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Digital Ecosystem in Public Services of the Northeastern Local Administrative Organizations: Initial Findings

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Abstract— **Due to the rapid change in technology and the epidemic of COVID-19, the private and public sectors have adjusted more readiness to use digital technology services, but public services of local government organizations are not yet concrete. Hence, this work aims to explain the current state and supporting factors of the digital ecosystem in public services of local administrative organizations, The data were collected through semi-structured in-depth interviews and group meetings from 80 key informants directly involved in digital public services at both policy and operational levels. In this phase, the data were collected in 5 research units with 20 key informants and were analyzed using the thematic analysis method under the research framework. From the preliminary results, the organizational structure and knowledge and skills of personnel dimensions are the major factors that are the lowest availability. However, all research units report no problem with the readiness of service recipients and infrastructure in both hardware and software. The results of this research are only the initial findings, and still need to be analyzed and explained further.**

Keywords—public services, digital Ecosystem, local government, e-government

I. INTRODUCTION

Due to the rapid change in technology, the way of life of the world's population has changed like never before. It creates new types of goods and services, including many types of government services. especially in developed countries in Europe, America and Asia [1]. In Thailand after the announcement The National Strategic Plan of Thailand 4.0 has set up an agency at the ministry level, namely the Ministry of Digital Economy and Society, and sub-departments to drive the policy. As a result, government agencies have to adjust. As a result, government agencies are adapted by introducing digital technology to enhance efficiency and effectiveness of public services that can be accessed easily, quickly and transparently by the public. The information is opened on its website for interested people to access the information. As can be seen from government agencies, there are open databases on their websites for interested people to access information
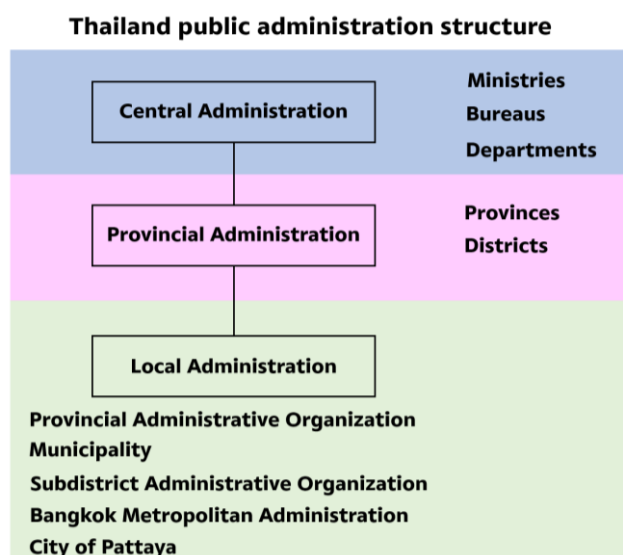

Fig.1 Thailand public administration structure.

or many mobile applications are launched; Pao Tung, Tang Rath, etc.

Fig. 1 illustrates the structure of Thailand public administration. It consists of 3 levels: central, provincial, and local administrations [2]. For central administration consist of ministries, bureaus, and departments. Provinces and districts are in Provincial administration, while local administration is an integration of provincial administration organization (PAO), municipality, subdistrict administration organization (SAO), Bangkok metropolitan administration (BMA), and city of Pattaya. The local administration occurred from the current demand for decentralization of governance for the locals to be self-reliant and make local decisions themselves according to the Thai constitution BE 2540 and continued up to the present Constitution. Although Thailand has been driving through the national strategy for many years. However, the movement of digital technology policies is mainly carried out by central ministries and agencies. It is not
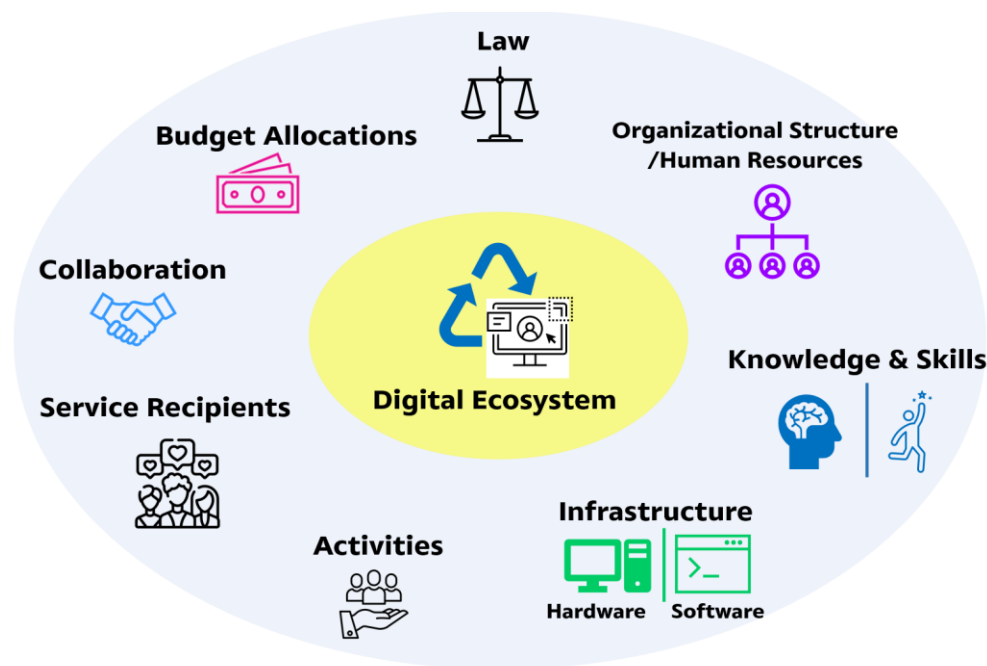
Fig. 2 Factors related to the digital ecosystem framework.

widely seen at the local level, where the local administrative organization is the main public service unit in the area. who are close to the people in the area and has the most important role and importance related to the wellbeing of the citizen.

In the past few years, the Covid-19 epidemic has become a catalyst and forced all sectors to adopt digital technology in their management in order to comply with social distancing and DMHTT concept [3]. This leads to working from home, which is like remote working, online conferencing. cashless behaviour and/or using food delivery service. While the private and public sectors have adjusted more readiness to use digital technology services, but the public service of the local government does not change the public service to be consistent with concrete as it should be, in other word, many sectors have adopted digital technology concretely, but the public services of local government organizations are not yet concrete.

Therefore, this work aims to explain the current state and supporting factors of the digital ecosystem in public services of local administrative organizations that can enhance the public service of the local administration make it easier and more convenient for people to be able to access anywhere, anytime. However, this work is just an initial finding and still need to be analyzed and explained further.

