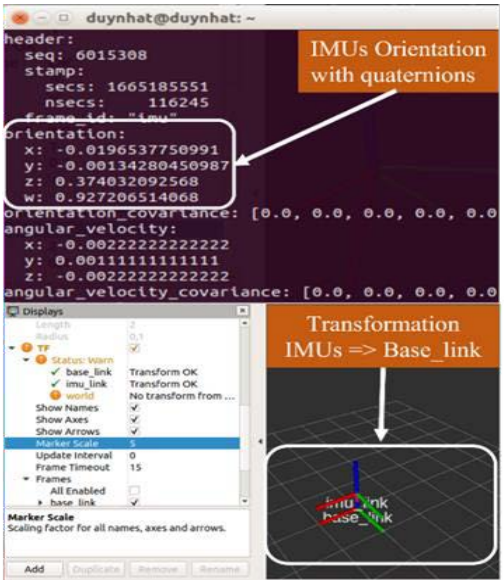

Figure 10. Show IMUs data

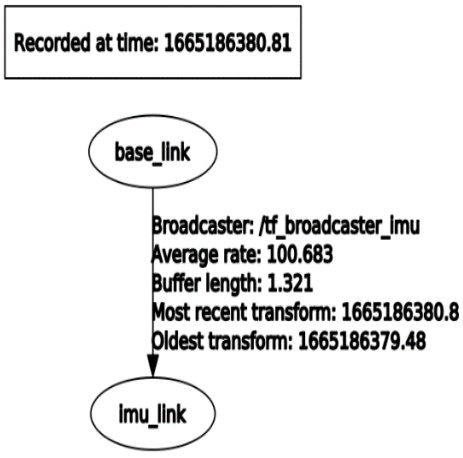

Figure 11. The diagram transformation between IMUs and base_link

Figures 12, 13 illustrate odometry data before and after fusion algorithm implementation, we performed moving the robot with (x = 0.5, z = 0.5) and (x = 0.2, z = 0.2), (x = 0.2, z = 0.0), respectively.

With x : linear velocity, z : angular velocity.

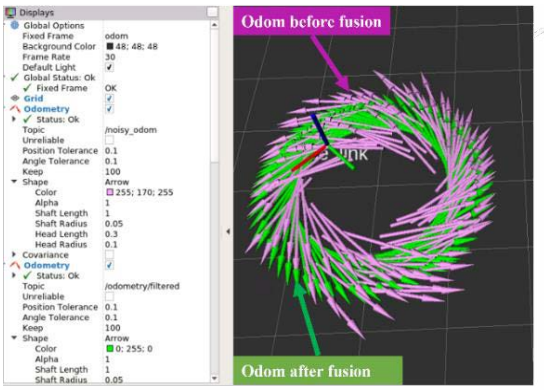

Figure 12. Experimental result of fusion algorithm

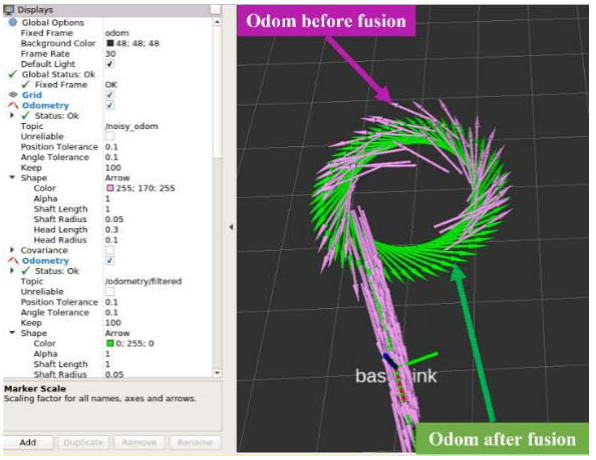

Figure 13. Experimental result of the fusion algorithm

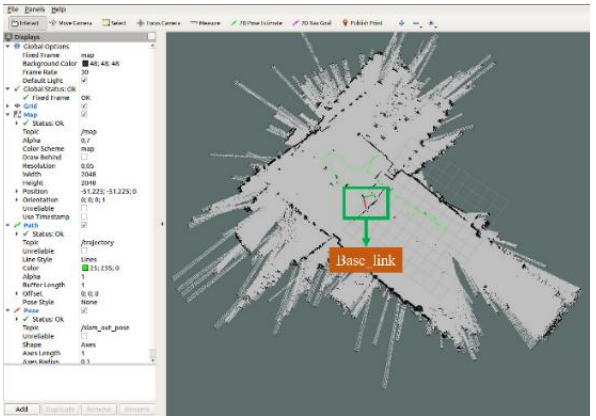

Figure 14. Applied odometry in building 2D mapping

Furthermore, I also tested the combination of filtered odometry and laser scan via the G-mapping package to build 2D Mapping, which has quite good results according to the

author's assessment and experience. However, this has not been detailed in this paper.

IV. CONCLUSION

This paper proposes odometry data from other sensors, converting the Euler angle to a quaternion, and control approaches for unicycle mobile robots. The method combines the moving robot through a joystick and estimates precise odometry data using a sensor fusion algorithm instead of only a single sensor for localization. This approach was on an actual mobile robot at EIU FabLab. The performance of the proposed sensor fusion Kalman Filter algorithm (*ekf_localization_node*) [8] is based on observations and experiments showing that more measurements will give a better estimation accuracy.

However, through personal practical experiences, we find that merging with only two sensors dramatically reduces the error in positioning the robot but still does not bring give the highest reliability, and it will drift over time (more or left drift depends on sensor quality). We are motivated to continue improving this topic in the next plan by integrating an RGB camera to localize the robot with the visual odometry method.

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MATHEMATICAL MODEL TO ESTIMATE ENERGY CONSUMPTION AND MOVING TIME IN STORING CELLS IN SMART WAREHOUSES

Duy Nhat Tran[1], Van Y Huynh[2], Ngoc Bich Le[3], Ngoc Huan Le[2]

[1]*EIU Fablab Center, Eastern International University, Binh Duong, Viet Nam*

[2]*School of Engineering, Eastern International University, Binh Duong, Viet Nam*

[3]*School of Biomedical Engineering, International University, Ho Chi Minh City, Viet Nam*

nhat.tran@eiu.edu.vn, y.huynh@eiu.edu.vn, lnbich@hcmiu.edu.vn, huan.le@eiu.edu.vn

Abstract: Energy and time are factors that play an essential role in optimizing an intelligent warehouse system. This paper aims to present surveying the energy consumption levels of the AGV system when arranging packages into the storage cells. We used an AC PZEM-004T sensor module and an Arduino microcontroller to measure and record data of average time and energy level parameters over a travel distance of the AGV system (Home to cells A, B, C…). This measurement is implemented from the home cell to other cells along the X-axis and Y-axis with three types of masses (0.5 kg, 1 kg, and 1.5 kg). With the data collected through this experiment, we will build a mathematical model based on a polynomial regression algorithm to quickly predict energy consumption and moving time at all storing cells with different masses. As a result, this solution directly supports the optimal sorting process according to the energy and moving time requirements.

Keywords: *Smart warehouse, Energy consumption, Polynomial regression algorithm*

I. INTRODUCTION

Automatic guided vehicle (AGVs) is becoming more popular in innovative warehouse systems. Many e-commerce warehouses worldwide are investing in developing this system to optimize the warehouse[2]. Another essential task of an AGV is replenishing pods, in other words, placing stocks in the warehouse. There are two types of stations, pick stations and replenishment stations. Human workers work in these stations to collect orders (picking) or place items in the pods (replenishment). Robots carry the pods to and from the station in all tasks. The picking process consumes more energy and time than replenishment, up to 80%, according to [1]. It is evident that robots need power and charging to complete their tasks. When a system completes the assigned task and is ready for another one, the AGV will decide to give one of the three tasks: order picking, energy, and time. In this research, we mainly analyze the problems of prediction energy and times that based on traveled distance.

In this paper, we apply the Polynomial regression algorithm to survey and predict the energy consumption of the system and the time it takes for AGV to complete the process of storing goods in the warehouse.

II. METHODOLOGY

A. Mathematical modeling for systems

The intelligent warehouse system consists of two main parts: Goods storage and AGV.

Warehouse specifications: Long = 2260mm, Width = 2042mm, Cell=49. These are the typical parameters for us to calculate and design, shown in Fig. 1 and Fig. 2.

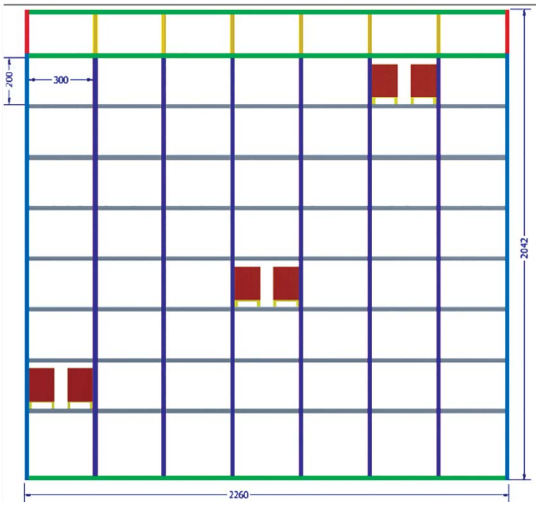

Figure 1. 3D models of Rack

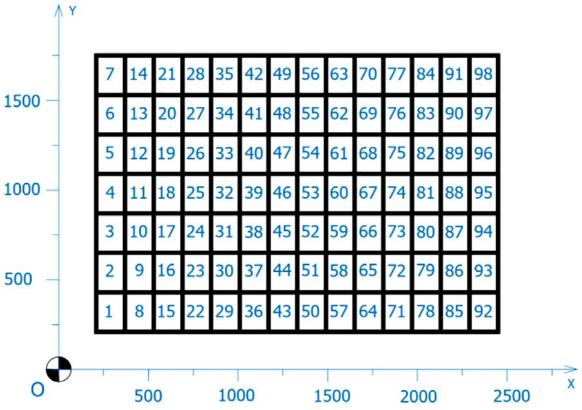

Figure 2. 2D drawing of Rack

AGV specifications: Long=848 mm, Width=158 mm, Hight= 1957. These are the typical parameters for us to calculate and design, shown in Fig. 3 and Fig. 4.

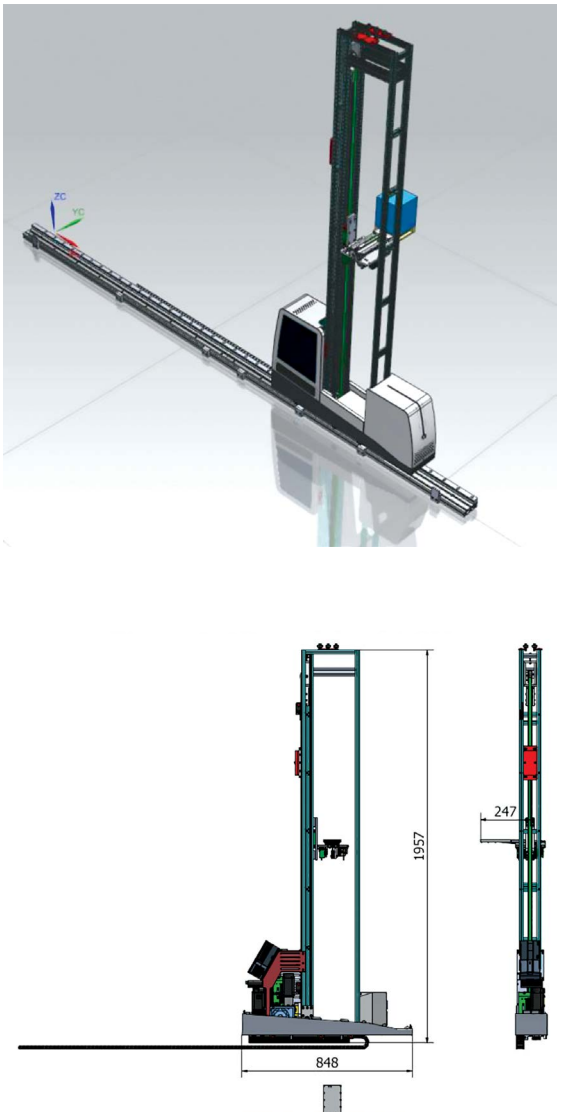

Figure 4. 3D models on CAD software

Polynomial regression model and evaluating its accuracy

The polynomial regression method describes our data distribution as non-linear [4]; it could be some multivariable equation as below.

$$y_i = \beta_0 + \beta_1 x^1 + \beta_2 x_i^2 + \beta_3 x_i^2 + ... + \beta_k x_i^k + \varepsilon \quad (1)$$

with i = 1, 2, 3, ... n

Where k is the degree of the Polynomial, ε the bias parameter, and the features that will be updated during model training.

The mean squared error (MSE) method compares the error between ground data and predicted data [4].

$$\text{MSE} = \frac{SSE}{df_E} = \frac{\sum_{i-1}^{n}(y_i - \hat{y}_i)}{n-(k+1)} \quad (2)$$

The heart mean squared error RMSE = MSE is not an unbiased estimator of σ, but it is still a good estimator. MSE and RMSE measure the size of the errors in regression and do not indicate the explained component of the regression fit [4].

In contrast, stochastic gradient descent (SGD) updates parameters for each training process $\hat{y}_i$ [3].

$$\theta = \theta - \eta * \nabla_\theta J(\theta; x^{(i)}; y^{(i)}) \quad (3)$$

Where θ is bias and features: ε and β0, β1, ..., βn respectively, n the parameter is learning rate and partial derivatives of each parameter described by $\nabla_\theta J(\theta; x^{(i)}; y^{(i)})$.

From (1), (2), (3), a gradient descent (GD) algorithm performs to optimize the parameters, which helps our model converge via the training process with suitable input parameters, such as learning rate, batch size,… [3].

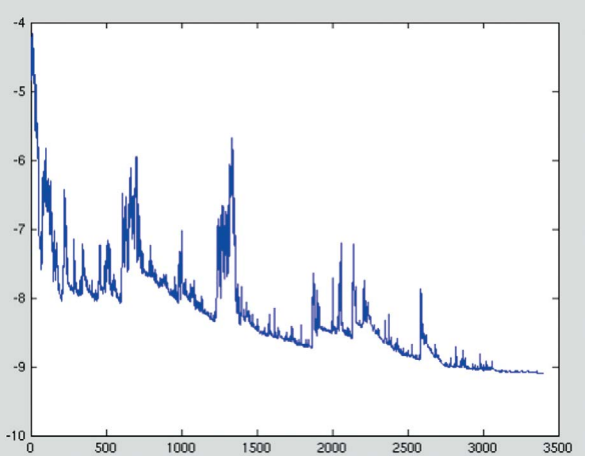

Figure 5. SGD fluctuation

(Source: Wikipedia)

The training process in our model follows the following steps.

We choose the quadratic equation 2 to build these models based on turning and data distribution. The TensorFlow framework is utilized to perform this calculation.

Randomly initialize the θ (β_0, β_1, β_n, ε)

Calculate prediction values

$$\hat{y} = \beta_0 + \beta_1 x_1 + \beta 2 x_2^2 + \varepsilon = \theta^T x \quad (4)$$

Calculate loss function

$$L = \frac{1}{n}\sum_{i=0}^{n}(y_i - \hat{y}_i)^2 = \frac{1}{n}\sum_{i=0}^{n}(y_i - (\beta_0 + \beta_1 x_1 + \beta_2 x_2^2))^2 \quad (5)$$

Calculate partial derivatives

$$\frac{\partial L}{\theta} = \frac{-2}{n}\sum_{i=0}^{n} x_i^2 * x_i * (\hat{y}_i - y_i) \quad (6)$$

Update parameter θ

$$\theta_{new} := \theta_{old} - n * \frac{\partial L}{\theta} \quad (5)$$

C. Measuring devices placed for data collection

For accurate data, we integrate it into the SCADA system of the smart home that measures the time online. The starting point is the Home point to the target displayed on the WinCC screen, shown in Fig. 6.

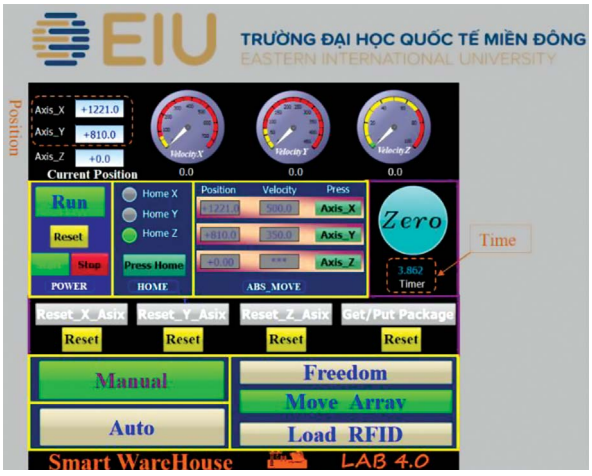

Figure 6. Relationship between distance and energy

To measure the system's power consumption, we used an AC PZEM-004T sensor module and an Arduino microcontroller to measure and record data of average time and energy level parameters over a travel distance of the AGV system (Home to cell A, B, C…). We have shown it in Fig. 7 and Fig. 8.

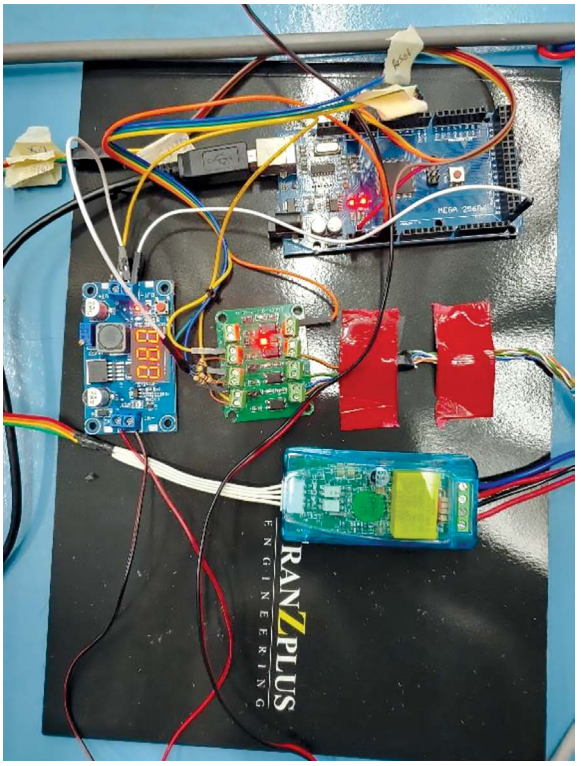

Figure 7. Device for measuring energy

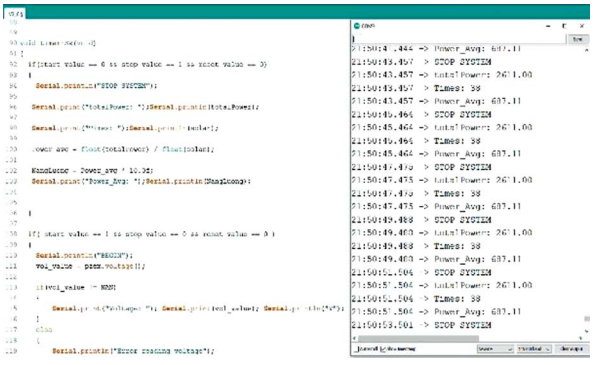

Figure 8. Controller of the energy measuring system

In this paper, we analyze the relationship between the travel distance of the AGV traveling with the energy consumption, and relationship between the distance and the time that the AGV has traveled all that distance. We analyze and find which equation is closest to the obtained data from that data. Our statistical information is shown in the chart in Fig. 9 and Fig. 10 below.

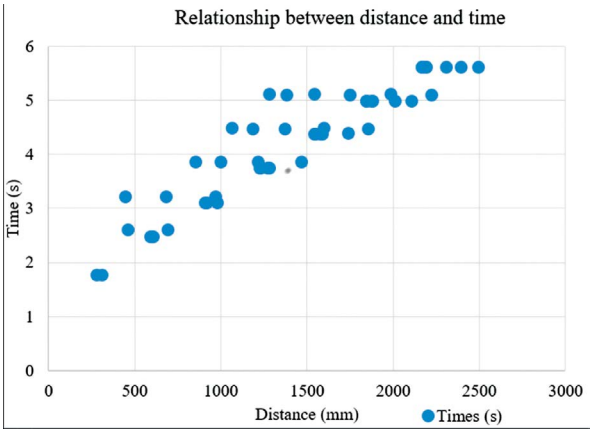

Figure 9. Relationship between distance and time

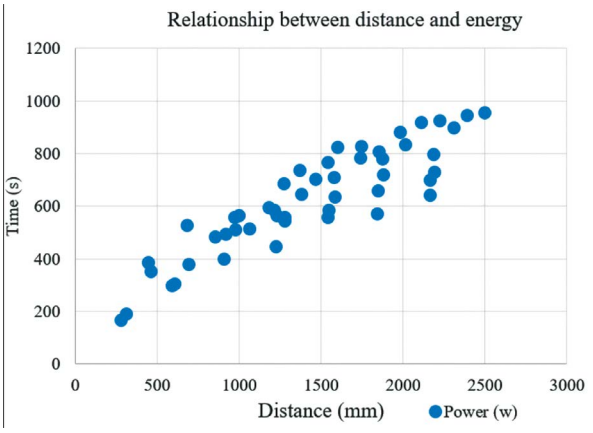

Figure 10. Relationship between distance and energy

III. RESULTS

Comparison between the two algorithms linear regression and Polynomial regression algorithm

From the available data, we use two methods to find the equation that minimizes the error. Below is the application of the Linear Regression algorithm to describe the time function according to the distance in Fig. 11.

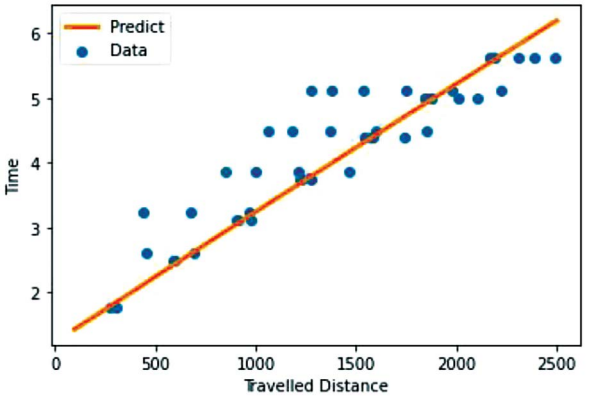

Figure 11. Time function along the path of the Linear Regression algorithm

The graph depicts the algorithm's error decreasing over time shown in Fig. 12 below.

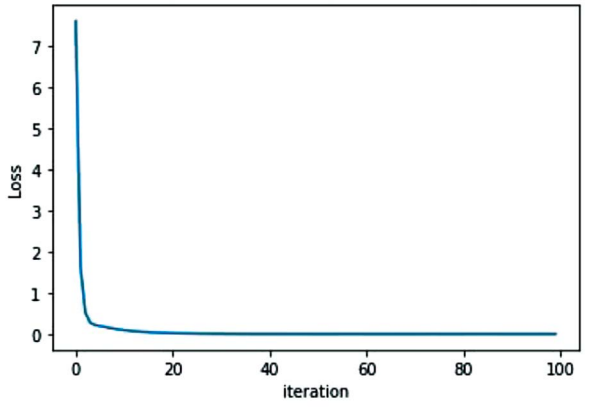

Figure 12. Time error according to the distance

Calculation results are quadratic equations over time.

$$y = -1.64498*x^2 + 2.0237*x + 1.2345 \quad (8)$$

Next, the projection of energy over distance is shown in Fig. 13.

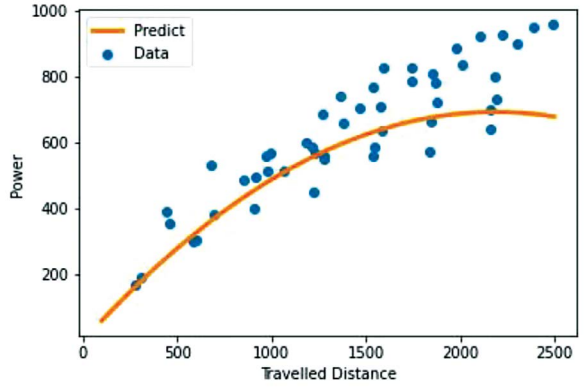

Figure 13. Time function along the path of the Linear regression algorithm

Calculating the error of the energy function is shown in Fig. 14 below.

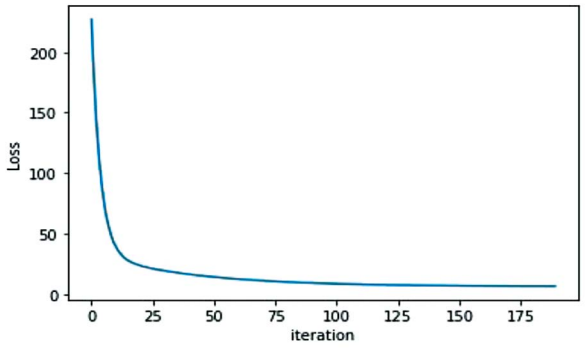

Figure 14. Energy error according to the distance

Calculation results are quadratic equations over time.

$$y = -1.4529668 * e\text{-}04 * x^2 + 6.35491214 * e\text{-}01 * x - 2.7339 \quad (10)$$

Next, we apply the algorithm Polynomial Regression to find the rule of the data and calculate the exact function according to the available data. Fig. 15 depicts the time function in terms of distance.

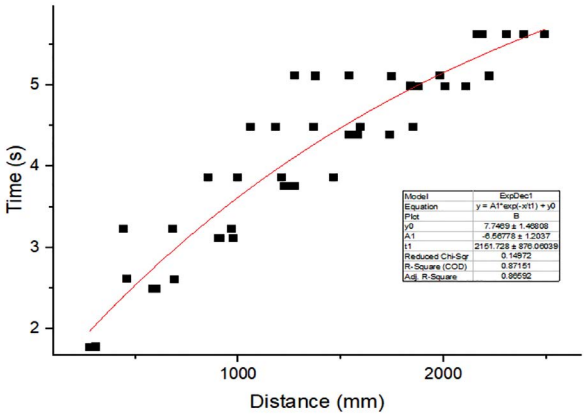

Figure 15. Time function along the path of the Polynomial Regression algorithm

Calculation results are quadratic equations over time. Polynomial regression algorithm is applied:

$$y=A1*\exp(-x/t1)+y0 \quad (9)$$

Where:

A1= -6.56778±1.46808

y0=7.7469 ± 1.46808

t1=2151.728 ± 876.06039

Next, we apply the algorithm Polynomial Regression to find the rule of the data and calculate the exact function according to the available data. Fig. 14 depicts the energy function in terms of distance.

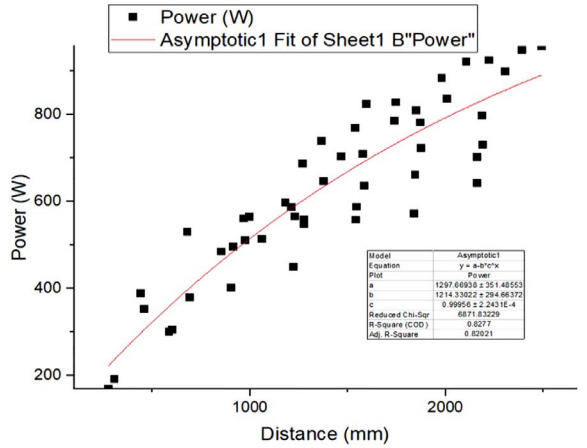

Figure 16. Energy function along the path of the Polynomial Regression algorithm

Calculation results are quadratic equations over time. Polynomial regression algorithm is applied:

$$y = a-b*c\hat{}x \quad (11)$$

Where:

a = 1297.66938 ± 351.48553

b= 1214.33022 ± 294.66372

c= 0.99956±2.243E-4

Finally, from (4), and (5), comparing the results of the two algorithms above is presented in Fig. 17.

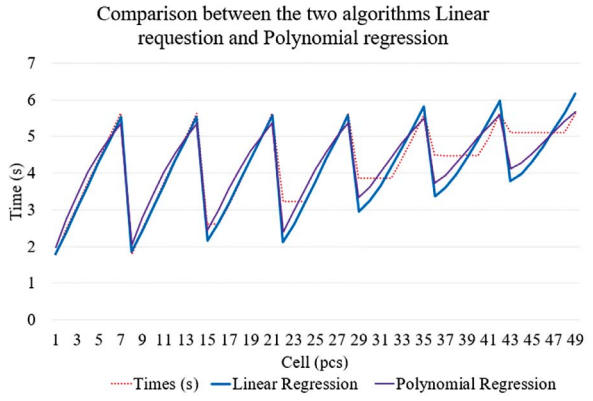

Figure 17. Compare the performance of two algorithms over time data

Fig. 17 shows the average efficiency of two algorithms for time data, Linear Regression and Polynomial, shown in Fig. 18 below.

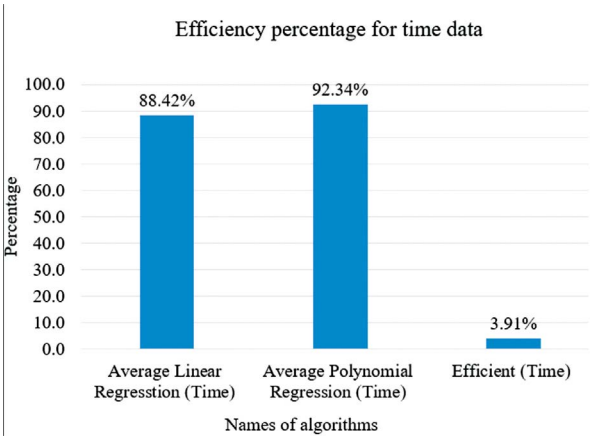

Figure 18. Efficiency percentage of Linear Regression and Polynomial Regression algorithms for time

Fig. 18 shows that the Polynomial Regression algorithm is about 4% more efficient than the Linear Regression algorithm with this data.

Form (6), (7), we have the same energy as shown in Fig. 19 below.

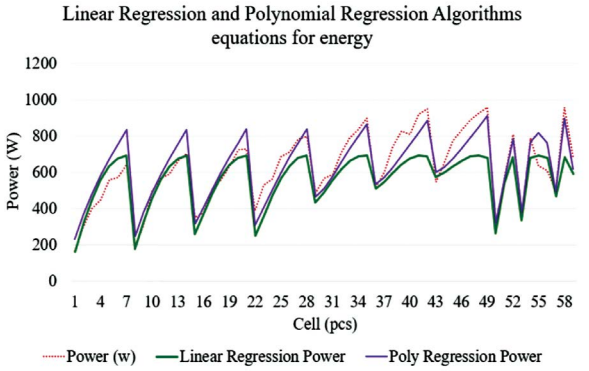

Figure 19. Compare the performance of two algorithms over energy data

Fig. 19 shows the average efficiency of two algorithms for time energy, Linear Regression, and Polynomial, shown in Fig. 20 below.

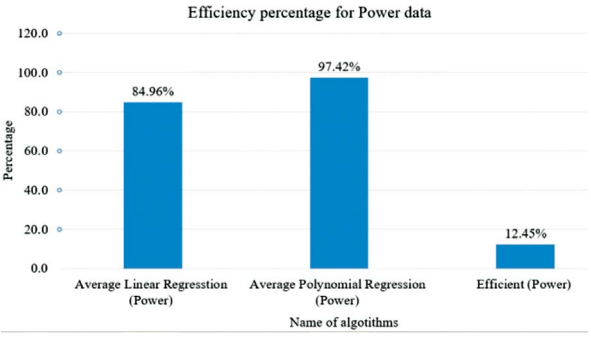

Figure 20. Efficiency percentage of Linear Regression and Polynomial Regression algorithms for energy

Fig. 20 shows that the Polynomial Regression algorithm is about 12.45% more efficient than the Linear Regression algorithm with this data.

IV. CONCLUSION

In this study, we proposed a solution to quickly determine energy consumption and

travel time from the Home position to every cell on the storage shelf. We used two methods, Linear Regression power, and Poly Regression power to interpolate mathematical functions from actual data. The results show that applying the Polynomial algorithm to analyze the time and energy data of the intelligent warehouse system gives outstanding results. From there, we can predict the time of the production process and calculate the energy cost in advance for the work to be performed. This research's result helps us be proactive in production, planning the production process to bring about high economic efficiency.

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THE IMPLEMENTATION OF COPPELIASIM IN COMPUTATION AND SIMULATION 5 DOFS ROBOTIC ARM

Linh Vo Doan[1]

[1]*EIU FabLab Center, Eastern International University, Binh Duong, Viet Nam*

Linh.vo@eiu.edu.vn

Abstract: One of the most important in control of the robotic arm is computation of the kinematics. However, figuring out the results for the kinematics is not straightforward especially for students even if the problems are solved, it is difficult for them to assess. Therefore, a simulator – CoppeliaSim is utilized due to its free of cost and Open source. This paper presents the methodology for modeling, simulating, and evaluating the kinematics of 5 Dofs robotic arm in CoppeliaSim (V-REP). Using the 5 Dofs robotic arm as the case study, the steps of computing the kinematics, importing SolidWorks CAD model as well as interfacing in CoppeliaSim, and finally comparing between the calculation and simulation are described in detail.

Keywords: *Kinematics, CoppeliaSim, V-REP, robotic arm*

I. INTRODUCTION

The automation and robotics are closely related as the automation solve the problem of control the machinal, electronics and computer – based system [1]. Robotics plays a wide range in the industrial automation as the robotic manipulators, the self-guided cars [2]. Robotics arms perform the function which is similar to the human arm with greater accuracy and consistency, this type of robot mainly used in the industrial for pick and place and skilled application. It is not only improving the efficiency and the accuracy of the work but also leading the higher production rate [3].

The existing robotic arm is mainly used in the Industries, which leads to the high cost and makes the robotic algorithm study with hardware models difficult [4].

This is one of the reasons why the simulation software plays an important role in robotic research. Simulation tools are widely used for the kinematics and dynamics modeling, motion optimizations, performance evaluation and control strategy verification [5]. In this paper, the author uses the CoppeliaSim (formerly known as V-REP) [6] developed by Coppelia Robotics for modeling and simulating the kinematics of the robotic arm due to free availability for the academic purpose.

II. METHODOLOGY

A. Modeling and Simulation in CoppeliaSim

1. Creating model in CoppeliaSim

The first step of robot simulation is to create a manipulator model that satisfies all the mechanical constraints, so the model of manipulator can behave as same as possible its real physical prototype [6].

The model is designed in SolidWorks software and imported to the CoppeliaSim Environment by generating the URDF file. A complicated and heavy CAD model might slow down the graphical visualization and numerous computational modules of the software, so the CAD model imported to CoppeliaSim was simplified. Moreover, each joint of the designed robot must be attached to the right orientation and translation frame for implement the coordinate system for the model in the CoppeliaSim.

After Importing the URDF which contained the STL file for visualization of the model in software, the fixed frame (base frame) and the end – effector frame are attached to the robot for intuitive utilization.

With these two frames, the robot software can provide the tools for the user to compute the forward kinematics and inverse kinematics of the robot automatically.

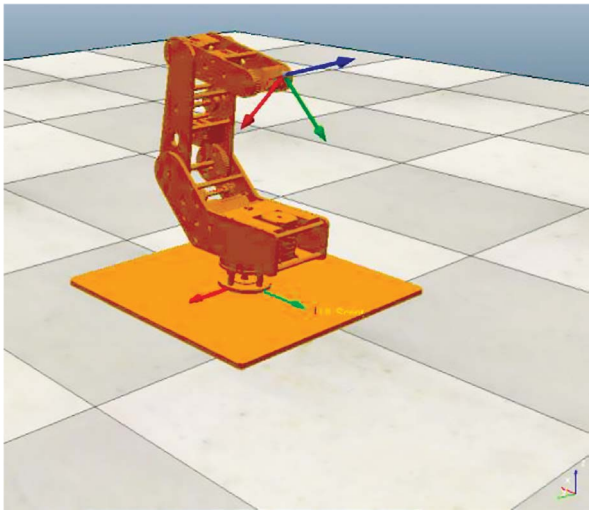

Figure 1. Skeleton model of the robot

The base platform, actuators and gears were simplified in order to reduce the computational cost. Every simulation model in the software has the scene hierarchy to describe the connection between the components of the model and the surrounding. The resulting scene hierarchy is shown in Fig. 2. It is clear that joint 1 contains joint 2, then joint 3 is placed inside joint 2 and so on; it depicts the serial connection of the robot arm where the following joint must be attached to its previous joint.

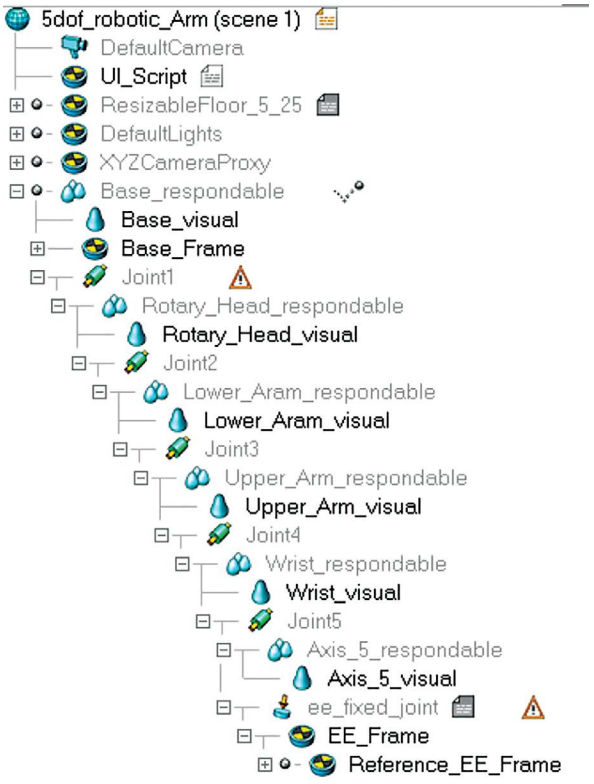

Figure 2. Scene hierarchy of the robot model interface

Generally, there are numerous ways to control the simulation model in CoppeliaSim such as using the other software and communicating through the APIs. Alternatively, directly utilize internal resources of the model to run the simulation. In this paper, the second step was applied by building the user interface inside the software with Lua and XML programming.

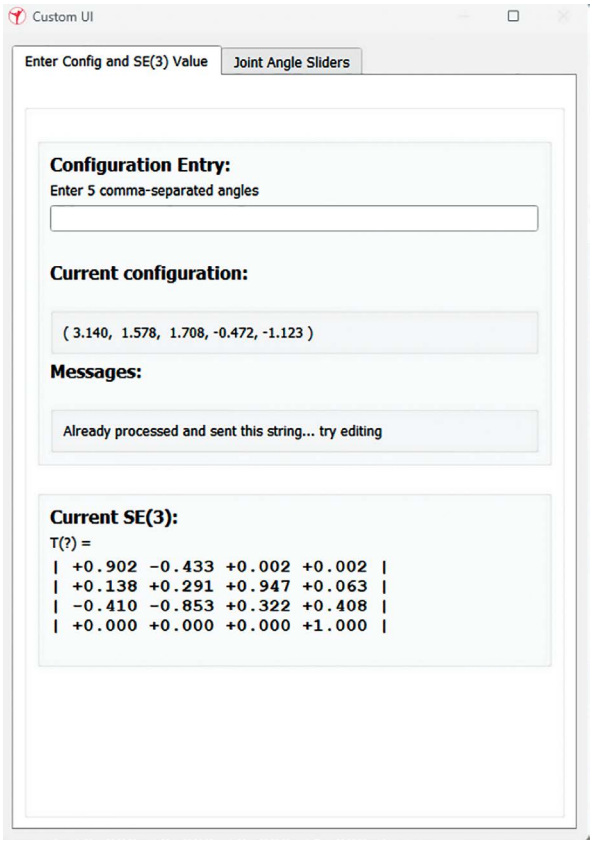

Figure 3. Custom UI

The Custom UI provides the calculation for the homogeneous transformation matrix of the robot and the angles of joint corresponding to it.

B. Equations

1. Forward Kinematics (FK)

The general formulation of the POE for solving the FK, corresponding to a screw motion is described as follows:

$$T = e^{[S_n]\theta_n} M$$

Where $M \in SE(3)$ is the end – effector configuration when the robot is at the zero (home) position, the joint variables θ_1, θ_2,..., θ_n, the screw axes

The robot has 5 Dofs, which is illustrated in Fig. 4.

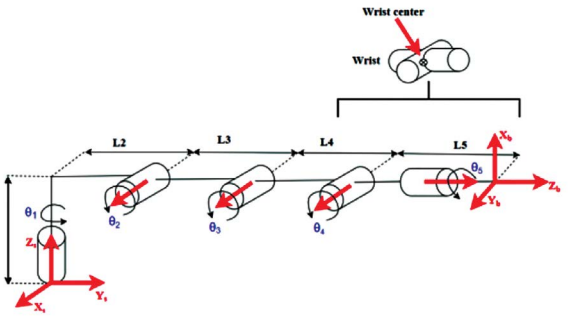

Figure 4. The robot's 5 Dofs

The fixed frame and the end – effector frame are denoted as the {s} and {b} respectively. After that, the forward kinematics of the robot are expressed in the fixed frame {s} of the robot. The term of the FK has the form

$$T_{sb}(\theta) = e^{[S_1]\theta_1} e^{[S_2]\theta_2} e^{[S_3]\theta_3} e^{[S_4]\theta_4} e^{[S_5]\theta_5} M$$

By inspection, the end – effector frame of the robot at the zero position can be obtained:

$$M = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & L_2 + L_3 + L_4 + L_5 \\ 1 & 0 & 0 & L_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Then, implementing the definition of screw axis for each of the joint, the results are:

- The screw axis $S_1=(\omega_1, v_1)$ for joint axis 1 is the given by $\omega_1 = (0,0,1)$ and $q_1=(0,0,0)$, because the convenience of choosing the point $v_1=(0,0,0)$ lying on the fixed frame origin (0,0,0).
- To determine the joint axis $S_2=(\omega_2, v_2)$, observed that joint 2 point in the direction x_s – direction, so $\omega_2=(1,0,0)$. Then, choosing $q2=(0, L_2, L_1)$ is that the origin of the joint 2, in which case $v_2 = -\omega_2 \times q_2 = (0, L_1, L_2)$

- The crew axis of joint 3 is in the direction ω_2=(1,0,0). Choose $q3 = (0, L_2 + L_3, l_1)$, so $v_3 = -\omega_3 \times q_3 = (0, L_1, -(L_2 + L_3))$.
- For joint 4, observer that $\omega_4 = (1,0,0)$, next select the point $q_4 = (0, L_2 + L_3, L_1)$. The linear velocity of joint 4 is $v_4 = -\omega_4 \times q_4 = (0, L_1, -(L_2 + L_2 + L_4))$.
- Finally, the joint axis for joint 5 is in the direction $\omega_5 = (0,1,0)$, choosing $q_5 = (0, L_2 + L_3 + L_4 + L_5, L_1)$, leads to $v_5 = -\omega_5 \times q_5 = (-L_1, 0, 0)$.