II. RESEARCH QUESTION

This research attempted to answer the question, "What is the current state of the digital ecosystem in public services of the northeastern local administrative organizations?"

III. RELATED WORK

A. Digital Public Service

From Determining plans and process of decentralization to local government organization act B.E. 2542 and the revised version in B.E. 2549, the Local Government Organizations have the roles, powers and duties in public services to the people in many terms which can be divided into 6 categories as follows 1. Infrastructure 2. Promoting quality of life 3. Organizing communities, society and maintaining public order 4. Planning investment promotion commerce and tourism 5. Management and conservation of natural resources and the environment. 6. Arts, culture, customs and local wisdom [4].

The definition of government services that are easily read and understood by the public was published by ETDA explaining that government services through electronic systems (Government e-Service) is the management of government services through online channels. In order to respond to the needs and behaviours of people and related sectors in a timely manner, governments in many countries around the world including Thailand, aiming to use e-Service to achieve the goal of providing convenient and fast public services causing the participation of civil society Improve service quality making use of resources economically There was flexibility in management. and can use various information to make policy decisions [5].

B. Digital ecosystem

Any technology ecosystem is largely thought of as a hardware device and software architecture layers including applications, but in terms of public service must be cornered from both technology and sociology, which is defined as it is a coordinated social and technical system established by governments, citizens, as well as other stakeholders such as companies, the private sector and their representatives [6]. Factors involved in the transformation of an organization to e-government are numerous from various research groups. However, from [7]–[11] there are overlapping cofactors in the digital ecosystem term as shown in Figure 2. Therefore, the framework for consideration the digital ecosystem in this work consists of 8 factors - laws, organizational structure and
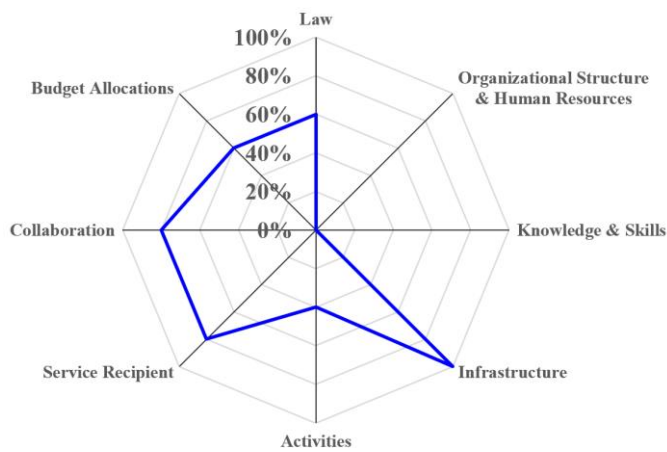
Fig. 3 Digital ecosystem status.

human resources, knowledge and skills, infrastructure, activities, service recipient, collaboration, and budget allocations., organizational structure and human resources, knowledge and skills, infrastructure, activities, service recipient, collaboration, and budget allocations.

IV. METHODOLOGY

The unit of study in this work is 2,899 local government organizations throughout the northeastern region of Thailand. This includes PAO, municipalities, and SAO. The sample number was aimed at 20 units based on provinces with city municipality as the main and then selected PAO, town municipality, subdistrict municipality, and SAO in that province, respectively. This resulted in 80 key informants directly involved in digital public services at both levels of policy and operational.

The data were collected through semi-structured in-depth interviews and group meetings. In this phase, the data has been collected in 5 research units with 20 key informants. From the information obtained, the weight of importance of supporting factors that promote the public service of the Local Government Organizations can be calculated in percentage by following equation:

$$\%weight = \frac{N_A}{U_T} \times 100 \qquad (1)$$

where *%weight* is the weight of importance of each aspect of the digital ecosystem. N_A is the number of research units that agree with that factor. U_T is a total number of the unit research. Furthermore, the data was analyzed by using the thematic analysis method with the research framework, digital ecosystem, as mentioned above.

V. RESULTS AND DISSCUSSIONS

From Eq. (1), the obtained data can be illustrated in the form of a radar chart in the digital ecosystem of 8 issues as shown in Fig 3. It is shown the relationship of weight values to digital ecosystem factors. The lower of the weight value means the lower the readiness in that aspect, it should promote and develop those issues for the achievement of digital public service. It is found that, an organizational structure issues and a knowledge and skills of personnel issues are the lowest availability while infrastructure issues are most readily available. and followed by the availability of service recipients

and collaboration with other agencies. Another point of interest is the low availability of digital public service compliance activities. This means that most agencies are not taking their corresponding activities seriously.

In addition, by using thematic analysis with the obtained data, the organization structure dimension of all research units have a directly responsible department for providing digital public services, but it is not the main task of the position. In terms of the current law, the most of research unit think that there is enough support. Only some provincial administrative organizations still see that some laws are still lacking clarity, making them unfavorable for implementation.

Moreover, the issue of knowledge and skills of digital personnel in all unit agree that they are not ready enough. Only some provincial administrative organizations and municipalities have continued public service activities. While most have not yet clearly initiated a concrete initiative. Only the town municipality does not collaborate with any sector. While the others have collaboration, either in the education sector and local authorities.

Most provincial administrative organizations do not have an annual budget allocation plan. which is opposite to the municipality and municipalities that clearly allocate budgets for public services. However, all research units have no problem with the readiness of service recipients, and infrastructure in both of hardware and software. The results of this research are only the initial findings that still need to be proven and explained further.

VI. CONCLUSIONS

In this work, the current state of the digital ecosystem in public services of the northeastern local administrative organizations are explored. From the result, it is clearly that the organizational structure and knowledge and skills of personnel issues are the major factors that are the lowest availability. There are a directly responsible department for providing digital public services, but it is not the main task of the position. For knowledge and skills issue of digital personnel in all organizations are not ready enough. The minor factor is the implementation of activities consistent with the support of digital public services, which most local governments have not yet undertaken. However, on infrastructure and service recipient, all local government unit are well prepared and ready. Again, the results of this research are only the initial findings that still need to be proven and explained further.