In summary, the screw axis $S_i = (\omega_i, v_i)$, $i = 1,2,...,5$ are as follows in the tabular form:

Table 1. Table of screw axis for each joint of robot

i	ω_i	v_5
1	(0,0,1)	(0,0,0)
2	(1,0,0)	$(0, L_1, -L_2)$
3	(1,0,0)	$(0, L_1, -(L_2 + L_3))$
4	(1,0,0)	$(0, L_1, -(L_2 + L_2 + L_4))$
5	(0,1,0)	$(-L_1, 0, 0)$

2. Inverse Kinematic (IK)

For the IK of the robot, the process is finding the joint angles where the position and the orientation of the end – effector are known in advance.

$$\alpha, \beta, \gamma, x, y, z \rightarrow \theta_1, \theta_2, \theta_3, \theta_4, \theta_5$$

Where α, β, γ are Euler angles; x,y,z are the translation of end – effector frame expressed in fixed frame {s}; $\theta_1, \theta_2, \theta_3, \theta_4, \theta_5$ are the angles of joints.

In order to acquire the IK of the robot, it should be divided into 2 separate parts, the wrist which is represented the orientation of the robot and the first 3 joints which express the translation of the end – effector.

$$T_{desired} = \begin{bmatrix} R(\alpha, \beta, \gamma) & p \\ 0 & 1 \end{bmatrix} \in SE(3)$$

Given the Euler angles and the translation of the end – effector, combine them together to get the homogeneous transformation matrix, named $T_{desired}$ for the desired position and angels of the end-effector.

Where $p = (x, y, z) \in R^3$ and $R(\alpha, \beta, \gamma) \in SO(3)$ is the rotation matrix.

The next step is removing the rotation frame of the robot (Fig. 1 – the wrist) by multiplying $T_{desired}$ with $T_{removed}$, where:

$$T_{removed} = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & -L_5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The main purpose of decoupling the last 2 frames of the robot is obtained the homogeneous transformation matrix for the center of the wrist of the robot which is contained the first 3 joints of the robot. $T_{wristcenter}$ has the form:

$$T_{wristcenter} = \begin{bmatrix} R_{wristcenter} & p_{wristcenter} \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & x_{wristcenter} \\ r_{21} & r_{22} & r_{23} & y_{wristcenter} \\ r_{31} & r_{32} & r_{33} & z_{wristcenter} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

After getting the $T_{wristcenter}$, the translation vector $p_{wristcenter}$ is implemented to calculate the IK of the first 3 joints. For the intuitive representation, the skeleton model for the first 3 joints are redrawn below.

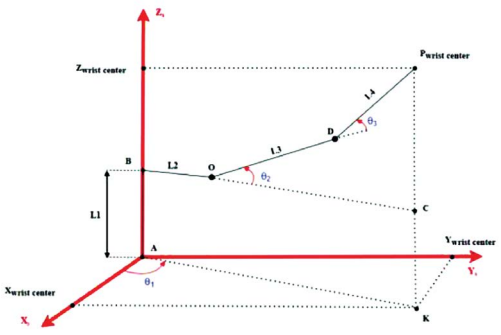

Figure 5. Skeleton representation of first 3 joints

Inspecting the Fig. 2 and applying the geometry, the results for can be achieved by the following:

$$\theta_1 = atan2(y_{wristcenter}, x_{wristcenter})$$

For determining the angles θ_2, θ_3, firstly, finding the distance OC by substituting the length of BC to BO, which is equivalent to L_2 and AK respectively, where $AK = \sqrt{X^2_{wristcenter} - Y^2_{wristcenter}}$, so $OC = \sqrt{X^2_{wristcenter} + Y^2_{wristcenter}} - L_2$. Moreover, the length $PC = Z_{wristcenter} - L_1$. After getting OC and PC, focusing on the triangle $P_{wristcenter}CO$ to solve θ_2, θ_3.

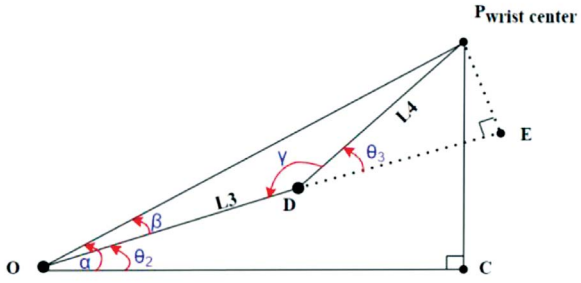

Figure 6. Geometric shape for figuring out

θ_3 can be obtained by applying the law of cosine and trigonometric formula for the γ

$$\cos\theta_3 = \frac{PO^2 - OD^2 - DP^2_{wristcenter}}{2.OD.DP_{wristcenter}}$$

Where $PO = \sqrt{OC^2 + PC^2}$, $OD = L_3$ and $DP_{wristcenter} = L_4$. Then $sin\theta_3$ is found out by

$$\sin\theta_3 = \sqrt{1 - \cos\theta_3^2}$$

Now θ_3 is given by

$$\theta_3 = atan2(sin\theta_3, cos\theta_3)$$

Then θ_2 obtained by two angles α and β.

$$\alpha = atan2(PC, OC)$$

$\beta = atan2(PE, OE)$ where $OE = L_3 + L_4 cos\theta_3$, $PE = L_4 sin\theta_3$.

The last 2 angles are received by the transform matrix of the first 3 joints and $T_{desired}$.

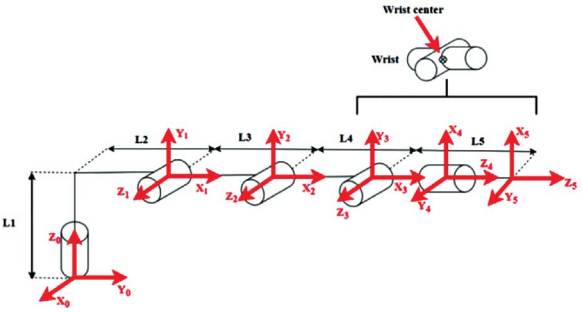

Figure 7. The attached frames for all joints of the robotic arm

Using the calculated value of θ_1, θ_2, θ_3 to form the transformation matrix T_{03}, then compute the transformation matrix for 2 wrist joint by $T_{wrist} = T_{desired}.T_{30}$. Finally, transfer the rotation matrix of the T_{wrist} into Euler angles to get the value θ_4, θ_5.

III. SIMULATION RESULTS

Consider the input joint positions $\theta = [\pi/4, \pi/2, \pi/6, \pi/3, \pi/12]$, the results for the FK of the robot are shown as follows:

FK result:

$$T_{cal} = \begin{bmatrix} 0.183 & 0.6830 & 0.7071 & -1.5851 \\ 0.183 & 0.6830 & -0.7071 & 1.5851 \\ -0.9659 & 0.2588 & 0 & 542.002 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_{sim} = \begin{bmatrix} 0.184 & 0.683 & 0.707 & -5 \\ 0.182 & 0.683 & -0.707 & 1 \\ -0.966 & 0.259 & 0.002 & 542 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Then, using the following transformation matrix to compute the IK of the robot. Where θ_{cal} implemented the equations from the IK above, while the simulated orientation of the robot in CoppeliaSim obtained the IK by using built – in function in the software.

$$\theta_{cal} = [0.785, 1.57, 0.523, 1.05, 0.262]$$

$$\theta_{cal} = [0.785, 1.57, 0.523, 1.047, 0.262]$$

It is seen that the simulated inverse kinematics of the robot closely match the expected numerical computation.

IV. CONCLUSION

In this study, evaluation of the kinematic equations of 5 Dof robotic arm is conducted by implementing the simulation and built-in functions of the CoppeliaSim Software. Kinematics of the robot was discussed following the explanation of CoppeliaSim modeling steps. The simulation provides the intuitive tools for the user to build and testing their own model of robot.

This work is setting the foundation for the future extension of the author's research work on the robotic arm such as calculation and simulation of singularity, detecting the collision – free workspace for manipulators, and building the real prototype of the robot for testing. The other idea is used this software to develop the path planning or learning algorithm via the simulation.

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HUMAN TRACKING ALGORITHM USING KINECT CAMERA FOR MOBILE ROBOTS

Nhat An Thai[1], Viet Thang Nguyen[1], Tan Hung Huynh[1], Minh Khiem Nguyen[1], Tran Thanh Loi Phan[1], Trung Dung Trinh[1], Viet Anh Dung Cai[1], Ngoc Huan Le[1]

[1]*School of Engineering, Eastern International University, Binh Duong, Viet Nam*

an.thai.set19@eiu.edu.vn, thang.nguyen@eiu.edu.vn, dung.cai@eiu.edu.vn, huan.le@eiu.edu.vn

Abstract: This paper describes the development of an algorithm for human tracking using a Kinect camera mounted on a mobile robotic platform. The robotic platform structure is equipped with 2 independent motorized driven wheels located right in the middle of its platform and 4 other caster wheels that are located at the front and the back of the platform that allow it to be driven in differential mode. This solution allows the robot to change its direction simultaneously as any location of its instantaneous center of rotation can be realized. The algorithm consists of detecting the human skeleton as well as estimating the distance from the latter to the camera. Then, a closed loop controller is applied allowing the robot to maintain this distance, as well as to keep the detected skeleton in the center of the camera's matrix. Solutions to assure the robustness of the system are discussed and first experimental results are presented.

Keywords: *Kinect Camera, Human Detection and Tracking, Mobile Robotics, MIMO controller*

I. INTRODUCTION

Mobile Robotics is one important robotics research topic that regroups multi-disciplinary knowledge from different scientific fields such as: Mechanical Design, Electronics Design, Control, Computer vision and Artificial Intelligence (to perform perception and cognition tasks). It has a wide range of applications varying from military and security applications (dangerous places exploration, surveillance) to industrial and domestic ones (logistical warehouses, delivery services). In [9], the authors mentioned numerous research topics to be investigated in order to make these applications feasible, such as: Locomotion, Perception & Cognition, Control and Navigation. Among these research topics, navigation is one of the most attractive one for researchers as it has tremendous application potential. SLAM (Simultaneous Localization and Mapping) [4] plays an essential role as this technique allows to position the robot in the working space. Different technologies have been used to allow the positioning of the robot in space using sensors fusion algorithms or mapping. Kalman filter [5][10][12], which provides a recursive solution for filtering discrete data, is today the most well-known technique for sensor fusion (consisting of estimating & updating a mobile robot's state). A sensor fusion algorithm consists of using different kinds of sensors such as: fixed geometric beacons, odometry, IMU, GPS etc. to continuously estimate the actual position of the robot [8]. For a navigation in a changing environment, the use of map [7] allows the

robot to dynamically chose and update new beacons according to its news position.

Another theme that could lead to concrete applications is object & human detection. Object Recognition is one most basic computer vision's research theme. A well-performed object/human detection and tracking algorithm will not only allow the robot to avoid collisions and plan the optimal paths during navigation, but also to track and follow the motion of a human subject [1][13]. Different techniques for human detection using RF or Depth Camera (Kinect) have been developed by researchers recently [2] [3][6][11]. The human recognition algorithm consists of two parts: the training part to distinguish each segment of the human body and the selection part to make decisions. In part 1, an algorithm is called the random decision forest (RDF). This can be seen as an improved algorithm of the decision tree algorithm. In this RDF algorithm, a series of decision trees will be generated through training an existing dataset. This dataset consists of many depth photographs with each segment of the human body already marked. In part 2, when using RDF to identify each human body segment, the decision trees will return each human body segment along with its position, size, and shape. After the recognition results are available, combined with the depth image will show the distance from the person to the camera, along with the person's position in 3D space. From here, the computer will send data down to the controller to run according to the flowchart.

In this paper, the authors present the experiments of human tracking using Kinect camera mounted on a mobile robotic platform. These experiments were realized in order to verify the feasibility of using Kinect camera to track a user in real scenarios. The description of the mobile robotic platform, its kinematic model as well as the Kinect camera used in the experiment are presented in section II. Section III presents the human tracking algorithm, followed by the first results and discussions in section IV.

II. SYSTEM DESCRIPTION

A. The Mobile Robotic Platform

Figure 1. The mobile robotic platform

Fig. 1 shows the robotic platform developed at EIU that was designed to function with loads of more than 70 Kg. The experiment is carried out in both manual control mode and automatic mode. The schematic diagram of the robot's electrical and electronic system is shown in Fig. 2. In detail, the robot is driven by 2 wheels attached to 2 BLDC motors, operated by 24V DC power source and controlled by 2 drivers. The main control board includes 2 MCUs. The first MCU is responsible for controlling the speed of 2 BLDC motors using the PID algorithm. This board also receives the data from distance sensors mounted

around the robot. This sensor system includes 12 infrared sensors and 6 ultrasonic sensors, allowing the detection of all obstacles within 50 centimeters around the robot. The second MCU is in charge of receiving information from the localization system (indoor GPS), analyzing the data, and communicating with the user through 2 wireless transmitters (Bluetooth and PS2).

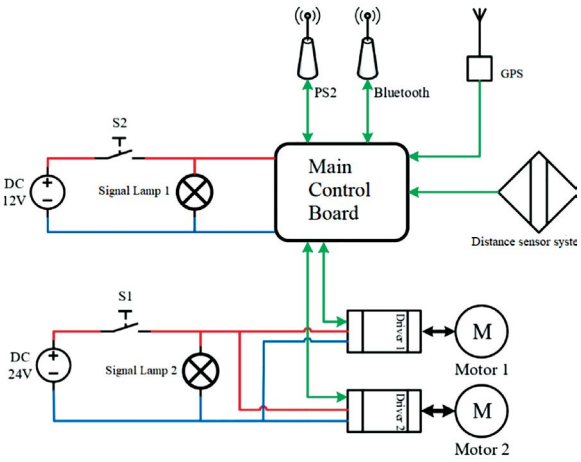

Figure 2. General diagram of electrical and electronic system for the robot

Fig. 3 presents the kinematic model of the robot that allow the determination of the mobile robotic platform velocity vector (Eq. 1 &2) from odometry data (which are here the optical encoders pulses obtained from the 2 wheels' rotations). The detail of calculations is presented below.

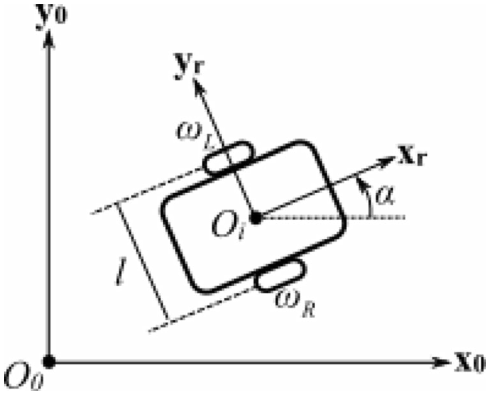

Figure 3. Kinematic model of the robot

- $O_i(x_i, y_i)$ – The robot's center position in the coordinate system $R_0(O_0, \mathbf{x_0}, \mathbf{y_0})$ of the map.
- $\mathbf{x_r}$, $\mathbf{y_r}$ – Unit vectors of the coordinate system $R_r(O_i, \mathbf{x_r}, \mathbf{y_r})$ associated with the robot.
- α – The rotation angle between the $\mathbf{x_r}$ vector and $\mathbf{x_0}$ vector of the map
- ω_L – Rotational speed of the left wheel
- ω_R – Rotational speed of the right wheel
- l – Distance between 2 robot wheels

The linear velocity of the robot vehicle in the map, measured at the robot's center position, is calculated by the formula (1).

$$v_{O_i} = \frac{v_L + v_R}{2} = \frac{r}{2}(w_L + w_R) \quad (1)$$

where r is the radius of the 2 wheels while v_L and v_R are the translational velocities of the 2 wheels. The rotational speed ω (according to the z_0 direction) of the robot can be calculated as:

$$w = \frac{2(v_R - v_L)}{l} = \frac{2r}{l}(w_R - w_L) \quad (2)$$

From (1) and (2), we can deduce the formula for calculating instantaneous position $O_i(x_i, y_i)$ and instantaneous rotation angle α of the robot as:

$$\begin{cases} \alpha = \alpha_0 + \int \omega \\ x_i = x_{i0} + \int v_{O_i} \cos\alpha \\ y_i = y_{i0} + \int v_{O_i} \sin\alpha \end{cases} \quad (3)$$

B. Kinect Camera

The Kinect sensor provides depth data that help identify the pixels of the object more easily. Here we use SKD tools that

provide access to human skeleton joints [14], with a maximum of 20 joint points. The skeleton-tracking state can be chosen by the programmer. To track the skeleton, the SDK uses multiple channels.

Figure 4. Result of human body frame detection

A complete human skeleton detected by the Azure Kinect Camera provided in total 20 joint points that can be used for tracking (see Fig. 4). Each joint point will return positions in 3 direction X, Y, Z converted into millimeter (mm). The middle pixel of the image is the origin of the coordinate frame. The maximum number of humans the Azure Kinect camera can track is 6. However, this project only requires tracking one human at a time, so the robot will only follow the first person that it detects.

III. HUMAN TRACKING ALGORITHM

Fig. 5 presents the experiments of using the Kinect Camera to check the feasibility of using the system to localize a human subject when the latter moves in real time. In this experiment, the subject was asked to move forward – backward, then from left to right and finally to move in circle. The sampled data were computed and sent to the GUI every 0.3 s. This sampling rate was considered sufficient by the research team to be used for dynamic tracking when the camera is mounted on a mobile robotic platform.

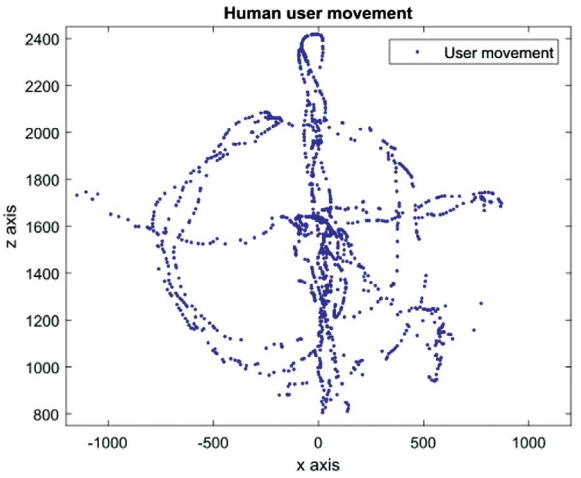

Figure 5. Test result of human body frame position tracking. The axes x and z are in mm.

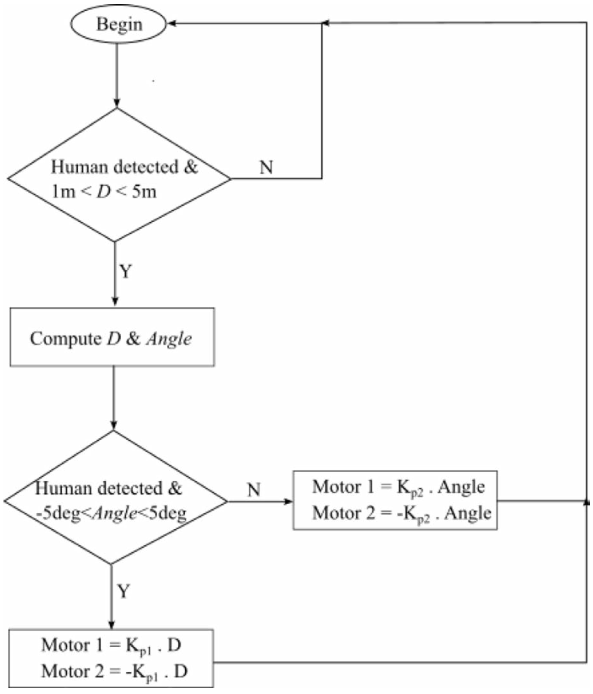

Figure 6. Algorithm for the determination of robot's motors velocities to track the detected body frame

Fig. 6 illustrates the algorithm that was implemented in the system to dynamically track the human subject. In this Chart, *D* is the estimated distance from the camera to the detected skeleton and *Angle* is the deviation of the skeleton with respect to the image's origin. These 2 values can be determined simply by

using the X and Z coordinates as shown in equation (4).

$$\begin{cases} D = \sqrt{X^2 + Z^2}; \\ Angle = \dfrac{\arctan 2(X, Z).180°}{\pi}; \end{cases} \quad (4)$$

Here the algorithm was set to function only when the human subject entered into the functioning range, which is defined by D = [1 m, 5 m]. The proportional gains K_{p1} and K_{p2} were determined experimentally to allow the robot to follow the subject in an optimal manner. The robot was set to correct automatically its orientation each time the deviation *Angle* was greater than ±5 degree, otherwise it just moved forward to follow the subject.

IV. RESULT AND DISCUSSION

Fig. 7 presents the images of an experiment during which the robotic platform dynamically tracked the human subject in real time. During the experiment, the system was able to detect the subject each time his image appeared in the camera. The range of optimal detection is from 1.5 m to 5 m. The minimal distance accepted by the algorithm is 1 m so that when the user approaches the robot, the tracking algorithm will be disabled for safety.

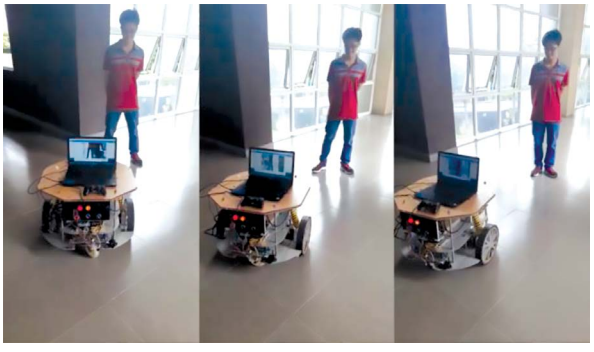

Figure 7. First experiment images: The robot was tracking the motion of a human subject.

The first experiment result is illustrated in Fig. 8 & 9. In this experiment, during the first 60 seconds, the user realized large movements which resulted in large values of the deviation angle (see Fig. 9). He was then asked to move slowly at normal pace so that the system could track and follow his motion stably and continuously (without any interruption caused by image loss). One can see in Fig. 8 that once the robot followed the user in a stable manner, there were small variations of the x coordinates even if the z coordinates varied greatly when the subject accelerated or decelerated.

The data presented in Fig. 9 confirmed what was stated in the previous paragraph. The deviation angle remained small when the robot tracked and followed the subject in a stable manner. When this happened, the distance D from the camera to the detected skeleton was maintained in between 1.5 m to 2.5 m. Here the robot succeeded to follow the subject when the latter moved in normal and slow speed. However, when important acceleration occurred, especially in X direction, the skeletal data could be lost, which resulted in a stop of the robot.

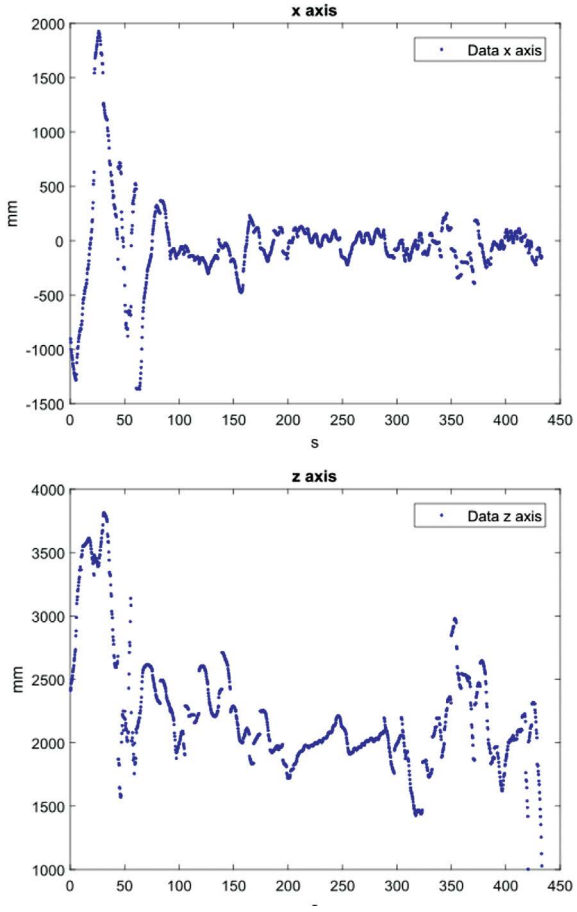

Figure 8. First experiment data: The skeletal data identified by Kinect camera.

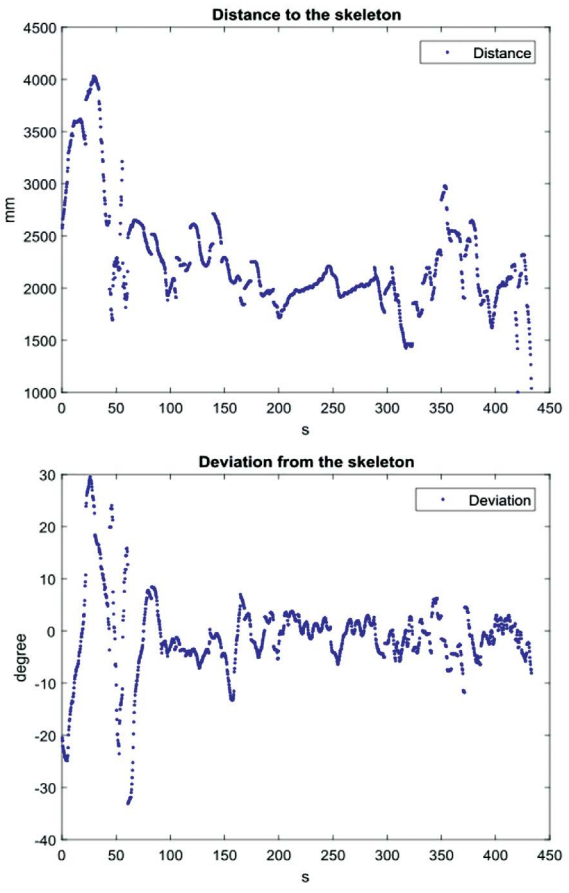

Figure 9. First experiment data: Distance and Deviation Angle determined during the experiment

V. CONCLUSION

In this paper, the authors presented the very first experimental results using a mobile robotic platform equipped with Kinect Camera to track and follow the movement of a human subject. The algorithm was based on using the position of the human body skeleton provided by Kinect Camera to determine the velocities of the 2 wheels of the robot. Acceptable results were obtained as the robot was able to continuously detect and follow the subject and there was no concern for safety. In the near future, different strategies should be tested in order to find the optimal control parameters to allow the robot to track and

follow a human subject at high pace, without interruption.

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MICRO ELECTRO MECHANICAL SYSTEM AND ITS CURRENT DEVELOPMENT IN VIETNAM

Nhat Tam Le[1]
[1]*School of Engineering, Eastern International University, Binh Duong, Viet Nam*
tam.lenhat@eiu.edu.vn

Abstract: Along with the development history of semiconductor industry which bloomed with the appearance of the first transistor in 1948, many semiconductor fabrication methods had been created. One of the ultimate aims of semiconductor industry was to integrate as many transistors as possible on a single chip to reduce the size of the chip for producing compact devices. This aim resulted in the emergence of the core technology of microelectronics fabrication methods with the successes in Integrated Circuits (ICs) and Large-Scale Integrated Circuits (LSIs). As there were more and more demands on saving materials, improving energy efficiency and reducing the size of devices, by applying the mechanical working principles into microelectronics fabrication technology, Micro Electro Mechanical Systems (MEMS) technology bloomed with a variety of achievements around the 1980s. With the emergence of MEMS with the core technology inherited from the microelectronics fabrication technology, micro sensors and micro actuators appeared. Nowadays, almost the surrounding equipment for supporting human life is to be with the existence of MEMS technology; such as transportation equipment, home appliances, smart wearable devices, medical devices, and so on. Recognizing the importance of developing the core technology of MEMS technology, Vietnam government began investing in researching this technology around the 2000s. This paper will discuss the current development and give opinions on the focus of Vietnam in MEMS technology in the near future.

Keywords: *MEMS, micromachining, micro sensor, micro actuator, micro channel, micro fluidics, nano wire*

I. INTRODUCTION

Along the ongoing research directions in the normal scale (about millimeter scale or more) which can be seen by human eyes, one of the trending focuses of research in the world nowadays is the studies on micrometer or nanometer scale systems. For creating such extremely tiny systems, traditional manufacturing methods cannot be used. Instead of that, non-traditional manufacturing methods are required. Some of them have already been very popular in semiconductor industry. By the time, there are more and more demands on reducing cost, saving materials, improving energy efficiency, operating efficiency as well as reducing the size of the devices. The core technology to realize such kinds of devices is to develop Micro Electro Mechanical Systems (MEMS) or Nano Electro Mechanical Systems (NEMS). The use of MEMS technology brings a lot of advantages in fabricating the micro sensors

which are popularly used in automotive industry; such as the acceleration sensor used in the airbag system presented in [1]. The emergence of MEMS technology also creates a lot of applications in home appliances, such as the house controlled by a smartwatch [2]. Especially in the current stage, in the field of bio-medical, we aim to create such things like extremely tiny size devices for many applications in medical devices. For instance, by bio-mimicking the needle of a mosquito, it is possible to develop micro needles for medical uses. This kind of micro needles can collect blood from a vessel, transporting drugs into the cancer cell inside the human body with no bleeding or hurting to human [3]. This branch of MEMS technology is now focusing on developing micro channel, micro fluidics devices [4].

Although up till now, abundant of achievements in MEMS technology have been found in the world, Vietnam has just had the first steps in this field. MEMS technology is actually an evolution of semiconductor technology in a higher level. The development of MEMS technology in Vietnam was inherited with the fundamental background from the development of semiconductor technology. Some government research centers in semiconductor have set up the foundation for the development of the current MEMS technology in Vietnam. Then, day back to the years around the 2010s when some Vietnamese scholars began to attain their blooming research achievements in this technology, such as [5], [6]. These articles presented the study on developing micro/ nano mechanical sensors & actuators on silicon on insulator (SOI) and the study on the piezoresistive effect in single crystalline SiNWs. They also presented a transporting system in micrometer scale that used comb drive actuators to drive the micro container. Since then, there were many studies on MEMS technology from the research institutes and universities throughout Vietnam in sensor, actuator [7-12]. There are also the studies on the concepts of micro channel, micro fluidics [13-16], nano wire, nano rod [17-19].

The next parts of this paper include: The methodology to fabricate MEMS devices, the discussion on the current development status of MEMS technology in Vietnam and its possibility to be developed in the near future. Finally, the main points are summarized in the conclusion.

II. METHODOLOGY

The fabricating methods for MEMS devices are discussed in [20]. Based on the characteristics of them, there are three main methods for MEMS fabrication:

A. Bulk micromachining

This method is the simplest micromachining method. The most popular technique is using chemical etchant to remove the unused parts on the silicon substrate. In that way, the micro structures like holes, channels, grooves can be fabricated.

B. Surface micromachining

In this method, the micro structure will be fabricated on top of the surface of silicon substrate. Sacrificial layer is needed to add on top of the silicon substrate for shaping the micro structure. Later, this layer will be removed to reveal the fabricated micro structure. This method is suitable for fabricating independent moving objects like

the ones in the acceleration sensor, gyroscope, and so on.

C. High aspect ratio micromachining

This method uses X-ray to break the chemical bonds in the resist. Hence, high aspect ratio (depth versus lateral dimension) can be achieved. High aspect ratio can also be achieved by using an etching technology called Deep Reactive Ion Etching.

The fabricating process is complicated as far as the complicated structure of MEMS device. A typical MEMS fabricating method contains a sequence of the main processing techniques as shown:

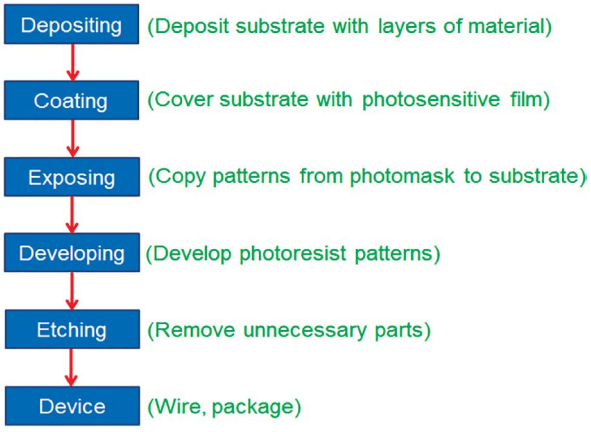

Figure 1. A typical MEMS fabricating process

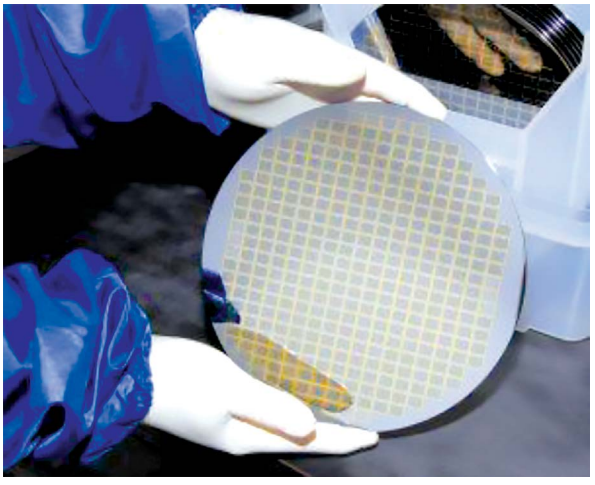

Figure 2. Typical wafer for MEMS manufacturing [21]

The material for manufacturing MEMS devices are the typical wafers made of Silicon and are popularly used in semiconductor industry. A photo of a wafer is shown in Fig. 2.

After spending through the fabricating process discussed above, the typical MEMS products could be the micro sensor as shown in Fig. 3; the micro actuator as shown in Fig. 4 or the micro channel as shown in Fig. 5.

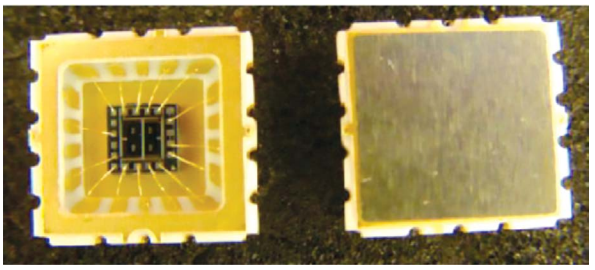

Figure 3. Three Dofs acceleration sensor [5]

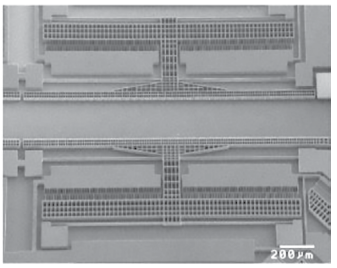

Figure 4. SEM image of micro comb drive actuators [6]

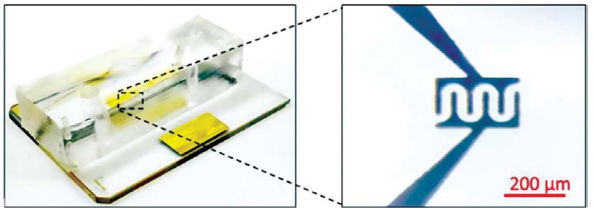

Figure 5. Micro fluidics chip [15]

III. DISCUSSION ON THE CURRENT DEVELOPMENT STATUS OF MEMS IN VIETNAM

One of the reasons why Vietnam government would like to invest in MEMS technology is because of the essential

importance of information security. It is very dangerous if we are continuing to depend on the outsourced chips. Because of the quick development and the miracle achievements in MEMS technology around the world in recent years, it's possible that extremely tiny spy chips might be installed inside the outsourced chips. This results in the risk of leaking personal information, enterprise information or confidential national information. Therefore, it is essential that Vietnam has to have the capability to manufacture the chips as well as the related devices independently by ourselves. The shortage of chips all over the world as well as the rushing digital transformation during the Covid-19 pandemic have shown clearly the urgent necessity for developing MEMS technology on our own.

Table 1. MEMS development in Vietnam

No.	Timeline			
	1979-1990	*1991-2000*	*2001-2010*	*2011-now*
1.	Developing Vietnam semiconductor factory [22]			
2.		National Universities, research centers [23,24]		
3.			Foreign investing companies [23, 25, 27]	
4.				Vietnam corporations [26]

Table 1 presents the MEMS development in Vietnam in the past until now. As usual, semiconductor industry is fundamental to develop MEMS technology. Then, the MEMS technology is imported to Vietnam as the demands of mass production of large foreign companies. MEMS was also recognized as an essential important leading industry so it was investigated in the national universities and research centers [23, 24]. Later, the current large Vietnam corporations are starting to highly invest on IC and MEMS technology [26]. The involvement of the large Vietnam corporation makes high potential of developing MEMS in Vietnam.

Table 2 shows the companies that are doing business in MEMS together with their products. Most of the companies are in their initial stage in the MEMS technology. They are currently focusing on manufacturing PCB, IC as the main products while organizing teams of doing research and designing MEMS devices for their up-coming products.

Table 2. MEMS commercialization in Vietnam

No.	Brand name	Products	Investment		Target market
			Place	*Time*	
1.	Check [23]	ink injector	Hanoi capital	2002	International
2.	Check [10, 24]	Pressure sensor	Ho Chi Minh city	2006	Domestic
3.	Check [25]	Micro processor	Ho Chi Minh city	2006	International
4.	Check [26]	5G chipsets	Hanoi capital	2022	International & Domestic
5.	Check [27]	PCB, MEMS	Danang city	2022	International

While the cost for building up a conventional semiconductor factory is more over billions of dollars, a possible way to build it up with only 1/1000 of that huge cost which is called "minimal fab" is discussed [28]. Minimal fab has some units with the size only about a fridge size. All the micromachining processing will be within these fridge size units. Therefore, there will be no huge expense for clean room like the conventional semiconductor factory. The 12.5 mm diameter size of the wafer is the smallest one and it is to fabricate only one chip. Although minimal fab is very convenient for doing research or training on MEMS fabricating in small scale to make prototypes, its efficiency in mass production should be considered carefully. For mass production purpose, profit is the most priority over of all. To receive the maximum

profit, size of the wafer as well as the number of chips on a wafer should be in proportion to the enterprise capacity. Therefore, minimal fab might not be a good invest for a mass production MEMS factory.

Table 3 presents the MEMS research in Vietnam. It is recognized that regarding many barriers, the status of doing research on MEMS technology in Vietnam can catch up with the current trends in the world. Following the table, currently there are a few divisions doing research or business in MEMS technology throughout Vietnam. Sensor received the interest of research while there are a limit number of studies on actuator. Although micro fluidics is a new emerging direction, it is moving very quickly with many applications in bio medical.

With the orientation of developing smart cities, sensors and IoT systems are essentially important elements. Ho Chi Minh City has succeeded in fabricating the pressure sensor for the application of flood prediction, the air flow sensor for air monitoring and the strain gauge for health monitoring of road & bridge. They also built up an IoT gateway air monitoring system for monitoring the polluted air or particle matters [24]. The experience and equipment in developing MEMS technology will be extremely useful to develop different kinds of MEMS products in the future. The pressure sensor, air flow sensor are fabricated using the bulk micromachining technique. It is highly predicted that the next focus will be the studies on surface micromachining technique for fabricating other kinds of MEMS devices as the world has gone through. There will be also studies on sensor packaging and system integration for MEMS devices which are in line with their applications.

Table 3. Status of MEMS research in Vietnam

No.	Research direction	Published papers, funds
1.	Sensor	[8-12], [17-19]
2.	Actuator	[6], [7]
3.	Micro channel, micro fluidics	[13-16]
4.	nano wire, nano rod, string based MEMS devices	[17-19]

Besides the common issues like: core technologies, human resources, facilities, materials; one big question that needs to answer is "What are those MEMS devices used for in Vietnam?" For micro sensor, it is easier to get the answer as micro sensor has a variety of applications in automotive, smartphone, wearable devices, healthcare devices, and so on. However, it becomes tough to get the answer for micro actuator as it is still strange to most of us and hence, its application has not yet been clarified. While the study on micro actuator is currently facing barriers for development, the direction of micro channel, micro fluidic has the potential to develop. Therefore, an essential important issue to be considered is to find out the applications of MEMS devices in Vietnam.

As the above discussion, the focus of Vietnam in MEMS technology in the near future might not be one but includes the below works: equipping with the proper facilities that are in line with the developing orientation of each division; improving the connections among the divisions; calibrating the sensors for their characteristics, such as their accuracy, sensitivity, range of work, etc.; sensor packaging; integrating sensors into IoT systems; commercializing the products; studying new core technologies to fabricate

other MEMS devices; finding the applications of MEMS devices. It is up to the potential strength of each own division that they should decide their suitable strategy to develop MEMS technology.

IV. CONCLUSION

Vietnam has the potential to develop MEMS devices based on the resources of human, core technologies, facilities, government supports. There are a few divisions currently doing research on MEMS technology that scattered throughout Vietnam. Each division has its own strengths. Currently, there are initial connections among them. It's possible for Vietnam to attain huge achievements when the connections become strong.

The focus of Vietnam in MEMS technology in the near future might be on: equipping with proper facilities; improving the connections among divisions; sensor packaging, calibrating & system integration; product commercializing; developing new core technologies; finding applications. Each division should understand their own potential strength to decide their strategy and their focus on developing MEMS technology.

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REAL-TIME FALL DETECTION SYSTEM BASED ON DEEP LEARNING

Pham Mai Uyen Vo[1], Quang Giap Nguyen[1], Nguyen Thanh Binh Lu[1], Duy Nhat Tran[2], Van Luan Tran[1]

[1] *School of Engineering, Eastern International University, Binh Duong, Viet Nam*

[2] *EIU Fablab Center, Eastern International University, Binh Duong, Viet Nam*

uyen.vo.set18@eiu.edu.vn, giap.nguyen.set18@eiu.edu.vn, binh.lu.set15@eiu.edu.vn, nhat.tran@eiu.edu.vn, luan.tran@eiu.edu.vn

Abstract: We are living in an age of technology where people are provided millions of services and live longer with the benefit of machines and artificial intelligence (AI). Therefore, taking care of the health of elders is an essential part of the social policies in numerous countries. Supervising falls in elderly people is challenging work for anyone; it takes time, money, and concentration all the time, and elders also need their own private space. In this research, we have applied the YOLOv4-tiny approach with an embedded computer system to create a detected falling system. YOLO is an algorithm that detects and recognizes various objects in a picture. Object detection in YOLO is done as a regression problem and provides the class probabilities of the detected images. YOLO algorithm employs a convolutional neural network to detect objects in real-time. As the suggested name, the algorithm requires only a single forward propagation through a neural network to detect objects. This means that prediction in the entire image performs in a single algorithm. It is used to predict various class probabilities and bounding boxes simultaneously. We have created a motive camera that can detect objects and do calls and send messages to the family of falling people or the nearest medical establishments.

Keywords: *Deep Learning, Fall Detection, YOLO*

I. INTRODUCTION

Falls can result in various traumas, some of which can be fatal. Nowadays, many studies reveal that about half of all falls globally result in medical treatment, diminished functioning, reduced social or physical activities, and even death [1]. Especially in the elderly group over 65 aged, even while they can heal most wounds, healing abilities have a slower speed compared with the younger group, and all phases of wound healing are impacted [2]. Falling caused related-injury deaths, heart disease, blood pressure, and stroke, which are the causes of the death of 29,668 U.S. residents aged ≥65 years in 2016 [3]. In the same place in 2018, seniors reported about 36 million falls, 8.4 million of which led to injuries from falls and claimed the lives of more than 32,000 elderly people [4]. With a dream to protect the lives of our loved ones from harm and helps everyone (especially the elderly who live alone) can have an "assistant" who will follow but still keeps private space for users; a real-time object detection system based on artificial intelligent (AI) and artificial learning algorithms has been developed to detect quickly and effectively at affordable prices for most people. Many hospital patients are at risk of falling because of drugs that make them queasy or rehabilitation from surgery. Computer vision systems installed in recovery

areas act as extra eyes to spot falls quickly and notify medical personnel.