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Economic Gardening and Leadership Styles: A Case Study of Udon Thani, Thailand

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Abstract—*The purpose of this paper is to scrutinize the association between the concepts of Economic Gardening, Leadership Styles, and city growth in a case study of Udon Thani Province, Thailand. Initially, this research applies the mixed methods in the processes of data collection and analysis. 72 respondents participated in the survey questionnaire. Based on the performance (The capabilities of each local organisation in contributing and proving related activities to increase level of economic gardening in the area) score of each return survey questionnaire, the extreme case study of the mayor of Udon Thani was purposively selected to explain the phenomenon of the Economic Gardening and Leadership Styles of the mayor or leader in the community. More specifically, in this research article, the data analysis and results are proposed in the view of qualitative research approach since the selected case presented is the distinguished case.*

Findings indicate that there are substantial effects between the relationship of economic gardening and leadership styles, and then this could bring about the greater level of city growth. Implications are discussed, along with limitations and suggestions for future research. Furthermore, the implications on how to increase the levels of the growth of the city through applying the appropriate concepts of Economic Gardening and the styles of leadership under rapid changing and unstable world environment. In term of the originality, this is the first research to establish that there is association between the concept of Economic Gardening and Leadership Styles and how to develop the growth of the city in the Thai contexts.

Keywords—*City Development, Economic Gardening, Growth of the City, Leadership Styles*

I. INTRODUCTION

The AEC (the ASEAN Economic Community of the Association of Southeast Asian Nations) was recognised in 2015, with a total contribution of approximately six hundred million. Thailand, one of the members, has a population of approximately 70 million. Udon Thani, in the Northeast region, is one of the most densely settled areas. The requirements of the fast-growing cities in this region are met by the current infrastructure, including high-speed trains, light railways and Internet connection [1][2].

The terms 'Economic Gardening' or 'Economic Gardening Concepts' are recognised as the participation and collaboration from all partners or stakeholders (e.g., outward-looking strategies aiming to attract firms through the use of incentives, inward-focused strategies designed to retain and expand existing firms, and inward-focused community and small business development activities) to make it possible to provide facilities and increase the wellbeing of the residents and, in turn, increase the growth of the cities in terms of improving the economic situation by best utilising the limited local resources, both tangible and intangible [3][4].

Furthermore, the vision of the leaders or key persons to make it possible to organise stakeholders, including the mayors, chief executive officers (CEOs), chief administrative officers (CAOs), officials, and the residents [5][6]. Hence, understanding the directions of those organising and managing the city is clearly valuable in recognising how to apply the economic gardening concepts to improve the overall growth of the city.

II. RESEARCH QUESTION

This research attempted to answer the question, "To what extent are there the relationship between economic gardening and leadership styles?"

III. RESEARCH OBJECTIVE

By using various research techniques, we examine the relationship between economic gardening and leadership styles and provide recommendations on how to increase the levels of growth of the city through applying appropriate learning styles.

IV. LITERATURE REVIEW

The term 'economic gardening' is one of examples of inward-looking policies of local economic development. This term was coined by Phil Burgess for an innovative approach to local economic development he proposed for the City of Littleton, Colorado [7]. In the United States, local economic development activities are generally bottom-up in the sense that they are led by local governments themselves. There are some limited federal grants available to fund these activities, but local governments must come up with their own proposals and applications. The traditional bottom-up approach is for local governments to entice outside businesses to relocate by offering all kind of incentives. By contrast, the City of Littleton piloted a strategy for increasing jobs through entrepreneurship and small business investment rather than recruiting companies to a community. According to Phil Burgess [7]:

'We have all these economic development agencies running around hunting for businesses. They really should just stay at home and work with local entrepreneurs. They should get out of the economic hunting business and into the economic gardening business.'

Research has found links between business incentives provided by local governments and economic development in those localities [8][9][10][11]. Furthermore, some studies find that incentives granted to smaller establishments have better performance in terms of job creation compared to very large establishments [12]. However, it has been argued in the literature that only inward-looking policies ('Economic Gardening') are likely to benefit the national economy, as a whole [7]. By contrast, outward-looking policies ("economic hunting") pursued by individual localities are likely to degenerate into what is essentially a zero-sum game for the national economy as a whole. As Acs and Szerb [13] put it:

'When one city or state offers tax breaks or other financial inducements to encourage firms to locate new plants or headquarters, some alternate city or state loses that economic activity. However, the idea of economic development centered around entrepreneurship is a fundamentally different approach. The formation and growth of new firms, wherever this occurs, is clearly a positive sum game – not just for the locality, but for the nation as a whole.'

Furthermore, to make it possible in terms of improving the wellbeing and the growth of the city, the visions of the leaders or managers of the city are significant, as suggested by McConnell, McFarland & Common [14] and Chan & Chan [15]. There is a relationship between economic gardening and leadership styles that should be investigated to understand how to groom economic growth within the local areas. Transformational leadership is one of the most notable leadership styles known as contingency theory. There are four key components of transformational leadership: idealised influence, intellectual stimulation, inspirational motivation, and individualised consideration. Idealised influence is behaviour inspiring subordinates' intention and determination coinciding with their leaders or managers [16][17]. Transformational leaders take an administrative approach capable of instilling in their employees' belief, trust and appreciation, by concentrating on idealised influence, individualised consideration and inspirational motivation [18][19], which in turn lead to a charismatic role model and empowers achievement. This type of leadership also involves intellectual capabilities, because in firm management there is a need for intellectual stimulation integrated with the other leadership traits [20]. Bass [21] defined transformation leadership as questioning old assumptions and the status quo. Managers are therefore likely to concentrate on encouraging subordinates' motivation by inspiring a vision of the future. This type of leader has four characteristics: 1) idealised influence, 2) inspirational motivation, 3) intellectual stimulation and 4) individualised consideration [22][23].

Bass et al. [24] also established that transactional leadership could be simplified as the predominant nature of the old paradigm of leadership style. There are three elements of transactional leadership: contingent rewards, management by exception-active and management by exception-passive. These three components are more concerned about how subordinates manage their assigned tasks, after which the rewards system can be applied.

Finally, laissez-faire leadership is related to the managers who are less likely to be involved in any activities [25]; they avoid making decisions and taking responsibilities, as they do not wish to be responsible for any consequences of the subordinates' outcomes [16].

To sum up, House et al. [26], in the Global Leadership and Organisational Behaviour Effectiveness (GLOBE) study of 62 societies, and in terms of Hofstede's [27] individualism vs collectivism established that a number of Thai households or family members prefer to live together as a large group, dependent on each other as a close network for driving business or day-to-day living, known as an extended family [28][29]. Hence, the concept of proving the convenience of living in the city is necessary for Thais since the current research indicates that in the next five years Thai society is moving forward to be one of the societies gathering in the city-centre [30]. This means that it is necessary for the city manager or mayor to consider the necessity of improving living for the residents in the region in order to help them to have the greater levels of wellbeing by utilizing the local resources within the area (Economic Gardening Concepts). Thus, the concepts of economic gardening and leadership styles are investigated in this research to answer how to increase the level of wellbeing of the residents.