Understanding the fearful outcomes that falling leads to, many groups, laboratories, and companies also took a lot of time and money to study these and illustrate numerous methods. However, some of them still include a little trouble that we had synthesized and would like to present as follows: Using multimodal data to detect objects: that method uses traditional algorithms on PC [5]. In comparison to embedded systems, their effectiveness and mistakes are hence constrained (deep learning) in the long term. 4D mm-wave radar and a Hybrid Variational RNN AutoEncoder [6]: a good idea and a new solution for the future, but it is possible indoors only and costly too while needs both camera and radar sensors to monitor objects, a work that a camera equips AI software can do better.

Another approach is used to fix a smartphone accelerometer that can work well indoors and outdoors [7]. However, bringing smartphones at all times is impossible for the elderly, as they tend to forget things. Accelerometer-based fall detection technique uses algorithms that apply a threshold to angular velocity from a gyroscope or accelerations from an accelerometer worn on the thigh, waist, or chest. However, the accuracy of this system is poor, uncomfortable, and difficult for the users [8]. Using CNN algorithms to draw bounding boxes to determine objects. R-CNN needs to extract an image into 2000 regions; then these regions will be warped into a square and fed into a convolutional neural network that produces a 4096-dimensional feature vector as output [9]. These days, YOLO has become a new revolution in object detection while more and more popular than other methods due to its effectiveness in processing speed and higher reliability [10]. Therefore, we suggest a system combining YOLO and Raspberry as another method for falling detection.

In this paper, we propose a method for fall detection based on YOLOv4-tiny and embedded in Raspberry Pi 4, in which we used a camera to detect the target to determine the class and location of a specific object in an image and send feedback to Module SIM to do calling and sending SMS message while detect "Falling". Generally, this system is less expensive and more possible in public as compared with most other solutions. By utilizing deep learning, our proposed method is accurate and effective in detecting falls.

II. METHODOLOGY

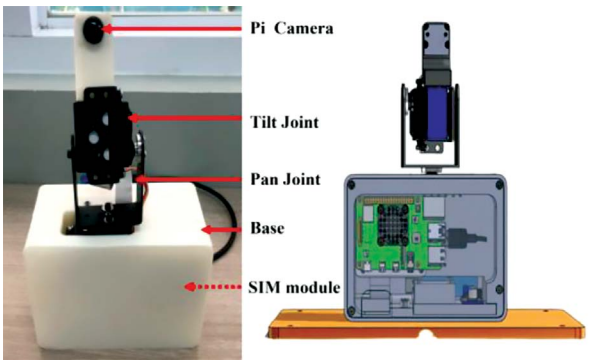

Figure 1. YOLOv4-tiny network structure for our fall detection

In this section, we will discuss in more detail the system's structure in hardware and software and how it works. Fig. 1 shows a fall detection platform equipped with two RC servos, a camera Pi, an embedded device, and a SIM module. While Fig. 2 and Fig. 3 describe the processes of our system at the beginning of the operation, Raspberry gets a video stream

from the camera PI. Then this video stream will be pre-processed before being executed by the trained model. Finally, If the system identifies "falling", a warning SMS is sent or called to the mobile phone device through the SIM module.

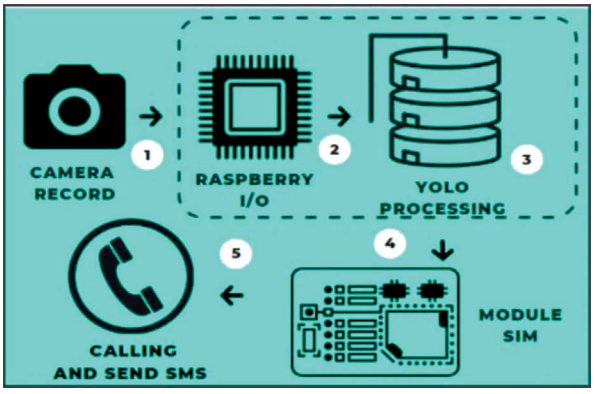

Figure 2. System operation process

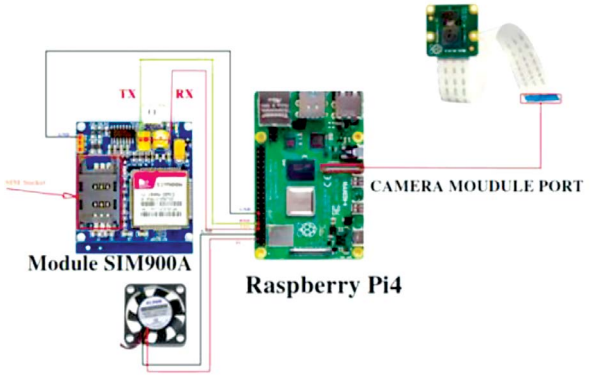

Figure 3. The connection between components as module SIM900A and Pi camera with Raspberry Pi4. To be more specific, with module SIM900S, we use UART protocol to communicate with the embedded device via AT command.

YOLO (You Only Look Once): Joseph Redmon developed a state-of-the-art and real-time object detection system in 2015 [17]. With algorithms, it can predict the class for the object, and a bounding box will specify the object's position so that the searching region can localize the object within the image at high speed [16]. YOLO has many versions (mainly 7 versions recently) and each of them also has differences. The reason why we do the project in YOLOv4-tiny with Raspberry Pi4 instead of higher performance is that YOLOv4-tiny has a more straightforward network structure and lower parameters need to do compare with other series at other versions, but it is strong enough to process data quicker than the "tiny-version" before. Although YOLOv4-tiny's accuracy is roughly 2/3 as performant on MS COCO (a very hard dataset) compared with YOLOv4, its speed is roughly 8 times fast [11]. Moreover, Raspberry has limited storage, and standard YOLO versions require a large space; a simple structure network like "v4-tiny" can run easier in this embedded circuit.

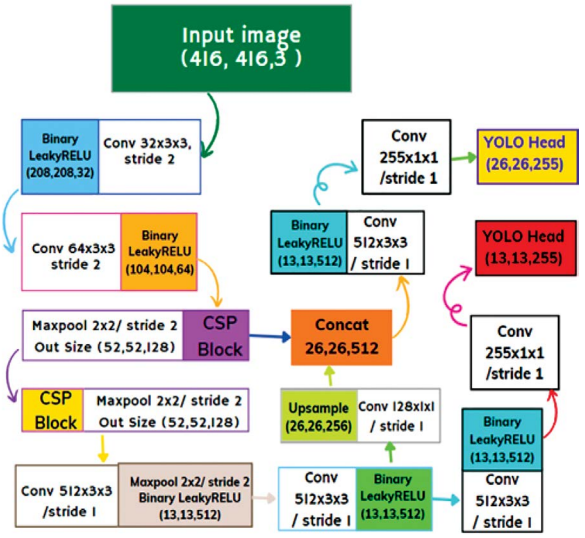

Figure 4. YOLOv4-tiny network structure for our fall detection

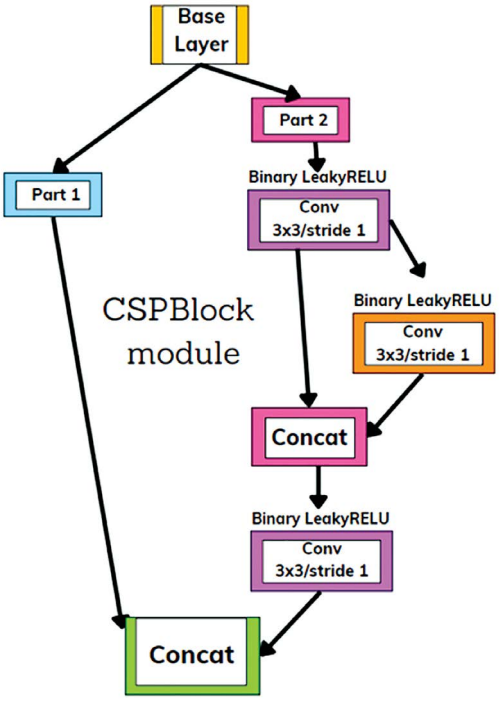

Figure 5. Cross-stage partial block (CPSBlock) module

Yolov4-tiny structure [14]: First, we go through the structure of YOLOv4-tiny. If YOLOv4 uses the CSPDarket53 Module as the backbone, YOLOv4-tiny uses the CSPDarknet 53-tiny Module as presented in Fig. 2 and Fig. 3 CSPDarknet53-tiny module block can be divided into two parts, and then a cross-phase hierarchy will unite two-part. This way, the gradient flow can propagate through two different networks, enhancing the correlation difference of gradient information. There are three Conv Layers and three CSPBlock Modules. CSPBlock module consists of 2 Conv Layers using a kernel with the size of 3x3 and stride by 1 pixel, and a Conv Layers applying a kernel with the size of 1x1 and stride by 1 pixel. LeakyRELU is used as an activation function. YOLOv4-tiny uses two scales which are 13x13 and 26x26 support, to predict detection results.

Yolov4-tiny will divide the input image into a matrix of grids with the size of SxS. For specific grids containing B bounding boxes to detect the object, these bounding boxes predict the object's appearance by defining the object's center point, whether or not be in the grid. Each bounding box will have five parameters [11] as Equation 1.

$$T = [x, y, w, h, confidence] \quad (1)$$

In this way, the object can have several extra bounding boxes. To solve this problem, a confidence threshold is proposed. When the confidence score of a bounding box is higher than the confidence threshold, this bounding box will be saved; otherwise, the bounding box will be removed. The equation of confidence score [12] will be shown as Equation 2.

$$C_i^j = P_{i,j} * IoU \quad (2)$$

With j^{th} bounding box in a grid of i^{th} intersection over union (IoU) between the predicted box and ground truth box [13] as Equation 3.

$$IoU = \frac{Area\ of\ Overlap}{Area\ of\ Union} \quad (3)$$

Area of Overlap is the intersection area between the predicted bounding box and ground truth bounding box, and the Area of Union is the area combining the predicted bounding box and ground truth bounding box. The bounding boxes are manually labeled in the training set and test set. If IoU > 0.5, then the prediction is evaluated as good. The difference between the bounding box predicted and the ground truth box is smaller while a confidence score is higher. The smaller the distance between the predicted bounding box is, the higher confidence is, and vice versa.

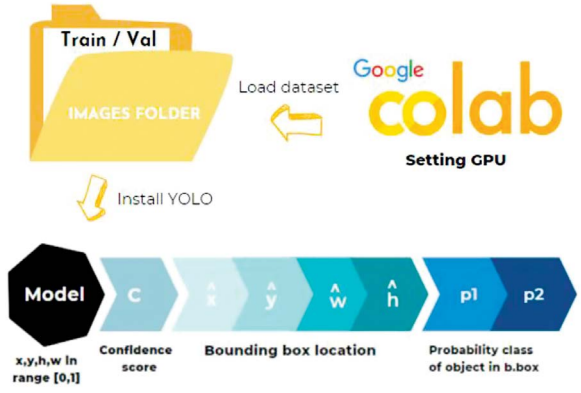

Figure 6. Our system hardware

The chart in Fig. 6 illustrates the steps in training model. In it, Raspberry acts as a "BlackBox" that picks up the input dataset and provides an output model. Specifically, Google Colab works as an environment to install YOLO - architecture. At the same time, the image folder will be loaded as dataset for teaching for the YOLO model, which detects objects with data parameters, including number classes, name classes, and dataset (training and testing) before doing training model process in real-time. At the end of the process, the model will contain values as Confidence score (C), bounding-box coordinate (x, y, w, h) and probability class (p1, p2). From these values, YOLO can predict class for objects (Person or Falling) and shows the output including name labels and bouding-boxs surrounding the detected entity (person).

III. EXPERIMENTAL RESULTS

The dataset of the project was collected with two classes that included falling and non-falling persons. Roughly 3000 images have been gathered for this dataset, in which 90% for the training data and 10% for the testing data, respectively.

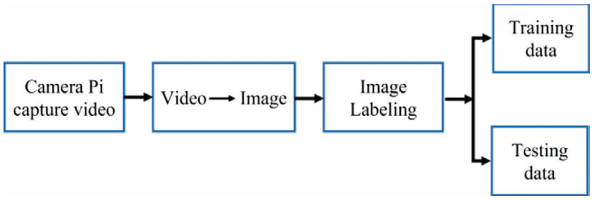

Figure 7. Collecting dataset process

Fig. 7 describes our collecting dataset process. Firstly, a Camera Pi is used to record videos of falling and non-falling postures, these videos will be converted to images via the Wondershare Free Video Converter tool. Furthermore, the LabelImage tool is also utilized to label the bounding boxes and class names into the image which are essential information for training model tasks. Finally, the dataset has been split into two differential folders to be used for training and testing.

In Fig. 8, we have done training results after 6000 epochs. The red line is the mean average precision at 50% Intersection over Union, so the chart shows that the red line with 86% increases sharply to 98% and gradually saturates at 99%. From 0 to 600 iterations, the Loss function is the blue line that has dropped sharply and gradually approached saturation at times 6000. According to the overall assessment, this model showed good training which could detect falling and non-falling persons.

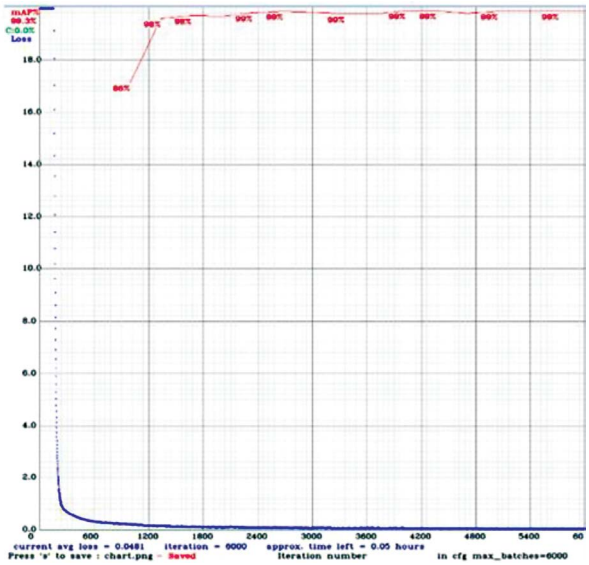

Figure 8. Evaluation of our training data with YOLOv4-tiny

In Fig. 9, we present our experimental results tested on our system with people detection and fall detection. The proposed fall detection system has been surveyed by utilizing a camera to collect data which includes numerous corners and light conditions in different spaces and times. For this purpose, we trained to fall in front of the camera and moved around indoors and outdoors several times. The system will make a call to the mobile phone device for alert purposes, which is shown in Fig. 10.

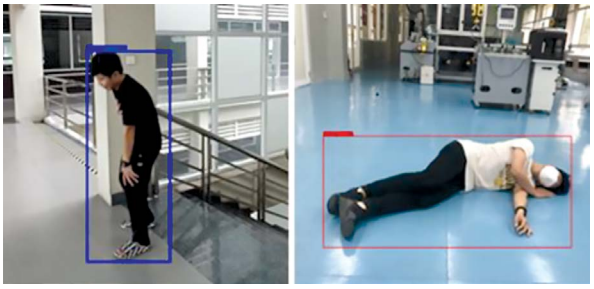

Figure 9. Results of our fall detection based on YOLOv4-tiny; the left image is a people detection in a blue box, and the right image is a fall detection in a red box.

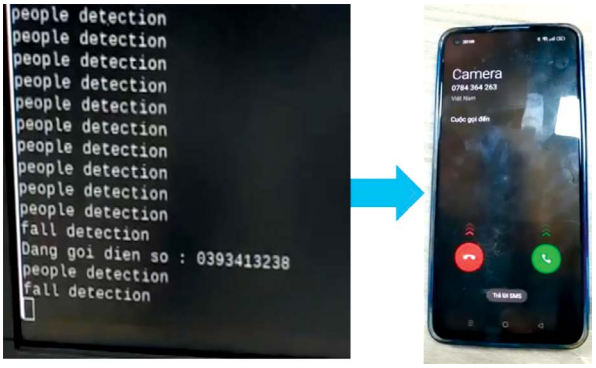

Figure 10. A warning was sent to a specific number.

IV. CONCLUSION

This paper proposed a fall detection method with an embedded device. Our custom dataset and training model was experienced, and this proposed method has a good performance and accuracy rate of falling detection. However, our model is in the early stages of following people who fall, and the current system has not yet followed persons and cannot detect human behaviors. For example, if someone falls intentionally, the system will detect that this case falls by accident.

ACKNOWLEDGMENT

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RESPIRATORY RATE MONITORING DURING SLEEP USING CAMERA

Thi My Thanh Nguyen[1], Viet Cuong Pham[2], Van Luan Tran[1], Xuan Quy Dao[1]
[1]*School of Engineering, Eastern International University, Binh Duong, Viet Nam*
[2]*Ho Chi Minh City University of Technology, Ho Chi Minh, Viet Nam*
Thanh.nguyenthimy@eiu.edu.vn, pvcuong@hcmut.edu.vn, luan.tran@eiu.edu.vn, quy.dao@eiu.edu.vn

Abstract: Monitoring the survival of people at risk of sleep apnea is timely health protection. This paper proposes a method of measuring respiratory rate during sleep with a camera. Corner features based on lung and abdominal constriction are extracted and monitored continuously. The measurement accuracy is the result of using an Optical flow algorithm to track the feature points and Principal component analysis to retain the principal oscillation direction. The frequency of the movement is determined by a peak-to-peak technique. The results show that the accuracy remains stable even when the light intensity changes, the sleeping position is turned, and the participants are infants or adults at risk of stroke.

Keywords: *respiratory rate, optical flow, principal component analysis, computer vision, sleep apnea*

I. INTRODUCTION

Sleep apnea is a sign of a dangerous condition related to human life, timely emergency helps reduce the risk of death. According to the research in [1] and [2], sleep apnea is known as an early sign of stroke. In children, sudden infant death is a matter of concern for parents. A recent study [3] showed that 2% of infants in the first year of life are at risk of sudden death during sleep. Respiratory monitoring now seems to be done in hospitals using contact-based methods [8], in specially indicated cases because of the complicated process of installing the sensing elements and the high cost while recognizing the breath is necessary even when the patient does not have many serious signs of illness, especially when sleeping. This is more important in infants and people at risk of stroke. Therefore, the measurement of breathing rates outside medical facilities is interesting to many scientists. In which, non-contact respiratory rate measurement is being prioritized by many benefits.

The non-contact measurement method reduces the inconvenience of wearing electrical measuring devices on the body. This measurement way can be implemented continuously at home and is suitable for children and patients who are facing sleep problems. In previous research, a camera was assembled above a person, at a distance from about 0.5 to 1.5 meters; images at the regions of interest (chest, abdomen) were extracted and monitored continuously. The body's movement is the key solution of these proposals, and the respiratory rate is measured by tracking the motion of the body. There are 2 main motion data analysis techniques used to measure motions including Background subtraction and Optical flow combined with the Principal component analysis (PCA) algorithm. Research by Fang, Chiung-Yao,

Hsin-Hung Hsieh, and Sei-Wang Chen [4] estimates breathing rate based on the change in the background color of the image in pixels, the measurement uses many complex algorithms to enhance the accuracy, but this method is still affected of noise. The research of Ganfure, and Gaddisa Olani [5] focuses on observing the movement at the corner feature points. The advantage of this method is taking the main dimension of the motion, which reduces the influence of noise and increases the measurement reliability.

This paper proposes a respiratory rate monitoring method during sleep using a camera (smartphone camera or normal surveillance camera). Human detection is performed first to identify the individual and feature areas (chest-abdominal region). Corner features are selected based on the shirt color constraint. Next, these features are tracked continuously when an individual sleeps using the Optical flow algorithm [6]. After applying PCA [7], the respiratory rate is determined based on the difference in peak-to-peak time of the breathing signal.

II. METHODOLOGY

The system is a combination of human detection using YOLOv4's architecture and motion tracking technique. Motion tracking is the most important part of the research. The feature points from the Corner detector will be tracked by the Optical flow algorithm, then pushed in PCA. PCA helps reduce 2 dimensions of motion data to 1 main dimension. Finally, the respiratory rate is calculated by measuring the time that the signal reaches its peak. The block diagram of the proposed system in Fig. 1 shows that the video stream is the input and respiratory rate (breath per minute-BPM) is the output of the system.

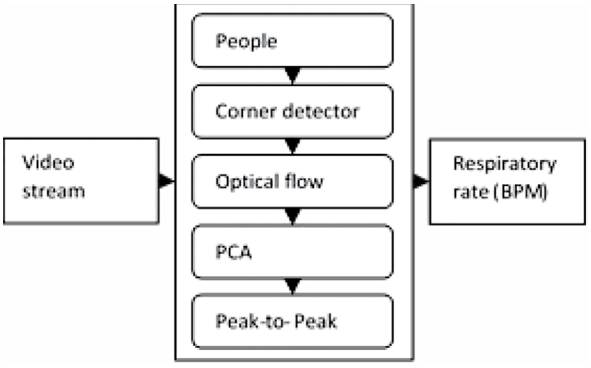

Figure 1. Block diagram of the proposed system

A. Human detection

The human detection result is the fundamental step to determine the individual and region of interest. The algorithm executes when the subject's body is found. This reduces wrong predictions if the subject is lying on their face while sleeping.

A convolution neural network is used to identify the individual and the chest-abdominal area. With the advantages in speed, suitable for real-time detection, we use a YOLOv4 here [9].

B. Motion tracking

The movement of the chest-abdominal region reflects the respiratory process. This is observed through the up-and-down movement of the feature points. We apply the Shi-Tomasi corner detector, proposed by Jianbo Shi and Carlo Tomasi in 1994 [10], to find the strongest corners in the image. These points will be tracked over time during the sleeping time of the object.

Motion tracking is implemented by the Optical flow algorithm. To apply this method, we assume that the brightness level between

two consecutive frames does not change and that the pixels that are close to each other have similar motion motions. The optical flow method calculates the motion of motion pixel points from the corner detector between two image frames which are taken at times t and t+ t. The intensity at the I(x, y, t) pixel point will have moved by Δx, Δy, and Δt in the next frame. By Taylor approximation, we get the velocity vector related to the movement of the points. The velocity vector has 2 components, the vertical and the horizontal elements of the motion which contain the direction of respiratory motion and non-respiratory oscillations caused by fans and air conditioners.

Respiratory rate is identified from the motion trajectories of feature points by the principal component analysis algorithm (PCA). The output of the optical flow releases the velocity vectors in X and Y directions in 2 consecutive frames of the video while we need one main dimension only which is respiration. In the PCA algorithm, the covariance matrix was calculated to determine the correlation in the motion data. The highest eigenvalue calculated from all eigenvectors and eigenvalues of the covariance matrix is the principal component. This technique keeps the main direction of the respiratory motion and removes non-respiratory oscillations.

Visualizing the respiration motion in the timing graph, we see the respiration signal. The interval between the 2 signal peaks is the time of 2 consecutive inhalations. Taking the average measuring time in 1 minute, we get the respiratory rate of the person. For getting a smooth respiratory signal, a Butterworth filter is used.

III. RESULTS

Video data were recorded by a 2.0MP IPC-C22EP-A-IMOU camera and an iPhone XS camera. 20 minutes of sleep was recorded randomly from 1 adult and 1 infant. Two participants slept on their backs and side, also at day and night time.

The system program is built on Python programming language, open-CV library, visualized by GUI which is implemented on a laptop.

a) Feature extraction

The feature points are basically based on the color constraint of the object, so for more accuracy in taking feature points, the object are required to wear a shirt with many contrasting colors in the chest and abdominal region. The recorded videos are collected in different conditions, brightness intensity, and infrared lights. The individual sleep position can be on their side or back.

Fig. 2 shows the human detection result from YOLOv4. The bounding box containing the individual will be cropped and resized for clearly see the breathing fluctuations. The feature points are detected in the bounding box of the individual's body.

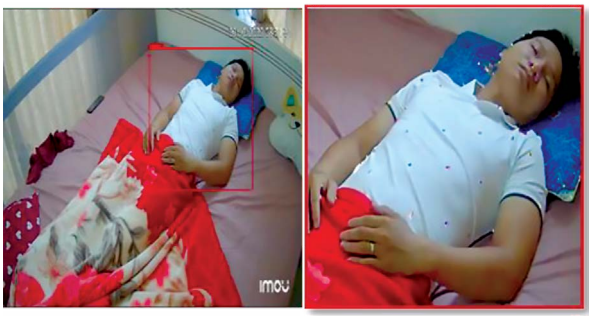

Figure 2. Feature detector results

b) Respiratory tracking results

Fig. 3 provides the respiratory signal and the peak points. The respiratory signal is the inhalation and exhalation of the object. The amplitude of this signal depends on the moving amplitude of the feature points. Infant signal oscillations have a small amplitude and high frequency while adult signal has a high amplitude and lower frequency. The peaks of the oscillation are found correctly even when the amplitude and frequency of the oscillation change.

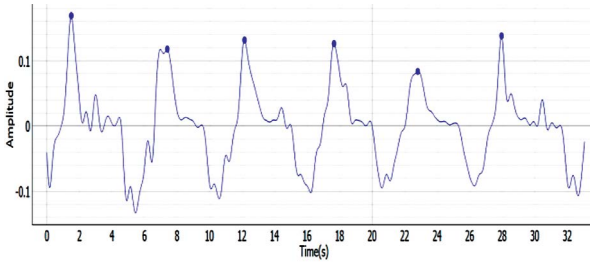

Figure 3. Respiratory signal

The evaluation results of the proposed method are compared with the results of breathing analysis by apple watch, showing that the proposed system makes accurate conclusions about breathing rate.

Table 1. The absolute and relative error

Subject	Adult		Infant	
Day/Night	Day	Day	Day	Night
Position	On back	On back	On side	On side
Distance (cm)	135	135	130	100
Fan	No	Fan	No	No
Testing time(min)	5	5	10	10
Absolute Error	**0.20**	**0.20**	**0.50**	**0.57**
Relative Error	**1.5%**	**1.2%**	**2.4%**	**2.8%**

Table 1 shows the absolute and relative error of the method between the fact and the algorithm. Videos are recorded at 20 fps, 1080p resolution. The proposed method has a small error, the absolute error is 0.2 for adults, 0.57 for infants. The error is higher when the baby sleeps on the side. In different conditions of brightness, position, and distance, the relative error is less than 3%.

IV. CONCLUSION

The proposed method performs a method of non-contact respiratory rate monitoring based on computer vision using the camera which is used to detect sleep apnea in infants and people at risk of stroke.

The system still has limitations. Results will not be accurate if the subject sleeps on their stomach because the breathing fluctuations are not clearly visible. The proposed algorithm requires participants to wear contrasting colors.

The performance could be improved by using multi cameras because many good feature points can be found without being obscured by the camera installation angle. Monitoring the respiratory rate of 2 individuals at the same time should be considered when implementing at home.

ACKNOWLEDGMENT

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MEMRISTOR CROSSBAR BASED SPATIAL POOLING FOR NEAR-IOT-SENSOR COMPUTING

Tien Nguyen Van[1], Thanh Nguyen Thi My[1], An Vo Van[1], Bien Ngo Bac[1]
[1]*School of Engineering, Eastern International University, Binh Duong, Viet Nam*
tien.nguyen@eiu.edu.vn, thanh.nguyenthimy@eiu.edu.vn, an.vovan@eiu.edu.vn, bien.ngo@eiu.edu.vn

Abstract: The amount of data generated by IoT sensors is rapidly increasing nowadays. As a result, cloud computing is becoming increasingly. This work presents a memristor crossbar based spatial pooling to minimize the number of calculations in the server owing to the enormous volume of data. The quantity of data handled in the cloud may be reduced from 784 bits per image to 128 or 256 SDR bits by transforming binary data, such as the MNIST dataset, to the spare distributed representation utilizing spatial pooling. The loss of recognition rate for the 128-column and 256-column crossbars of spatial pooling is as low as 3.68% and 2.48%, respectively.

Keywords: *memristor crossbar, spatial pooling, hierarchical temporal memory, near IoT Sensor Computing*

I. INTRODUCTION

Many applications have recently used IoTsensors, such as image identification, healthcare,vehicle driving, and so on [1-5]. The IoT sensors collect raw data from the real environment and send it to the cloud server for processing, as shown in Fig.1(a). As a result, the amount of data might impact the capacity of the data storage and the processing the energy of the cloud server.

To mitigate the overhead of computing in the cloud server, the data should be processed. This allows for the reduction of data before it is sent to the cloud server. A spatial pooling memristor crossbar is employed in Fig. 1(b) to transform the raw data into the Sparse Distributed Representation (SDR).

Because the SDR indicates an extracted characteristic of the raw data, the number of bits in the SDR is less than that of the raw data. The SDR is then delivered to the cloud server. Thus, the number of computations on the server can be significantly decreased.

The requirements for power, area, and speed are necessary for near-IoT sensor computing. To meet these requirements, the memristor crossbar emerges as a plausible candidate.

A memristor is a nano-scale electronic device. It can be constructed in three dimensions. The memristor crossbar performs vector-matrix multiplication (VMM) rapidly due to layer stacking [6-8]. Furthermore, the memristor changes conductance according to the applied voltage, so it can mimic the function of a synapse in a real biological neuron. Because of its energy-efficient processing and nano scalability, the memristor crossbar is suitable for near-IoT sensor computing.

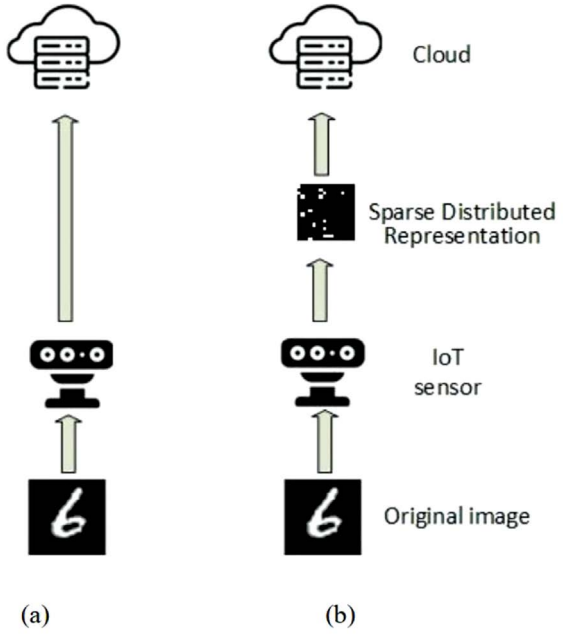
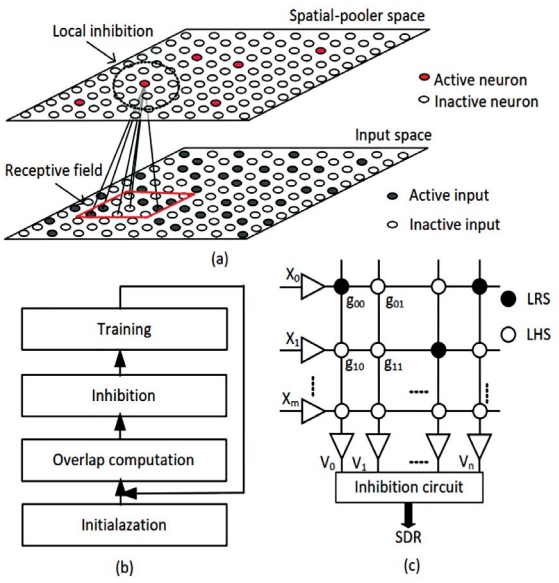


Figure 1. (a) The diagram of computing in the cloud, the data is collected by the sensor and is transferred directly to the cloud (b) the diagram of computing for near-IoT sensor, the data collected by sensor is converted to SDR before sending to the cloud.

In section II, we will explain how spatial pooling can be used to convert the raw data that has been collected from the real environment into sparse distributed representation. The simulation results of the spatial pooing memristor crossbar are shown in Section III. Finally, Section IV contains the conclusions.

II. SPATIAL POOLING MEMRISTOR CROSSBAR

The Hierarchical Temporal Memory (HTM) algorithm is used to describe neocortical functions such as vision, touch, or navigation. The HTM is divided into two parts: spatial pooling and temporal pooling [9, 10]. In which the sensory data from sensory organs like the cochlea, retina, etc. is transformed into the sparse distributed representation by spatial pooling. A collection of active neurons in the neocortex constitutes the sparse distributed representation. "Sparse" indicates that not all neurons are active at the same time, but just some are, and "Distributed" means that the activity frequencies for all neurons are even. As depicted in Fig. 2(a), the input space comprises the active and inactive input sensed by the sensory organ. Through synapses, cortical neurons in the spatial pooler space react to the inputs pace. The lines represent the connections between the input neurons and the cortical neurons. The red box indicates the receptive field, in which a collection of neurons from the input space are chosen randomly to connect to one cortical neuron from the spatial pooler space. The inhibition area is represented by the dashed circle. Among the many neurons in this area, only a few are active. The number of activated neurons is approximately 2% [11, 12]. This indicates that just 2 neurons among 100 are active, while the others are inactive. Therefore, the activated neurons in the spatial pooler space are "sparse" and "distributed".



(b) the flow chart of spatial pooling training (c) the schematic of spatial pooling memristor crossbar.

The flow chart of the spatial pooler is depicted in Fig. 2(b). The flow chart contains four steps. The first step is initialization, in which a set of synaptic connections is chosen at random in each receptive field. The synaptic connection may be connected or disconnected. Next, the input neurons are overlapped with the synaptic connections to calculate the cortical neuron value in the spatial pooler space. Cortical neurons in the same inhibition area are compared to identify which neurons are the winners. The neurons with the large computed value from the overlap computation step are the winners. Because the winner neuron is also the active neuron, the other neurons become inactive. The strength of the synaptic connection associated with the winning neuron is strengthened or weakened throughout the training step depending on the value of the input neurons. The rule is based on the Hebbian learning rule. Here, the synaptic connection value is increased when the input neuron is active. If the input neuron is inactive, the synaptic connection value is reduced. The simple spatial pooler schematic is shown in Fig. 2(c). In the schematic, the synaptic connections in the receptive field are represented by a group of randomly selected cells in each column of the memristor crossbar. Here, either LRS or HRS may be used to program the synaptic connection. The terms LRS and HRS, respectively, stand for low resistance state and high resistance state. Here, g_{00} denotes the memristor conductance of row '0' and column '0'. Similarly, g_{10} represents the memristor conductance of row '1' and column '0'. Input voltage is provided for the crossbar that comes from the sensory organ. The input voltages for rows '0' and '1' correspond to X_0 and X_1. The input voltages are multiplied by the memristor conductance of each column in the crossbar to obtain the current of each column in order to perform the overlap omputation step. As a result, the column currents are transformed into column voltages, which are represented by Y_0, Y_1, etc. The inhibition circuit receives the column voltages. Then they are compared together to determine the winning columns. The collection of winning columns or active neurons is referred to as a sparse distributed representation and is transferred to the cloud. In the training step, the strength of the synaptic connection is referred to as permanence. The permanence is continuously changed during training from 0 to 1. The permanence is reset to 0 when it is less than 0. Similar to this, if the permanence is larger than 1, it is set to 1. The HRS and LRS are utilized to express the 0 and 1 values in the crossbar, respectively.

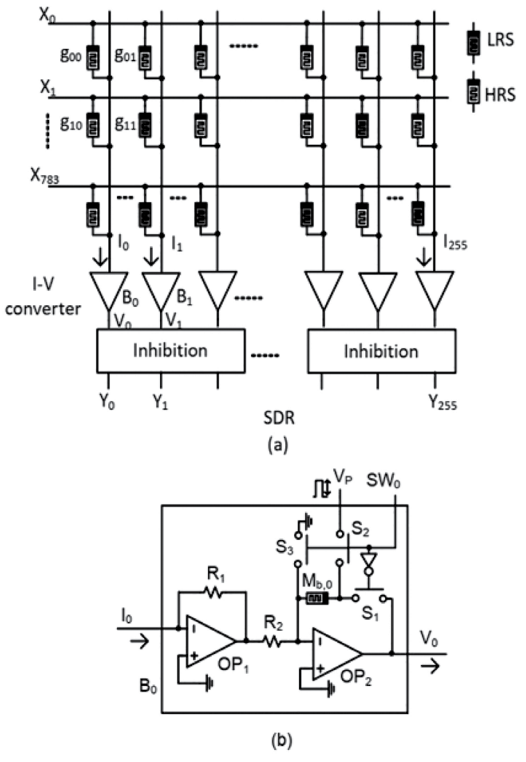


Figure 3. (a) The detailed schematic of spatial pooling memristor crossbar (b) the current to voltage converter with the boost factor.

Fig. 3(a) depicts the detailed schematic of the spatial pooling memristor crossbar. The MNIST dataset is used to evaluate the performance. There are 784 rows in the memristor crossbar because each MNIST sample comprises 28x28 pixels. The input voltages are labeled from X_0 to X_{783}. The memristor's conductance of row '0' and column '0' is represented by the symbol g_{00}. Likewise, g10 stands for the conductance of row '1' and column '0'. The column current is generated by the overlap of the input voltages and the conductances of each column. I_0 and I_1 stand for the corresponding currents in columns '0' and '1', respectively. Current I_0 is then converted to voltage V_o by the current to voltage converter, B_0. The voltage V_o enters the inhibition circuit to be compared to the other column voltages. If some of those columns are bigger than the rest, they tend to become active. The outputs Y_0, Y_1, etc. represent the sparse distributed representation that is delivered to the cloud.

To control the activation frequency of the column, the boost factor is used. When some columns are active too frequently, it means that they often become the winning column among many columns. This occurs when a column has a large number of LRS cells. To avoid it, the boost factor is added to the current-to-voltage converter circuit. The column activation frequency can be decreased by lowering the boost factor's value. The boost factor's value rises if the column is hardly active. The amplitude of column voltage rises as a result. Here, the memristor M_{b0} is added to the current-to-voltage converter. Memristor M_{bo}'s resistance may vary from LRS to HRS. So, the gain of the Op-amp circuit then changes from low to high. If the column's activity frequency is high, LRS should be programmed to the memristor M_{bo}. Otherwise, the value of the memristor Mbo is HRS if the column's activity frequency is low.

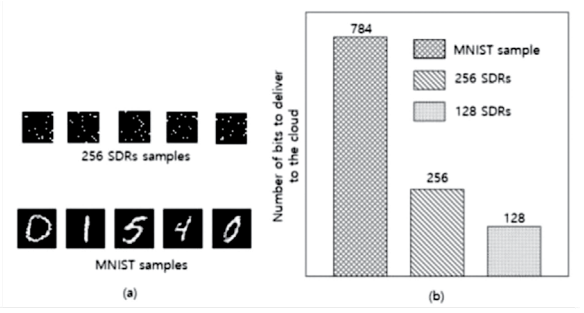


Figure 4. (a) The original MNIST samples and 256 SDRs samples (b) the number of bits to deliver to the cloud of MNIST sample, 128 SDRs and 256 SDRs.

Fig. 4(b) depicts the boost factor's schematic. First, the current is converted to inverter voltage using the Op-amp OP_1. Then, the Op-amp OP_2 converts the voltage again with the memristor boost factor M_{b0}. Here, the gain of the circuit can be adjusted by changing the resistance of M_{b0}. Switches S_1, S_2, and S_3 are utilized to do this. The programming pulse is used to program memristor M_{b0} when SW_0 is high. Otherwise, the Op-amp OP_2 functions as an amplifier when SW_0 is low.

III. SIMULATION RESULTS

The MNIST dataset is used to test theperformance of the spatial pooling memristor crossbar in the experience simulation. Here, the crossbar converts the MNIST image sensed from IoT sensors to the SDR. After that, the SDR is transferred to the cloud for processing. Since there are 28x28 pixels of each MNIST image, the number of rows of the memristor crossbar is 784. The number of columns is assumed to be 128 or

256 columns. This means that the memristor crossbar converts the image with 784 bits to 128 or 256 SDR bits. Two memristor crossbars with 128 and 256 columns each are tested in Table 1.

Table 1. The recognition rate for the different numbers of crossbar columns and number of active bits per SDR

# of active bits per SDR			
Number of crossbar columns	8	16	32
128	90.22	91.41	94.12
256	92.34	92.64	94.92

In this table, the number of active bits per SDR is increased from 8 to 32 bits. As a result, the recognition rate for 128 columns increases from 90.22% to 94.12%. Similarly, 256 columns at 8 active bits and 32 bits have recognition rates of 92.34% and 94.92%. In comparison to the reference recognition rate of 95.64%, the loss of recognition of 128 and 256 columns are as low as 1.52% and 0.72%, respectively. The MNIST samples and the SDRs are shown in Fig. 4(a). Here, the size of the MNIST sample is 28x28 while the size of the SDR is 16x16. Fig. 4b shows the reduction in the number of bits to be sent to the cloud from 784 bits of the original MNIST to 128 or 256 SDR bits. The processing on the cloud is decreased by reducing the number of bits.

IV. CONCLUSION

In the near future, a huge volume of data collected by IoT sensors will need to be processed on a cloud server. Due to the cloud server's capacity limitation, this leads to an overload of computation. The spatial pooling memristor crossbar might be thought of as a solution for near-IoT sensor computing to alleviate the issue. Using the spatial pooling memristor crossbar, the original 784 bits of MNIST may be reduced to 128 SDR bits or 256 SDR bits. The loss of recognition rates of 128 and 256 columns are 1.52% and 0.72%, respectively.

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BUILDING A SMART GARDEN MODEL USING IOT TECHNOLOGY

Van An Vo[1], Bac Bien Ngo[1], Thi Ngoc Thao Nguyen[2], Van Tien Nguyen[1], Phuong Nam Tran[1]

[1]*Eastern International University, Binh Duong, Viet Nam*

[2]*Binh Duong Economics and Technology University, Binh Duong, Viet Nam*

an.vovan@eiu.edu.vn, bien.ngo@eiu.edu.vn, thao.ntn@ktkt.edu.vn, tien.nguyen@eiu.edu.vn, nam.tran@eiu.edu.vn

Abstract: The paper presents the design of a real-time automated control and environmental information monitoring system using IoT technology that is highly applicable in agriculture. The system uses a wireless sensor network, including sensors, a central processor, and actuators. The system allows users to monitor environmental information and control electrical equipment through the web browser on smartphones/ computers. The sensor data collected from the environment will be sent to the central processor. Based on the collected information, the central processor will send warning signals or commands to the actuators such as activating the pump system, fan, and lamp system. The development system created a favorable environment for optimizing the development of plants. Moreover, the collected data simultaneously be stored in the database on the internet for future research. The system is designed to help improve product quality and crop yield while saving labor, time, and effort.

Keywords: *Arduino, IoT, NodeMCU, Webserver, Sensors, Smart Garden*

I. INTRODUCTION

Today, the development of the agricultural sector is a direction that brings economic benefits to the country. However, if traditional agrarian methods are still applied, the cultivation efficiency, as well as the economic efficiency, will be very low. Therefore, applying technical technology is a smart direction to inherit as well as promote the technical technologies that science has found, especially the use of IoT technology in agriculture that is being invested and widely applied in life as well as production. Along with that clean food, fresh vegetables are getting more attention from people over the world. Besides, the pollution of soil, water, and plant protection chemicals leads high risk of vegetables. Moreover, fungi, pests, and diseases in normal environmental conditions can also harm vegetables and indirectly adversely affect the health of consumers. To solve this situation, there have been many smart garden models with proposed automation solutions to increase production efficiency and quality [1], or smart garden monitoring and control using sensor and modern technology [2]. Optimizing water use in irrigation is also a pressing issue as water supplies become scarce and polluted. One of the most prominent studies is the use of wireless sensor networks to control water which is used in farms more efficiently [3], or the use of solar energy sources to minimize maintenance and save water [4]. In addition, climate change greatly affects the growth of crops, the solution to solve this issue is using

sensors of light, soil moisture, pressure, and temperature to collect weather information such as heat, cold, cloudy, thunderstorms and rain, making it possible for users to control crop growth in the best way [5]. Along with the development of technology, the smart garden model is increasingly improved in terms of quality and convenience. Applying IoT technology in smart garden models makes it possible for users to monitor crop growth in the best way, leading to increased life expectancy for both plants and humans [6-8]. The above studies offer smart garden solutions for application in agriculture in the most effective way.

In this paper, the authors have studied, proposed, and designed a small-scale automated smart garden system with standard functions such as 1- collecting environmental information data using sensors; 2- the actuators are automatically controlled based on the parameters collected by the sensors; 3- the website interface supports users to monitor environmental information, set sensor thresholds and control garden devices remotely via smartphones/computers.

The design and structure of the system are presented in section 2. Analytical parameters and algorithms are also introduced in this section. Part 3 provides information about the design and operation of the system on the actual model.

II. BUILDING SMART GARDEN SYSTEM STRUCTURE

The structure of the smart garden model based on the IoT technology proposed in this study is shown in Fig. 1. In particular, the central processing block has the function of updating environmental information data from sensors and transmitting data to the management and monitoring block including LCD, computers/smartphones, and electrical devices that is connected to the dynamic block and controlled through applications pre-installed on smartphones or web browsers on computers.

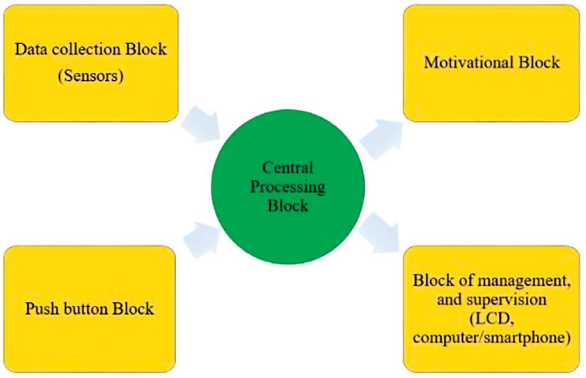
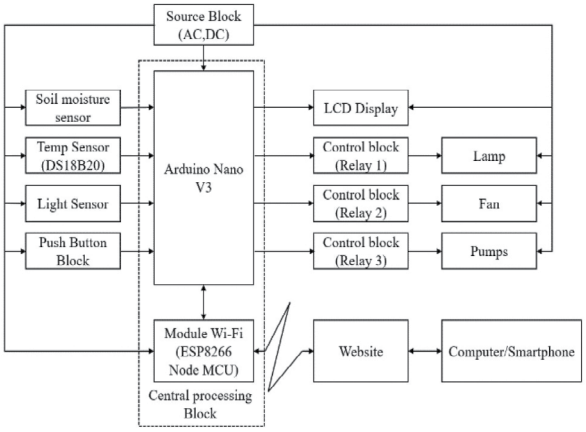


Figure 1. Smart garden model using IoT technology

A. System block diagram

In the paper, the author presents the design of a smart garden system (Fig. 2). This control system is designed by the author using the Arduino Nano V3 kit connected to the ESP8266 NodeMCU Wi-Fi module to form a central processing block that performs the function of updating environmental information data from soil moisture sensors, temperature sensors, light sensors; and then the data is displayed on LCD screens and websites. The control blocks in turn operate based on differences in temperature, soil moisture, and ambient light compared to the threshold set through electrical appliances. All control information of electrical equipment and information of control sensors are updated, monitored, and controlled through the website on computers/smartphones.



B. Webserver functions

The server receives data from the ESP8266 NodeMCU Wi-Fi module via TCP/IP protocol configuration. For agricultural management, building an independent channel to collect environmental data is important. This makes it possible to evaluate the agricultural cultivation process automatically, continuously and especially can make reports at any time.

The results of the analysis and statistics automatically generate the following basic data:

- Monitor environmental parameters to maintain the best habitat for plants.
- Monitor the state of plant development, thereby introducing timely treatment measures.
- The proportion of quality agricultural products according to each crop, and the proportion of substandard agricultural products according to the operating periods are updated according to environmental parameters.
- Monitor the operation status of the equipment in real-time, thereby making recommendations on maintenance and treatment of the equipment.
- The work report is by the actual operating status of the smart garden model.

In addition, other factors in management are also evaluated such as agricultural cultivation results, and inventory management,…

C. Algorithm flowchart

After initializing the system, sensor data information and control statuses of pumps, fans, and lights will be checked. Besides, the system is connected to the internet so that the data can be updated, displayed, and controlled on the website (Fig. 3). The sensor parameters after the update will be compared with the set threshold depending on the environment of each crop. Soil moisture sensors can be used to dictate the control of irrigation equipment in agriculture, the pump will be started when the soil moisture is below the set value and vice versa the pump will shut down when the soil moisture is greater than the set value (Fig. 4). The temperature sensor measures the ambient temperature parameter to decide whether to control the fan to turn on or off depending on the set threshold corresponding to each crop (Fig. 5). Light sensors are used to measure ambient light to decide whether to turn extra lighting on/off for some crops when the weather is not lighted (Fig. 6).

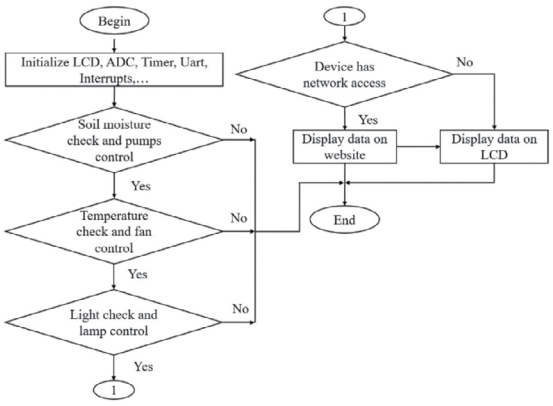


Figure 3. System-wide main program

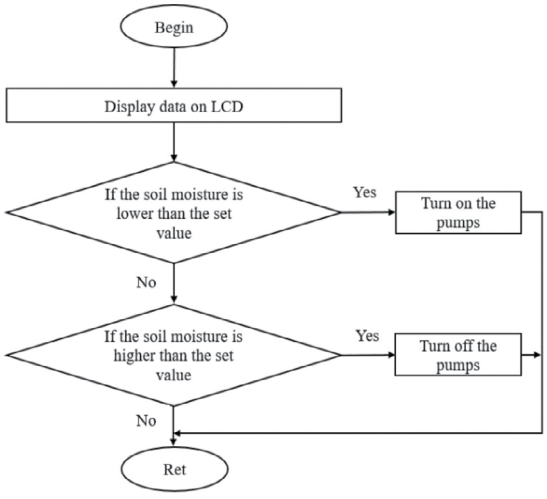


Figure 4. The program automatically controls the pump according to soil moisture.

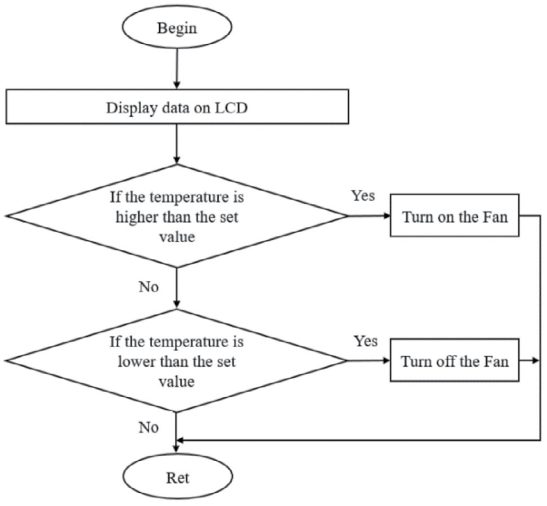


Figure 5. The program for automatic control of the fan by temperature

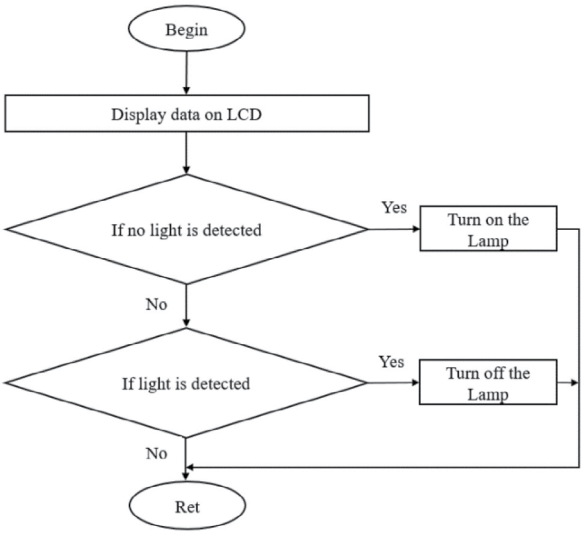


Figure 6. The program for automatically controlling the lamp according to the light

III. SYSTEM OPERATION RESULTS

A. Smart garden model

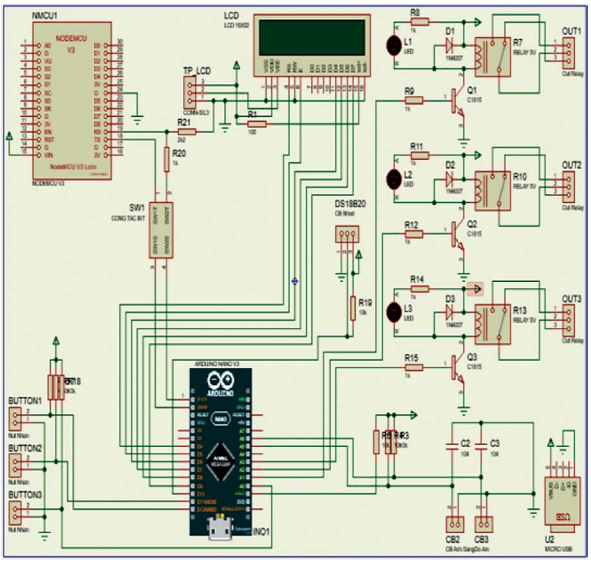


Figure 7. Diagram of the principle of smart garden circuits

Fig. 7 presents a diagram of the principle of design of system hardware including the central processing block, sensors, and control blocks. The central processing block consisting of a nano Arduino connected to the ESP8266 NodeMCU is the most important

component of the system, which is responsible for providing Wi-Fi connectivity, collecting, displaying, and managing the data of the sensors while giving commands to control the device such as pump, fans, lamps are connected directly to the central processing block. Fig. 8 depicts the hardware structure consisting of the following components: control block, soil moisture sensor, central processing unit, LCD screen, light sensor, and temperature sensor. The system operates in automatic mode, the devices are controlled automatically according to the schedule (on / off at intervals at specific times of the day). If any parameters exceed the threshold, the control device will activate the corresponding device (on / off).

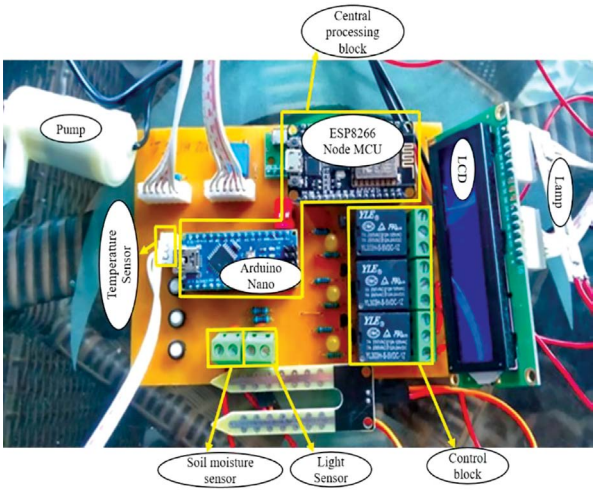


Figure 8. Hardware smart garden model

Arduino Nano V3 kit uses Atmega328-AU chip with processor core ARM 32-bit Cortex M3 with clock speed of 16Mhz, 32 kbytes Flash memory (programmable memory), 2kbytes SRAM, power supply 7-12VDC. Arduino Nano V3 kit is designed with multiple I/O ports to connect to different types of I/O devices, Micro USB power; GPIO port; serial port, SPI, I2C, PWM pins, external interrupt pins, connecting peripherals [9] (Fig. 9). The ESP8266 NodeMCU Wi-Fi module connects to the Nano V3 Arduino kit using the UART protocol, the RX pin on the ESP8266 NodeMCU Wi-Fi module connects to the TX pin on the Nano V3 Arduino kit, the TX pin on the ESP8266 NodeMCU Wi-Fi module connects to the RX pin on the Nano V3 Arduino kit, the GND pin of the ESP8266 NodeMCU Wi-Fi module and the Nano V3 Arduino kit connect (Fig. 7).

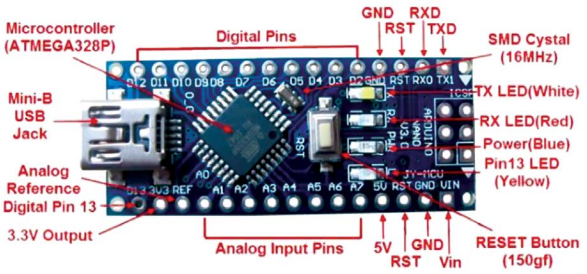


Figure 9. Arduino Nano V3 kit

The ESP 8266 NodeMCU Wi-FI module is a development kit based on the ESP8266 Wi-Fi SoC chip with this using design and especially the ability to use Arduino's compiler to program and load code, which makes it very simple to use and program applications on the ESP8266. The WI-FI ESP 8266 NodeMCU module also integrates the CP2102 IC for easy connection to applications, data collection, and control over Wi-Fi and IoT-related waves. With compact size, flexible modules are easy to link with peripheral devices to form projects and sample products quickly (Fig. 10).

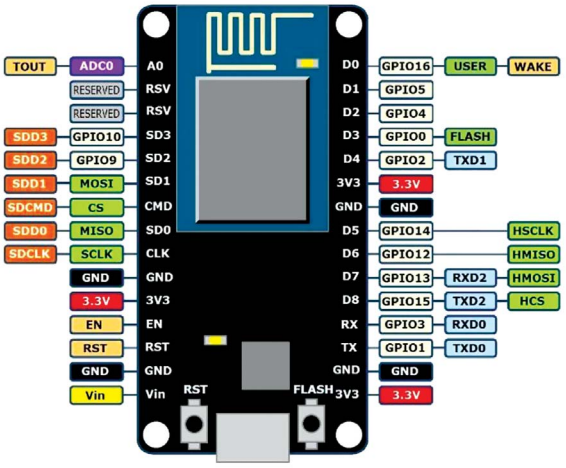


Figure 10. Module Wi-Fi ESP8266 NodeMCU

B. Experimental results

The test system consists of a central processing station, three sensors, and actuators. The sensors collect temperature, soil moisture, and ambient light and send data to the central processing station. The actuators operate automatically based on the value collected from the sensor compared to the set thresholds and are monitored and controlled directly through the website.

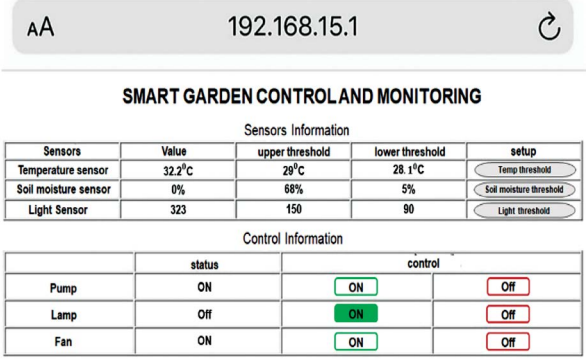


Figure 11. Smart garden monitoring and control interface on the website

Fig. 11 depicts the system monitoring and control interface, which allows users to continuously monitor environmental parameters and the control status of electrical appliances. By default, scheduled control devices turn on/off at certain times of the day or control based on sensor data collected. At the same time, the interface also allows users to set the threshold parameters of each type of sensor and control connected equipment such as pumps, lights, and fans directly on the website. For example, if the value of the current soil moisture sensor is lower than the set value compared to the lower threshold of the sensor, the pump is turned on to activate the steam injection system until the humidity is higher than the lower threshold value and does not exceed the upper threshold setting value.

C. Statistical data

Collected data is stored on the server to serve the purposes of reporting and evaluating the performance of the system. Fig. 12 presents the data in the form of a graph. From here, environmental information about temperature, humidity over some time, and other quality parameters will be statistically synthesized through algorithms. Depending on the actual requirements, it is possible to perform system operations through the web application in manual mode or set the system to operate automatically according to predetermined criteria. In addition, notices of maintenance procedures are also prompted to ensure agricultural production continues as planned.

Figure 12. Statistical data chart by day

IV. CONCLUSION

The paper introduced a smart garden which is monitored and controlled by IoT technology. The system has been successfully tested and is capable of being applied in practice. The system is designed to support users in collecting and monitoring environmental parameters that directly affect crops to provide timely treatment measures to improve productivity and reduce waste by automating the system based on collected environmental parameters. The information is collected from the environment and stored online, which is used as the necessary data for research, monitoring the development of crops and beyond is used as a basis for assessing the quality of agricultural products.

In the coming time, the team will focus on developing App monitoring control software on phones combined with the LORA communication network and designing and manufacturing central sets, and sensors using ARM Cortex M microcontrollers.

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MULTI-TASK INSPECTION ON X-RAY IMAGES BASED ON DEEP LEARNING

Van Luan Tran[1], Huei-Yung Lin[2], Hsiao-Wei Liu[3]

[1]*School of Engineering, Eastern International University, Binh Duong, Viet Nam*

[2]*Department of Computer Science and Information Engineering, National Taipei University of Technology, Taiwan*

[3]*Biomedical Technology and Device Research Laboratories, Industrial Technology Research Institute, Hsinchu, Taiwan*

luan.tran@eiu.edu.vn, lin@ee.ccu.edu.tw, rachel_liu@itri.org.tw

Abstract: Low back pain inspection on medical images is important to support doctors to perform medical examinations conveniently. Recently, deep learning has made significant advancements in a variety of medical applications. In this research, we propose multi-task deep learning for object segmentation and parameter inspection. Multi-task deep learning is based on deep CNNs for robust detection of obscure regions on images and spinal parameter assessment. In the experiments, trained and evaluated datasets are annotated by doctors at the pixel level and trained parameters. The datasets are used to train our model and test the performance of other networks. The suggested approach can segment objects on medical images and perform parameter inspection for low back pain examination better than the existing strategies. The outcomes have shown that our approach for object segmentation and automated parameter prediction for low back pain inspection is feasible.

Keywords: *Segmentation, Medical Image inspection, Multi-Task Learning*

I. INTRODUCTION

Recently, artificial intelligence (AI) and deep learning techniques are revolutionizing several research fields of computer vision as medical image analysis, robot vision, traffic supervision, and autonomous driving. Medical image analysis is crucial to modern medicine. In recent years, medical image analysis with deep learning techniques has been a very important contribution to modern medicine [1], [2]. Due to the difficulty of analyzing and diagnosing from a single picture, computer-aided diagnostic tools have been utilized to provide the inspection of potential illness mechanisms.

Low back pain is a painful condition in the lower back that can significantly affect a patient's quality of life. If treatment is delayed, the patient can face dangerous complications, even disability [4]. The lumbar spine consists of five vertebrae from L1 to L5 and the surrounding system of muscles, tendons, and ligaments. The spine is responsible for supporting and creating curves for the body. X-ray results show the alignment of the bones, helping the doctor to detect abnormalities such as inflammation, and fractures. MRI and CT methods allow doctors to detect anomalies

in tissues, muscles, nerves, ligaments, blood vessels, and bones. So, low back pain inspection on X-ray images is important to get automated parameter prediction.

One of the most frequent symptoms of lumbosacral spine discomfort is low back pain [3], [4]. Lumbar spondylosis often affects the discs and cartilage of the joints. The patient frequently has chronic lower back discomfort when the spine is degenerating. When you bend over, twist, or lift large things, the discomfort gets worse. The nucleus pulposus of the spinal disc slips out of place in a disease known as lumbar disc herniation, which can press on nerve roots and result in numbness and discomfort. This disorder, which can be brought on by injury or degenerative disc disease, can develop anywhere in the spine but most frequently does so in the lumbar region. Frequently, the discomfort spreads from the waist down to the legs (sciatica). The lumbosacral spine is made up of an intricate web of interwoven ligaments, muscles, joints, nerves, and bones. The most common cause of lower back pain is mechanical discomfort, which often comes from the muscles, ligaments, joints, or bones in and around the spine [5], [6]. Mbarki et al. outlined a deep learning technique to assist doctors and radiologists in lumbar disc localization through the segmentation of discs and apophyses in MRI images [7], [8]. Yeh et al. created deep learning models that can automatically identify 45 anatomical landmarks on a whole-spine lateral radiograph and then provide 18 radiographic parameters. In the evaluation of model performance, the cervical region's landmarks had the best localization accuracy and learning speed, followed by those in the lumbosacral, thoracic, and femoral areas [9].

In our research, we present a multi-task inspection technique on X-ray images to evaluate spinal parameter inspection accurately and efficiently. A segmentation network shares features with the inspection branch module to achieve high-precision inspected values of spinal parameters. It is built on a dependable segmentation network that is effective at finding continuous shadow areas that are difficult to see on medical images. Then, the criteria for lumbosacral spine diagnosis are derived. In the experiments, the training data are labeled by experts and doctors. The labeled datasets are utilized to train for evaluation of our method and other networks to compare their performance. The usefulness and viability of our suggested method for both object segmentation and spinal parameter assessment on X-ray images have been proved by experimental results with a high degree of accuracy.

II. MULTI-TASK INSPECTION

In this section, we discuss our architecture for multi-task inspection of X-ray images. Our model completely utilizes the connections between diverse activities and, via end-to-end training, automatically learns appropriate representation sharing. The model with supervised learning is employed for two main tasks, binary segmentation and parameter checking for the diagnosis of lumbar vertebrae. Our architecture has the segmentation branch and the inspection as shown in Fig. 1.

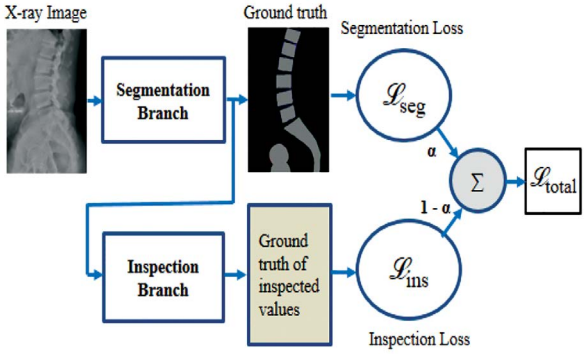

Figure 1. Our architecture for multi-task inspection with two branches, which are the binary segmentation branch and the inspection branch.

For binary segmentation problems, segmentation on medical images faces many challenges, so we have paid high attention to developing a model with high segmentation accuracy. The model is used to segment the objects of vertebrae, sacrum, and two femoral heads. In our method, we build a deep learning architecture for binary segmentation based on ResNet [11] as shown in Fig. 2. ResNet's approach is more straightforward and concentrates on enhancing information through the network's gradient. These designs can be taught using neural networks with hundreds of layers, according to experiments, and they swiftly rose to the top of the list of computer vision architectures. In our model, the input layer is a binary image by 512x512 with convolution, max pooling, Conv-blocks, and identified blocks for downsampling the features. Upsample block concatenated with identified blocks as shown in Fig. 2. The upsampling module's final output will be coupled to a convolution with softmax activation. The output in the last layer is the same size as the input.

As seen in Fig. 1, the binary segmentation branch's last layer serves as the input for the inspection branch. According to Fig. 3, the inspection branch was created to be derived from the shared feature maps. This network branch was built as an examined values classifier and comprises two convolutional layers, two max-pooling layers, and three fully connected (FC) layers. There are 1024 neurons with sigmoid activity in the first and second FC layers. 18 neurons make up the output FC layer, which is followed by a sigmoid activation function that shows the probability of the values under inspection.

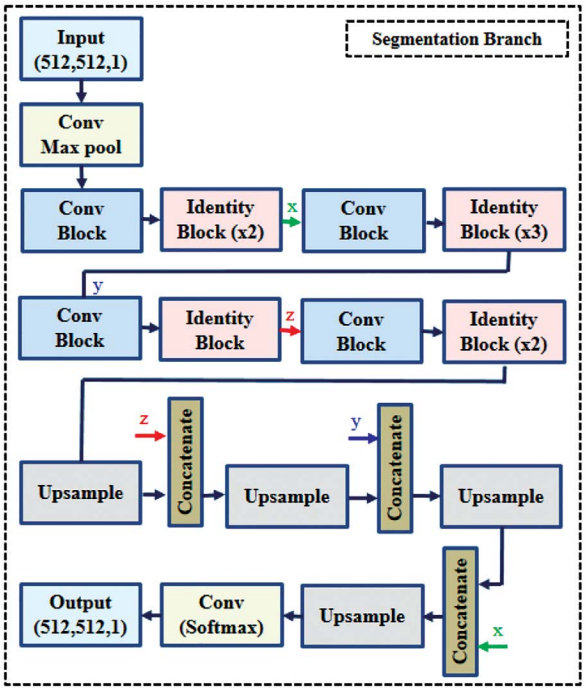

Figure 2. Our segmentation branch architecture for object segmentation with deep CNNs

The segmentation loss and the inspection loss are weighted sums in our loss function. For the segmentation loss, we employed the binary cross-entropy loss function. Problems involving binary classification are resolved with this function. Mean squared error regression loss serves to determine the inspection loss. The most used regression loss function is this one. The total of the squared

distances between the values of our target variable and the predictions is known as the mean squared error (MSE).

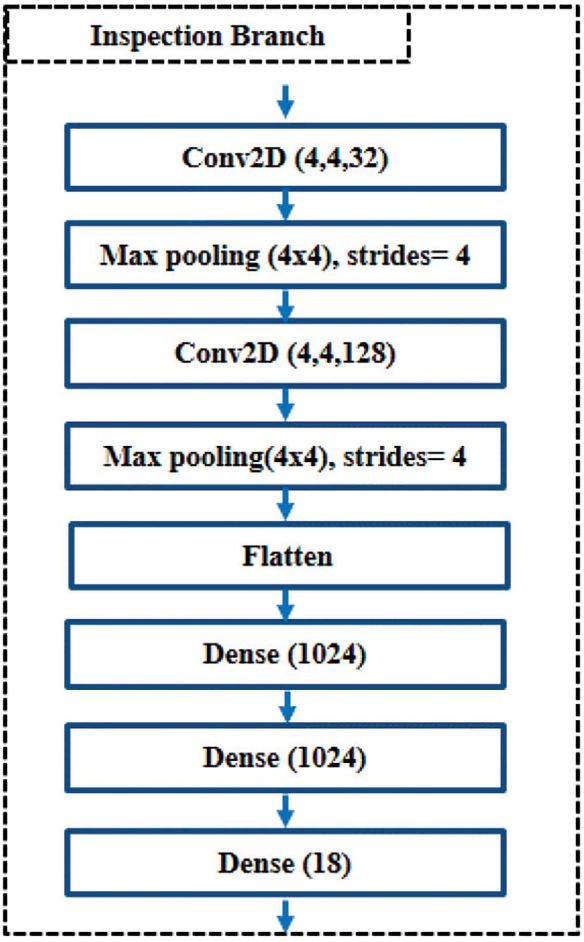

Figure 3. Our inspection branch with a fully connected layer

III. EXPERIMENTAL RESULTS

For network training, our experimental dataset comprises 1000 images, which are labeled by doctors. This dataset has 100 images for testing and evaluation. One vertebral region, the sacrum, and two femoral heads, as well as examined values annotated by medical professionals, are labeled on the training images. The initial learning rate for Adam is set at 3e-4, the number of epochs is 200, and the batch size is 4.

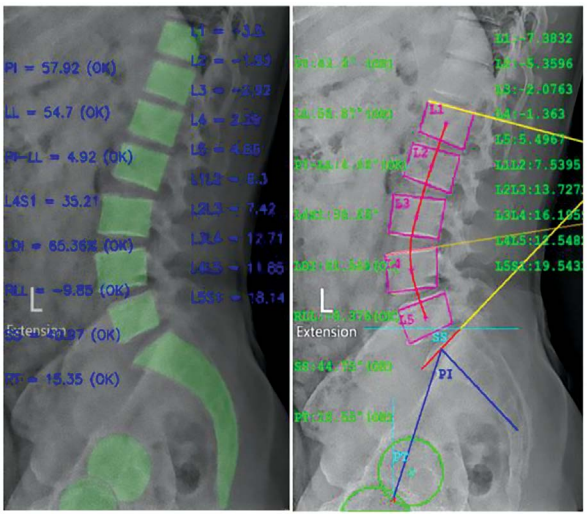

Figure 4. A testing result of object segmentation and parameter inspection on images. The left image is our testing result and the right image is ground-true.

The segmentation is carried out at the location of the objects of vertebra, sacrum, and two femoral heads represented by a green color as reported in Fig. 4. As shown in this figure, the parameter inspection of the lumbosacral spine on the left image is close to the ground truth image provided by doctors on the right image. The inspection values in the standard range values are OK and out of it is NG; the standard range values are as shown in Table 1. Table 2 reported the parameter evaluation results of our method and BiLuNet [10] evaluated on 100 images. It presents that this method achieves a high average accuracy on PI = 87.23%, LL = 95.60%, PImLL = 91.81%, LDI = 82.24%, RLL = 89.30%, SS = 92.06%, PT = 93.16%. Our evaluation reports that the segmentation accuracy has a significant impact on the lumbosacral spine examination. Especially, the positions of the femoral heads have an impact on parameter inspection with BiLuNet [10]. In this study, we compared and evaluated the method of applying deep learning combined with post-

processing for diagnosis and the multi-tasking deep learning method. The multi-tasking deep learning method is more efficient and faster.

Table 1. Standard range values for parameter evaluation

Names of parameter		Standard range
PI	Pelvic incidence	34° ~ 84°
LL	Lumbar lordosis	31° ~ 79°
PImLL	PI minus LL	-10° ~ 10°
LDI	Lordosis distribution index	50% ~ 80%
RLL	Relative lumbar lordosis	-14° ~ 11°
SS	Sacral slope	-20° ~ 65°
PT	Pelvic tilt	5° ~ 30°

Table 2. Evaluation of our method and comparison with BiLuNet [10] on our dataset with 100 X-ray images

Names	Acc BiLuNet [10] (%)	Acc Ours (%)
PI	88.30	95.60
LL	89.24	91.81
PImLL	78.14	87.23
LDI	83.90	82.24
RLL	81.36	89.30
SS	90.10	92.06
PT	83.77	93.16

IV. CONCLUSION

In this research, we suggested multi-task deep CNNs for parameter prediction for inspection and diagnosis as well as object segmentation. Object segmentation is performed using a deep CNNs structure. It automated segmentation of the sacrum, two femoral heads, and lumbar vertebrae can be done with great precision. To determine the clinical diagnosis of low back symptoms, our architecture conducts an examination of precise characteristics. The results of the studies have shown that our method can check the lumbosacral spine with great precision. For both the images taken before surgery and those taken following it, the suggested technique offers comparisons of accuracy levels.

ACKNOWLEDGMENT

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USING TIA PORTAL SOFTWARE TO SIMULATE THE USE OF PLC TO CONTROL DELTA ROBOT 3 DOF IN ATTACHING RFID TAGS ON PACKAGES IN THE SMART WAREHOUSE PROJECT

Van Y Huynh[1] , Phuong Nam Tran[1] , Dung Chinh Thach[1], Ngoc Huan Le[1]
[1]School of Engineering, Eastern International University, Binh Duong, Viet Nam
y.huynh@eiu.edu.vn, nam.tran@eiu.edu.vn, chinh.thach@eiu.edu.vn, huan.le@eiu.edu.vn

Abstract: While building the EIU Smart Warehouse system, attaching RFID Tag to each Package takes a long time to complete due to 2 factors: The larger number of packages 1372; mounting in the desired position. Therefore, we proposed to use delta robot 3DoF to support the process of attaching RFID tags to Packages. Delta Robot has the advantage of very fast operation and is being widely used in factories. In this study, we will simulate the kinematics and dynamics of controlling the delta robot by PLC. Tia portal software is used to do the simulation. This solution can also write Gcode commands to control the real robot arm. The proposed solution will be used for the following purposes: Attaching RFID tags to Packages when equipped with a real robotic platform; instructing students in classes about robotics.

Keywords: *Delta robot, Robot simulation, smart warehouse*

I. INTRODUCTION

Currently, on the market there are many lines of Delta Robots of famous brands such as ABB with Model is IRB 365 FlexPicker® Delta Robot – lightweight picking reorientating and packing and Delta robot controlled by OmniCore™ C30 [2], Yaskawa with The MPP3S can be programmed and controlled using IEC61131-3 and PLCopen programming standards [3], KuKa with the KR C5 microcontroller Kuka's latest generation [4], Mitsubishi... All types of Delta Robots manufactured by these companies work very well. However, accessing and wanting to intervene deep inside is impossible. In this paper, we use PLC S7-1500 to control the Delta Robot system, which is a breakthrough for the control of Robot lines, specifically the Delta Robot. We used Tia portal software to program kinematic algorithms to control Delta robots via PLC S7-1500 [5] and directly connected with Seimen's NX 3D CAD software, and to simulate the working process of a robot. That allows us to have an overview of the project. This new method allows us to fully exploit the robot's features and allows programmers to easily learn. Delta robot is fast operation and low cost. Since then, we have found that it is very suitable for integrating RFID tags on pallets in smart warehouses.

II. METHODOLOGY

A. Mathematical Modeling for Systems

Specifications: sB=157mm, sP=61mm, L=65mm, Ln=200mm. These are the typical parameters for us to calculate and design the Delta Robot shown in Fig. 1, Fig. 2, and Fig. 3.

Figure 1. 3D models on CAD software

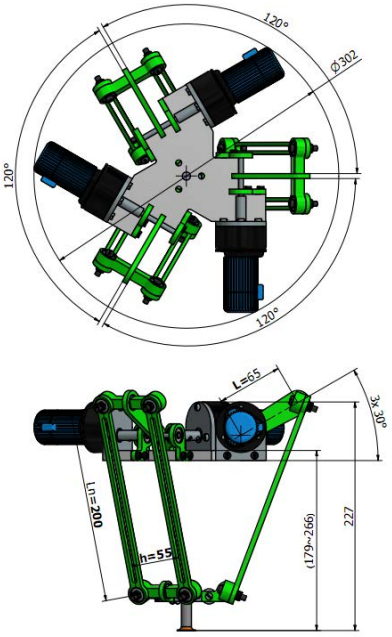
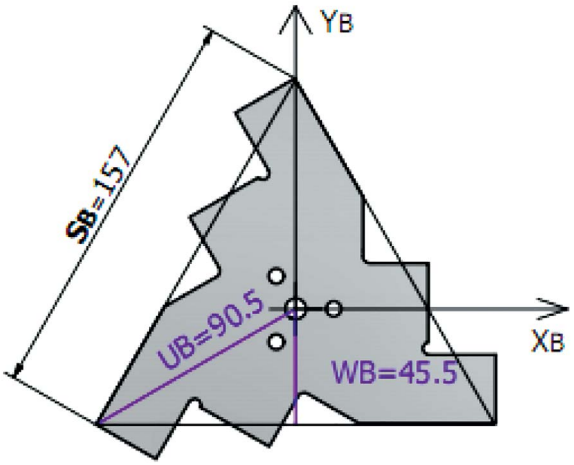
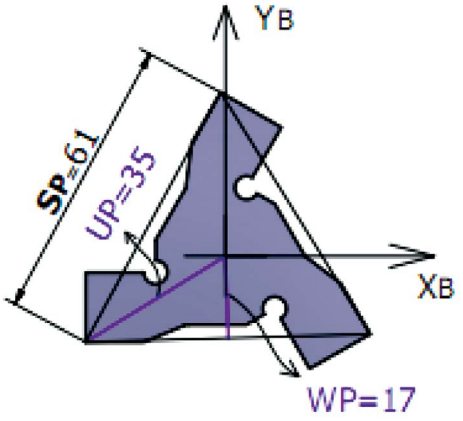


Figure 2. 3D models on CAD software



Base equilateral triangle side



Platfrom equilateral triangle side

Figure 3. 2D drawing of Base and Platform

B. Systems Position Kinematics

- Delta Robot's Forward Position Kinematics (FPK) equation: [1].
- Delta Robot's Inverse Position Kinematics (IPK) equation: [1].

III. RESULTS

A. Simulated Delta Parallel Robot

From Forward Position Kinematics (FPK) equation and Inverse Position Kinematics (IPK) equation. We calculate on Matlab to get the rotation angle and position of the Delta robot according to our design as shown in Fig. 5 and Fig. 6.

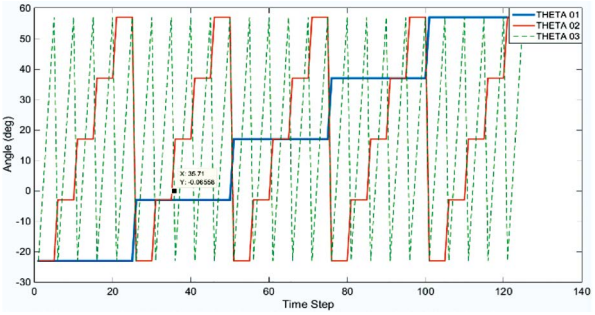


Figure 4. Delta robot's 3 rotary joints

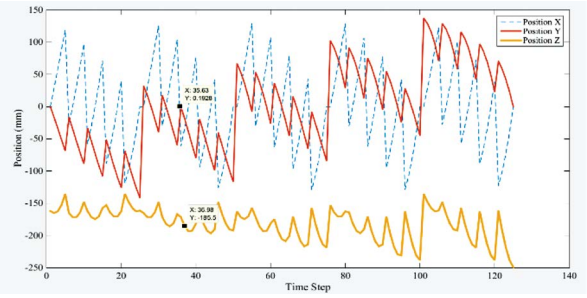


Figure 5. Delta robot's 3 spatial coordinates

Through Fig. 5 and Fig. 6, we see that when the rotation angles θ_1, θ_2, and θ_3, the coordinates X, Y, and Y change accordingly. Specifically, when the angle $\theta_1=\theta_2=\theta_3=0$, respectively, X=0, Y=0, Z=-185.5 mm, and this is also the Home position of the Robot. The above results are calculated on Matlab.

From the 3D model design section shown above. In the assembly environment, we can calculate the operating range of the rotation angles. Details of the rotation angles angle $\theta_1=\theta_2=\theta_3=[-23^o \sim 72^o]$ from which we can calculate the working space of the robot, shown in Fig. 7.

From Fig. 7, we see that the robot's operating space in each axis is: X axis = [-139.6 ~ 140.4]; Y axis = [-81.09 ~ 162.2]; Z axis = [-250.6 ~ -116.6]; the results are calculated on Matlab.

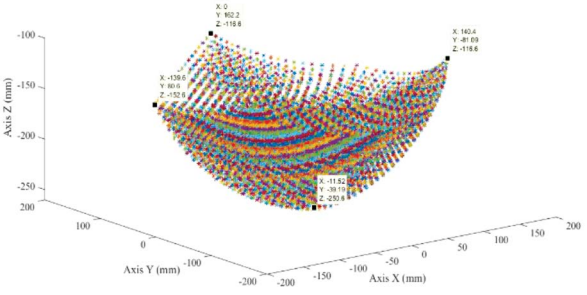
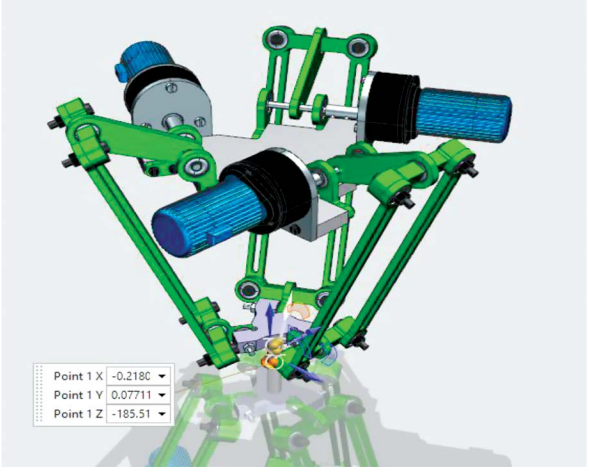


Figure 6. Working space of the robot

B. Robot Control Delta Robot with NX and PLC

Delta robot is controlled by the S7-1500 PLC program and connected with 3D NX software to simulate robot movement in real time. The home position of the robot is shown in Fig. 8. Let the robot move in some other positions shown in Fig. 9 and Fig. 10.



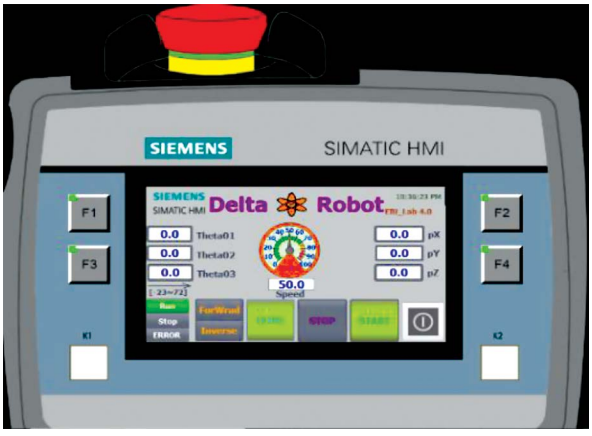


Figure 7. The Home position of the robot

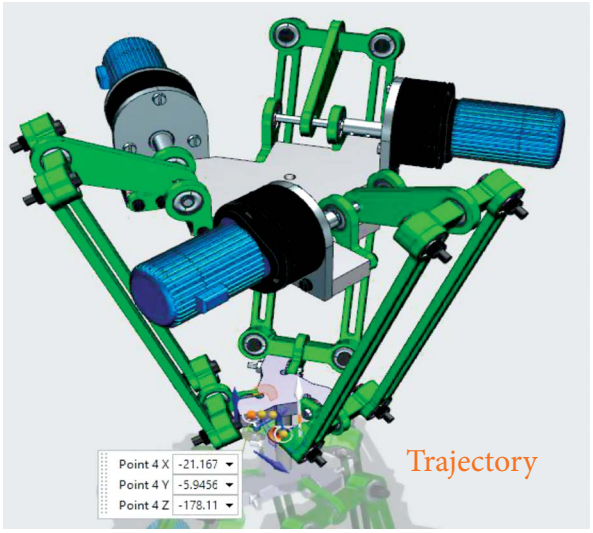


Figure 8. Another location of the Robot in NX

Figure 9. Another location of the Robot in PLC

Figure 10. Trajectory of the Robot in NX

IV. CONCLUSION

From the above results, we show that controlling Delta Robot by using the PLC method gives very good results. The robot simulation results move in the correct coordinates according to the actual space. We can combine the simulation of the system's working process with the actual model running directly. From there we can follow in detail the actual movements of the Robot through running in a virtual environment. In addition, it is very easy to integrate Delta Robot into attaching RFID tags to Pallets because they share the same PLC control system.