V. Research Methodology

The mixed method approach is applied to attain the advantages in terms of triangulations of both quantitative and qualitative approaches. Though the quantitative approach more heavily relies on the inference from a number of observed phenomena, the qualitative approach is based more on induction and is more likely to penetrate into the details of the relevant and interested themes [31][32]. However, due to time and budget constraints, the findings of the qualitative approach are discussed. As suggested by Gearing [33] and Zumitzavan [34], the distinctive cases could carefully be selected based on the extreme values that are either highest or lowest compared to the others in the same category. In addition, the findings from the quantitative indicate that Laem Chabang (a port city municipality in Si Racha and Bang Lamung districts of Chonburi Province) is keen to be the hub of industry; Chiang Rai (the northernmost major city in Thailand, with a population of about 200,000) is more likely to be a hub of services and agriculture; Krabi (the main town in the province of Krabi on the west coast of southern

Thailand) also provides services, tourism, and agriculture; and lastly Udon Thani is more likely to provide services, agriculture, transportation, and industry. Hence, to understand the distinctive case, Udon Thani (one of the four major cities of Isan, Thailand's north-eastern region) is chosen for further investigation as an extreme case [35][34].

Units of Study

The unit of study is the general local administrative organisation (LAO) in Thailand, with a total of 7,848 organisations in total throughout Thailand [36]. The respondents were the mayors, chief executive officers (CEOs), chief administrative officers (CAOs), and other officials.

Samples

The samples were drawn from the population of 7,848. Initially, the anticipated number was 80 but the actual sample size was 72, drawing from the multi-stage sample selection technique. Firstly, the samples were drawn by selecting from each region of Thailand; North, South, East, and Northeast. Next, provinces were selected from each region, with 16 provinces selected. Next, the five different types of local administration organisations: Municipality, City Municipality, Town Municipality, Provincial Administrative Organisation and Sub-District Municipality, were sent the survey questionnaires.

In each of the 76 provinces (Bangkok not included), there were five organisations that were selected, for a total of 380 organisations. In this study, 72 respondents were considered as 18.9% returned questionnaires. As suggested by Ames [37], a rate of returned questionnaires of 15% is considered as acceptable. Similarly, Hair et al. [38] suggested that to calculate the appropriate number of samples when the population is larger than 100, it could be represented as 15% of the overall number of the population; larger than 1,000 represented as 10%; and larger than 10,000 represented as 5%. In this study, the population is larger than 1,000, hence, the samples can be represented as 10% and the samples in this study of 72, representing 18.9%, can be considered as a more than satisfactory rate of respondents.

Data Collection and Analysis

Firstly, the information document and arrangement of appointments were sent to the respondents. The survey questionnaire was distributed to the local organisations throughout Thailand (via face-to-face meetings, phone calls, and online interviews). The targets were Municipality, City Municipality, Town Municipality, Provincial Administrative Organisation. and Sub-District Municipality.

Secondly, after completing the round of survey questionnaires, samples from four different local organisations were selected based on the performance of each organisation in terms of supporting the economic gardening concepts. The areas were Chiang Rai, Krabi, Laem Chabang, and Udon Thani. The four extreme cases were approached to arrange an appointment to further arrange for the focus-group and in-depth interviews with the leaders and organisational members of the local organisations.

Finally, in this study, since Udon Thani is considered as one of the extreme cases and prone to provide supporting activities and projects related to 'Economic Gardening', the contents of the in-depth interview of the mayor of Udon Thani was selected for analysis by applying the thematic approach to answer the research question. Interview descriptions were daftly categorised dependent upon the types and contents of the interview data. Subsequently, the data were distinguished based on the themes of the research to answer the research question.

VI. FINDINGS

The findings revealed that the mayor possesses the components of the transformational leadership style as shown by the interviews.

From the interview, findings show that the interviewee holds a high profile since he completed his PhD in Social Science and possesses long experience in the housing estate industry. He is also the key person managing the city with the clear visions to apply and move the city forward into a new chapter of urbanisation to face the rapidly changing environment in which the key is 'digital government'.

The Mayor said that "to enable all stakeholders to be able to communicate with us, it is necessary to provide the online channel to communicate 24/7." (Face-to-face interviews, 29 October 2021)

This shows that he realises that to facilitate communication through online channels would reduce costs and time and to help residents to remain safe from the pandemic.

He also mentions that the master plan of his area will be to improve the overall infrastructure to serve the transportation within the city.

"Our master plan is to make it convenient to the pedestrians or residents which anyone could travel from Vietnamese town to Chinatown within couple of minutes, and in order to do that we are going to place the electric cables into the underground cable system. This would help everyone to move freely with limited time." (Face-to-face interviews, 29 October 2021)

In addition, "we are trying to attain a greater amount of funds since we would like to improve the overall infrastructure, urban landscape, and to attract tourism." (Face-to-face interviews, 29 October 2021)

He mentions that the international airport within the area should be managed under the supervision of the municipality.

"Unlike others, our city has its own international airport, and it should be managed under our supervision since the airport locates within the range of municipality." (Face-to-face interviews, 29 October 2021)

"We also plan to make it possible for our city to be 'walkable city'". To do that, we plan to rebuild and renovate the footpaths all along the city to provide convenience to the pedestrians." (Face-to-face interviews, 29 October 2021)

"We are always available for our residents to contact us 24/7, and we believe that this is the only way that we can keep tracking the situation within the community. This would help us to draw cooperation from our residents." (Face-to-face interviews, 29 October 2021)

The Mayor also discusses a clear policy goal that "we plan to be a service and green city in that we plan to serve the community by saving the environment. So, we concentrate on providing the city to be the hub of education, entertainment,

healthcare, street food, and transportation." (Face-to-face interviews, 29 October 2021)

The interview shows that the Mayor holds a high profile and he has a clear vision to improve the city which is consistent with the existing academic research in terms of leadership styles and the outcomes of the organisations (See for example, [43] [44] [45]).

VII. IMPLEMENTATIONS AND SUGGESTIONS

Local administrative organisations in Thailand have been confronted with myriad problems and obstacles to providing quality public services in their localities and visionary local leaders are a key to making the local governments viable [42]. As shown in the findings, the Mayor established clear visions and possesses a transformational leadership style. Techniques of listening, communicating, and encouraging are applied to all residents to directly persuade them to regularly contact the local administrative organisation. The online channels or the digital platforms are funded and supported to enable accessibility to all residents (consistent with inspirational motivation). To improve the overall urban landscape is one of the key policies to draw businesses, travellers, and tourists to the city (consistent with idealised influence). Simultaneously, in terms of equitability, all visitors and residents should have an equal right to travel freely and conveniently for drivers and for pedestrians via the pathway, creating a 'Walkable city' (consistent with individualised consideration). Finally, developing and renovating the city as a hub of education, entertainment, healthcare, street food, and transportation are key subjects of the masterplan and that would improve the growth rate of the city in terms the economy (consistent with intellectual stimulation).

In addition, findings also show that the interviewees are applying and utilising limited resources to improve the growth of the city and the well-beings of the residents. This is also consistent with the existing academic finding of Resource-Based-View (RBV) concepts suggested by Barney [4]. The findings also suggest that those activities would improve the overall infrastructure, provide a variety of needs for the different lifestyles, enable online channels for communication at any time, and draw cooperation from all stakeholders consistent with the concepts of economic gardening as suggested by Acs & Szerb [13], McConnell et al. [14], and Chan & Chan [15]. Therefore, there is the connection between the transformational leadership style and the concept of economic gardening that would be useful to improve the overall growth of the city. To promote greater sustainable growth in cities throughout Thailand, the government, particularly the Department of Local Administration, and higher education institutions should design training courses and practical tools to assist local government leaders to improve their leadership style and initiate economic gardening measures and policies.

Last but not least, since the findings of this research are based entirely on the data collection of "The Development of Public Policies to Enhance the Capacity of Local Administrative Organizations in Reducing Economic Disparity and Improving the Quality of Life of People in The Area granted by National Research Council of Thailand

(NRCT) and Khon Kaen University (KKU), future research may consider collecting data from different types of organisations, areas, cultures, and so forth. Furthermore, it would be valuable to apply the set of data to test with different statistical techniques to discover the causal relationship by applying the Structural Equation Modelling (SEM). Finally, due to the limitation of time and budget, particularly, the diffusion of COVID-19 pandemic, the data collection process of this research faced the difficulties leading to the small amount of samples, future research may consider replicate the entire process of data collection and data analysis of this research and then collect the data in different ranges of time so that the future research would be able to understand in more details of the trends of the data in the sense of longitudinal studies.

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Abstractive Text Summarization for Covid-19 News with Data Augmentation

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Abstract— **Since the spread of Corona Virus disease or Covid-19 at the end of 2019, there has been an extensive amount of news about Covid-19 and it takes a long time for humans to read the news, process it and retrieve important information from it. Therefore, automatic text summarization is necessary in this matter as it can help us process information faster and use it to make better decisions. Currently, there are two main approaches to automatic text summarization: extractive and abstractive. Extractive text summarization is conducted by identifying important parts of the text and extract a subset of sentences from the original text. Abstractive text summarization is closer to human's method as it is the reproduction or rephrasing based on interpretation and understanding of the text using natural language processing techniques. In this paper, we present text summarization of Covid-19 news using abstractive method to be close to human's method of summary. We also apply data augmentation in the pre-processing part to be an example case of working with data that are not perfect or diverse enough.**

Keywords— Text summarization, data augmentation, Covid-19 news

I. INTRODUCTION

Since the spread of Corona Virus disease or Covid-19 at the end of 2019, there has been an extensive amount of news about Covid-19 and it takes a long time for humans to read the news, process it and retrieve important information from it. Therefore, automatic text summarization is necessary in this matter as it can facilitate information handling and utilization in order to have better decision making.

Currently, there are two main approaches to automatic text summarization: extractive and abstractive. Extractive text summarization is conducted by identifying important parts of the text and extract a subset of sentences from the original text. Abstractive text summarization is closer to human's method as it is the reproduction or rephrasing based on interpretation and understanding of the text using natural language processing techniques. In this paper, we present text summarization of Covid-19 news using abstractive method to be close to human's method of summary. We also apply data augmentation in the pre-processing part to be an example case of working with data that are not perfect or diverse enough.

In text summarization, Natural Language Processing (NLP), and Machine Learning (ML) especially Deep Learning (DL) techniques are exploited. NLP techniques are used in text preprocessing step while DL techniques are used in summarization.

Deep learning(DL) [1] is subfield of Machine Learning. DL concerns with the algorithms inspired by the structure and function of the brain called artificial neural network (ANN). DL uses multiple layers to progressively extract the features from inputs which will help in recognition and classification tasks. There are two types of DL: Convolution Neural Network (CNN) and Recurrent Neural Network (RNN). CNN is a multilayer perceptron or a network of neurons with full connectivity as shown in Fig. 1. RNN has the same structure as CNN consisting of input layer, hidden layer, and output layer but RNN uses memory to process a sequence of inputs. Moreover, there are many types of RNN architectures such as Long short-term memory (LSTM), Bi-directional, and fully recurrent, for example.
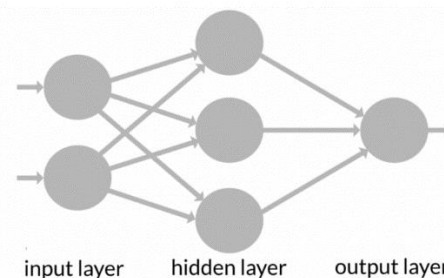

Fig. 1 Convolutional neural network (CNN)

In this paper, we apply RNN in abstractive summarization [2] to generate summarized texts. We also consider using data augmentation method. Data augmentation is the strategy to increase the diversity of training examples and it is used in classification tasks, for example. In our research, we apply data augmentation to increase the performance and flexibility of RNN. Data augmentation can handle new words that are not in the model and prevent the model overfitting by augmenting training data sets with variety conditions such as transforming words and randomly adding or deleting words.

II. RELATED WORK

In this section, we discuss related research that uses RNN for abstractive summarization of articles [2-3].

A. An abstractive text summarization

Abstractive text summarization, as opposed to extractive summarization, is close to human summarizing because it does not extract the words from original texts but generates summaries. The documents are processed and the summaries are generated by rephrasing. It requires data processing in the following steps:

- Pre-process the texts by filtering out unnecessary characters/sentences.

- Tokenize words from the articles and input those words into the model.