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NUMERICAL INVESTIGATION ON THE COOLING PERFORMANCE OF A LIQUID HEAT SINK WITH CROSS -VENULATE LEAF VEINS - LIKE FLOW PATTERN

Xuan Hung Nguyen[1,2], Doan Linh Vo[2], Duy Nhat Tran[2]

[1]*School of Engineering, Eastern International University, Binh Duong, Viet Nam*

[2]*EIU FabLab Center, Eastern International University, Binh Duong, Viet Nam*

hung.nguyenxuan@eiu.edu.vn

Abstract: Thermal management of high-power electronic devices is a critical challenge in their industrial applications. Due to high heat convection coefficient, liquid heat sinks have been widely used to maintain chip's surface temperature below the safe value. Flow pattern plays an important role in cooling ability of the liquid heat sink. In this study, the cross-venulate leaf veins - like structure was proposed for designing liquid flow pattern of a liquid heat sink. This one was numerically simulated by using OpenFoam (Open-source Field Operation and Manipulation), a computational fluid dynamics (CFD) software to investigate its cooling performance. The inlet flow rates of water were supplied ensuring the flow is under laminar regions. Supplied power into heater block was set up at 400W. Heat transfer and flow characteristics such as heater's surface temperature distribution, thermal resistance, and pressure drop at different flow rates were presented.

Keywords: *Leaf veins-like heat sink, OpenFoam, electronic cooling device, thermal resistance*

I. INTRODUCTION

Thermal management of high heat dissipation of electronic - electrical equipment such as high speed computer chips, insulated gate bipolar transistors (IGBT), Li-ion battery... is a vital challenge [1]. Many novel designs of heat sink have been proposed to solve this one. In the past decades, a plenty of research has been trying to improve heat transfer performance of the heat sinks. Regardless of the cooling devices, the fluid flow route geometries optimization always plays a big role. Therefore, dealing with optimization of flow structure and heat transfer characteristics has become increasingly important nowadays.

Because of high heat transfer coefficient, liquid heat sinks have been widely employed in cooling high power electronic devices, despite adding complexity and cost. Inspired by natural optimization, tree-like networks, a sort of bionic structure observed in nature such as bronchi, breast ductal networks, and plant leaf veins, have been examined to improve the heat transfer and flow properties of these cooling devices [2]. S. Wu et al. [3] conducted experiment with a tree-shaped liquid pattern heat sink using constructal law. This four-level-mini-channel heat sink was fabricated by using 3D printer. At the heat flux of 8W/cm^2, this device could maintain the chip's surface temperature at 66.6^{o}C which is suitable for the application of electronic cooling. L. Liang et al. [4] designed, constructed and tested a Y-fractal microchannel based heat sink to study the

effects of three distinct control parameters on the flow and heat transfer features including fluid flow rate, heat flux, and inflow temperature. Experimental results from this research could be a reference for improving the heat sink with more complex Y-fractal channels. B. Manshoor et al. [5] carried out numerical computation for comparing T-shape to Tree-shape microchannels. Their results noted that T-shape fractal heat sink could reduce pressure drop but decrease heat transfer compared to Tree-shape one. However, at small pressure drop and high heat transfer coefficient, Tree-shape was better than T-shape. K. Sakamatapan et al. [6] developed and tested a disc-type liquid-cooled heat sink in which leaf veins - like liquid flow pattern was constructed by using constructal law. According to their findings, raising the inlet Reynolds number raises the Nusselt number, and increasing the number of clusters may have a greater influence on the Nusselt number. T. Deng et al. [7] investigated the heat transfer of a looping leaf-like channels liquid cooling heat sink using numerical computation. The acquired data revealed that the heat sink design containing a width ratio of around 3/4, a length ratio close to 0.5, and a bifurcation angle in the 30-50° range offered the highest maximum temperature and temperature uniformity. Similarly, A. Asadi and F. Pourfattah [8] proposed a compact cooling system with leaf-inspired microchannels. Liquid flow pattern was designed using the leaf lateral vein structure which was generated by using the constructal theory. Their simulated results indicated that the leaf lateral vein heat sink is better than parallel conventional channels one in terms of the chip's surface maximum temperature. More detailed study, Y. Peng et al. [9] constructed and compared working performance between parallel leaf vein network and reticulate leaf vein network liquid heat sinks by using both numerical simulation and experimental test. Especially, in reticulate leaf vein network design, the authors implemented Voronoi diagrams for generating tertiary microchannel. This way helps their flow pattern similar to leaf vein from nature and has better heat transfer performance. H. Ling Liu et al. [10] performed experiment and optimization of tree-like mini-channel heat sinks for cooling Li-ion battery. The author also indicated that the tree-like mini-channel heat sink has much better thermal performance than that of the corresponding straight mini-channel. The optimal design of this heat sink could cool the battery cell at 4C discharge rate down to 33.69°C and the uniformity of temperature of 4.86°C difference.

By observing plant from nature, leaf veins structures are formed randomly and complexly. Comprehension of heat transfer and flow characteristics of the plant leaf vein – like heat sink is still a challegence for researcher. In this article, by using image processing in designing, a liquid heat sink using a cross-venulate leaf veins flow pattern was proposed and investigated numerically by using OpenFOAM® CFD software. This conjugate heat transfer model including multiple domains of heater block, heat sink body and fluid flow was solved by manipulating the chtMultiRegionFoam module. Heat transfer and flow characteristics such as heater's surface temperature distribution, thermal resistance, and pressure drop at different flow rates were reported.

II. NUMERICAL MODEL

A. Fluid Flow Pattern and Heat Sink Model

Fig. 1 (left) shows a structure of cross-venulate leaf veins. This is a post-processing image of the leaf structure. It was inserted into Salome software [11] and modified to extrude into fluid flow pattern and its three-dimensional model is shown in Fig. 1 (right).

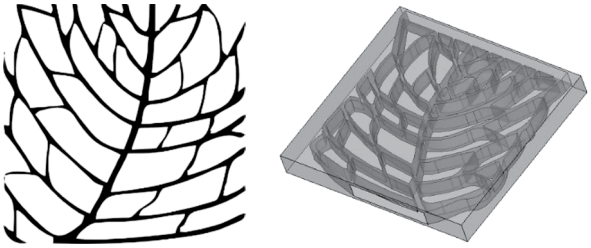

Figure 1. Cross-venulate leaf veins and flow pattern model

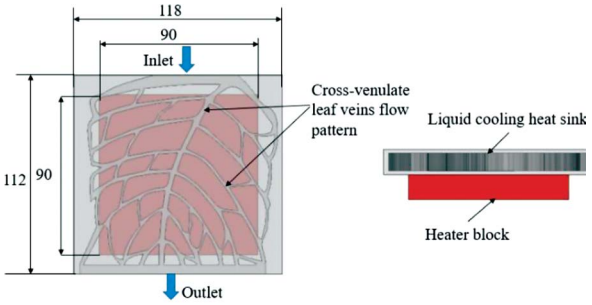

Figure 2. Heat sink in simulated model

B. Problem statement

The conjugate heat transfer model of liquid heat sink with cross-venulate leaf veins – like flow pattern is shown in Fig. 2. The size of the heat sink is 112mm × 118mm × 14mm. The heat dissipation device is assumed as a square block with 90mm × 90mm × 20 mm of size. Heat power dissipated from the heater block is assumed at 400W. The heat sink is fix-contact with the heater. Heat from the heater block is removed by liquid flow going from inlet port to outlet port. The liquid used in this simulation was water and its thermophysical properties are given in Table 1 including density (ρ), thermal conductivity (k), specific heat (c_p), dynamic viscosity (μ) and Prandtl number (Pr). Water flow rates were chosen in the range of 0.2L/min – 1L/min which can maintain the flow in the range of laminar regimes. The inlet temperature of the water was at 25°C.

Table 1. Thermophysical properties

Material	ρ (kg/m³)	k (W/m.K)	c_p (J/kg.K)	μ (Pa.s)	Pr
Water	1000	0.606	4180	959.10^{-6}	6.62
Aluminum	2700	200	900	-	-

C. Governing equations

In order to simulate this cooling model, a set of governing equations consisting of flow continuity, conservation of momentum and energy are solved. These equations can be represented with the assumptions of steady state heat transfer, single phase, incompressible fluid, no radiation heat transfer, and constant thermo-physical properties of water as follows:

Continuity equation:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \quad (1)$$

Momentum equations:

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+u\frac{\partial u}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\upsilon\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right) \quad (2)$$

$$u\frac{\partial v}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\upsilon\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right) \quad (3)$$

$$u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+u\frac{\partial w}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+\upsilon\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right) \quad (4)$$

Energy equation for liquid flow:

$$u\frac{\partial T_l}{\partial x}+v\frac{\partial T_l}{\partial y}+w\frac{\partial T_l}{\partial z}=\alpha\left(\frac{\partial^2 T_l}{\partial x^2}+\frac{\partial^2 T_l}{\partial y^2}+\frac{\partial^2 T_l}{\partial z^2}\right) \quad (5)$$

Energy equation for solid area:

$$0 = k_s\left(\frac{\partial^2 T_s}{\partial x^2} + \frac{\partial^2 T_s}{\partial y^2} + \frac{\partial^2 T_s}{\partial z^2}\right) \quad (6)$$

The heat flux between the interface of the liquid and the solid walls of the heat sink is coupled and its continuity equation is given:

$$k_s \frac{\partial T_s}{\partial n} = k_w \frac{\partial T_l}{\partial n} \quad (7)$$

Where:

u, v, w: are flow velocities in x, y, z direction

$a = k_w/rc_p$, is the thermal diffusivity;

$\upsilon = \mu/\rho$, is the kinematic viscosity;

k_s, is solid conductivity;

T_l, T_s are liquid and solid temperatures;

D. Boundary conditions

- At inlet:

Flowrate: 0.2-1 L/min corresponding to inlet Reynolds numbers in range of 128.62 to 643.08 respectively. So that this is laminar flow.

Temperature: T = 298 K.

- At heat bock:

Power density, q''' = 3527336.86 W/m^3

- At other walls:

No slip condition, velocity at the walls equal to zero.

The outer solid walls were set to be adiabatic.

- At outlet:

$P = P_{atm}$ = 0 kPa

E. Numerical model selection

The governing equations were solved by using chtMultiRegionFoam which is a "*solver for steady or transient fluid flow and solid heat conduction with conjugate heat transfer between regions, buoyancy effects, turbulence, reactions and radiation modelling*" in OpenFoam® [12].

F. Post-processing and data acquisition

The convective heat transferred by water flow in the heat sink channel can be calculated by:

$$Q = \dot{m} c_p (T_{out} - T_{in}) \quad (8)$$

$\dot{m}$ is mass flow rate of water flow:

$$\dot{m} = \rho A_c V \quad (9)$$

A_c is cross-sectional area (m2) and V is normal velocity (m/s)

Pressure drop in the heat sink channel:

$$\Delta P = P_{inlet} - P_{outlet} \quad (10)$$

Thermal resistance is a criterion for evaluating the cooler performance, it can be computed by:

$$R_J = \frac{T_j - T_{in}}{Q} \quad (11)$$

T_j is averaged value of the interface surface temperatures, namely junction temperature. T_{in} and T_{out} are temperatures of water at inlet and outlet of the heat sink.

III. RESULTS AND DISCUSSIONS

The simulated result could be approximately confirmed by comparing removal heat due to water flow (Eq. 8) calculated by using post-processed data (measured Q) to heat supplied at the heat source (given Q). Fig. 3 shows these different percentages according to water flow rate. At three values of flow rate, 0.2, 0.4 and 0.6 L/min, the difference was about 4% to 6% while this value was up to 12% and 14% for higher

flow rate of 0.8 and 1.0 L/min. This might be because the flow regime became turbulent at the branches of the channel owning to smaller cross-sectional area compared to main channel. The local Reynolds number was much higher, and the local flow became more turbulent, while, in this calculation, laminar regime was set up for all 5 values of flow rate. Therefore, the difference was bigger at high flow rate (0.8 and 1 L/min).

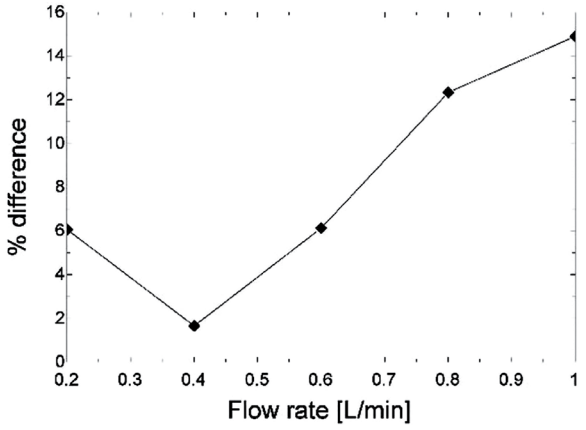

Figure 3. Different percentage between calculated *Q* and given *Q* versus flow rate

A. Interface temperature and temperature uniformity

In thermal management, the cooling devices have to spread heat as fast as possible and uniformly. It means that maintaining as low as the device's temperature and temperature differences on the interface surface is crucial. In order to investigate the working performance of the heat sink, firstly, the temperature of the device has to be considered carefully. Fig. 4 shows average junction temperature (T_J) and maximum temperature (T_{max}) versus inlet flow rates from the simulated results. Accordingly, at the lowest flow rate of water of 0.2 L/min, T_J was equal to 55.63°C and T_{max} was 63.92°C. Both temperatures decreased when the flow rate increased. At 1 L/min, T_J was down to 37.31°C and T_{max} was 42.82°C. All simulated conditions satisfied electric – electrical device's cooling requirement.

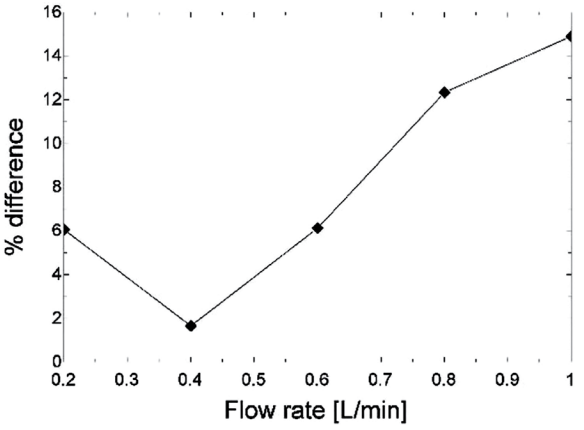

Figure 4. Temperature versus flow rate

Fig. 5 shows temperature distribution at heat source's side of the heat sink. It is seen that heat sink design is still existing a drawback represented by non-uniform of surface temperature. At near the outlet of the heat sink, the temperature is high in comparison with near inlet area. It looks like a "hot spot" which can be a risk making the device's failure when it operates at various and suddenly changed heat loads. This point needs to be considered carefully in next improvement of the heat sink design.

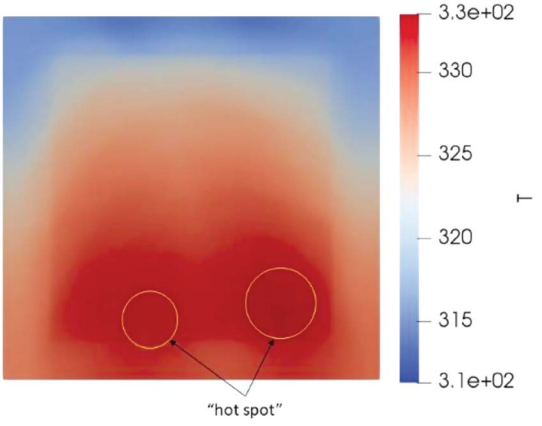

Figure 5. Temperature distribution (K) at 0.2 L/min

B. Thermal resistance versus flow rate

Thermal resistance can be calculated by using junction temperature as shown in Eq. 11. It is regarded as an indication of the thermal performance of a cooling device. The smaller the device's thermal resistance is, the better its cooling performance is. Fig. 6 demonstrates that thermal resistance decreased since increasing the flow rate. At 0.2 L/min, it was 0.077 (°C/W) and at 1 L/min, this value was 0.031 (°C/W).

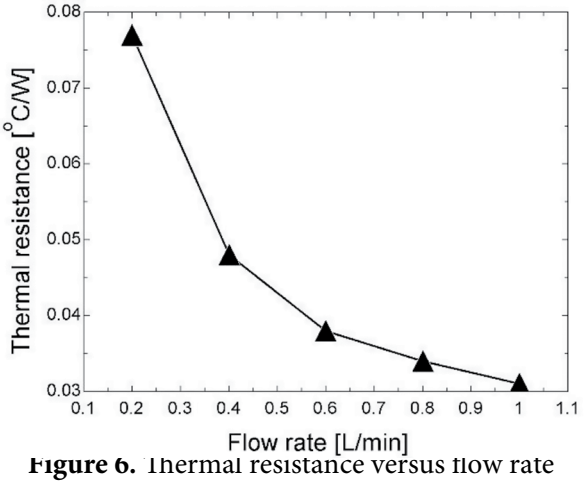

Figure 6. Thermal resistance versus flow rate

C. Pressure drop versus flow rate

Pressure drop or flow resistance is a quantity used to measure the pump power. Smaller pressure drop occurs along the heat sink channel, less power is consumed to pump the liquid flow through the channel. An "optimized" cooling device has to provide not only low thermal resistance (low junction temperature) but also consume less power to pump liquid through the heat sink. From post-processing data, pressure drop was determined by using Eq. (10). Fig. 7 shows the values of the pressure drop corresponding to inlet flow rates. Normally, the pressure drop is very sensitive to the flow regimes (laminar or turbulent), at turbulent flow, the pressure drop is very high. As mentioned above, at 0.8 L/min and 1.0 L/min, the flow became turbulent making the pressure drop increased rapidly and up to 152.85 Pa. Therefore, the simulation conditions need to be defined carefully later to get more reasonable results.

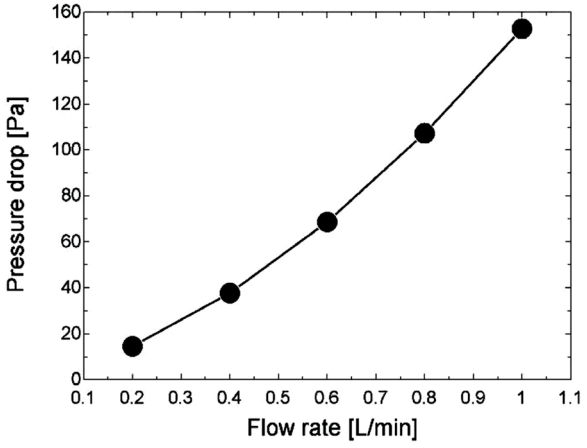

Figure 7. Pressure drop versus flow rate

IV. CONCLUSION

The simulation of the heat sink employing the cross-venulate leaf veins - like flow pattern has been conducted in this study. The heat sink with the size of 112 (mm) × 118 (mm) × 14 (mm) could maintain the heater surface temperature at 63.92°C since the dissipated power was 400 W and the water flow rate was 0.2 L/min. Although, this is a primary study of using "natural optimization - based" designing method to model the heat sink, the simulated results indicated that leaf vein's structure can be a potential candidate for designing of the liquid heat sink. Some findings from this study help authors to propose further research as follows:

- Investigate more kinds of leaf veins structure by using image processing to achieve "the best one" for liquid heat sink design.

- "The best leaf structure" can be combined with constructal law or Voronoi diagrams to optimize the liquid cooling device via open source CFD simulation.
- By using 3D metal printing, the optimal design can be manufactured and tested to compare with the numerically calculated results.

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PART III

HEALTH SCIENCE

KNOWLEDGE AND PRACTICE EYE CARE FOR PATIENTS OF INTENSIVE CARE UNIT NURSING STAFF AT BECAMEX INTERNATIONAL HOSPITAL

Liem Le Hong[1], Alison Merill[2]

[1]*Faculty of Nursing, Eastern International University, Binh Duong, Viet Nam*

[2]*University of Northern Colorado*

liem.le@eiu.edu.vn, Alison.Merrill@unco.edu

Abstract: Background: Eye care (EC) for the critical patient in the intensive care unit (ICU) remains inadequate because diseases of the ocular surface are reported to be common in these patients. An educational program that will enhance nurses' understanding of EC in the ICU. **Objectives:** Assess current knowledge and application of EC by nurses in the ICU then make recommendations for developing standard procedures for EC for critical patients. **Methods:** A non-experimental fieldwork was conducted including 14 female nurses participating in the study who were working at Becamex International Hospital, Binh Duong province from 05/2019 to 09/2019. This study was reviewed and approved by the IRB of UNCO university. **Results:** 71.4% of ICU nurses reported seeing eye disorders in patients. One barrier to EC practice was reported to be few EC training courses for nurses, accounting for 75% of ICU nurses. Notably, 92.9% of nurses said they had never attended eye training before. Nurses' information on EC in the ICU area significantly increased by an average of 5.54 points ($p < 0.001$) after the educational intervention. **Conclusion:** This finding was similar to previous studies that have done educational interventions and have improved nurses' knowledge of EC in the ICU. This study demonstrated the need to develop EC practice guidelines for ICU nurses to practice EC in patients.

Keywords: *eye care, knowledge, practice, intensive care unit*

I. INTRODUCTION

In the ICU, the treatment of patients in a life-threatening situation is primarily related to the ICU; As a result, ICU nurses often focus on taking care of patients to save the life of them, and other issues are often overlooked [1]. An important consideration is a reliance on technology and drugs for critically ill patients to support life. These people are at risk of corneal damage due to various elements, the most familiar of which is ocular exposure [3]. Nevertheless, the work of nursing care in the ICU is often arduous, and the performance of simple care such as EC is often overlooked [4]. This study purposed to specify the level of knowledge and practice of EC among the ICU of nurses. In addition, The study implemented an education program provided to ICU nurses about EC procedures and evidence-based practice guidelines to improve the current level of EC knowledge for ICU nursing.

II. METHODOLOGY

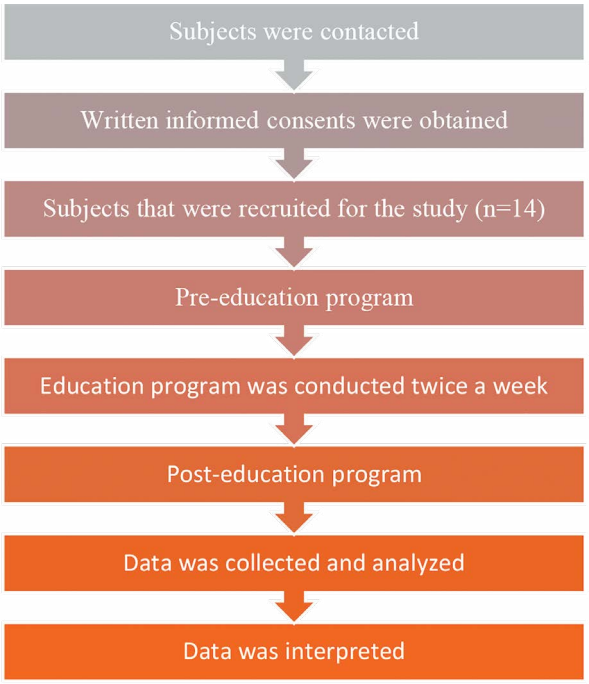

Figure 1. Study flowchart

Design: A non-experimental fieldwork was conducted

Setting: BIH Hospital is the sponsor of this study. This hospital has 17 ICU beds out of a total of 300 beds where in Binh Duong province, Vietnam.

Sample: For this survey, ICU nurses working at BIH were invited to participate, and were voluntarily to complete this survey.

Data Collection: Participating in the study were ICU nurses at BIH hospital. First, ICU nurses were sent an invitation to register for a scheduled training session. Second, the data collection was completed in 1 week. The training session was held twice a week. The training course lasted about 90 minutes and included a pre-test, a researcher's presentation, a question, a discussion, and a post-test.

Data Collection Tool: Survey tool was built by the author including pre-test and post-test including demographic information, EC knowledge, and self-report on EC practice [2], [4], [5], [7]. The collection tool consists of 29 questions, with 8 questions dedicated to determining the level of satisfaction of nurses with the training program.

Analysis: The data were analyzed and descriptive statistics were calculated for each variable and then a description of the relationship of the test before and after the test.

III. RESULTS

The demographic characteristics of the 14 nurses working in the ICU at BIH are shown in Figure 2. The participants are all female and range in age from 23 to 34 (N = 14). 21% of nurses have worked for 1 to 2 years, 57% have worked for 3 to 4 years and 21% have worked for 8 to 10 years. Among nurses working in the ICU, 43% have worked for one year or less and 57% have worked three to five years in the ICU. Education level: 57% of nurses have intermediate degrees, 21% have college degrees and 43% have bachelor's degrees. 93% of nurses reported working 12 hours per shift. It is noteworthy that 93% (n = 13) of the nurses reported that they had not received any prior eye training.

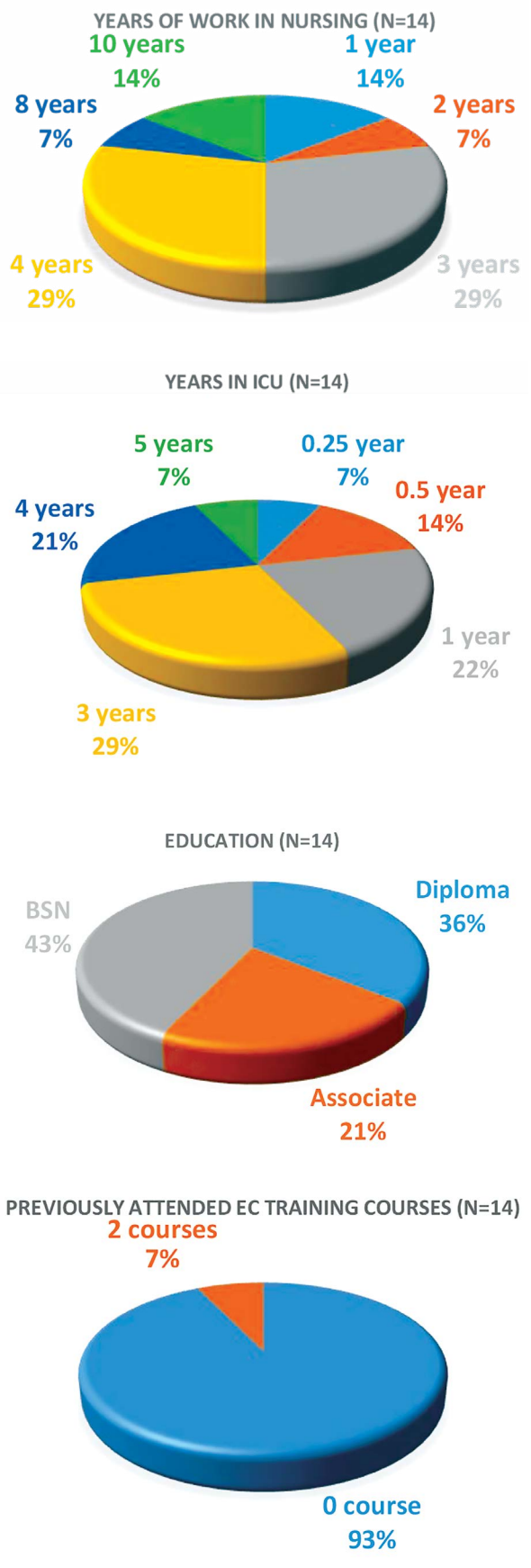

Figure 2. Demographic statistics of sample [7]

The EC knowledge section of the research survey tool consists of 13 multiple-choice questions. The correct and incorrect pre-test and post-test answers for each question were provided in Table 1. There appeared to be an improvement (positive difference) between the correct answer scores for 10 out of 13 questions in this section. A pair-sample t-test was conducted to assess whether there was an increase in nurses' knowledge after the education program by increasing the number of correct answers to the "test" from the test. test first to test after. In summary, scores for the educational intervention showed that nurses' knowledge of EC in the ICU setting had increased significantly. The nurses scored an average of 5.54 points (95% confidence interval, 2.87, 8.21) on the knowledge test. This increase was statistically significant with $p < 0.001$ for the paired (two-tailed) t-test.

Table 1. Data of the pre-post-test for knowledge of eye care [7]

Question	Pre-Test			Post-Test		
	N	n	%	N	n	%
Q1 **Correct** **Incorrect**	14	 13 1	 92.9 7.1	14	 13 1	 92.9 7.1
Q2 **Correct** **Incorrect**	14	 8 6	 57.1 42.9	14	 8 6	 57.1 42.9
Q3 Correct Incorrect	14	 10 4	 71.4 28.6	14	 12 2	 85.7 14.3
Q4 Correct Incorrect	14	 3 11	 21.4 78.6	14	 12 2	 85.7 14.3
Q5 Correct Incorrect	14	 2 12	 14.3 85.7	14	 10 4	 71.4 28.6
Q6 Correct Incorrect	14	 9 5	 64.3 35.7	14	 13 1	 92.9 7.1
Q7 Correct Incorrect	14	 10 4	 71.4 28.6	14	 14 0	 100.0 0.0
Q8 Correct Incorrect	14	 5 9	 35.7 64.3	14	 14 0	 100.0 0.0
Q9 Correct Incorrect	14	 2 12	 14.3 85.7	14	 13 1	 92.9 7.1
Q10 Correct Incorrect	14	 2 12	 14.3 85.7	14	 14 0	 100 0.0
Q11 Correct Incorrect	14	 7 7	 50.0 50.0	14	 12 2	 85.7 14.3
Q12 Correct Incorrect	14	 12 2	 85.7 14.3	14	 11 3	 78.6 21.4
Q13 Correct Incorrect	14	 4 10	 28.6 71.4	14	 13 1	 92.9 7.1

The results of self-reported EC practice was shown in Table 2. The study showed that 100% of nurses thought that EC for seriously ill patients was necessary and they were clear expectations for EC practice. Nurses rated their knowledge and understanding of EC as acceptable with 71.4% and poor with 14.3%. 100% of nurses reported that there is no specific procedure for EC for coma patients. 14.3% of nurses always check eyelid closure, 50% very often and 35.7% sometimes do this check. Up to 71.4% of nurses reported seeing eye complications in the ICU including Chemosis, conjunctivitis, corneal ulcers, dry cornea, keratitis, and pink eye. There were 64.3% of nurses reported that they were lack of education and 21.4% unclear escalation about EC practices.

Table 2. Result of self- reported eye care practice [7]

Question	*n*	%
Is EC an important part of nursing care? Yes No	 14 0	 100 0.0
Are there clear expectations for EC implementation? Yes No	 14 0	 100 0.0
How would you rate your knowledge of EC? Very Good Good Acceptable Poor Very Poor	 0 2 10 2 0	 0.0 14.3 71.4 14.3 0.0
Does your department have EC guidelines for unconscious patients? Yes No	 0 14	 0.0 100

Question	*n*	%
Is the evaluation of eyelid closure performed in critically ill patients who are comatose or mechanically ventilated?		
Always	2	14.3
Very Often	7	50.0
Sometimes	5	35.7
Rarely	0	0.0
Never	0	0.0
List all methods used for eye exposure protection in your unit.		
Artificial eye drops, tape eyes	4	28.6
Cover the eyes with gauze	1	7.1
Eye drops	3	21.3
Eye drops, cover eyes	4	28.6
Eye hygiene	2	14.2
How often is EC performed?		
Always	1	7.1
Very Often	9	64.3
Sometimes	4	28.6
Rarely	0	0.0
Never	0	0.0
How many eye complications have you had in the past year?		
0	4	28.6
1.0	4	28.6
2.0	2	14.3
3.0	2	14.3
4.0	1	7.1
5.0	1	7.1
What was the most recent patient eye complication you or your colleague saw?		
0	3	21.4
Chemosis	1	7.1
Chemosis, Conjunctivitis	2	14.3
Chemosis, Conjunctivitis, corneal ulcers	1	7.1
Conjunctivitis	4	28.6
Dry cornea	1	7.1
Keratitis	1	7.1
Pink eye	1	7.1
What are the barriers in your EC practice?		
Lack of education	9	64.3
Unclear escalation process when there were concerns about a patient's eyes.	3	21.4
No response	2	14.3

IV. CONCLUSION

This study provides rich data on nurses' knowledge of EC in the ICU. The main findings of this study are as follows: (a) after providing the planned education, EC knowledge for ICU nurses increased significantly; (b) overall, nurses were satisfied with the education department program and requested additional educational opportunities; and (c) the nurses involved in this study specifically noted the lack of EC guidelines for ICU patients. The results of this study will lay the foundation for future studies.

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PERCEPTIONS AND BARRIERS ASSOCIATED WITH COVID-19 BOOSTER VACCINATION ACCEPTANCE AMONG STUDENTS AT UNIVERSITIES IN BINH DUONG PROVINCE

Ngoc Diem Nguyen[1], Thi Thanh Hoa Nguyen[2], Thi Anh Nguyen[1], Thi Tuyet Vu[1], Thi Thanh Thuong Nguyen[1]

[1]*Faculty of Nursing, Eastern International University, Binh Duong, Viet Nam*

[2]*Faculty of Economics, Thu Dau Mot University, Binh Duong, Viet Nam*

diem.nguyen@eiu.edu.vn

Abstract: The COVID-19 epidemic has basically been controlled, but it is still complicated with the appearance of new variant strains. Delaying COVID-19 booster vaccination can reduce the rate of herd immunity and increase the risk of a resurgence. **Methods:** A cross-sectional descriptive study was carried among 731 students at 2 universities in Binh Duong province. The objective of this study is to examine the perceptions and barriers associated with acceptance of COVID-19 booster vaccination. **Results:** Students had a high level of perceptions about the COVID-19 booster vaccination. The group of students who accepted the second booster (fourth dose) had a higher perception than the group that decided not to inject ($p < 0.05$). Only 56.5% of students were willing to get the second booster of COVID-19 vaccine. In addition, receiving the first booster (third dose), studying first year and second year had an influence on the decision of getting the second booster ($p<0.001$; CI: 2.696-5.586). The majority of students said that the barriers related to the acceptance of getting the second booster were worries about serious side effects (51.4%), vaccine could be fault (56.9 %), vaccines were developed rapidly (54.6%), unforeseen future effects on health (50.2%) and 45.7% students wanted to choose which vaccines to take. **Conclusion:** Research results show that although students had high level of perceptions, the percentage of students willing to take the second booster was not high. Acceptance group had higher level of perceptions than refusing group. Having the first booster was associated with increased acceptance rate of second booster. The most confirmed barriers of COVID-19 booster vaccination were faultiness of the vaccine, rapid development, serious side effects.

Keywords: *acceptance, barriers, booster vaccination, Binh Duong, COVID-19, perceptions, students*

I. INTRODUCTION

The mass vaccination of populations was considered as one of the key measures to help countries around the world return to normal life after more than 2 years of fighting the COVID-19 pandemic. However, the situation of the pandemic is still complicated and unpredictable in many nations related to new fast-spreading sub-variants of Omicron BA.4 and BA.5 [1]. Hence, the world needs COVID-19 boosters to maintain strong immunization. According to the World Health Organization (WHO), high-risk individuals need to get vaccine

boosters every year and the general population need boosters every two years [2].

In Vietnam, many people who had previously been infected with COVID-19 or being vaccinated have begun to be subjective and neglect to apply preventive measures, especially they have not actively participated in getting booster vaccination. The Ministry of Health forecasted that the number of COVID-19 cases in the coming time may continue to increase and may cause a large-scale outbreak because the antibodies will decline after about 4-6 months after having second primary dose or infection from SARS-CoV-2 virus [3]. Therefore, the booster vaccination is necessary to reduce the risk of severe COVID-19 infection and mortality in the condition of emergence of new variants. According to the finding of a study in Canada, the protection of the fourth dose vaccine was 49% from infection, 69% from symptomatic infection, and 86% from severe outcomes [4]. To prevent another wave of COVID-19 which leads to the morbidity and mortality, the Vietnam Ministry of Health offered a thirst vaccine dose for people aged 18 years and over, a fourth vaccine dose for the target group.

It is clear that booster vaccinations are essential to prevent another surge, but many studies show that a high proportion of people hesitate to vaccinate, especially students who account for a high proportion of the population, and is a source of high risk infection in the community. In addition, the perception as well as the barrier factors related to the acceptance of COVID-19 booster vaccination has not been fully studied. Therefore, this study was conducted with the aim of examining the perceptions and barriers associated with the acceptance of the fourth dose of COVID-19 vaccine among students at universities in Binh Duong province. The results of the study provide scientific evidence that can be used to improve COVID-19 booster plan in Vietnam.

II. METHODOLOGY

A. Study Design And Sample

A cross-sectional survey was conducted to measure the students' perceptions and barriers related to acceptance of COVID-19 booster vaccination from March to September 2022 at two universities in Binh Duong province.

The survey used convenience sampling method. Students who agreed to participate in the study will be sent a questionnaire to answer within 5 minutes. A total of 731 students completed the survey during the data collection period.

B. Survey Questionaire

The structured questionnaire was designed based on Ministry of Health's COVID-19 vaccination guidelines and some previous studies on vaccination acceptance [5, 6]. The questionnaire included 2 parts: Part I was items regarding sociodemographic characteristics, COVID-19 vaccination and infection history, intention to receive a booster vaccine; Part II was perceptions of COVID-19 vaccination, and barriers that affected the decision to get a booster shot.

According to Jamil, the student's level of perception was low with a mean score ranged from 1.00 to 2.33, moderate with a mean score of 2.34 to 3.66, and a high level of perceptions with the mean score between 3.67 and 5.00 [7].

C. Statistical Analysis

Statistical Package for the Social Sciences software (SPSS) version 25.0 was used to analyze the data. Characteristics of the study sample and the acceptance of COVID-19 booster shot presented in the percentage and frequency. Mean and standard deviation (SD) were used to present the perceptions of COVID-19 vaccination. Independent T-test test was used to find statistical significance between accepting and not accepting second booster vaccination group. Finally, binary logistic regression analysis was used to investigate associations of socio-demographics, and vaccination history with willingness to get the fourth dose. A $p<0.05$ was considered significant for all analyses.

III. RESULTS

A. Characteristics of the study sample

Table 1. Sociodemographic characteristics of the participants

Demographic		Frequency	Percentage (%)
Gender	***Male***	200	27.4
	Female	531	72.6
Year of study	***First year***	193	26.4
	Second year	143	19.6
	Third year	176	24.1
	Fourth year	87	11.9
	Final year	132	18.1
Category of students	***Health***	129	17.6
	Non-health	602	82.4
Received third dose	***Yes***	551	75.4
	No	180	24.6
Having previous COVID-19 infection	***Yes***	252	34.5
	No	479	65.5
Family members had previous COVID-19 infection	***Yes***	506	69.2
	No	225	30.8
Sources of information	***News from TV, radio***	480	65.7
	Government agencies	228	31.2
	Social media	465	63.6
	Family and friends	371	50.8
	Healthcare workers	325	44.5
	Others	55	7.5

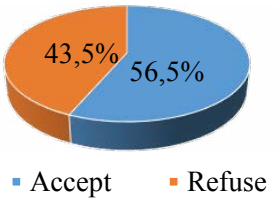

Figure 1. The proportions of second booster vaccination acceptance

As shown in Table 1, of the total sample (n = 731), the majority of the participants were female (72.6%).

More than one-fourth (26.4%) of the participants were first-year students, and only 17.6% were health science students. More than three-fourths (75.4%) of study participants had received a third dose of COVID-19 vaccine. Additionally, only 34.5% of participants were infected COVID-19 previously while more than two-thirds (69.2%) of study participants had relatives having previous SARS-CoV-2 infection. Regarding sources of information about COVID-19 vaccine, news from TV or radio and Social media were the main sources of information for about 65.7% and 65.6% of students respectively.

Overall, just over half of the students (56.5%) reported accepting second booster vaccination if there was a recommendation (Fig. 1).

B. Student's Perceptions Of COVID-19 Vaccination

Table 2 indicates that students had a high level of perceptions of vaccination (Mean = 3.79 ± .49), and there were statistical differences in the mean score of perceptions between acceptance and refusing groups ($p<0.05$). More specifically, those who were willing to get second booster dose were more likely to have the belief "that vaccine is safety, more benefits than risks", "trust in information of COVID-19 vaccine", "vaccine can eradicate the pandemic", and "effectiveness of vaccine" ($p < 0.01$), while students refusing to receive second booster have higher level of mean in perception that "having natural immunity can replace a booster dose".

Table 2. Perceptions of vaccination and second booster vaccination acceptance

Items	Accept	Refuse	t	p
	Mean (SD)	Mean (SD)		
1. The antibody levels will decline steadily after receiving two primary doses of COVID-19 vaccine.	3.15 (1.127)	3.18 (0.980)	-.296	0.767
2. COVID 19 vaccine is safe.	4.10 (0.874)	3.66 (0.898)	6.773	0.000[1]
3. Receiving the COVID-19 vaccine is more benefits than its risks	4.24 (0.854)	3.78 (0.822)	7.365	0.000[1]
4, Taking COVID-19 vaccine is a societal responsibility	4.41 (0.830)	4.04 (0.807)	5.981	0.000[1]
5. Trust in information of COVID-19 vaccine released by the government.	4.36 (0.777)	3.99 (0.831)	6.115	0.000[1]
6. COVID-19 vaccine will help in eradicating the pandemic sooner.	4.18 (0.868)	3.91 (0.860)	4.191	0.000[1]
7. Taking COVID-19 booster vaccination is necessary even for young people.	3.82 (1.187)	3.44 (1.057)	4.542	0.000[1]
8. COVID-19 vaccine is effective against infection.	3.72 (1.192)	3.50 (1.088)	2.595	0.010[1]
9. It is not necessary to get a vaccine booster dose because of having natural immunity from previous infection with COVID-19	3.13 (1.119)	3.33 (1.027)	-2.543	0.011[1]
Total	3.9 (0.48)	3.65 (0.46)	7.181	0.000[1]
	3.79 ± 0.49			

C. Factors associated with second COVID-19 booster vaccination acceptance

Bivariate logistic regression analysis was done to identify factors associated with second booster acceptance among students (Table 3). Accordingly, previous first booster vaccination history against COVID-19 (OR: 3.881; CI: 2.696-5.586; p= 0.000) was a strong predictor of second booster vaccination acceptance. In addition, students studying first year (OR: 1.730; CI: 1.025-2.935; p= 0.04) and second year (OR: 1.845; CI: 1.070-3.180; p= 0.028) (vs. final year) was associated with increased odds of second booster vaccination acceptance. In contrast, there were no significant differences between health care and non-health care students in the acceptance of second booster (p = 0.180). Similarly, COVID-19 infection history of respondents and their family members were not the influencing factors of booster acceptance.

Table 3. Factors associated with second COVID-19 booster vaccination acceptance

Variables and category	OR2	CI3	p
Year of study			
First year	1.730	1.025-2.935	0.041
Second year	1.845	1.070-3.180	0.0281
Third year	1.485	0.883- 2.498	0.136
Fourth year	1.306	0.735-2.320	0.363
Final year	1		
Received third dose			
Yes	3.881	2.696-5.586	0.0001
No	1		

1: pc = 0.05;

2: Odds ratio;

3: Confidence Interval

D. Barriers related to COVID-19 Booster Vaccination acceptance

Fig. 2 indicates that the most common barrier associated with acceptance of COVID-19 vaccination was concern about "faultiness of the vaccine" (56.9%). Other reasons for not accepting booster vaccination were "serious side effects" (51.4%), "rapid development" (54.6%), "unforeseen future health effects" (50.2%) and "cannot choose vaccine to take" (45.7%).

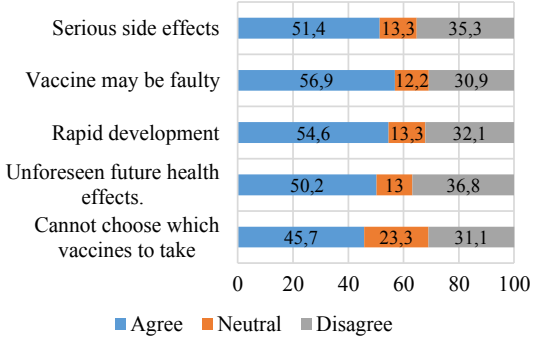

Figure 2. Barriers related to COVID-19 Booster Vaccination acceptance

IV. CONCLUSION

Our findings indicated that of 731 participants, only over a half (56.5%) confirmed to accept second booster of COVID-19 vaccine. This result was much lower than the booster acceptance rate (70.2%) reported by Al Janabi, T. and Pino, M in January 2022 [8]. Additionally, this study revealed that students had high level of perceptions about COVID-19 booster vaccination, and the perceptions related to the acceptance of booster vaccination. These results aligned with the previous study where the perceived safety of COVID-19 vaccine was related to willingness to vaccinate [9]. Our results also indicated that COVID-19 booster vaccination history was strongly associated with increased odds of accepting the second booster dose. Prior studies also found that COVID-19 vaccination history had a positive effect on booster vaccination intention [6]. Besides, students studying first and second year also expressed significantly higher booster acceptance. Some common barriers related to COVID-19 booster vaccination acceptance were concern about "faultiness of the vaccine" "serious side effects" and "rapid development".

In conclusion, the findings of this study have important implications to enhance COVID-19 booster acceptance rate, as well as could help formulate an effective plan for COVID-19 booster vaccination campaigns of the local government in the future.

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ANXIETY, STRESS AND THEIR ASSOCIATION WITH PATIENT CARE COMPETENCIES AMONG NURSING STUDENTS AT EASTERN INTERNATIONAL UNIVERSITY

Nguyen Phan[1], Duyen Tran[1], Dung Nguyen[1], Phung Ha[1]
[1]*School of Nursing, Eastern International University, Binh Duong, Viet Nam*
yenduyen.tran@eiu.edu.vn, nguyen.phan@eiu.edu.vn

Abstract: Nursing students were predicted to have high levels of stress and anxiety due to clinical practice environments, course content, student diversity. This can not only influence their personal well-being and academic performance, but also communication with patients during clinical placement, the quality and safety of the healthcare delivered, clinical practice competence. **Purposes:** The objective of this study is to investigate the relationship between nursing students' anxiety, stress, and their association with patient care competencies of nursing students. **Methods:** A descriptive cross-sectional survey was conducted from May 2022 to August 2022 on 205 nursing students at Eastern International University. Nursing students were selected by convenience sampling method. Data were collected using two subscale Anxiety and Stress of the DASS 21 Scale and a self-designed questionnaire based on basic competency standards for Vietnamese Nurses by Vietnam Ministry of Health *(MOH)* assessed patient care competencies of nursing students including 15 items. **Results:** The research results indicated that a significant negative association was found between patient care competencies of nursing students and stress, anxiety. The results of this study can be applied as reference for the enhancement of a nursing education program to improve the clinical competence of Vietnam nursing students.

Keywords: *patient care competencies, anxiety, stress, nursing students*

I. INTRODUCTION

Stress and anxiety are especially evident in students who undertake clinically-relevant degrees such as nursing [6]. A systematic review of stress in nursing students reported academic factors (examinations, managing study workload and lecturer's expectations) as common causes of mood disruption and clinical factors (causing pain to patients, perceived lack of competency) as common stressors [3]. Previous studies conducted have demonstrated that nursing students' stress, anxiety have a negative impact on their behavior [2, 4, 5]. This can not only influence their personal well-being and academic performance, but also communication with patients during clinical placement, the quality and safety of the healthcare delivered [4].

Patient care competencies is one of the essential requirements in providing nursing care based on professional performance standards [1]. Undergraduate nursing students play important roles in the future nursing profession, and their patient care competencies is essential to ensure the good quality of care and high standard of nursing services [7]. Patient care competencies is defined as the student's ability to incorporate

knowledge, skills, attitudes into specific patient care practices based on Basis competency standards for Vietnamese nurses of Vietnam Ministry of Health [1]. Nursing students are expected to achieve these competencies when they complete their Bachelor nursing program. To improve nursing students' clinical practice competence, many nursing researchers are committed to evaluating and exploring the factors that may affect students' clinical practice competence.

There were few studies that investigated the relationship among stress, anxiety and patient care competencies among nursing students. This study aimed to (1) investigate the overall level of stress and anxiety among nursing students; (2) identify the relationships among stress, anxiety and patient care competencies; (3) explore the factors that influence stress and anxiety of nursing students.

II. METHODOLOGY

A. Design and participants

This cross-sectional study was conducted on all 205 nursing students at Eastern International University on Binh Duong province. The participants were selected by convenience sampling method. The inclusion criteria were as follows: nursing students must have attended three years of the nursing program, those who were engaged in clinical practice and were willing to participate in this study.

B. Instruments

A socio-demographic information questionnaire was also completed by the participants. The questionnaire assessed the participants' age, gender, GPA, length of learning per week, part time job, self-study plan, professional interest.

Anxiety, and stress were measured using the DASS-21 Scale (DASS-21) [6]. The DASS-21 assesses two domains: anxiety and stress. Each domain contained 7 items. Participants gave a score of zero to three (0: did not apply to me, 1: applies to me to some degree, 2: applies some of the time, and 3: applies much of the time), pertaining to how much the participant felt the statements reflected the past week. Scores on the 4-point Likert scale for each domain ranged from normal to severe, with each domain containing different numeric values for each stage and the Cronbach's alpha for total scale was 0.77, and each subscale of stress and anxiety were 0.72, 0.81 respectively.

A self-designed questionnaire based on Basis competency standards for Vietnamese nurses of Vietnam Ministry of Health [1] was used to measure the and patient care competencies of nursing students. This tool comprises 15 items. Scores on the 5-point Likert scale for each item (1: never, 2: rarely, 3: sometimes, 4: often, 5: always). The Cronbach's alpha for total scale was 0.87.

C. Data collection

The data collection was conducted at school of Nursing at Eastern International University from May to July 2022. The researchers approached nursing students and explained the details of study procedure to them. The researchers distributed the questionnaires via the link of google form to students; it took approximately 20 minutes for students to complete the questionnaires, and the completed questionnaires were accepted.

D. Statistical analysis

Descriptive statistics (means, standard deviation, minimum and maximum scores) were used to analyze the participants' demographic data. Besides, bivariate correlations and multiple linear regression models analyses were used to examine the relationships between the variables (CI = 95%, p = .05). All statistical procedures were performed using IBM SPSS 25.0

E. Ethical Considerations

The study was approved by the Scientific Review Committee of School of Nursing at Eastern International University. The nursing students were asked to complete the questionnaire after obtaining written consent and explaining the goals and importance of the study. To comply with ethical requirements, the participation was voluntary and the participants' information was kept confidential and was used only for the purpose of this study.

III. RESULTS

A. Demographic characteristics of the participants

Table 1. Demographic characteristics of nursing students (n = 205)

Variate	Frequency/ Mean	Percentage/ SD
Gender		
Male	14	6.8
Female	191	93.2
Age		
>28	2	1.0
28-26	67	32.7
25-20	136	66.3
School year		
K3	5	1.5
K4	22	10.7
K5	75	36.6
K6	46	22.4
K7	30	14.6
K8	20	14.1
GPA		
Excellent	0	0
Very good	18	8.8
Good	182	88.7
Average good	5	2.5
Courses of clinical practice		
1 course	9	4.4
2-5 course	83	40.4
> 5 courses	113	55.2
Part time job		
Yes	80	39
No	125	61
Self-study plan		
Yes	158	77.1
No	47	22.9
Professional interest		
Yes	142	69.3
Neutral	48	23.4
No	15	7.3

The ages of nursing students ranged from 25 to 20 years old (n=136, 66.3%). Most of them were female (n = 191, 93.2%), and had good level of GPA (88,7). In addition, 95.6% (n = 196) of them performed 2-5 courses of clinical practice at hospitals, 39% (n = 80) of them had part-time job, 77.1% (n = 158) of them had self-study plan, and 69.3% (n = 142) of them had professional interest. The detailed demographics are presented in Table 1.

B. Level of patient care competencies among nursing students

The mean score of the total scale of patient care competencies was 4.12; the standard deviation was 0.64, and the lowest and highest scores were 4.17 and 4.58, respectively. The top five highest level including "**Provides appropriate information to the patients/ clients**" (M 4.58, SD 0.56); Utilizes the nursing

process (M 4.54, SD 0.61); Promotes safety, comfort, and privacy of patients (M 4.52, SD 0.65), Communicates with the patients/clients and families (M 4.48, SD 0.70); Demonstrates knowledge based on the health status (M 4.43, SD 0.76) in Table 2.

Table 2. Level of patient care competencies among nursing students (n=205)

Variables	Mean (SD)	Min	Max
1. Demonstrates knowledge base on the health status	4.43 (0.76)	1	5
2. Provides sound decision-making in the care of patients	4.27 (0.82)	1	5
3. Sets priorities in nursing care	4.42 (0.74)	1	5
4. Utilizes the nursing process	4.54 (0.61)	2	5
5. Promotes safety, comfort, and privacy of patients	4.52 (0.65)	2	5
6. Administer medication safely and effectively	4.23 (0.74)	1	5
7. Performs proper care techniques following nursing care process	4.17 (0.81)	1	5
8. Ensures continuity of care	4.45 (0.74)	1	5
9. Performs first aids and acts on emergencies	4.35 (0.63)	2	5
10. Establishes rapport with patients/clients, families, and member of the health team	4.35 (0.74)	2	5
11. Communicates with the patients/clients and families	4.48 (0.70)	2	5
12. Utilizes formal and informal channels to facilitate communicating with patients/clients, families	4.35 (0.69)	2	5
13. Provides appropriate information to the patients/ clients on their health and fitness status	4.58 (0.56)	3	5
14. Determines needs and performs health education	4.35 (0.72)	1	5
15. Establishes collaborative relationship with colleagues and other members of health team	4.36 (0.83)	1	5
Total	4.12 (0.63)	2.47	5

C. Level of anxiety, stress among nursing students

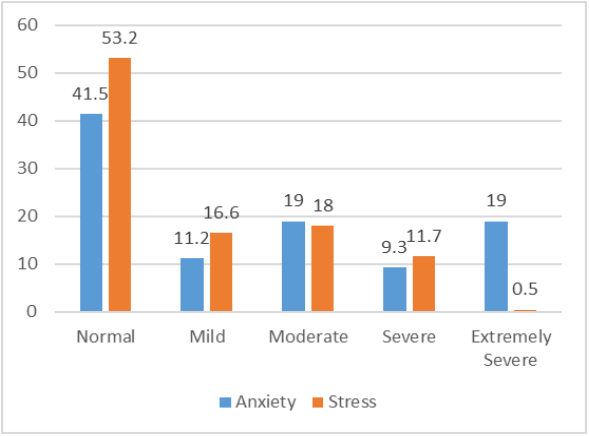

Figure 1. Level of anxiety, stress in nursing students (N=205)

Fig. 1 presents the level of anxiety and stress in nursing students. Most participants had normal levels of anxiety (41.5%) and symptoms of stress (53.2%). Nevertheless, the prevalence of extremely severe levels of anxiety, and symptoms of stress in this study is at 19%, 0.5% respectively.

D. Stress, anxiety among participants with different demographic and professional characteristics

Table 3. Differences between stress, anxiety according to demographic characteristics of nursing students (n = 205)

Characteristics	Anxiety		Stress	
	Mean (SD)	t or F (P)	Mean (SD)	t or F (P)
Courses of clinical practice				
1 course	23.11 (9.64)	**3.25** (0.000)**	18 (8.71)	**1.66* (0.08)**
2-5 course	10.20 (7.12)		15.62 (7.14)	
> 5 courses	11.21 (7.64)		15.58 (7.82)	
Self-study plan				
Yes	14.04 (10.28)	**4.51* (0.035)**	15.82 (8.12)	0.54 (0.816)
No	11.01 (8.02)		15.53 (7.58)	
Professional interest				
Yes	20.67 (11.63)	1.67 (0.191)	17.60 (6.51)	**12.920 ** (0.000)**
Neutral	12.20 (9.45)		16.87 (7.23)	
No	10.59 (7.44)		14.95 (7.90)	

Table 3 presents the comparison of stress and anxiety according to the characteristics of the participants. Students who were interested in the nursing profession (F = 12.920, p < 0.001), studying 1 course of nursing clinical practice (F = 1.66, p = 0.08) reported significantly higher scores of stresses compared to their counterparts. Nursing students studying 1 course of nursing clinical practice (F = 3.25, p < 0.001) have self-study plan (F = 4.51, p = 0.035) reported significantly higher scores of anxiety compared to their counterparts.

E. The relationships among stress, anxiety, and patient care competencies

Table 4. Correlation matrix for patient care competencies, anxiety, stress (n=205)

Variables	Patient care competencies	Anxiety	Stress
Patient care competencies	1		
Anxiety	-0.297**	1	
Stress	-0.096	0.66**	1

Significant correlations were found among the anxiety, stress and patient care competencies of nursing students. Stress was negatively correlated with anxiety (r = - 0.297, p <0.01). Anxiety was positively correlated with stress (r = 0.66, p< 0.01). (Table 4)

F. Associated factors of stress and anxiety among nursing students

Table 5. A multiple linear regression analysis of anxiety and stress among nursing students (n=205)

Independent variable	Anxiety		Stress	
	β (CI 95%)	p	β (CI 95%)	p
Course of Clinical practice	-1.33 (-3.41-0.74)	0.21	0.47 (-0.98-1.92)	0.523
Part-time job	-0.86 (-3.16-1.42)	0.46	0.50 (-1.09-2.10)	0.53
self-studying plan	-1.60 (-4.39-1.18)	0.26	1.21 (-0.73-3.16)	0.22
Professional interest	-1.67 (-3.74-0.39)	0.11	-0.98 (-1.55-1.35)	0.89
Patient care competencies	-3.63 (-5.99-1.26)	0.003**	1.04 (-0.64-2.72)	0.22
GPA	-3.10 (-5.99-2)	0.036*	0.89 (-1.14-2.93)	0.39
Adjusted R-squared	0.131		0.466	
No. observations	205			

Note: * *p<0.05, ** p< 0.01*

Performing a multiple linear regression analysis to identify the significant factors affecting anxiety and stress of nursing students. The factors with statistical significance (p<0.05) with level of anxiety including GPA, patient care competences. After controlling the other variables, GPA (β = -3.10, P = 0.036), patient care competencies (β = -0.63, P<0.001) were significant factors associated with anxiety, accounting for 13.1% of the total variance (Table 5).

IV. CONCLUSION

The results of this study indicated that nursing clinical competence is very important for nursing students. All influencing factors should be taken into consideration when developing a nursing curriculum to optimize nursing students' learning and improve the quality of care for the patients.

ACKNOWLEDGMENT

We are grateful to Eastern International University for supporting this study, and we wish to acknowledge nursing students who participated in this study.

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IMPACT OF COVID-19 OUTBREAK ON PATIENT CARE IN KHANH HOA PROVINCIAL GENERAL HOSPITAL

Phung Le Tan[1], Chinh Phan Huu[2], Anh Tran Bao[2]

[1]*School of Nursing, Eastern International University, Binh Duong, Viet Nam*

[2]*Khanh Hoa Provincial General Hospital*

phung.le@eiu.edu.vn

Abstract: Covid-19 outbreak has put long-term pressure on social-economic status globally, including countries' health care system. Khanh Hoa Province has experienced the Covid-19 outbreak starting at the beginning of 2020. The General Hospital of the Province has reported the decrease in its performance during the outbreak but yet statistically analyzed to clarify which aspects were affected. To analyze the performance of Khanh Hoa Provincial General Hospital before and during the Covid-19 outbreak from 2019 to the first six months of 2022. Data were collected through monthly reports of the Hospital. Data were then transformed to R format to analyze using R programming version 4.1.2. Total patient visits, admissions, surgery, hospital referral, and laboratory and imaging data were analyzed. Kruskal-Wallis and Wilcoxon tests were used to compare related medians for three-year period, 2019-2021, and the first six months of two years 2021 and 2022, respectively. Boxplots were created to visually compare related variables. Compared with the year 2019, the number of patient visits and admissions in 2020 and 2021 significantly decreased by 11.2% and 32.9%, respectively. A similar statistically significant decrease was also observed in the number of admissions by 9.3% and 23.1% in the years of 2020 and 2021. However, the number of surgeries performed was slightly decreased and not statistically significant. Furthermore, all kinds of imaging and laboratory procedures during three years were even increased although yet significant. Main hospital statistics, patient visits and admissions, have significantly decreased during the Covid-19 outbreak. There was still no indication of recovery in the first six months of the year 2022. However, surgery performance and imaging and laboratory statistics were not affected during pandemic time.

Keywords: *Covid-19, outbreak, Khanh Hoa, patient visit, admission*

I. INTRODUCTION

Since the end of the year 2019, Covid-19 pandemic has spread across the continents that enormously impacts the socio-economic system of the whole world. The most and first impact has been put upon the health care system of every country. On the one hand, Covid-19 pandemic has imposed the overloading of Covid-19 patients, especially in ICU departments of infectious or tropical disease hospitals. On the other hand, the pandemic has made a drop in patient visits and admissions in other hospitals. Isolation, social distancing, and lockdown policy have contributed mostly to this situation.

At the peak of the pandemic in March 2020, a drop at 12.6% in the total number of STEMI patients (ST-Elevation Myocardial Infarction) as compared to the mean number treated in the March months of the preceding years was reported in 41 specialty hospitals in Germany [1].

In emergency departments (ED), a study in Finland showed that national lockdown has made a decrease of 16% in emergency department visits and 15% in inpatient admissions. Visits due to back or limb pain decreased by 31% and infectious diseases by 28%. However, these statistics remained stable in acute myocardial infarction and strokes [2].

Using incident rate ratio (IRR) to compare daily numbers of medical/surgical hospital admissions via the ED between March 16-September 23, 2019 (pre Covid-19) and March 16-September 23, 2020 (post Covid-19 public health measures), study conducted by Rennert-Mayet al [3] in Alberta, Canada reported a significant reduction in both daily medical (incident rate ratio (IRR) 0.86, $p<0.001$) and surgical (IRR 0.82, $p<0.001$) admissions through the ED. A significant decline in daily ED visits (IRR 0.65, $p<0.001$) was also observed. However, the number of admissions for mental and behavioral disorders due to the use of alcohol increases instead.

In China, a pandemic center of the world, a decrease in outpatient and inpatient cases was reported in a pediatric tertiary hospital in Wenzhou [4]. Up to 55.9% and 46.7% decline were disclosed in the number of outpatients and inpatients respectively during a time frame of 22 weeks since the beginning of the pandemic (from December 30, 2019 to June 2, 2020), compared with data from the same period in 2019.

At national level, a retrospective observational cohort study of health services utilization from health facilities in mainland China has been conducted based on the statistics of monthly all-cause health facility visits and inpatient cases in health facilities before and during the SARS-CoV-2 outbreak (from January 2016 to June 2020). Main findings of this study included, (1) The magnitude of decline of all-cause visits at hospitals or at primary care units in February ranged from 10% to 71%; (2) The reductions in both health facility visits and inpatient volume were greater in hospitals than in primary health care facilities and greater in developed regions than in underdeveloped regions; and (3) by June 2020, nearly all indicators except outpatient and inpatient volume in regions with low HDI (Human Development Index) and inpatient volume in private hospitals had not achieved their pre-SARS-COV-2 forecasted levels [5].

In Vietnam, there were studies on the impact of Covid-19 pandemic on socio-economic status [6,7]. Some researchers investigated the overwhelming workload situation of health care staff in coping with the outbreak [8,9]. However, not many studies relating to the performance of general hospitals were conducted.

Khanh Hoa Province announced the first confirmed case of Covid-19 at the end of January 2020. The number of detected cases increased and spread across all districts of the province. The highest wave of the outbreak was reported in the last three months of 2021.

This study extracted data of hospital indicators from monthly reports to investigate the impact of Covid-19 pandemic on the activity of Khanh Hoa provincial general hospital.

II. METHODOLOGY

Data were collected through monthly reports of the Hospital, from January 2019 to June 2022. Data were then transformed to R format to analyze using R programming version 4.1.2. Total patient visits, admissions, surgery, referral, and laboratory and imaging data were analyzed. Kruskal-Wallis and Wilcoxon tests were used to compare related medians for three-year period, 2019-2021, and the first six months of two years 2021 and 2022, respectively. Boxplots were created to visually compare related variables.

III. RESULTS

A. Data description and exploration

Monthly data collected to be analyzed include patient visits, inpatient admissions, performed surgeries, number of laboratory and imaging diagnostic procedures, and number of referrals to higher-level hospitals. These variables were examined their distribution using histograms to see whether the distributions are normal on nearly normal.

Fig. 1 shows non-normal distribution of the six variables. The following statistical analysis therefore would be non-parameter approach. Median and IQR (Interquartile Range) would be used instead of Mean and SD (standard Deviation).

Figure 1. Histograms of six variables

B. Hospital Indicators during three year, 2019-2021

Six indicators as mentioned above were analyzed based on comparison related medians through three years to explore possible significant differences across this period of time.

Kruskal Wallis test showed statistically significant differences at the level of less than 0.01 in the number of patient visits and inpatient admissions with the reference is the medians in 2019. Table 1 showed the decreasing percentages of patient visits was 11.2% in 2020 and 32.9% in 2021, compared with the numbers in the year 2019. The results for the number of inpatient admissions were 9.3% and 23.1%, respectively.

The decline of the above two indicators is higher in the year 2021 when the outbreak peak was at the end of 2021.

Table 1. Comparison of the main six hospital indicators during three years, 2019-2021

Year	Median	Min	Max	IQR	% Changed	Kruskal Wallis Test
Patient visits						
2019	33,108	26,109	37,903	2,400	ref.	χ^2 = 17.19 p = 0.00018
2020	29,416	22,683	33,893	2,800	- 11.2	
2021	22,222	6,326	34,040	9,399	- 32.9	
Inpatient admissions						
2019	7,610	6,135	8,499	730	ref.	χ^2 = 14.36 p = 0.00076
2020	6,902	5,034	8,026	1,271	- 9.3	
2021	5,848	1,928	7,834	2,110	- 23.1	
Performed Surgeries						
2019	1,840	1,177	2,179	224	ref.	χ^2 = 2.975 p = 0.2259
2020	1,832	1,302	2,293	265	- 0.4	
2021	1,518	413	1,518	682	- 17.5	
Labo and imaging						
2019	131,514	106,219	142,943	10,870	ref.	χ^2 = 0.294 p = 0.863
2020	128,260	98,411	152,321	29,494	- 2.5	
2021	132,882	66,688	300,027	40,208	+1.0	
Referral						
2019	1,004	823	1,948	199	ref.	χ^2 = 8.87 p = 0.0118
2020	948	547	1,480	148	- 9.2	
2021	524	132	1,754	436	- 49.8	

The decreased magnitude was higher in the number of patient visits than in inpatient admissions. Social distancing and lockdown policy could be the cause of this reduction. However, performed surgeries were slightly reduced but not statistically different. Further, laboratory and imaging diagnostic procedures even increased in 2021 compared with 2019.

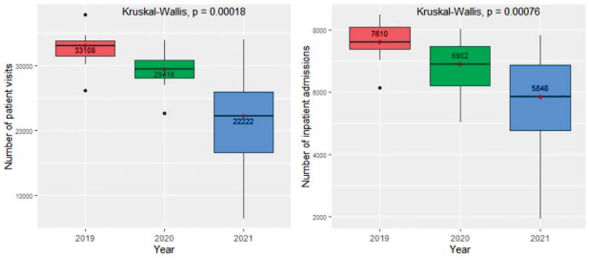

Figure 2. Boxplots of patient visits (left) and admissions (right) in 2019-2021

A possible explanation for this could be that there were more patients with serious condition that needed to be operated or more laboratory tests or imaging diagnostic procedures.

Fig. 2 showed three non-overlapped boxplots visualizing medians of patient visits during three years with Kruskal Wallis test at a significant level < 0.001.

A similar pattern was also observed in the indicator of inpatient admissions. Although with a less magnitude, the reduction in this indicator was statistically different as seen three boxplots with a more dispersion of data in the years 2020 and 2021.

C. Comparison of patient visits and admissions by gender

To explore the difference of patient visits and admissions by gender for three years, statistics in Table 2 showed a significant decrease across three years in both males and females with a larger magnitude in females.

Table 2. Patient visits and inpatient admissions by gender

Year	Male		Kruskal Wallis Test	Female		Kruskal Wallis Test
	Median	% Changed		Median	% Changed	
Patient visits						
2019	**15,592**	**ref.**		**17,416**	**ref**	
2020	**13,886**	**-10.9**	**χ^2 = 19.059**	**15,481**	**- 11.1**	**χ^2 = 16.572**
2021	**10,436**	**-33.1**	**p < 0.001**	**11,490**	**- 34.0**	**p = 0.0002**
Inpatient admissions						
2019	**3,414**	**ref.**		**4,229**	**ref**	
2020	**2,997**	**-12.2**	**χ^2 = 12.848**	**3,905**	**- 7.7**	**χ^2 = 13.695**
2021	**2,592**	**-24.1**	**p = 0.0016**	**3,254**	**- 23.1**	**p = 0.0011**

Reduction in patient visits was higher in Female and both genders were significant difference across three years.

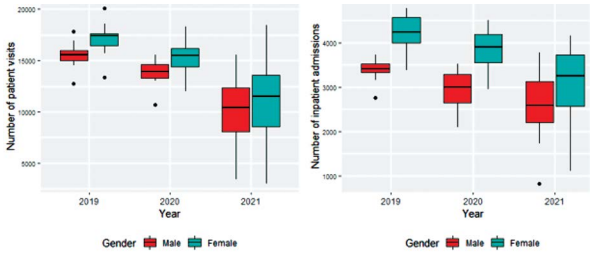

Figure 3. Boxplots of patient visits (left) and admissions (right) by gender in 2019-2021

D. Main Indicators in the first six months of 2021 and 2022

Patient visits and admissions in the first six months of 2021 and 2020 were compared to examine a possible recovery of the hospital performance after the outbreak peak and after easing strict quarantine and social isolation from the end of year 2021.

Analysis showed that a decline in median of patient visits (by 9%) and a slight increase in median of inpatient admissions (0.3%) were reported but no significant difference was found as shown based on the result of Wilcoxon Test (Table 3). This finding implies that Covid-19 outbreak continued to impact the patient care activity of the hospital for a while.

Table 3. Patient visits and patient admissions in the first 6 months of years 2021-2022

First 6 months of year	Median	Min	Max	IQR	% Changed	Wilcoxon Test
Patient visits						
2021	27,082	23,157	34,040	5,575		W = 25
2022	24,636	17,558	27,188	6,665	- 9.0%	p = 0.3095
Inpatient admissions						
2021	6,411	5,582	7,339	1,293		W = 24
2022	6,431	4,389	6,698	893	+ 0,3%	p = 0.3939

Fig. 4 presented boxplots that illustrate the comparison of patient visits and patient admissions during the first six months between year 2021 and 2022. Although median of inpatient admissions in six months of the year 2022 was higher than that of the year 2021, the data distribution of the first six months of 2022 was highly skewed, and its 25% quartile and 75% quartile were less than the previous year.

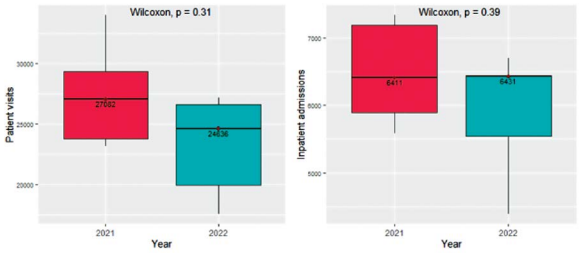

Figure 4. Patient visits (left) and patient admissions (right) in the first six months of the years 2021 and 2022

IV. CONCLUSION

Examination of monthly data of Khanh Hoa Provincial General Hospital before and during Covid-19 outbreak demonstrated a significant impact on hospital activities regarding patient visits, inpatient admissions, and patient referrals to the hospitals at upper level. A decline up to 32.9% in patient visits and 23.1% in inpatient admissions were reported in year 2021 compared with year 2019. Because of the procedures of social isolation and strict quarantine during the peak time of the outbreak in year 2021, a decrease up to 49.8% in hospital referral was reported in comparison with 2019.

There was yet evidence of recovery after outbreak peak and after easing social isolation and strict quarantine in the first six months of 2022 compared with the same period of the previous year.

However, performed indicators relating to surgery and laboratory–imaging examination were not affected during the outbreak of Covid-19.

More studies should be conducted to investigate thoroughly the impact of Covid-19 pandemic on the hospital system at the provincial and national levels.

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THE EFFECTS OF EMPOWERING LEADERSHIP IN HEALTHCARE ON NURSES' JOB-RELATED OUTCOMES: A STUDY IN VIETNAM

Quang Nguyen Minh[1], Hau Le Nguyen[2]
[1]*Eastern International University, Binh Duong, Viet Nam*
[2]*University of Technology Ho Chi Minh City*
quang.nguyen@eiu.edu.vn, lnhau@hcmut.edu.vn

Abstract: In modern healthcare, nursing is one of the core pillars and nurses' job-related outcomes have a significant linkage with nursing quality and patient experience. Today's nurses, however, are facing numerous work challenges of being stressed, dissatisfied with their job and uncommitted to their profession, which can negatively affect their work performance. Meantime, the deficiency of leadership among healthcare providers constrains quality improvement in healthcare organizations. In terms of management, by engaging the entire staff members and empowering them to act, empowering leadership shows many transformational characteristics that a nursing manager in hospitals should have. The research objectives are to examine the impacts of a nurse's perception on empowering leadership behaviors on his or her job satisfaction, job stress, career commitment and job performance and to provide managerial recommendations regarding empowering leadership practices for managers in healthcare organizations to enhance nurses' job-related outcomes. The research model is built to explore the underlying correlations among the five concepts empowering leadership, job satisfaction, career commitment, job stress and job performance. The data (N=227) for analyses was collected from nurses of diverse demographic backgrounds in different kinds of hospitals in Binh Duong Province. Results of this empirical study reveal that empowering leadership directly has a positive impact on nurses' job satisfaction but a negative correlation with their job stress. By increasing job satisfaction, empowering behaviors of nursing managers indirectly fosters nurses' career commitment and job performance. Empowering managers also can enhance a nurse's job performance by reducing their stress at work. Besides some similarities with theoretical literature, the findings show dissimilarities of independent correlations of career commitment with other factors empowering leadership, job stress and job performance. This possibly results from the nature of the nursing profession and the characteristics of the healthcare working environment in Vietnam.

Keywords: *nursing quality, patient experience, nurses, empowering leadership, job satisfaction, career commitment, job stress, job performance*

I. INTRODUCTION

In modern healthcare, nursing work has a great contribution to enhancing patient-centeredness, efficiency of care delivery and the overall quality of care. Among healthcare

professionals, nurses are those who spend most working time providing direct care for patients [1], [9]. Happening in every step of a patient's journey, nurses' work contributes to creating values in healthcare services by connecting and ensuring expected outcomes of all curing activities as well as improving processes and the organizational environment where these services are delivered [8]. Improving nurses' performance directly and largely affects nursing quality and patient experience; however, the transformation in modern healthcare has caused several professional challenges of being stressed, undervalued, and decline in professional satisfaction and commitment for nurses. This problematic situation creates a big question of how to manage nurses' performance at work to ensure outcomes of nursing quality and make them more committed to this profession.

Leadership styles and behaviors are among the key factors that influence employees' satisfaction, stress, commitment and performance [6]. Unlike the common belief that leadership only occurs at top level, it happens at any organizational level and becomes one of the important competencies for any healthcare professionals [7]. Nurse leaders or managers are able to increase patient safety and improve the working environment for the staff by using appropriate managing strategies [3]. It is essential for nurse managers to have the ability to involve all staff nurses, which helps increase their job satisfaction and retention [3]. Empowering leadership behaviors, based on support-related concepts [2], show many suitable characteristics that a manager in modern healthcare should have such as informative, participative, supporting, empowering, etc. Therefore, it is necessary to have a deep study of the effectiveness of this kind of leadership in the healthcare context in Vietnam where the traditional kind of autocratic leadership still dominates.

This study aims at investigating the effects of empowering leadership on nurses' job-related outcomes in Vietnamese healthcare context. Through the findings, nurse leaders or nursing managers or other members of management teams in hospitals can know how to empower their nurse staff so as to reduce stress, promote job satisfaction, career commitment and job performance of nurses for the ultimate purpose of enhancing quality of care for patients. This research will also give empirical proof to the theoretical construct of empowering leadership in organizations, particularly in healthcare context for further studies.

After reviewing research literature, nine hypotheses and research model were formed as follows:

H1: Empowering leadership behaviors have a positive effect on nurses' job satisfaction.

H2: Empowering leadership behaviors have a positive effect on nurses' career commitment.

H3: Empowering leadership behaviors have a negative effect on nurses' job stress.

H4: Empowering leadership behaviors have a positive effect on nurses' job performance.

H5: Job satisfaction has a positive effect on nurses' career commitment.

H6: Job stress has a negative effect on nurses' career commitment.

H7: Job satisfaction has a positive effect on nurses' job performance.

H8: Career commitment has a positive effect on nurses' job performance.

H9: Job stress has a negative effect on nurses' job performance.

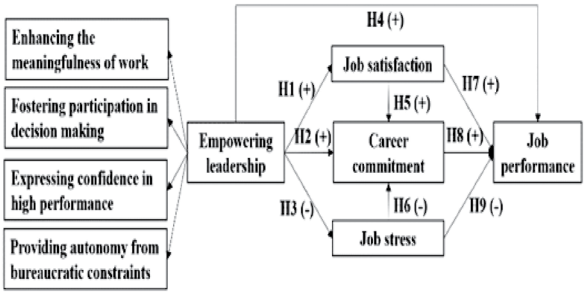

Figure 1. Research model

II. METHODOLOGY

The study was initiated by reviewing much theoretical literature regarding diverse concepts of leadership in healthcare, empowering leadership behaviors, job satisfaction, job stress, career commitment and job performance. Through the preliminary research, nine hypotheses and a research model have been established to test the underlying correlations among the conceptualized constructs.

The research process concludes with two main stages: pitot test and main study. Many qualitative interviews with professionals in the field were conducted to ensure the consistency, meaning, wording and the appropriateness of the measuring scale in the healthcare environment before delivering paper questionnaires to 45 nurses in the pilot test. In the main study, online and offline surveys were carried out to ask 254 nurses from four hospitals. The selected sample is representative enough for the participants from a wide range of departments in both private and public hospitals and from class 3 to class 1 hospitals. After eliminating responses with uncompleted answers or one answer for most questions, 227 responses were selected to test the hypotheses and the research model fit.

Upon the completion of data collection and screening, an official set of data was tested with SPSS version 21.0 for getting insights about participants' demographic information, Exploratory Factor Analysis (EFA) test for unidimensionality and reliability of the measurement scale. Then retained variables were continued with Confirmatory Factor Analysis (CFA) test, test of convergent validity, discriminant validity, composite reliability of the whole model measures and finally the fitness of the model with Structural Equation Modeling (SEM) analysis on AMOS software.

III. RESULTS

A. Sample descriptions

By using paper survey questionnaires and online surveys, 254 responses were recorded from nurses in four hospitals in Binh Duong province (Becamex International Hospital, Tan Uyen Hospital and Binh Duong Traditional Medicine Hospital, Binh Duong Provincial General Hospital). The data was synthesized in an Excel file prepared for preliminary screening. After eliminating uncompleted and one-answer-for-all responses, only 227 responses were used for the study. For the sample size should be five times the number of the measuring variables in the questionnaire [5], a sample size of 227 observations can be relatively accepted to be analyzed in 46 variables in the questionnaire.

A summary of demographic information of respondents is shown below:

Table 1. Sample descriptive statistics

	Frequency	%
Gender		
Male	33	14.5
Female	194	85.5
Age Range		
Under 25	12	5.3
From 25 to 35	165	72.7
Above 35	50	22.0
Working Experience		
Under 3 years	16	7.0
3 -7 years	97	42.7
Above 7 years	114	50.2
Qualification		
Vocational Certificate	73	32.2
College Degree	91	40.1
University Degree	62	27.3
Others	1	0.4
Hospital		
Private	110	48.5
Public	117	51.5
Unit		
Clinical	173	76.2
Subclinical and Outpatient	54	23.8

B. Preliminary assessment, uni-dimensionality and reliability assessment of measurement scales

For preliminary assessment of measurement scales, a factor analysis technique is conducted on SPSS to investigate the correlations amongst variables and the reliability of the measuring scales.

In the first step of EFA, a uni-dimensionality test using the method Principal axis factoring and Promax rotation is conducted to discover the underlying structure of measured variables of a construct. The result showed that measuring scales of empowering leadership (12 items) with four sub-categories ensure unidimensionality. However, measuring scale for job satisfaction (8 items), career commitment (8 items), job stress (8 items), job performance (10 items) did not satisfy criteria. Eight items were eliminated and measuring scales all extracted one factor and factor loading of items range from 0.550 to 0.875.

The next step in EFA analysis is to test the reliability or internal consistency of the measuring scale using Cronbach's Alpha. After eliminating 8 items from the unidimensionality test, the retained measuring scales all satisfied the criteria of the reliability test. Cronbach's Alpha of these scales are all fluctuating from 0.805 to 0.882 and corrected-item-total-correlation indexes of items are between 0.470 to 0.781.

C. Assessment and refinement of measurement scales with CFA analysis

Confirmatory factor analysis (CFA) was executed on AMOS 21.0 to assess and refine the entire research model. 38 retained items measuring 5 constructs from the previous test were input in this analysis. As proposed by [4], absolute fit measures RMSEA value should be under the cut-off points at 0.08 and incremental fit measures CFI and TLI should be at least 0.9.

The whole model measurement was refined by discarding 14 items having significant covariance of the error terms and low CFA factor loading. The remaining 24 variables were retained, and the research model was a satisfactory fit with RMSEA = 0.063, CFI=0.911 and TLI=0.928.

The entire measurement of the research was also tested for convergent validity, discriminant validity, composite reliability via running Plugin tool in AMOS software.

Composite reliability indexes are all between 0.809 and 0.868. The model also ensures convergent validity with Average Variance Extracted AVE from 0.585 to 0.687. MSV are all smaller than AVE and inter-construct correlations among measures are all smaller than Square Root of AVE.

D. Testing Structural Equation Modeling and hypotheses

a) Testing Structural Equation Model:

After the CFA test, SEM analysis was executed to test the causal relations amongst concepts: empowering leadership, job satisfaction, career commitment, job stress, and job performance. The analysis was performed with bootstrap ML method of 500 which helps to confirm the appropriateness and validity of the model at larger scale.

The result of SEM analysis shows that the research refined model is fitted with RMSEA = 0.064, TLI = 0.908 and CFI = 0.921.

b) Hypotheses testing:

Through the testing results, only five hypotheses whose significant value less than 0.05 were supported. Among these supported hypotheses, empowering leadership behaviors have a positive effect on nurses' job satisfaction but have a negative effect on nurses' job stress; nurses' job satisfaction has a positive effect on nurses' career commitment and job performance while nurses' job stress has a negative effect on nurses' job performance.

The squared multiple correlation coefficient, R^2, of job stress is 0.417, which indicates that its predictors can explain 41.7% of its variance. The result R^2 of job satisfaction is 0.408, which explains 40.8% of its variance. The R^2 of job performance is 0.360, which explains 36% of its variance. The R^2 of career commitment is 0.193, which explains 19.3% of its variance. In the reflective second-order construct of empowering leadership, the coefficient of determination R^2 of its four components enhancing the meaningfulness of work, fostering participation in decision making, expressing confidence in high performance and providing autonomy from bureaucratic constraints are respectively 0.571, 0.581, 0.823 and 0.204.

Table 2. Hypothesis testing results

Hypothesis	Beta	P value	Result
H1: Empowering leadership behaviors have a positive effect on nurses' job satisfaction.	.64	.004	Support
H2: Empowering leadership behaviors have a positive effect on nurses' career commitment.	.07	.746	Not supported
H3: Empowering leadership behaviors have a negative effect on nurses' job stress.	-.65	.004	Support
H4: Empowering leadership behaviors have a positive effect on nurses' job performance.	.08	.556	Not supported
H5: Job satisfaction has a positive effect on nurses' career commitment.	.35	.016	Support
H6: Job stress has a negative effect on nurses' career commitment.	-.07	.541	Not supported
H7: Job satisfaction has a positive effect on nurses' job performance.	.24	.049	Support
H8: Career commitment has a positive effect on nurses' job performance.	-.08	.398	Not supported
H9: Job stress has a negative effect on nurses' job performance.	-.42	.004	Support

IV. CONCLUSION

Modern healthcare is transforming in approaching a greater balance between "curing" and "caring" and nursing work has undoubtedly become one of the main factors determining the quality of healthcare services provided by hospitals and can create distinct value for the general healthcare system [9]. Nurses now account for approximately 59% of the workforce in the healthcare sector around the world [10] and the authorities, policymakers, leaders, and managers in any healthcare provider should pay more attention to this group of professionals.

A. Summary of findings

The research result reveals that nursing in hospitals mostly feels empowered by their direct managers in four main groups of behaviors: enhancing the meaningfulness of work, encouraging participation in making decisions, expressing confidence in high performance and giving more autonomy from bureaucratic constraints. The first three groups show a strong correlation with empowerment of nursing managers from the staff's perception whilst the last group of behavior is not popular.

Empowering leadership indicates a positive influence on nurses' job satisfaction. Once nurses are more empowered by their direct managers, they show higher levels of satisfaction with the relationship at the workplace, particularly with their direct manager and other direct colleagues. Moreover, they are also more content with the general working conditions which is publicly seen as the drawback of most hospitals in the current time. On the contrary, empowering managers can help to decrease a certain amount of job stress for nurses. When empowered, nurses find it easier to talk to their direct managers and colleagues and seek support from their managers. This comfortable feeling results in positive mental health of nurses and contributes to lessening their tension when dealing with disease, injuries and people with high mortality rates every day.