- Create word embedding for representing words numerically

The last step, word embedding, is crucial as it creates the learned representation of texts. In word embedding, individual words are represented as real valued vectors in a predefined vector space. This can be used for the machine to understand the meaning of texts as embedding the meaning expressed through the textual contexts. Word embedding together with Recurrent Neural Networks (RNN) are applied to conduct abstractive text summarization as in [2,4].
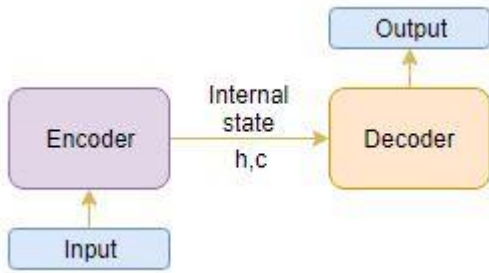
Fig. 2 Text summarization process

The summarization task involves processing the input which is a long sequence of words and the output which is a shorter version, as shown in Fig.2. Here, neural network models can be applied in encoder and decoder components. In ordinary neural networks, the set of inputs and outputs are independent of each other. This creates a problem when we need the model to predict the next word of the sentences. Thus, it is required that the model remembers the previous words. RNN can provide a model that memorizes words by using a hidden layer. However, repeating this process many times in a hidden layer may cause vanishing or exploding gradients. That means when the long text inputs come into the neural network it can become too complex and might crash. Long Short Term Memory Network (LSTM), a type of recurrent neural networks, as in [4,5] is a special category of RNN which can solve the problem of gradient explosion and gradient disappearance. Also, LSTM is appropriate for classifying, processing, and making predictions based on time series data as it can keep the required information and discard the information which is not required or useful for further prediction.

For the architecture of LSTM network, it has three components: forget gate, input gate and output gate. The forget gate must decide the value of the cell at h_{t-1} and x_t as input vector plus a bias b_f that must be discarded or not. If it needs to be discarded, the value in the cell will be 0 and the forget gate keeps current state of the value 1 by using (1) which uses sigmoid function as decision layer.

$$f_t = \sigma(W_{xf}x_t + W_{hf}h_{t-1} + b_f) \qquad (1)$$

The input gate will generate the value within 0 to 1 that defines how much input that is added to the memory content at the current timestamp. This equation also using the sigmoid function as decision layer.

$$i_t = \sigma(W_{xi}x_t + W_{hi}h_{t-1} + b_i) \qquad (2)$$

Moreover, once the input gate decides to update, it must identify which value needs to be updated or *input modulation* gate, using Tanh function as result of value.

$$g_t = tanh(W_x cx_t + W_{hc}h_{t-1} + b_c) \qquad (3)$$

After two inputs and input modulation gate have been declared, it can be combined into one cell called cell state.

$$c_t = f_t \odot c_{t-1} + i_t \odot g_t \qquad (4)$$

The forget gate decides which c_{t-1} in a cell state should be kept considering the value of f_t. Furthermore, the input modulation keeps the value of g_t and g_t. In addition, f_t and i_t will return the value between 0 and 1 by using the sigmoid function to consider about the value sent out of (4).

The output gate takes the content h_{t-1} of the previous state, an input vector x_t, and a bias b_o, input and produces o_t as output. Finally, the content of the current state h_t is produced using the value of o_t. In addition, output gate uses the same formula as the forget gate as well as using the sigmoid function for decision.

$$o_t = \sigma(W_{xo}x_t + W_{ho}h_{t-1} + b_o) \qquad (5)$$

Then, the output gate is now declared but which value should be the output of the cell will be decided by using (6).

$$h_t = o_t \odot tanh(c_t) \qquad (6)$$

Output gate using o_t as decision value. It means that if o_t is 0, h_t will return 0 out of the cell. Otherwise, o_t is not 0 h_t and it will return value of the result of (4) out of the cell.

To sum up, LSTM cells have 3 gates that control the data coming in and out of the cell: input gate, output gate, and forget gate. Input gate controls the input or update data into the cell. Output gate decides about the result that must be correct according to the language structure and forget gate controls by removing the unwanted data in the network. It means that LSTM network can eliminate unused information and reduce calculation timing and cost.

B. Data Augmentation

Apart from RNN, we exploit data augmentation (DA) in our research. [7] discusses data augmentation as a strategy for increasing the diversity of training examples without collecting new data and gain more computation efficiency with limited resources as mentioned in [8]. Aiming to reduce overfitting when training models, data augmentation can be classified based on their formulation into 3 groups as follows:

- Rule-based technique which is an easy-to-compute method, with a set of token-level random perturbation operations including random inserting, deletion, and swapping to perform on many text-classification tasks as shown in TABLE I.

- Example interpolation Technique or Mixed Sample Data Augmentation (MSDA). In this method, DA works by adding explored interpolating inner components, general mixing schemes, and added adversaries.

- Model-based technique which is used in sequence-to-sequence and language models by replacing words with others randomly drawn according to the recurrent language model's distribution based on the current context.

TABLE I.   Sample of rule-based technique DA

Rule-base techniques	Example
None	I am running
Random swap	Tiger am running
Random deletion	I running
Random Insertion	I like am running

III.   METHODOLOGY

In this section, we describe the dataset used in our research experiment, the preprocessing process, encoder-decoder, the attention mechanism and training and testing.

A. Dataset

The dataset used in this project is the Kaggle online dataset of CBC news articles on COVID-19. This dataset is the CBC news about COVID-19 disease, each of which includes the date-time of the news published, and the summary as the description column and the full article as text column as shown in Fig. 6. The dataset contains over 3,500 news articles, 80% of which will be used for training set and the rest for testing set.

- Training data Set. In this set, the data set will be processed and augmented with random deletion, random swap, and random insertion.
- Testing data Set. This data set will be used for evaluation of the final model fit on the training data set. The data in the testing data set has never been used in the training data set.

B. Text preprocessing

Text preprocessing uses natural language processing (NLP) method to preprocess news articles. Text preprocessing involves the steps described below:

- Stop word removal: In English, there are common words such as "a", "an", "the" which have less or no meanings so they have to be removed in order to focus on meaningful words. Stops word removal is as shown in Fig. 3.
- Tokenization. Sentences in the news articles will be tokenized before inputting them into the neural network, as shown in Fig. 4.
- Stemming and lemmatization are used for transforming words into root words or stems to prevent overfitting in the neural network and reduce the various forms of words as shown in Fig. 5.

Fig. 3 "I" and "a" in the sentence are removed in stop word removal.

Fig. 4 Tokenization

Fig. 5 Examples of stemming and lemmatization

C. Encoder-Decoder

To apply LSTM model in text summarization, all the words, after the preprocessing step, will be passed through encoder-decoder process to change the words into the set of numbers for the encoder. Then, the decoder will change from numbers to words as the output.

D. Attention Mechanism

Attention Mechanism is used to implement the action of selectively concentrating on a few relevant things and ignoring others in DL [11]. For encoder-decoder neural networks, given the encoder's and the decoder's hidden states, the use of attention allows for the creation of a context vector at each timestep, which can improve the performance accordingly.

E. Traning and testing

In using LSTM for summarization, we separate the dataset into 2 groups which are the training set and testing set.

- The training data set will be used twice: with data augmentation and without data augmentation.
- The testing data will be used for evaluating the result for the model after training in order to validate the model.

IV.   EXPERIMENTS AND PRELIMINARY RESULTS

Experiments on the input data set are as shown in Fig.6, considering the author, title, publish date, description, text, and URL column of the article. The description column contains the summary and the text column contains input texts. Both columns must be preprocessed.

After converting the data into vectors, we send those vectors to compute in order to train the model. Meanwhile, the training data set would be passed through the data augmentation method. The data are augmented by synonym replacement, random insertion, random swapping, and random deletion methods. All of these methods will generate new sentences into the dataset. For example, the random insertion method inserts new words to a sentence, not more than 10 percent of the amount of words in that sentence. Similarly, the random deletion method deletes words not more than 10 percent from a sentence. Then, the results of model can be applied to Covid-19 news to generate summaries.

title	publish_date	description	text
'More vital now:' Gay-straight alliances go vi...	5/3/2020 1:30	Lily Overacker and Laurell Pallot start each g...	Lily Overacker and Laurell Pallot start each g...
Scientists aim to 'see' invisible transmission...	5/2/2020 8:00	Some researchers aim to learn more about how t...	This is an excerpt from Second Opinion, a week...
Coronavirus: What's happening in Canada and ar...	5/2/2020 11:28	Canada's chief public health officer struck an...	The latest: The lives behind the numbers: Wha...
B.C. announces 26 new coronavirus cases, new c...	5/2/2020 18:45	B.C. provincial health officer Dr. Bonnie Henr...	B.C. provincial health officer Dr. Bonnie Henr...
B.C. announces 26 new coronavirus cases, new c...	5/2/2020 18:45	B.C. provincial health officer Dr. Bonnie Henr...	B.C. provincial health officer Dr. Bonnie Henr...

Fig. 6 Sample columns in raw dataset

For the result of the summary by our model, it can be compared with the whole text input data as shown in Fig.7 and text summary done by humans from the data set shown in Fig.8. Example result of summary generated by our abstractive text summarization with data augmentation is as shown in Fig.9.

Fig. 7 Example of text input in a cell on text column.

Fig. 8 Example of summary done by human in a cell on description column.

Fig. 9 Our generated summary with data augmentation.

Overall, the results of our text summarization are noticeably shorter summaries than human summaries. For evaluation, we apply ROUGE (Recall-Oriented Understudy for Gisting Evaluation) which is a set of metrics for evaluating tasks such as text summarization or machine translation. Based on ROUGE scores, it shows that the model that exploits data augmentation performs about 20% better than the model that does not use data augmentation. This is because the model trained with data augmentation is more flexible and can handle new or unknown words better.

V. CONCLUSION

In this paper, we presented the abstractive text summarization of Covid-19 news using LSTM neural network. We also apply attention mechanism to the encoder-decoder neural network to focus on certain words and improve the performance of the process. For our experiments, we create training data set with data augmentation and testing data set from COVID-19 CBC News articles. The preliminary results of the experiments show that our summarization can generate shorter texts which are concise and easily comprehensible by the readers.

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Digital Transformation of Public Service by MAEHIA Municipality

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Abstract— **Maehia Municipality is in Chiang Mai Province, it is a local government which had received an Excellent Local Administrative Organization with Good Governance Award in 2020 with a creative innovation. The award is given by office of the Permanent Secretary, the Prime Minister's Office. The Project deals with the increasing an efficiency in providing and excellent public service which will lead to an achievement in sustainable development. This document is made up to present the innovative project that Maehia Municipal had launched to asset the administrative work in providing an excellent public service. The main feature involves the history of present problems, the result and success of the project. The project focuses on the administration of the organization, the transparency and good governance. The main concept of the project is a participatory approach; every concerned party must be an integrated part in everything that comes to an attention of the municipal. Being responsible together, sharing information and bringing in technology to help working among parties on platforms to provide solutions. Maehia Municipality is proudly to present this innovative project to complete for the UNPSA 2021 It is hope that by introducing this project to other agencies, This project can be seen as a prototype and will be widely recognized, accepted and utilized in their own local government throughout Thailand. Not only is it applicable to Thailand but also to other UN country members as well**

Keywords— local government, sustainable development, transparency and good governance

I. INTRODUCTION

Maehia Municipality is in Chiang Mai Province, it is a local government which had received an Excellent Local Administrative Organization with Good Governance Award in 2020 with a creative innovation. The award is given by office of the Permanent Secretary, the Prime Minister's Office. The Project deals with the increasing an efficiency in providing and excellent public service which will lead to an achievement in sustainable development

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Fig. 1 Digital Transformation of public service by Maehia Municipality

In order to resolve the problem for good in a long term, The Maehia Municipality most review the function and mission and also to develop a new approach in public service. [1]-[3]
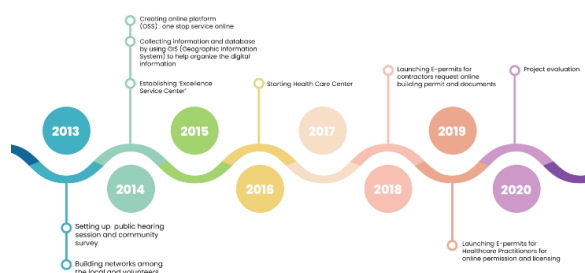
Fig. 2 Action plan throughout the project

The municipality organized a public hearing session to deal with all kind of problems submitted by all concerned partied in the community. It become obvious that there are two parts that are the main cause of the problem

1. The service receivers

2. The service providers

Fig. 3 The issues addressed in public hearing

II. PROBLEMS REFLECTED

A. Problems reflected from service receivers

In general service receivers would refer to general local people, people who are not accounted for (outside people / foreign workers who do not register but live in the community), the vulnerable group. There are two main complaints. First, the problem of not knowing the right to welfare that local people are entitled to receive. There are many departments/divisions and staffs. People are confused not knowing exactly where they should go to or who they should address the problem to. It is very difficult to get assistance.

Second, Problem in dealing with accessibility due to the complexity and overlapping of the administrative structure and policies. There are so many procedures and means for staffs to follow which can delay the requests, not only it takes time to contact proper staff but also it is impossible to follow the whereabouts of requests that cause the quality of public service bad and not so good at all. [4]

B. Problems reflected from service providers

Due to the fact that Maehia Municipality is under staff, not enough personnel to pervade services. The ratio between service providers and service receivers is 183 staffs VS 13,872 local residents too much work and not enough staff and time to deal with all the demands. The annual budget is tight and it is hard to get help from the outside. The task of work is sometime overlap with the work inside department. It takes much time to deal with any problems at hand. The municipality lack in-depth data which must be used to analyze and find ways to solve particular problems to suit the needs of each group.