Through job satisfaction and job stress, empowering behaviors of managing personnel have an indirect influence on nurses' job performance. Nurses' job satisfaction and job stress, however, have opposite correlations with how nurses perform at work. The more satisfied and less stressed nurses tend to have better performance. These nurses show much more energy and enthusiasm in their work. These positive attitudes also create an invisible motivation for nurses to do better than expected so that their managers do not have to complain about the quality of work they are responsible for.

Nurses' career commitment appears to show no correlation with empowering leadership, job stress or job performance. Their decision to stay in the profession is not affected by the way their managers behave. This conclusion can be understandable because when nurses choose to work in the healthcare field, they are mentally prepared for the inevitability of work pressure and numerous standards and requirements to follow which largely formulate their work performance. However, nurses' career commitment can be improved by increasing their job satisfaction. The more satisfied they are with their job, the better feeling they want to remain in the career regardless of financial condition.

B. Study implications and further research

Nowadays healthcare quality is judged by not only treatment efficiency but also nursing services. In fact, healthcare is still a sensitive field and most of the research work focuses on the clinical aspect rather than management improvement in healthcare institutions. Apparently, nurses are frontline service providers in hospitals and their performance can have a significant effect on patient experience and even the overall result of the treatment process. This study brings unique values when it provides the management team in hospitals with useful insights of how managing behaviors can make effects on nurses' job satisfaction, job stress, job performance and career commitment. Rather seeking solutions from external factors, recommendations of this research suggest the managers several ways of how to improve nurses' job-related outcomes through their own managing behaviors. Once nursing managers apply empowering behaviors appropriately, they can foster job satisfaction and reduce job stress for nurses. Consequently, nurses' job performance and career commitment can be improved. This support is not only beneficial for hospitals to ensure their provided service quality but also contributes to keeping nurses more committed to the nursing field regarding the fact that there is a great shortage of this workforce in hospitals in Vietnam.

In the future, however, there should be more investigations on the correlation between leadership and concepts of commitment, performance not only at individual level but at organizational level. Furthermore, since leadership is a complex term and managers in healthcare should be flexible when leading their subordinates, an integrated research of multi kinds of leadership behaviors would offer a possibility for a clearer picture of characteristics of effective management in healthcare institutions.

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LONG-TERM PHYSICAL AND MENTAL HEALTH EFFECTS OF POST-COVID-19 AMONG STUDENTS AND STAFF SURVIVORS OF THE UNIVERSITIES IN BINH DUONG PROVINCE

Thi Anh Nguyen[1], Ngoc Diem Nguyen[1], Thi Minh Phuong Ha[1], Thi Oanh Nguyen[2], Quoc Minh Truong[3]

[1]*Faculty of Nursing, Eastern International University, Binh Duong, Viet Nam*

[2]*Imaging Department, Binh Duong General Hospital*

[3]*Faculty of Management Science, Thu Dau Mot University*

anh.nguyen@eiu.edu.vn

Abstract: We conducted comprehensive, discernible health consequences and sequelae among COVID-19 survivors in Binh Duong provinces. The descriptive cross-sectional research was conducted with 409 COVID-19 survivors who are students and staff at universities in Binh Duong province to assess the long-term effect of COVID-19 on survivors' physical and mental health. The results show that 98% of COVID-19 survivors reported at least one symptom. Post-COVID symptoms are reported in all organ systems. The most common sequelae among the COVID-19 survivors such as memory loss (76%), attention disorder (71.3%), fatigue (66.3%), cough (64.3%), sleep disturbance (55.7%), feeling out of breath (59.9%), coughing up mucus (51,1%). The linear regression model showed that the factors that there are some factors which were positively correlated with the appearance of post-COVID-19 symptoms include: the number of symptoms of infection COVID-19 and duration of treatment, number of times re-infected with COVID-19. Meanwhile, recovery time was negatively correlated with the appearance of post-COVID-19 symptoms. Besides, women had higher post-COVID-19 symptoms than men.

Keywords: *COVID-19, COVID-19 survivors, Post-COVID-19 symptoms*

I. INTRODUCTION

The world has been facing the COVID-19 epidemic and its impact on all aspects of life. Variants of Coronavirus are constantly appearing with different degrees of severity of illness and rapid spread every day. Like COVID-19 disease, post-COVID-19 syndrome is still very new, medicine is still being researched. The previous studies showed that the post-COVID-19 condition is quite common and is reported by many studies. COVID-19 survivors reported that they had got many health issues such as respiratory symptoms, fatigue, reduced ability to function, and quality of life after infection [1], [2]. According to Kazuki Matsumoto, approximately half COVID-19 survivors had some physical symptoms after COVID-19 and that post-COVID-19 conditions may lead to the onset of mental disorders [3]. This shows that COVID-19 affects both physically,

mentally, and economically and it is necessary for models or measures to support patients after COVID-19 especially those of working age. In Vietnam, the data on the physical and mental health among COVID-19 survivors is limited. Hence, this study was done with the intention to provide baseline data related to the long-term impact of COVID-19 on the physical and mental health of COVID-19 survivors who are staff and students at universities in Binh Duong, Vietnam. For this reason, the purpose of the present study was to assess the prevalence of long-term COVID-19 symptoms and determinant-influenced factors of occurrence post- COVID-19 symptoms.

II. METHODOLOGY

A. Study Design

We conducted a cross-sectional study at Eastern International University and Thu Dau Mot University, Binh Duong Province, Vietnam from February to July 2022 and collected the data through a questionnaire. The only eligibility criterion was staff and students who have been infected and have a certificate of negative for COVID-19 for at least 2 weeks. The sample size was calculated based on the formula for an unlimited population.

$$n = \frac{Z^2}{4e^2} = \frac{(1.96)^2}{4(0.05)^2} = 385$$

n – Minimum sample size

Z – 95% confidence interval, at 1.96

e – The acceptable sample error (±0.05)

B. Data Collection

Data was collected using a structured questionnaire designed based on common post-COVID-19 symptom reports [4]. Participants were interviewed face to face, responding to occur commonly post-COVID-19 symptoms.

C. Statistical Analysis

Data was analyzed by using Jamovi version 2.2.5. For categorical variables, we used descriptive statistics which was performed with frequencies and percentages. A multivariable linear regression model was used to predict factors affecting symptom appearance of post-COVID-19 survivors. All the significant differences in variables were considered if the p-value showed <0.05.

III. RESULTS

A. Baseline Characteristics of Participants

Table 1 indicates that the majority of participants are aged between 18 - 45 years old (95.6%), 54.2% of participants were female and most of them were treated at home (96.6%), the duration of treatment is a 1-week accounting for 68%. 63.2% of participants had completed the third vaccination before infection (52.8%). Besides, 42 participants have reinfected COVID-19 for the second time. Most of the patients took common flu medicine for relieving symptoms (59.9%) and 94% of participants do not have history of illness. The results also showed that 99.3% of survivors reported that had at least 1 symptom.

Table 1. Characteristics of the participants (n=409)

Baseline Characteristics		**n (%)**
Age	18 - 45	390 (95.6)
	45 - 60	12 (2.9)
	≥ 60	6 9 (1.5)
Gender	Male	185 (45.2)
	Female	224 (54.8)

Occupation	Staff	134 (32.8)
	Student	275 (67.2)
Recovery time	<1 month	198 (48.4)
	<2 months	60 (14.7)
	<3 months	52 (12.7)
	≥ 3 months	99 (24.2)
Place of treatment	Home	395 (96.6)
	Hospital	14 (3.4)
Duration of treatment	1 week	278 (68)
	<2 weeks	105 (25.7)
	<3 weeks	26 (6.4)
Number of COVID-19 vaccination shots	1st	25 (6.1)
	2nd	160 (39.1)
	3rd	220 (53.8)
	None	4 (1)
Times of COVID-19 infection	1st	367 (89.7)
	2nd	42 (10.3)
History of illness	Yes	24 (5.9)
	No	385 (94.1)
Used medication	Flue medicine	245 (59.9)
	Medicine for COVD-19 treatment	114 (27.9)
	None	50(12.2)
Symptom of COVID-19	None	2 (0.5)
	≥1 symptom	407 (99.5)
	≥ 2 symptoms	395 (96.6)

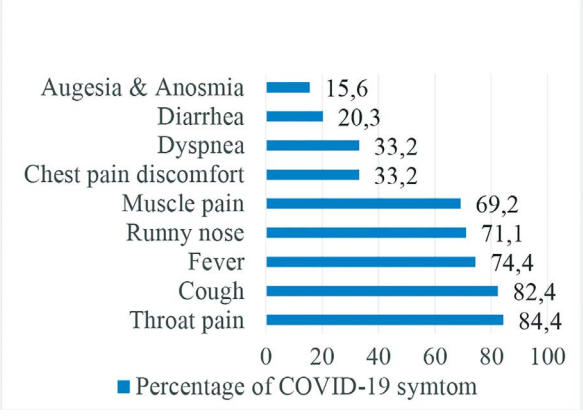

Figure 1. Symptoms of COVID-19

The COVID-19 survivors had had various symptoms. From Fig. 1 we can see that COVID-19 survivors in the study had many common symptoms of COVID-19 when they were infected such as sore throat (84.4%), cough (82.4%), headache (74.4%), fever (73.1%), runny nose, muscle pain (71.1%), headache (69.2%). Other symptoms such as diarrhea, shortness of breath, chest pain, ageusia and anosmia are less common.

Physical and mental symptoms of post-COVID-19

Table 2 shows that 98% of participants have at least 1 post-COVID-19 symptom after recovering and 384 survivors had at least 2 symptoms. Only 8 participants (2%) did not have any symptoms of post-COVID-19.

Fig. 2 presents that post-COVID-19 symptoms have occurred in all organs of the COVID-19 survivors. There are many physical symptoms, and there are four common symptoms appearing in over 50% of participants: fatigue (66.7%), cough (64.3%), feeling out of breath (59.9%), and sputum (51.1%). The popular of long – term symptoms in COVID-19 survivors have been belong to respiratory systems.

Table 2. Frequency of post-COVID-19 impact

Symptoms	**n (%)**
None	8 (2)
At least 1 symptom	401 (98)
At least 2 symptoms	384 (96)
At least 3 symptoms	358 (87.5)

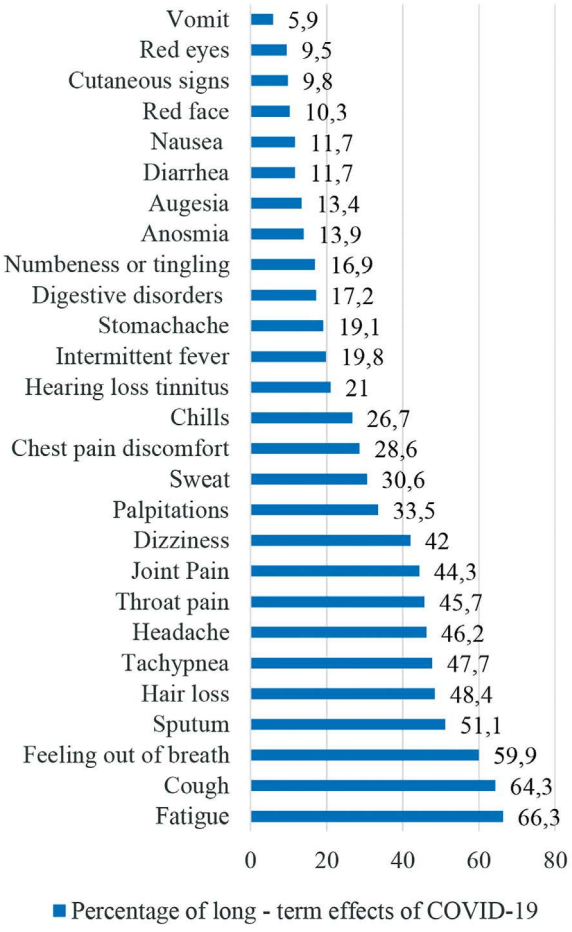

Figure 2. Physical symptoms of post-COVID-19

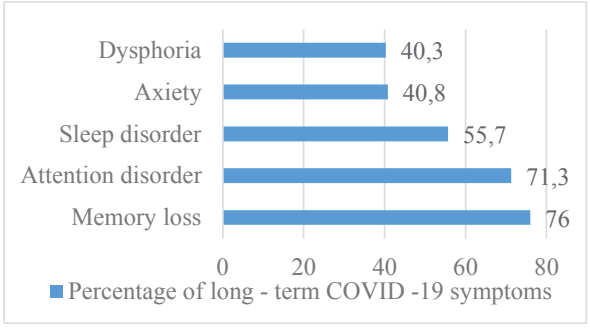

Figure 3. Mental symptoms of post-COVID-19

From Fig. 3, we can see that the mental symptoms of participants are more popular than physical symptoms. 76 percent of patients with COVID -19 have memory loss while the rate of participants with an attention disorder is 71.3%. Besides, 40.8% of participants have anxiety while the rate for dysphoria is 40.3%. The study found that most COVID-19 survivors have many disorders related to mental health.

The results indicate that COVID-19 survivors have diverse long–term COVID-19 symptoms that manifest in all the body systems such as respiratory, cardiovascular, digestive, skin, hair, nails, musculoskeletal, and immune systems. The common symptoms of patients with COVID-19 after recovery include memory loss, attention disorder fatigue, cough, feeling out of breath, sleeping disorder, and sputum. This finding is supported by previous findings of Sandra Lopez Leon (2018) who reported that 80% of COVID-19 survivors have long-term symptoms which noted that attention disorder, fatigue, cough, headache and shortness of breath were commonly long-term COVID-19 symptoms [4]. Other reports also recorded that sleep disturbances, memory loss, attention disorder, and anxiety occurred commonly in COVID-19 survivors [5]. This shows the widespread impact of post-COVID-19 on physical health after COVID-19 infection.

Associated Factors Between Characteristics of Participants and Occurrence of post-COVID-19 Symptoms (n=409)

Table 3. Results of multiple linear regression on factors associated with occurrence of post-COVID-19 symptoms (n=409).

Characteristics	R^2	β	p
COVID – 19 symptoms	0,343	0,496	<0,001
Gender		0,417	<0,001
Duration of treatment		0,147	<0,001
Recovery time		-0,122	0,007
Times of COVID-19 infection		0.463	<0,001

The result of the multiple linear regression model (Table 3) presents that when the time of recovery after COVID-19 infection accretes the number of post-COVID-19 effects will decrease (β=-0.122, p=0.007). This just means that the longer the COVID-19 patient is out of the disease, the less likely they will have health problems. This is similar to Sykes et al. who reported that after 28 days 13.3% of COVID-19 survivors had got physical symptoms after 28 days, this rate decreased to 4.5% after 8 weeks, only 2.3% after 12 weeks [6].

However, there is a positive correlation between the number of post-COVID-19 symptoms and the number of COVID-19 symptoms (β=0.402, p<0.001), duration of treatment (β=0.117, p=0.007), time of reinfected COVID-19. Furthermore, women had higher post-COVID-19 symptoms than men (β=0,417, p<0.001). Previous studies reported also an association between symptoms during acute COVID-19 infection and the occurrence of post-COVID symptoms such as in patients with fatigue symptom after 3 months of recovery, those with fatigue still accounted for 50% of the time compared to the group that did not show symptoms at the time of infection [7], or women showed more common post-COVID-19 symptoms than men [8) and duration of treatment has an impact on post-COVID-19 symptoms [9].

IV. CONCLUSION

Our research findings show that post-COVID is a popular health issue which occurs in at least 98% of survivors. The symptoms of COVID-10 syndromes are diverse in all systems, but the most popular symptoms recorded are respiratory manifestations (cough, sore throat, shortness of breath, dyspnea, sputum, tachypnea); nervousness (impaired concentration, sleeping disorder, memory loss, fatigue), hair loss, bone and joint pain. The COVID-19 infection leads to long-term physical health problems and raise the risk of mental disorders.

Thence, more researches and evidence from others are essential to deeply understand the COVID-19 to develop preventive measures and more information about prospective researches to better assess the natural course of COVID-19 infection and define the long COVID-19 syndrome.

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FACTORS AFFECTING STUDENTS' ACADEMIC PERFORMANCE AT EASTERN INTERNATIONAL UNIVERSITY

Trang Le Thi Thu[1], Duyen Tran Thi Yen[1], Bich Pham Thi Ngoc[1]
[1]*School of Nursing, Eastern International University, Binh Duong, Viet Nam*
trang.le.sns18@eiu.edu.vn, yenduyen.tran@eiu.edu.vn

Abstract: This study aimed to determine the perception of students on factors affecting academic performance and their association with academic performance. **Study Design:** Cross-sectional study. The study was carried out at Eastern International University in Binh Duong province from July 2022 to September 2022. A total of 189 students were recruited. Students were selected by a convenience sampling method. The self-designed questionnaire with a five-Likert scale to examine related factors to academic performance including self-motivation, learning consistency, learning environment, self-learning methods, competency-based learning, and academic achievement was measured by cumulative grade point average (GPA). Preliminary analysis using descriptive statistics for items. To identify factors related to academic achievement, bivariate correlation analysis was also employed. **Results:** The factors affecting academic performance were learning consistency (r =0.319, p=0.02), and learning environment (r = 0.216, p< 0.001). Self-learning methods were positively correlated with self-motivation (r = 0.319, P = 0.02). **Conclusion:** Learning consistency and learning environment mostly affected academic performance. Exploring these factors would enable the university and educational administrators to have solutions to boost satisfaction and academic achievement among students.

Keywords: *factors, self-motivation, learning consistency, learning environment, self-learning methods, competency-based learning, academic performance*

I. INTRODUCTION

Students' academic achievement has been a main focus of employers in the competitive studying environment [8]. Surveying student perceptions about factors affecting academic performance is also considered the most essential activity to examine and improve the educational quality of universities [6]. According to several authors, academic performance has been employed as a cumulative grade point average [7]. Different studies have been made to explore the factors affecting students' academic performance and the negative elements affecting it [5]. As a result, the vital role of factors such as self-motivation, learning consistency, learning environment, self-learning methods, and competency-based learning in optimizing students' academic performance is emphasized and acknowledged in the literature [2, 7]. However, there are limited datasets of primary data which are available to explore the effect of these factors on academic performance among students at

Eastern International University. This study aimed to explore the perception of students on factors affecting academic performance and their association with academic performance, which can be served as a reference source for the university and educational administrators to enhance the educational quality.

II. METHODOLOGY

A. Design and participants

This cross-sectional study was conducted on all 189 students at Eastern International University in Binh Duong province. The participants were selected by a convenience sampling method. The inclusion criteria include students who were engaged for at least 1 academic year and participated voluntarily in this study.

B. Study instruments

A socio-demographic information questionnaire assessed the participants' age, gender, school year, facilities, and GPA. A self-designed questionnaire measured related factors affecting Students' Academic Performance [1, 3-5, 7] and comprises 5 domains and 32 items including self-motivation, learning consistency, learning environment, self-learning methods, and competency-based learning. Scores on the 5-point Likert scale for each item. Cronbach's alpha was calculated to evaluate the internal consistency of the total scale was 0.97, and each subscale was 0.70, 0.83, 0.84, 0.69, and 0.81 respectively.

C. Data collection

The data collection was conducted at Eastern International University from July 2022 to September 2022. The researchers explained the details of the study procedure to them. The researchers distributed the questionnaires to students, it took approximately 15 mins for students to complete the questionnaires, and the researcher collected the completed questionnaires.

D. Data analysis

Collected data were organized using IBM SPSS Statistics for Windows, version 23.0. The means, standard deviation (SD), frequency, and proportion were used to display demographic characteristics. Anova One-way to examine the difference between variables among students of different faculties. To identify factors related to academic achievement, bivariate correlation analysis was also employed.

E. Ethical Considerations

Informed consent was signed by each participant before enrolling in the study in compliance with ethical standards in scientific research. The students responded to the questionnaire anonymously with no identifying information.

III. RESULTS

A. Demographic characteristics of the participants

The average ages of students were (M=21.9, SD 1.8). Most of them were female students (n = 127, 67.2%); the highest number of participants was BBS students (n = 94, 51.3%); 40.7% (n= 77) had a school year from 2018-2023, the average of GPA (M=3.01, SD 0.4). The detailed demographics are presented in Table 1.

B. Students' academic performance and its related factors

The average scores of five subscales from highest to lowest were competency-based learning (M=3.52, SD 0.84) self-learning methods (M=3.54, SD 0.69), learning consistency (M=3.71, SD 0.68), self-motivation (M=3.74, SD 0.72), learning environment (M=3.88, SD 0.76), which showed that students agreed that these variables affect students' academic performance (Table 2).

Table 1. Demographic characteristics of the participants (n = 189)

Variate		Frequency (%)/ Mean (SD)
Gender		
	Male	62 (32.8)
	Female	127 (67.2)
Age		21.9 (1.8)
Learning Facilities		
	Nursing	53 (28)
	Engineering	25 (13.2)
	BBS	97 (51.3)
	CIT	14 (7.5)
School year		
	4	8 (4.2)
	5	5 (2.6)
	6	11 (5.8)
	7	17 (9.0)
	8	77 (40.7)
	9	25 (13.4)
	10	18 (9.5)
	11	28 (14.8)
GPA		3.01 (0.4)

Table 2. The level of students' perception of related factors to academic performance (n=189)

Variables	Mean (SD)	Minimum	Maximum
Self-motivation	3.74 (0.72)	1.50	5
Learning consistency	3.71 (0.68)	1.43	5
Competency-based learning	3.52 (0.84)	1.50	5
Learning environment	3.88 (0.76)	1.33	5
Self-learning methods	3.54 (0.69)	1.79	5

C. Differences between the level of students' perception-related factors and academic performance

Table 3. Comparison between the level of students' perception of related factors and cumulative grade point average (n=189)

	Nur	Eng	BBS	CIT	p
	M (SD)	M (SD)	M (SD)	M (SD)	
1	3.75 (0.63)	3.75 (0.70)	3.74 (0.78)	3.50 (0.70)	0.341
2	3,63 (0.59)	3,80 (0,56)	3.75 (0.76)	3.51 (0.53)	0.202
3	3.44 (0.85)	3.54 (0.90)	3.56 (0.83)	3.42 (0.86)	0.439
4	3.77 (0.79)	3.87 (0.75)	3.96 (0.77)	3.74 (0.65)	0.331
5	3.58 (0.66)	3.54 (0.71)	3.54 (0.68)	3.26 (0.77)	0.152
6	2.87 (0.31)	2.91 (0.48)	2.96 (0.34)	3.11 (0.40)	0.003**

Note: *1. self-motivation, 2. learning consistency, 3. competency-based learning, 4. learning environment, 5. self-learning methods, 6. GPA*

In Table 3, the highest mean score of academic achievement was nursing and engineering students (M=4.00, SD 0.58), (M=3.97, SD 0.46), respectively. Analysis of factors affecting academic performance, all of the students had the highest mean score

of the learning environment from 3.96 to 3.74. Nursing students had the lowest score for competency-based learning (M=3.44, SD 0.85), and BBS and CIT students had the lowest score for self-learning methods (M=3.54, SD 0.68), (M=3.26, SD 0.77), respectively. The mean score of competency-based learning and self-learning methods were lowest among engineering students (M=3.54, SD 0.90), (M=3.54, SD 0.71). There was a significant difference between GPAs among students' different faculties.

D. Association between students' academic performance and its related factors.

Significant correlations were found among academic performance and learning consistency, and learning environment. Academic performance was positively correlated with learning consistency ($r = 0.319$, $p = 0.02$), and learning environment ($r = 0.216$, $p < 0.001$). Self-learning methods were positively correlated with self-motivation ($r = 0.245$, $p < 0.001$). (Table 4)

Table 4. The association between students' academic performance and its related factors (n=189)

Variables	1	2	3	4	5	6
Academic performance (GPA)	1					
self-motivation	0.157	1				
Learning consistency	0.319*	0.176	1			
Learning environment	0.216**	0.200	0.020	1		
Competency-based learning	0.139	0.809	0.085	0.498	1	
Self-learning methods	0.611	0.245**	0.055	0.139	0.02	1

Note: ** p<0.05, ** p<0.001; 1. GPA, 2. self-motivation, 3. learning consistency, 4. competency-based learning, 5. the learning environment, 6. self-learning methods*

IV. CONCLUSION

The results of this study indicated that students agreed that these variables affect students' academic performance. Nursing and engineering students had the highest mean score for academic performance. There was no difference between academic performance and its related factors among students' different faculties. All of them agreed that the most factor affecting academic performance was the learning environment. Significant correlations were found among academic performance and learning consistency, and learning environment. Especially, self-learning methods were positively correlated with self-motivation.

ACKNOWLEDGMENT

We are grateful to Eastern International University for supporting this study, and we wish to acknowledge the nursing students who participated in this study.

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PART IV

INFORMATION TECHNOLOGY

A MOBILE APPLICATION FOR ROBUST SKIN CANCER DETECTION-BASED DEEP LEARNING MODEL

Cao Chi Ha[1], Linh Gia Thi Khong[1], Phat Hoang Pham[1], Vinh Dinh Nguyen[1]
[1]*School of Computing and Information Technology, Eastern International University, Binh Duong, Viet Nam*
cao.ha.set18@eiu.edu.vn, linh.khong.set17@eiu.edu.vn, hat.pham.set18@eiu.edu.vn, vinh.nguyen@eiu.edu.vn

Abstract: Early diagnosis of skin cancer is extremely important to save a human life. Therefore, this research introduces a system to predict skin cancer on a mobile device by using deep learning algorithms. Existing machine learning-based method obtained high accuracy. However, it is really difficult to implement them on limited-resource devices such as mobile phones because a huge number of network parameters need to store and process. Therefore, this paper proposed an efficient framework to detect and classify skin cancer by investigating both client and server sides. First, the skin cancer application is implemented on Android platform. Second, the proposed deep learning-based skin cancer detection algorithm is implemented on the server side to handle the user request.

Keywords: *deep learning, skin cancer, mobile application, machine learning*

I. INTRODUCTION

Nowadays, skin cancer causes thousands of deaths. The being type can be considered less dangerous the malignant melanoma and can be cured successfully [1-3]. Several methods have been introduced to detect and classify cancer by using machine learning algorithms, such as Faster RCNN, Residual Net, YOLO, Efficient Net, or Retina. The existing machine learning-based algorithms work well under normal environment. However, their performance is degraded under noise conditions appearing in the real world. Therefore, this research will introduce an efficient approach to accurately detect and classify skin cancer under both normal and difficult conditions by studying the benefit of LBP. Moreover, our system is developed and implemented on Android platform to help users (Doctor or Patient) easily use our application. The remaining research paper is structured as follows. We briefly summarise the benefits and limitations of existing skin cancer detection in section II. The proposed method was described in Section III. We discussed the experimental results of the proposed method in section IV. Finally, we concluded our research in section V.

II. RELATED WORK

Skin cancer is an important issue that has been launched for many years in many countries. There are various methods to detect and classify skin cancer by using machine learning approaches. Without loss of generality, the existing skin cancer detection algorithms are divided into two groups, single-stage-based method and two-state- based methods. Two-stage-based methods, such as Faster RCNN, or Mask RCNN, were first designed to generate

possible candidates. The next step is to verify the candidate's information. Single-stage-based methods, such as YOLO and SSD, were originally designed to directly detect and classify the object from the input images. The processing time of single-stage- based method is much faster than those of two-stage- based methods; however, the accuracy of single-stage-based method is lower than those of two-stage-based methods. It is really difficult to select a method which obtains both high accuracy and fast processing time. In addition, the performance of existing system degraded when noise appear in the input images. Therefore, our study is to find an efficient approach to increase the performance of the state-of-the-art single-stage-based method (YOLO) by deeply investigate the benefits of LBP.

Moreover, the proposed method was also implemented on Android platform to evaluate its performance in real conditions.

III. PROPOSED METHOD

Existing deep learning-based model achieve good accuracy under normal testing, while their accuracy is degraded under difficult condition. Our research finds and introduces a novel approach for improving the performance of existing object detection and classification systems (Fig. 2).

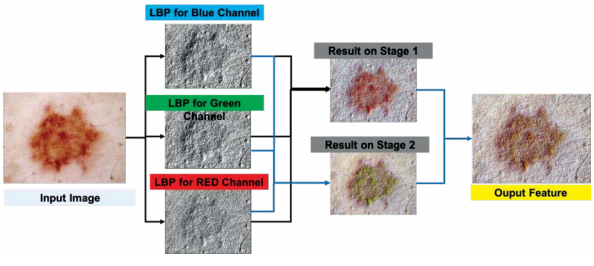

Figure 1. The proposed robust feature for skin cancer classifier system

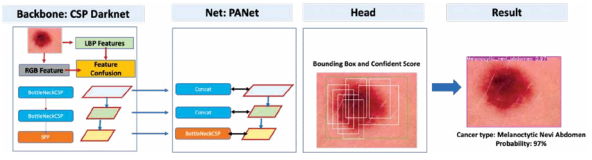

Figure 2. Diagram of the proposed deep learning system of skin cancer detection and classification based on YOLOv5s

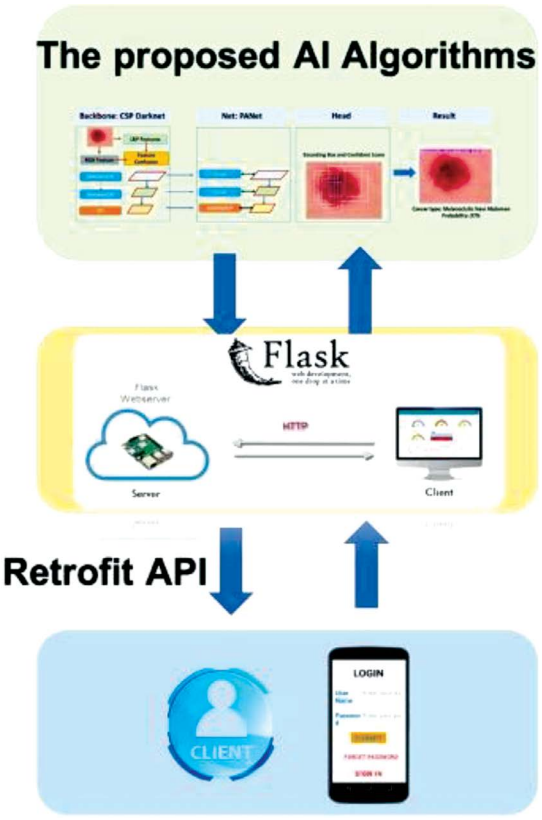

Figure 3. Main architecture of our system

A. The Proposed Robust Feature

LBP was often used to extract stable texture from the local region. This research aims to develop a method to accuracy extract and provide robust features based on LBP (Fig. 1). First. The input feature was selected to compute LBP results on three separate channels, blue, green and red. Next the LBP results were then combined by the proposed fusion feature-based method in two stages to generate the intermediate results.

Finally, the results from two stages were then combined to create final robust feature for training the system.

B. The proposed YOLOv5s for detecting and classifying skin cancer

The robust feature of the proposed method is used to input into the YOLOv5s [4] to train and classify skin cancer as shown in Fig. 1. YOLOv5s were trained with SGD (momentum of 0.8).

C. Detail implementation of our system

We implemented our system on Android platform. Fig. 3 shows the proposed architecture of our systems. The proposed system consists of three parts: a client- side for developing Mobile UI of user, a server-side for developing a server which receives a quest from the client, and AI algorithm integrated along with the server side to handle a task of skin cancer detection.

IV. EXPERIMENTAL RESULTS

A. Dataset

We used HAM10000 dataset with the 10015 sample pictures. Before the advent of digital cameras, the Austrian site began to gather photographs, and it has since saved images and metadata in a variety of formats over time. HAM10000 is divided into 7 types of skin cancers.

We divide the dataset to 80% for training and 10% for validating and 10% for testing. We trained the proposed method for 24 hours. The proposed method was evaluated on a workstation with i9 CPU @ 3.7GHz, 64GB, and 2 Nvidia GTX 3080 10GB as shown in Fig. 4

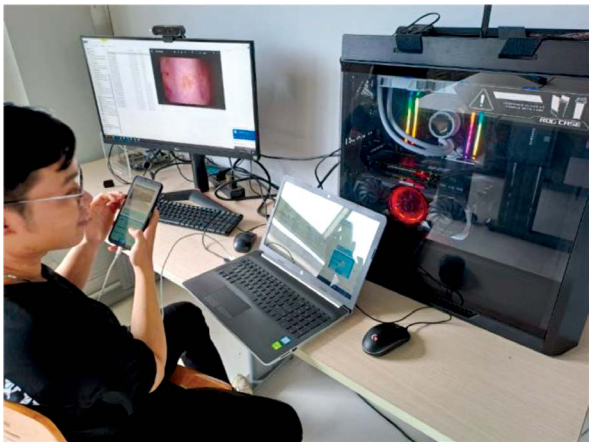

Figure 4. The system configuration of the proposed method

B. Results and Discussion

YOLOv5s is used to evaluate the performance of our system by using the HAM10000 dataset. Figs 5 and 6 show the train and validation loss and precision of YOLOv5s, respectively. Our system got better results than YOLOv5 when considering two metrics: precision and recall. We further evaluate the performance of our system and YOLOv5s on testing images as shown in Fig. 7 and Fig. 8. The proposed method accurately detect and classify the skin disease.

We also deployed the proposed system on the Android platform as shown in Fig. 9. The proposed mobile application is user-friendly and easy to use to detect and classify the skin cancer.

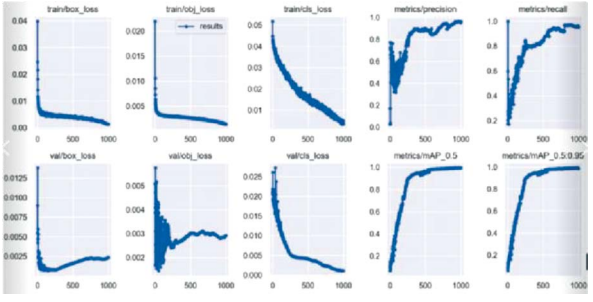

Figure 5. Results of train and validation after 1000 epochs

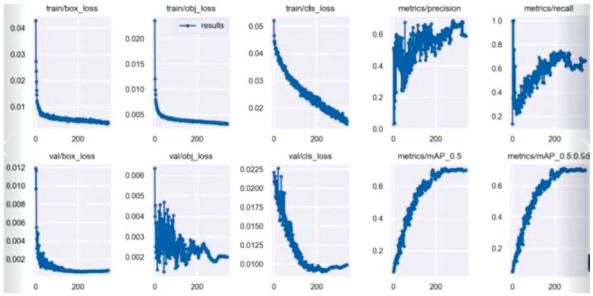

Figure 6. Results of loss of training and validating of the YOLOv5s after 400 epochs

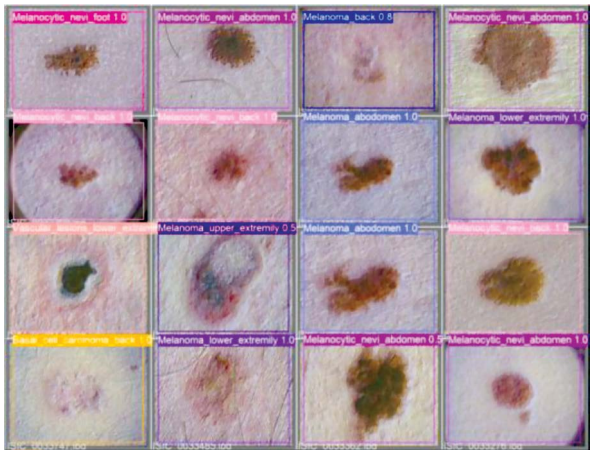

Figure 7. Experimental results of the proposed method using validation dataset

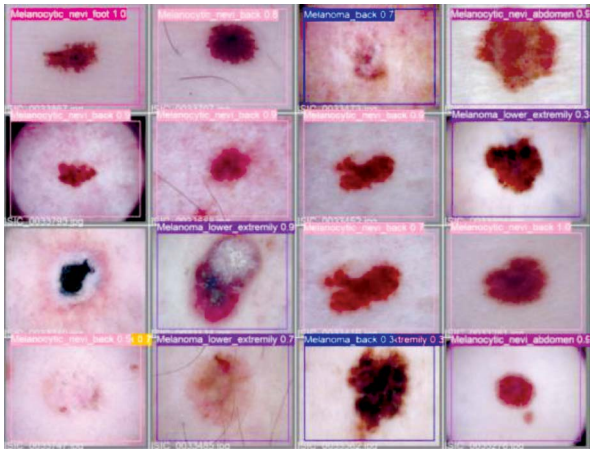

Figure 8. Experimental results from the validating datasets of the existing method (YOLOv5)

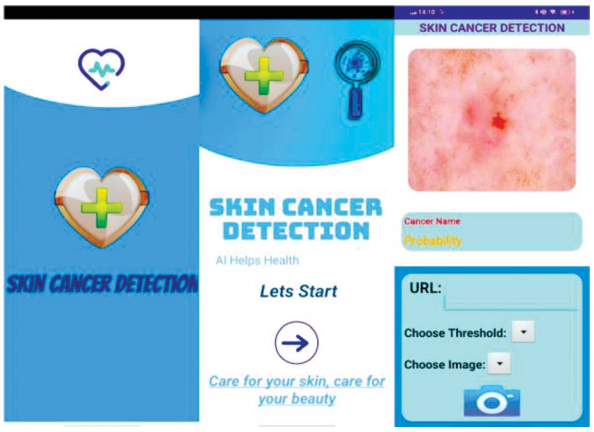

Figure 9. The proposed application on Android platform

V. CONCLUSION

Our research introduced an efficient method to increase the accuracy of existing skin cancer detection systems. Our system improves the accuracy of the YOLOv5. Moreover, our system also implemented on the mobile to be realized as commercial product. However, the proposed system still has several limitations that need to be improved in the future: 1. The preprocessing time is slow due to the proposed robust feature. 2. The accuracy of the proposed system decreased under noise situations.

ACKNOWLEDGEMENT

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APPLICATION OF AMAZON WEB SERVICES WITHIN TEACHING & LEARNING AT THE SCHOOL OF COMPUTING AND INFORMATION TECHNOLOGY

Doan Thai Dang[1], An Xuan Mai[1], Khoi Huu Trinh[1]

[1]*School of Computing and Information Technology, Eastern International University, Binh Duong, Viet Nam*

doan.dang@eiu.edu.vn, an.mai.cit19@eiu.edu.vn, khoi.trinhhuu.cit19@eiu.edu.vn

Abstract: The alteration to cloud computing has significantly impacted today's technological innovation, especially in the education sector. Unlike the traditional curriculum that does not have rapid innovation and poor practical interaction, cloud training provides most of the knowledge while allowing students to connect and practice directly on the cloud internet with natural resources from the user's computer through the provider's services deployed. Cloud training innovates courses to create the best conditions for students and associated businesses to approach and train future human resources providers. Universities may receive a free, ready-to-teach cloud computing course from Big Tech Academy through a partnership, preparing students for industry-recognized certifications and in-demand cloud careers. Bridging gaps between academia and industry contributes to the benefit of businesses and students, giving students a significant advantage in the job market. The recommendations and proposals stem from real AWS training programs, which included AWS Academy. Specifically, this article introduces one of the latest courses from AWS Academy, AWS Academy Data Analytics, and how to integrate AWS resources in courses that can give students the knowledge and abilities they need to land a job in one of the fastest-growing industries. Moreover, some recommendations are proposed for administrators.

Keywords: *Academia-Industry Partnership, AWS Academy, Data Analytics, Cloud Computing*

I. INTRODUCTION

The pandemic-induced global lockdowns may have boosted the demand for e-learning platforms [1]. However, the demand might decline post-lockdown, especially in higher education [2]. The reasons may come from the quality of online courses or others (e.g., economics, habit, methodology). Conversely, many businesses are experimenting with removing the necessity for a degree for employment. The necessity for a bachelor's degree is being eliminated by an increasing number of organizations, particularly many in the technology industry, for many middle-skill and even higher-skill professions, which reverses the so-called "degree inflation" trend. Instead, in order to expand their talent pool, many businesses are concentrating on skills-based hiring [3].

This study intends to show how, based on that transition, industry cloud technology platforms can be used in practical teaching and learning. As an alternative to a simulated

learning environment, this has made sure that scenario-led evaluation for learning is possible. This paper will examine several communication avenues and assess how they encourage close ties between academia and business. It is demonstrated through a case study of a research partnership between a university and a big tech corporation. This paper serves as the foundation for discussing the best practices required to improve joint discovery research that benefits academia and industry [4]. AWS subject matter experts create and update the AWS Academy curriculum to reflect current services and best practices. AWS Academy-trained instructors who are accredited by AWS academy to teach the courses [5]. In order to close the skills gap and satisfy the demand for thousands of new cloud computing specialists, AWS Academy works to connect higher education institutions, students, and business leaders. Due to the increased demand for IT workers with cloud expertise and our ongoing efforts to forge connections between business and academia, Eastern International University (EIU) has joined the AWS Academy program and is now able to offer its students AWS Academy courses in exchange for AWS certifications. With the help of AWS Academy, students will graduate with the education and experience necessary to find high-quality positions in one of the industries with the fastest growth rate. The School of Computing and Information Technology (CIT) has begun training students in cloud technologies in collaboration with AWS Academy.

Students will gain from learning about the cloud, machine learning, and analytics through the AWS Academy program, which will also assist the university in creating a stable talent pool with the IT skills necessary for its growth, particularly with the knowledge of designing, constructing, and maintaining the cloud.

The remainder of this paper is structured as follows: first, we present AWS Academy and how to join this program. Second, a case study from applying AWS resources to develop student's skills in their project is shown; third, some benefits for students, educators, universities, and enterprises when deploying an Academia-Industry partnership are proposed. Lastly, we discuss the results and present the implications of our study.

II. INTRODUCING THE AWS ACADEMY PROGRAM

In order to make it easier for educational institutions and educational non-profits (collectively, "institutions") to deliver cloud computing courses to their students, AWS Academy is a global program that gives them access to an AWS-developed and authorized curriculum. Institutions can assist students in becoming certified in using Amazon Web Services (AWS) technology by taking part in AWS Academy.

The modules that make up AWS Academy courses allow synchronous or asynchronous learning in a traditional or virtual classroom setting. The curriculum aligns with the AWS Certification and prepares students for it. Students at the AWS Academy are more likely to be job ready. Their participation in learning while enrolling in classes lays a more than theoretical, practical foundation for the cloud.

AWS Academy member has access to AWS Academy-approved courses that can be taught to students by AWS Academy-

accredited instructors. The AWS Academy curriculum consists of nine courses, and they have more planned for development that will be in line with industry demand for subjects including Big Data, Networking, IoT, and Blockchain.

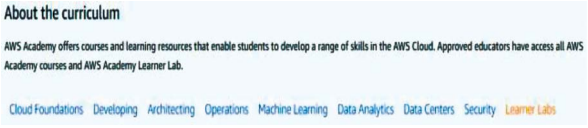

Figure 1. AWS Academy curriculum

Members of the AWS Academy receive several benefits that are only available to organizations, lecturers, and students taking part in the AWS Academy. The AWS Academy is dedicated to remaining at the forefront of cloud development and providing its members with the most innovative courses possible. Obtain AWS Certification to demonstrate learner technical knowledge and proficiency with a recognized credential. Maximize the earning potential of both students and educators and use the benefits to display their accomplishments and continue studying.

Institutions are given access to learning materials approved by AWS, enabling them to offer students current instruction in AWS cloud computing. The curriculum is created and updated by subject matter experts in AWS, thus, it considers the most recent AWS releases and best practices. The curriculum is made to be easily incorporated into an institution's current academic offerings.

Educators who complete the AWS Academy instructor accreditation procedure are granted free access to AWS LMS to create and maintain a curriculum to deliver lessons to their students. In addition to being recognized through both AWS Certification and AWS Academy instructor accreditation status, AWS Academy Accredited Instructors can confidently and competently instruct students.

The curriculum is created for degree programs and courses in extension, continuing education, professional development, and vocational education. AWS updates the curriculum, but the university controls how it aligns with its standards and course catalog [6].

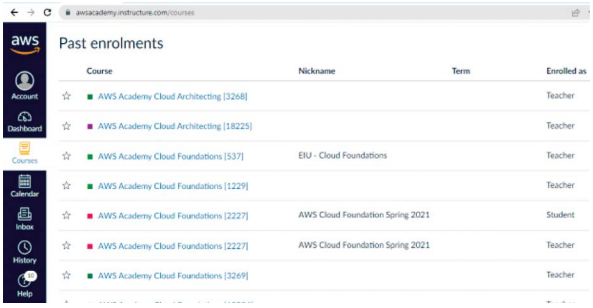

Figure 2. AWS Academy Portal

How to join the AWS Academy program

Participation criteria

The institution level is when AWS Academy membership begins. Institutions may apply if they satisfy the following requirements:

- The institution provides authorized degrees, certificates, diplomas, and continuing education programs.
- If the applicant is authorized to do so, they can provide the name and contact information of a person competent to function as the Central Point of Contact (CPOC) for the institution they represent.

Getting started

Following the institution's acceptance of the application, the Central Point of Contact will suggest one or more instructors teach AWS Academy classes.

III. PROPOSED APPROACH AND IMPLEMENTATION

A. The proposed model for data analytics using AWS resources

To enable users to construct, protect, and scale end-to-end big data applications, AWS offers a wide range of managed services rapidly and efficiently. AWS offers the infrastructure and resources to handle the learner's next big data project, regardless of whether applications require real-time streaming or batch data processing. Whatever is necessary for the user to collect, store, process, and analyze large amounts of data needs to be built, maintained, or expanded. AWS has an ecosystem of analytical tools to manage this expanding volume of data and offer insight into any organization.

Big data issues frequently call for instantaneous fixes. This is the velocity part of the five Vs of big data (Volume, Variety, Velocity, Veracity, and Value) [7]. Video feeds, application logs, and infrastructure devices are typical data sources for these instances. Streaming data is the term for the data in certain velocity conditions. Students can utilize the Amazon Kinesis suite of services to examine streaming data. These programs can capture GB of data per second from tens of thousands of sources using Amazon Kinesis Data Streams. For processing and analyzing streaming data, Amazon Kinesis Data Analytics offers a simple way to build SQL or Java queries.

Project scenario summary

In this project [6], students are data analysts working for an online retailer of computer supplies and peripherals. Their manager asked them to create a system to evaluate customer behavior on the website in real-time. Specifically, the project would like students to investigate the following research questions:

- Are the operating system and web browsers that visitors choose and the products they choose related in any way?
- Which page-the search results or the recommendations-drives more customers to product pages?

Students request that Kinesis Data Firehose be used to gather information from web server logs. Students discovered that Amazon ES can receive streaming data from Kinesis Data Firehose, and that students can use Kibana to create visualizations to represent the data. Students choose to create a proof of concept (PoC) with a straightforward website before they build the system. Students will use this Proof of Concept to demonstrate the solution's architecture.

The following graphic illustrates the architecture of the PoC:

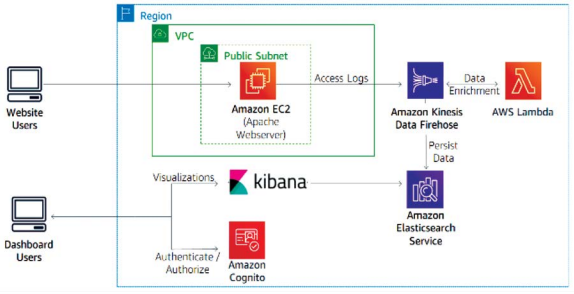

Figure 3. The architecture of the project

B. Implementation

1) Storing data in Amazon Simple Storage Service (Amazon S3)

In the initial step, the student will approach the S3 bucket and add an AWS

Identity and Access Management (IAM) user to a group with full access to Amazon S3.

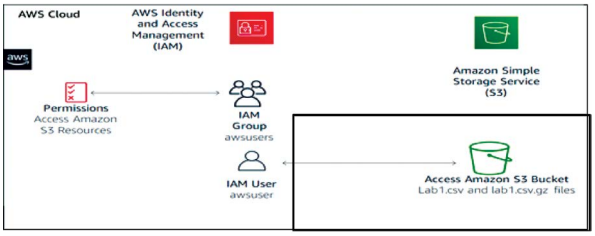

Figure 4. Add an IAM user to a group

2) Query data in Amazon Athena

In the next step, the student will use Athena to aggerate the files in Amazon S3 and restructure the data for further analysis.

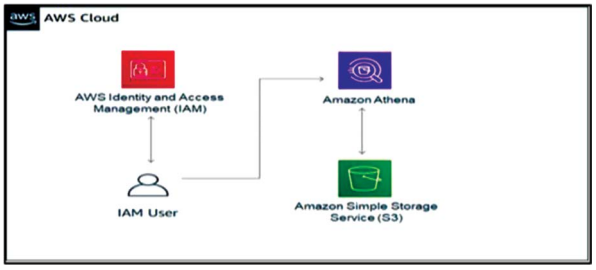

Figure 5. Model of Amazon Athena

3) Analyze Streaming data with Amazon Kinesis Data Firehorse, Amazon Elastic Search and Kibana

The infrastructure we will set up to analyze streaming data consists of the following five components:

- A public subneted instance of Amazon Elastic Compute Cloud (Amazon EC2). Run a web server on the EC2 instance.
- A delivery stream for Kinesis Data Firehose that collects live data from web server logs.
- An AWS Lambda function to transform the data.
- An Amazon ES cluster to store the data.
- A Kibana instance for building data visualizations.

C. Result & Discussion

After implementing the model, students built a model from simple parts to complicated ones. Based on the knowledge and resources of AWS, we have built the necessary services to build the final model: using Kibana to visualize the number of accessions in a hypothetical website and using data to perform later tasks.

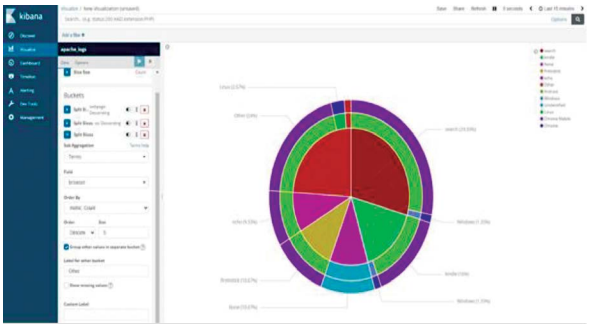

Figure 6. Create the pie chart with Amazon Kibana

Thanks to AWS services, students successfully constructed a visualization to view data from a website. With the help of more AWS services, students can build on this model in the future to manage, maintain, and enhance its performance. We have successfully finished our first learning project in the near term, thanks to our familiarity with cloud computing and the assistance of AWS services. We will keep delving more deeply into this expanding topic in the future.

IV. PROGRAM BENEFITS

The problems with higher education are well known and regularly criticized, including the widening gap between graduates' credentials and the skills employers need, rising tuition costs that lower the perceived

return on investment, and difficulties with equity and accessibility. The following diagram summarizes the information from AWS Academy and shows how joining the program can benefit institutions, educators, students, and employers [8]:

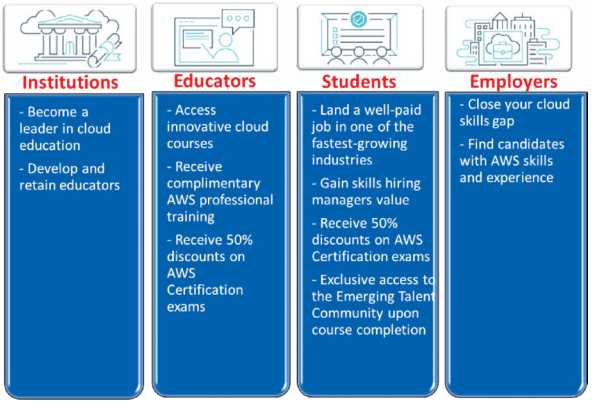

Figure 7. Program benefits

V. CONCLUSION

This research has discussed a key divergence trend in global knowledge cooperation. The structure of university-industry partnerships that we examined in this research presents the possibility of a unique, hybrid model for linking the domains of industries and universities that benefit all stakeholders. The partnership program assists academic institutions and teachers in bringing tech role models into the classrooms and provides them with access to a curriculum made to help students develop skills from the fundamentals to the more advanced levels, learn about cloud computing and data analytics, and create app ideas to prepare them for working in the enterprise's environment [9]. We suggest that EIU and CIT managers find more programs and businesses that support university-industry partnerships to support the development of stakeholders. In future work, studies should examine and evaluate factors that affect students' performances using the resource from the Academia-Industry partnership, then modify the strategies to cooperate to gain more benefits for all stakeholders.

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ARTIFICIAL INTELLIGENCE IN SOFTWARE TESTING

Shreya Banerjee[1]
[1]*School of Computing and Information Technology, Eastern International University, Binh Duong, Viet Nam*
shreya.banerjee@eiu.edu.vn

Abstract: Nowadays Artificial Intelligence (AI) is a buzzword and has been applied in various domains such as business, domestic, medical, military, education, law, arts, etc. On the other hand, software testing is as old as software engineering. This field exhibits a lot of evolution in its methodologies and tools. New trend is the application of AI in software testing. Traditional software testing techniques are mostly manual. It requires a lot of human effort and labor to verify and validate today's complex software systems. Consequently, increased software development time and cost, unsatisfactory test coverage and additional workforce were manifested. To resolve these issues, nowadays, automated testing methods are used in industry. Automated testing methods save software development cost, effort and time. At the same time, it improves the quality of testing and reliability of software. In recent days, AI is applied in software testing to acquire the highest level of automation. In this context, this paper is aimed to study the role of AI in Software Testing based on three different aspects – Software Testing Life Cycle (STLC), Test Levels and Test Automation Tools. Based on this study, the paper has listed several novel research directions.

Keywords: *Artificial Intelligence, Software Testing, Test Automation*

I. INTRODUCTION

In the modern world, software system becomes highly complex to cope with the growing demand of Information Technology (IT) solutions in every aspect of humans' life. In this context, effective software testing methods are required to deal with the high complexity of the modern software systems, so that adequate verification and validation of software systems can be confirmed [1]. Traditional software testing methods are manual and need lots of human effort and labor. This increases the software delivery time, and the budget due to additional manpower. Manual testing processes also resulted in achieving poor test coverage because humans are error prone. In this context, quality of testing process is not maintained as well as unreliable software is delivered.

The emergence of automation testing has been a key advancement to empower software engineers in their Quality Assurance (QA) process [2]. In this kind of testing process, a test program known as test script is executed to test Software under Test (SUT) and compare actual results with expected results [5]. Thus, automation tools have been developed that assists to automate several activities of the manual testing process to enhance quality and timely delivery [3]. However, automated tools do not cover all the sections of manual testing [4].

Using automated testing process, distinct types of tasks related to software testing can be performed. Automated code analysis, unit testing, API testing, end-to-end testing, acceptance testing or performance testing for many different software products are some examples of those testing tasks [6]. Yet, several test automation tools such as Selenium, have exhibited limitations. Several crucial drawbacks are – *firstly*, testers need good programming skill and nontrivial testing knowledge to use these tools [2] because these tools have limited support to produce high quality test code. This issue leads to the fact that still testers need to do several tasks manually for example to develop deterministic test scripts. *Secondly*, in modern world, customers' requirements are changing rapidly. To accommodate these changes, today's industry uses Agile methodologies along with continuous integration and continuous delivery (CI/CD) pipeline [3]. In this scenario, automation tools are becoming less effective due to flaky tests and making test scripts almost unusable. Flaky tests are unmodified tests that have non-deterministic outcomes such as sometimes those test fail, and sometimes those test pass [7]. *Thirdly*, testing maintenance is still a tedious job due to the limited automation of existing tools in this respect.

To resolve these issues, in recent days, both academia and industry have been exhibited employing AI-based technologies in software testing. AI enables computers to emulate human intelligence by programming them to think like humans and mimic their actions and reasoning [2]. AI can improve the software testing methodologies, affecting the whole testing phase by automating testing activities such as test planning, authoring, development, and maintenance. AI can use statistical methods to facilitate testers' work. Primarily, data is the most basic component of all software. Likewise, test data, test case, test oracles, test coverage, test scripts are all examples of testing activity related data. AI algorithms and techniques excel in data management, mining and learning from data. Thus, AI can improve the quality of software testing, reliability of software and make software development more efficient and cost-effective.

II. APPLICATION OF AI IN SOFTWARE TESTING

This section has specified the use of AI in distinct aspects of software testing. AI has different branches that can be applied towards software testing. The crucial branches that can be applied in software testing are Neural Network (NN), Machine Learning (ML), Natural Language Processing (NLP), AI planning, Expert Systems, Fuzzy Logic, Bayesian Networks, and Genetic Algorithm. Artificial Neural Network (ANN) is an interconnection of nodes analogous to biological neurons. ANN learn through training, and thus improving its performance [9]. Deep Neural Networks, solve the problem of finding the right representation by introducing hierarchies of representations [11]. Machine Learning [ML] is aimed to recognize patterns and learns from data using different algorithms to solve similar class of issues [8]. Natural Language Processing (NLP) is an AI method using which an intelligent system can understand human languages as it is spoken and written [10]. Fuzzy Logic emulates the way of decision-making

in humans that involves all intermediate possibilities between digital values YES and NO [10]. Applications of these distinct AI-based methods in different aspects of software testing are specified next.

A. Application of AI in Software Testing Life Cycle (STLC)

STLC is consisting of phases such as test planning, test design, test execution, test closure and test maintenance.

a) Test Planning: This phase is determining what is going to be tested and how this will be achieved. Recent approaches have applied AI methods in planning the test objective, long release cycles, and in critical path identification problems [2]. AI planning, Bayesian Networks (BN), Expert systems, Info-Fuzzy Networks (IFN), C4.5 are some AI-based approaches that have been applied in this phase. AI planning aids in dealing with sequential decision making [3]. A BN is a probabilistic graphical model for representing knowledge about an uncertain domain where each node corresponds to a random variable and each edge represents the conditional probability for the corresponding random variables [12]. BN is effective in finding out critical paths. Further, an expert system can give suggestions towards planners based on knowledge base and inference engine. IFN can be used to recover missing and incomplete specification from execution data.

b) Test Design: Test case design is the main objective of this phase. In general, the goal is to create minimum test cases to get maximum test coverage. There are three kinds of test case design methods. White-Box Testing, Black-Box Testing and Gray-Box Testing. In white box testing, test cases are developed based on the source code or internal structure of the software. In black-box testing, test cases are synthesized based on the input and output specification of software. In this method, internal structure or source code is unknown towards the testers. Gray-Box testing is combination of white-box and black-box testing. In this testing, the modules are studied for the design of test cases (white-box), but the actual tests are performed in the exposed interfaces (black-box) [13]. In all of these test design methods, domain knowledge and/or programming skills are required for testers. Thus, designing test cases sometimes take lengthy time that can be added towards extensive cost for software development. This issue synthesizes problems where recent approaches apply AI methods such as manual code development, manual test data generation, programming skill and domain knowledge requirement, and test object identification problems [2]. Unsupervised ML algorithms, fuzzy logic, ANN (controlled and reinforcement learning, Genetic Algorithms (GA) are good one for applying in black-box testing methods to solve the issues related to test design. NLP is used to predict manual test case failure. GA is popular one that is applied for automated test data generation [3]. Further, Ant colony optimization algorithms, deep learning, Hill climbing are also used for structural test data generation.

c) Test Execution: This phase involves running tests and a comparison is made between expected results and actual results. This phase also includes several problems that make testing process lengthy. Several important issues are slow test execution time, flakey test, untested code, test oracle construction [2]. Recent studies have applied

AI approaches such as ANN, Support Vector Machine, Decision Trees for test oracle construction [3]. Different ML algorithms (Supervised, unsupervised and reinforcement) are used commonly to detect flakey test. Further, IFN can be used to deal with untested code.

d) Test Closure: In this phase, it is ensured that testing documentation such as coverage report is in order, and result is inspected correctly. This phase exhibits issues such as overhead related to manual debugging, high cost due to result inspection, and visual analysis. Intelligent test analytics for example fuzzy logic is utilized to analyze test reports and identify the reason for the failure of test scripts [2].

e) Test Maintenance: In this phase, test scripts and test cases are maintained. If some changes happened in requirements or in the code base, in this phase, it is checked if the previous test cases are working as previously or not. Regression testing is a popular testing method applied in this phase. In modern days, an agile methodology along with CI/CD pipeline has conducted continuous testing based on this regression testing approach. Hence, in this phase, test case prioritization is an important issue. Recent approaches have used different AI-based methods for example ANN Reinforcement Learning, K-means, Marcov Model, SVM to solve the issue of test case generation. Several approaches also have used Bee Colony Optimization (BCO) algorithm for fault coverage regression system [1].

B. Application of AI methods in Software Testing Levels

In practice, Software testing level is consisting of three levels – Unit, Integration and End-to-End Testing. In unit testing, basic method or classes are tested. Integration level testing happens at component level to test the interfaces between the third-party module and the SUT. Further, end-to-end test validate the whole SUT from user's point of view. AI approaches can be applied in these different levels of software testing. In general, in unit testing, white-box methodologies are used to create test cases. On the other hand, in integration level and in end-to-end testing mainly black-box methodologies are used to create test cases. Thus, at end-to-end testing level, AI approaches such as fuzzy logic, reinforcement learning is used to create black-box testing based test cases. SVM approaches are used in unit testing to create white-box related test cases.

C. AI-based Test Automation Tools

Table 1. Performance Indicators of AI-based Automation Tools

Criteria	(i)	(ii)	(iii)	(iv)	(v)	(vi)
AI-based Automation Tools	H	H	H	H	H	H
Other Automated tools	M	P	M	M	P	H
Manual Approaches	P	P	P	P	P	P

H: Highly Effective, M: Medium Effective, P: Poor Effective

Several test automation tools based on AI exist in literature and industry. A selected list of AI-based tools is specified next.

a) Mabl: This testing framework simplifies the functional testing process for

developers using ML algorithms. This tool is devised for agile and CI/CD environment. Fundamentally, this tool assists in creating end-to-end test cases for web applications. Testers using these tools need not to write test code manually. Instead, developers only show the workflow and mabl will do the rest. Mabl runs on Google cloud platform and conduct continuous testing process in an easy and continent way [1].

b) Applitools: This tool is a visual testing and monitoring platform and uses AI-based algorithm. Visual testing compares that visual output of the application against the results expected by design. Thus, this kind of testing evaluates the output of applications. This too serves team especially in DevOps. The tool can be used for all kinds of platform – desktop, mobile and web. This tool's application is mainly in cross platform testing and test maintenance.

c) Testim: This tool is also used for testing of web applications. It ensures auto-correction features to diminish the manual work required when SUT is changed. In addition, this tool assists the testers to use distinct datasets and browsers concurrently by doing visual evaluation on the tested pages [1].

d) Functionize: This tool creates end-to-end test cases that self-heal and run at scale in cloud platform. This tool is primarily used in CI/CD environment. This tool also uses ML algorithms to create and maintain test cases. Here, the test plan can be written in English, then the NLP engine of the tool will process and automats each step of the test plan. Thus, thousands of tests can be performed in few minutes with this tool [1].

Table 1 has specified the effectiveness of AI-based approaches over other automated tools and manual testing. This comparison is conducted based on the following set of criteria – (i) *Short Test Duration*, (ii) *Identification of Flakey Test*, (iii) *Test Maintenance*, (iv) *Test Coverage*, (v) *Test Case Selection* and (vi) *Testing Accuracy*. From Table 1, it can be summarized that AI-based automation tools are highly effective for the specified performance criteria of software testing.

III. FINDINGS AND FUTURE RESEARCH DIRECTION

Based on the above-specified study, it can be said that application of AI in software testing is very promising. In each phase of STLC, AI approaches are applied. In the beginning phases of STLC, for example test Planning and test case analysis, testers can take decisions less than a second using AI approaches. In the subsequent phases of test creation, execution, and closure activities tasks such as test script generation, test data generation, test case prioritization, test oracle construction can be performed using high-level automation by applying AI-based approaches. Thus, more AI-based study and approaches will be required for these four steps. Further, recent AI approaches are used mostly in unit, regression, and end-to-end test level. Less AI-based approaches are conducted in Integration level testing. Besides this, existing test automation tools are primarily aided for end-to-end test case generation and test maintenance. However, for other activities such as test planning, test coverage report, quick fault identification, test object identification more industry based

AI solutions are required. Based on these above-mentioned findings, a set of novel research directions on AI in software testing are listed next.

a) Automated Oracles: AI-based approaches in test oracle automation are mainly applied in static SUT. Wherever, the SUT becomes dynamic which means the SUT starts to be modified by customers' changed requirements, automation in test oracle problem become difficult to achieve. More research will be required in this filed to achieve promising automation in entirely document free test oracle generation.

b) Integration Level Based Test Case Generation: Existing AI-based test automation tools are mainly applied for unit and end-to-end test level. In addition, several tools are also applied in regression testing level. However, there is no effective tool exist in industry that can be applied for integration level based test case generation. Hence, to solve this issue, more AI-based approaches from both of industry and academy are required to devise effective integration level based testing tools.

c) Acquisition of Training Data: In AI, the basic step is to train models with highly correlated data. However, in software testing, it is sometimes difficult to achieve data due to the fact of manual activities. Hence, effective research needs to be conducted to resolve this bottleneck of AI.

d) Automated Test Script: Presently, existing AI approaches have devised simple test scripts. These test scripts often are not empowered to find out identification of faults that can only be found by corner cases. To recognize these kinds of fault, test scripts need to be of more robust.

e) Testing coverage criteria: Standard coverage criteria such as test, data, requirement coverage and quality assurances systems will be required to measure the efficiency of AI-based approaches applied in software testing.

IV. CONCLUSION

This paper is aimed to study the usage of AI-based methodologies in different aspects of software testing. The study has found that most of traditional manual activities in software testing such as test case generation, test data generation, test planning are improved by automated testing tools and further high-level automations can be achieved through application of AI-based approaches. This paper has discussed the role of AI-based approaches in mainly three aspects of Software Testing – STLC, Software Test Levels and Test Automation tools. Based on this study, the paper has listed a set of novel research directions on AI in software testing.

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EMPLOYEE ATTENDANCE TRACKING SYSTEM WITH FACE RECOGNITION

Tran Trong Hieu[1], Truong Le My Thanh[2], Bui Huy Thong[2]
[1]*Eastern International University, Binh Duong, Viet Nam*
[2]*School of Computing and Information Technology, Eastern International University, Binh Duong, Viet Nam*
hieutranjan15@gmail.com, thanh.truong.set18@eiu.edu.vn, thong.bui.set17@eiu.edu.vn

Abstract: Facial recognition is a computer operation able of detecting, tracking, feting, or vindicating faces from images or videos captured by digital cameras and is being applied in numerous fields of life similar to security and identity and serves the purpose of attendance. This research paper presents building a mobile app using Flutter Framework and new programming language called Dart to help display information and identify workers for automatic checking. Our test results show that this operation is veritably useful, dependable, and important for a face recognition system that can be virtually stationed in a real terrain as an automatic attendance operation for the future.

Keywords: *facial recognition, automatic, mobile app, real environment*

I. INTRODUCTION

Image recognition or computer vision technology is a technique that refers to the search for ways to automate all the work that a human vision system can do. Nowadays, new applications related to this new field are increasingly interesting and widely applied, especially camera manufacturers are increasingly focusing on the development of cameras that provide high resolution to support reception. Face detection works best in bad conditions where previous cameras couldn't. In addition, applications related to automation of presence monitoring, warning, and timekeeping automation systems appear more and more on the market.

II. METHODOLOGY

A. Related Work

Flutter Framework:

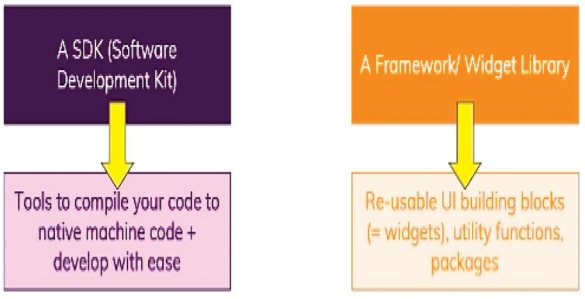

Figure 1. Flutter Framework Definition

It is an open-source and a tool that is developed by Google, and it allows you to build native cross-platform (iOS, Android) apps with one programming language and codebase (write code once and still get two different apps).

But the one programming language Flutter uses does not work on iOS and Android so it needs to compile to native code for iOS and native machine code for Android with help of the SDK (Software Development Kit)

so that we can have code that runs on these platforms (Fig. 1).

It gives a framework, a widget library for that one programming language which is called Dart including a vast collection of reusable widgets (buttons, tabs, text, input) (Fig. 1).

Dart Programming Language

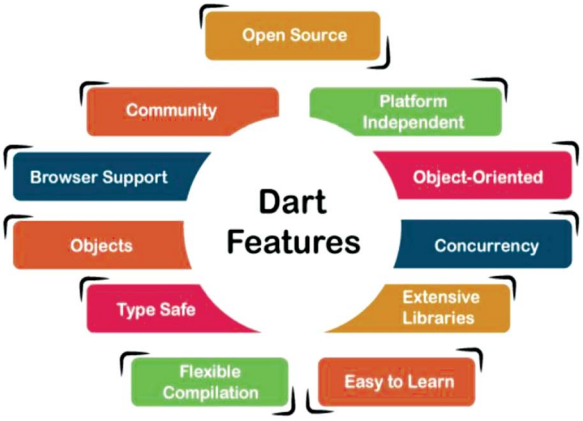

Figure 2. Dart Features

Dart is an asynchronous programming language developed by Google. It's an object-oriented and strongly typed language. It focuses on building front-end UI for mostly mobile apps but also on webs. (Fig. 2)

Dart provides the flexibility to compile the code and fast as well. It supports two types of compilation processes, AOT (Ahead of Time) and JIT (Just-in-Time).

Dart code transmitted in another language can be run in modern web builders. The Dart has its own Virtual Machine (Dart VM), which allows us to run the Dart code in almost every operating system.

Dart treats everything as an object and inherits from The Object class (Fig. 2). The Syntax is a bit like a mixture of JavaScript, Java, C# and Kotlin.

B. FaceNet Architecture

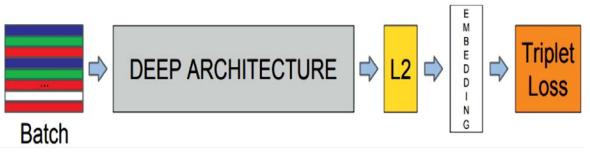

Figure 3. FaceNet Architecture

FaceNet is a face recognition system using deep neural network introduced in 2015 by experimenters at Google. The main idea of this system is to train a **CNN** (Convolutional Neural Network) to extract a 128-element vector from a face image, called **Embedding**. The vectors uprooted from same person's images should be veritably close to each other, while the distance value between vectors uprooted from two different person's face image should be sensibly much further [1,4, 5].

In short, the CNN is trained with three images named **Anchor, Positive and Negative**. The Anchor and Positive images belong to the same person and the Negative is from a different one. This new loss function is called **Triplet Loss** [6].

Deep CNN Model based on Zeiler and Fergus Network Architecture

The image below shows the model detail, which has 22 layers and trains on 140 million parameters at 1.6 billion FLOPS per image (Fig. 4). FLOPS (Floating Point Operations Per Second) a standard measure of computer performance that requires floating-point computation. In addition, the accuracy of model is higher with larger FLOPS [1-3].

layer	size-in	size-out	kernel	param	FLPS
conv1	220×220×3	110×110×64	7×7×3, 2	9K	115M
pool1	110×110×64	55×55×64	3×3×64, 2	0	
rnorm1	55×55×64	55×55×64		0	
conv2a	55×55×64	55×55×64	1×1×64, 1	4K	13M
conv2	55×55×64	55×55×192	3×3×64, 1	111K	335M
rnorm2	55×55×192	55×55×192		0	
pool2	55×55×192	28×28×192	3×3×192, 2	0	
conv3a	28×28×192	28×28×192	1×1×192, 1	37K	29M
conv3	28×28×192	28×28×384	3×3×192, 1	664K	521M
pool3	28×28×384	14×14×384	3×3×384, 2	0	
conv4a	14×14×384	14×14×384	1×1×384, 1	148K	29M
conv4	14×14×384	14×14×256	3×3×384, 1	885K	173M
conv5a	14×14×256	14×14×256	1×1×256, 1	66K	13M
conv5	14×14×256	14×14×256	3×3×256, 1	590K	116M
conv6a	14×14×256	14×14×256	1×1×256, 1	66K	13M
conv6	14×14×256	14×14×256	3×3×256, 1	590K	116M
pool4	14×14×256	7×7×256	3×3×256, 2	0	
concat	7×7×256	7×7×256		0	
fc1	7×7×256	1×32×128	maxout p=2	103M	103M
fc2	1×32×128	1×32×128	maxout p=2	34M	34M
fc7128	1×32×128	1×1×128		524K	0.5M
L2	1×1×128	1×1×128		0	
total				140M	1.6B

Figure 4. Deep CNN Model's Layers

Face Embedding

For example, the face embeddings of sizes (1x1x118) are resulted from the L2 normalization layer of the deep CNN model (Fig. 5). This embedding is used in face verification and face clustering [4,5].

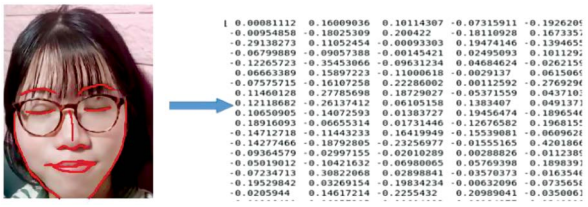

Figure 5. Face Embedding Works

Face verification

It compares the facial embeddings of all trained images with the given image to find matching faces (Fig. 6) and find whether two query and reference images belong to the same person [4,5].

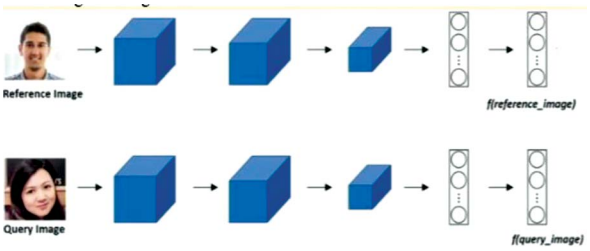

Figure 6. Face Verification Concept

Face clustering

Face clustering is the way of grouping images of the same person together for different categories. (Fig.7) [5].

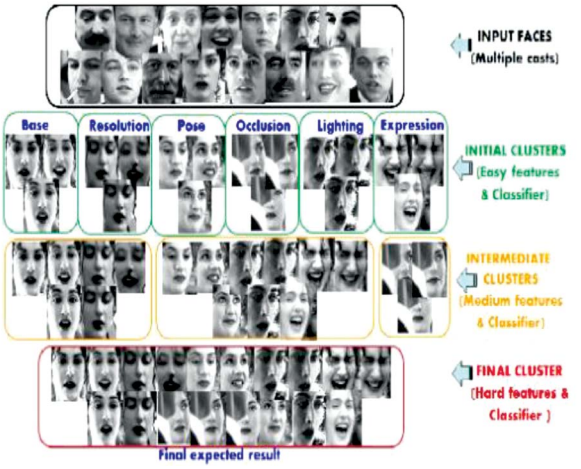

Figure 7. Face Clustering Concept

Take a picture below (Fig. 8) as the explanation of how to recognize a person using FaceNet Model.

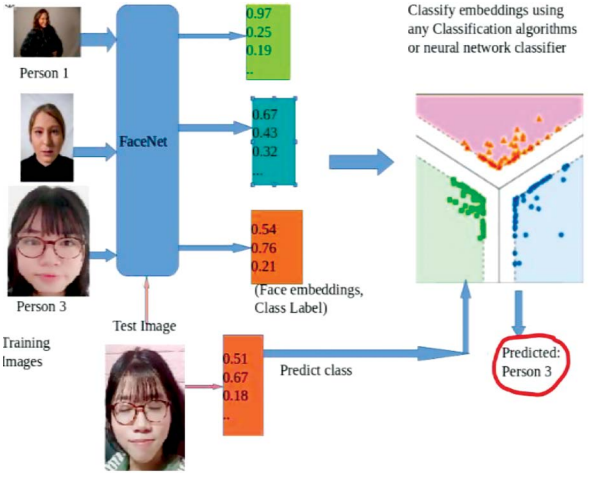

Figure 8. Example of how to recognize the same person

C. FaceNet Architecture Comparision

This picture below (Fig. 9) shows the result of different between some popular face recognition model.

	Cosine	Euclidean	Euclidean L2
VGGFace	Threshold: 0.31 Accuracy: 89.28 Precision: 97.41 Recall: 80.71 F1: 88.28	Threshold: 0.47 Accuracy: 81.42 Precision: 97.82 Recall: 64.28 F1: 77.58	Threshold: 0.79 Accuracy: 89.28 Precision: 97.41 Recall: 80.71 F1: 88.28
FaceNet	Threshold: 0.40 Accuracy: 98.21 Precision: 100 Recall: 96.42 F1:98.18	Threshold: 11.26 Accuracy: 98.57 Precision: 100 Recall: 97.14 F1: 98.55	Threshold: 0.90 Accuracy: 98.21 Precision: 100 Recall: 96.42 F1: 98.18
OpenFace	Threshold: 0.11 Accuracy: 57.85 Precision: 95.83 Recall: 16.42 F1: 28.04	Threshold: 0.47 Accuracy: 57.85 Precision: 95.83 Recall: 16.42 F1: 28.04	Threshold: 0.47 Accuracy: 57.85 Precision: 95.83 Recall: 16.42 F1: 28.04
DeepFace	Threshold: 0.13 Accuracy: 54.64 Precision: 100 Recall: 9.28 F1: 16.99	Threshold: 42.21 Accuracy: 52.50 Precision: 100 Recall: 5.00 F1: 9.52	Threshold: 0.51 Accuracy: 54.64 Precision: 100 Recall: 9.28 F1: 16.99

Figure 9. Model Comparison

Table 1. Deepface model

DeepFace
In 2014, DeepFace was the first to use 9 layers.
54.64% accuracy
Most popular for facial analyzing emotions

Table 2. VGG-Face model

VGG-Face
In 2015, VGG-Face had a large-scale dataset from the Internet. It trained the VGGNet on this dataset and then used the loss function via a triplet loss like FaceNet.
89.28% accuracy
Most popular for face recognition: mask, obstacles on the face

Table 3. Facenet model

FaceNet
In 2015, FaceNet had a large-scale private dataset to train a new GoogleNet. Like VGGNet it also uses the loss function called triplet loss to aligned matching/ nonmatching faces.
98.21% accuracy
Most popular for full face detection: who they are

Fig. 9 and Table 3 are the results tested by another common research. So, for full face recognition we choose FaceNet Model (Table 3) with the highest accuracy.

III. RESULTS

A. Front-end Mobile Application

The pictures below show the front-end of the mobile app, we design it with some basic functions such as if employees do not have an account, then they can register a new one and the login for employee and admin so the menu and sidebar will be different for the type of account logging (Fig. 10).

For example, as an admin I can see all information of employees and important ones such as list of cameras and the event that occurred (Fig. 11).

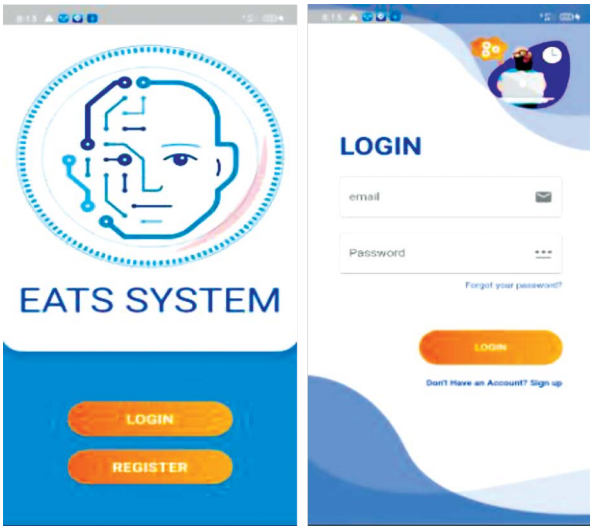

Figure 10. Front-end Design

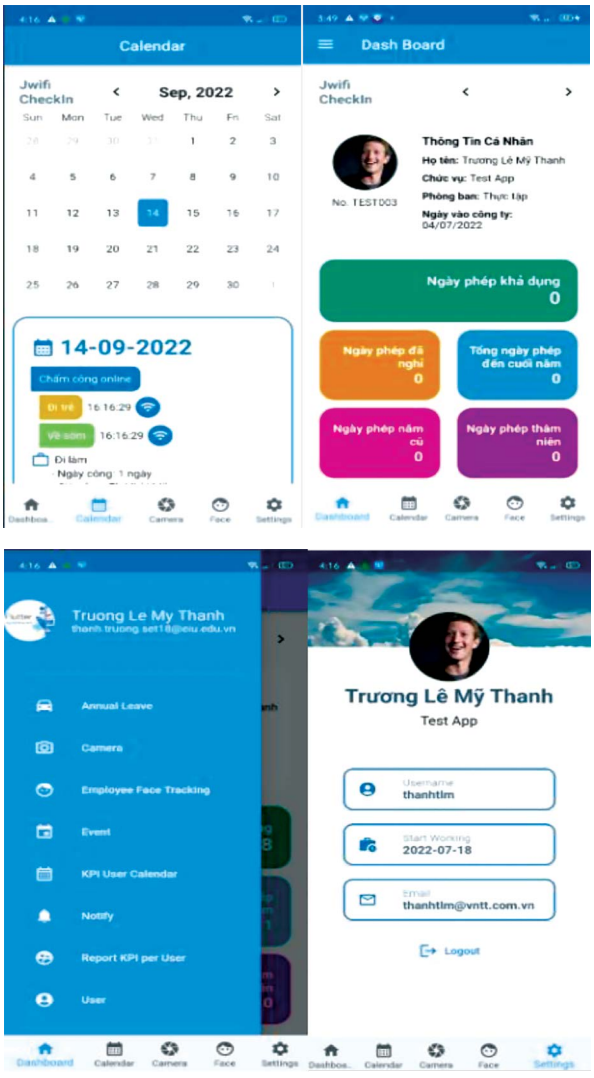

Figure 11. Front-End Side Bar and Bottom

B. Result of Face Recognition

Face Training at local application

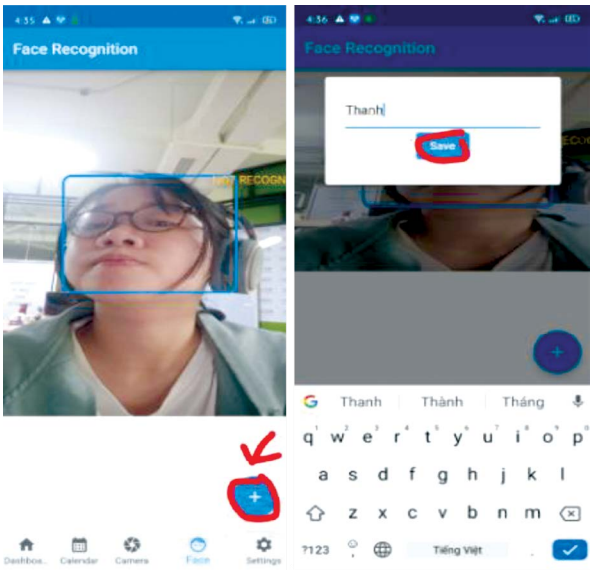

Figure 12. Training Image at local app

For local training images, at first when the app does not recognize an employee that means it does not have the data of this face. So, you need to add label for this face by press the "+" button then type the name that you want the app will show the name of this face, and finally press *"**save**"* button for completely.

- About the dataset, this app takes and drops image of users then trains it in local app. The result of training will be saved on the *modelfacenet.tflite* file in assets folder. At this point, the trained dataset is in the root of the app.

So, if anything goes wrong for training, we need to re-execute the app again and this will take time.

Face Recognition at local application

The result after you add label for faces is shown below (Fig.13).

The image that you took before is now used for the comparison recognition; it will recognize faces based on it. This is very important for labeled faces above is right.

For higher accuracy you need to take more picture of faces from different angles of the same person that is labeled 'NOT RECOGNIZE'.

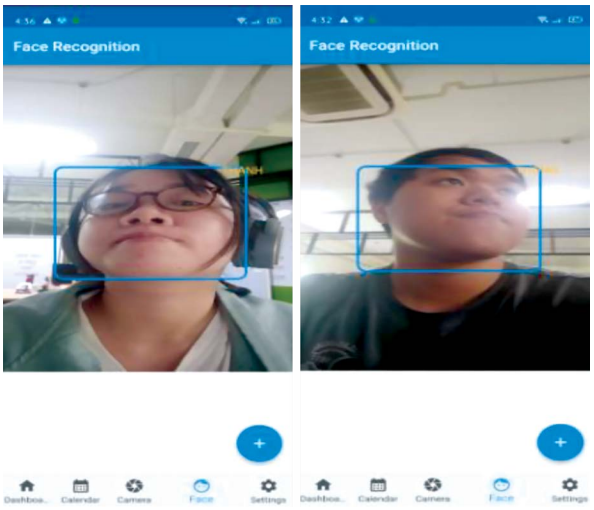

Figure 13. Result of face recognition

IV. CONCLUSION

In this research paper, we presented a study on the implementation of the Flutter Framework for face reocgnition utilizing the FaceNet model.

Additionally, we developed a mobile app that integrates with this model for user intteraction. The result of our study demonstrated a relattively high level of accuracy, although the process of capturing images from various angles and labeling them within the app proved to be time-consuming. To enhance both accuracy and efficiency, it is recommended to trainsmit and store the trained data on a remote server rather than within the local application.

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Headquarters:

Room 501, VNU-HCM Headquarter, Linh Trung Ward, Thu Duc District, HCMC

Phone: 028 62726361

E-mail: vnuhp@vnuhcm.edu.vn

Website: www.vnuhcmpress.edu.vn

Publication Director

Dr DO VAN BIEN

Editor

SIN KE DUYEN

Proofreader

NHU NGOC

Book Cover Designer

NGOC TRAN

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Nam Ky Khoi Nghia Street,
Hoa Phu Ward, Thu Dau Mot City,
Binh Duong Province, Vietnam

(0274) 222 0372

info@eiu.edu.vn

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