III. PROCEDURE IN PROBLEM SOLVING

After collecting local data from the past and present provided by both the receivers and providers, Maehia Municipality analyzed the core of the problems and created a plan to solve the problems. The plan is divided into 3 ways as follows:

1. Building networking group involving all the agencies in the community who are the main stakeholder in dealing with public service. The main duty of the networking group is to help develop means to create an excellent public service and also to design an appropriate and sustainable master plan for the future.

2. Creating database collecting and storing system by using GIS to help gather all the data to be used in administration and development of Maehia

3. Establishing an Excellent Service Center, under the provision and control of Maehia Municipality. The main goal is to increase the efficiency of providing public service by using technology and blending with assistance from networking partners in moving and developing an appropriate public service scheme.

Under the 3 plans, Maehia municipality has started and implanted service since 2013. Our objective is to become Maehia Smart Public Service so it can offer the best public service for the whole community.

A. Building networking group among outside and local agencies

The municipal needs to establish a relationship with other agencies to be as cooperative partners, seeking cooperation , sharing data and information and inviting them to assist in solving same or similar problems together. Local people and volunteers are invited to participate in design ways and means to solve problems and create a scheme to be use as guideline to tackle problems.

Fig. 4 Connecting Stakeholders

B. Creating a collection of database

- From previous problems, the municipality does not have enough in-depth data about various problems that people were having. Data collection was done to find out about problems and the need of local people that must be given attention and priority. The networking group involve municipality itself, local volunteers such as village headman, sub district headman, public health volunteers. Household primary data is collected by trained volunteers who were attending a workshop and a training session in data collecting. Data is collected from 10 villages with the assistance of 749 volunteers with other government agencies, covering the area of 24,405 square kilometers. Maehia area has a full access to the internet, so the municipality introduced the use of Drone, Computer and laptop, Smart phone and gadget IT as tools in collecting data which provide fast and accurate outcomes.

Fig. 5 Training local volunteer on how to collect and restore information and database

The general information and in-depth database are divided under 6 categories in total of 83 layers of Unit

1. Quality of life 22 units

2. Basic Infrastructures 9 units

3. Social community organization 30 units

4. Planning and promoting investment 12 units

5. Natural resources and environment 5 units

6. Traditional culture and local custom 4 units
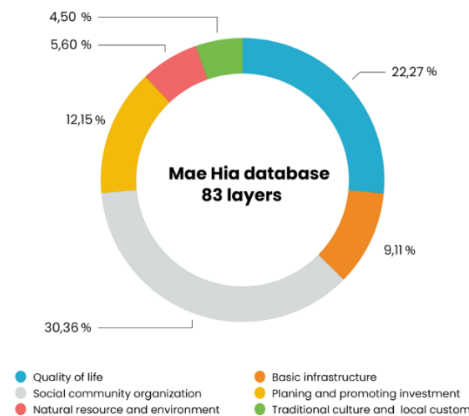
Fig. 6 Mae Hia database 83 layers

C. *By grouping the data into 2 types*

1) Information that can be disseminated to the public, such as the location of medical facilities, areas at risk of natural disasters, waste disposal points, local learning resources of Maehia that residents can take advantage of.

2) Government information that may contain details of personal or confidential information. The municipality will protect and manage access rights for agencies or other related persons in accordance with the Government Information Act.

In the same year, the information above was compiled as Geographic Information System with a purpose to facilitate use of information and access to all relevant parties. For the same purpose, those data have been used to create a database, which appears in the satellite and aerial imagery.
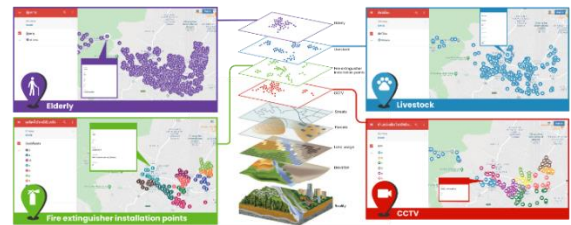
Fig. 7 Results layer

Results - citizens, municipalities, local volunteers and other departments can take advantage of the information to design activities and contribute to the development of suitable service models and solve problems precisely on the data set point. [5]

IV. PROPOSED SOLUTION
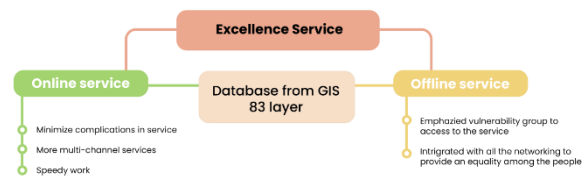
Fig. 8 Excellence Service flow

When having prepared basic information about the sub-district in all aspects, the municipality has established the "Excellence Service Center" in 2014 aiming to transform the service model of the municipality to focus on service efficiency. 83 sets of local databases were used as the base information and made improvements to these 2 aspects:

A. *One Stop Service Online platform usage*

With the goal of organizing public services efficiently under the conduct of the Excellence Service Center, the municipality has therefore developed the online public service platform, Platform One stop service Online (OSS) by using the GIS information database that has been established as a service reference source. The platform that has been developed includes both a website and a mobile application. This allows more contact methods for requesting services or for receiving news, saving time for residents from having to travel directly to the Maehia Municipality. It also allows residents to access the service efficiently and conveniently and helps to reduce inequality service. The technology has been proved success.
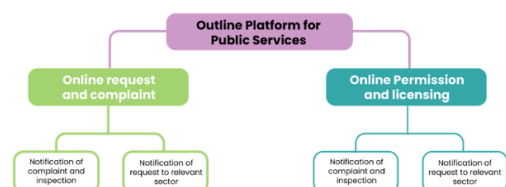
Fig. 9 Outline Platform for Public Services flow

Link Steps of how to access the online service: http://meahia.go.th/catalogs/mhsps

Fig. 10   Using an online platform to obtain government services

B. Receiving notification from public services online

Online learning via the OSS platform consists of 2 parts: Complaint Notification and Result Checking System for public use And a system of Requests Notification to Relevant Agencies for staff use (1) Complaint Notification and Result Checking System is a system for residents to report problems or request services from the municipality. The residents can use this system to track the outcome of requests through OSS platform, and also can track the status of complaints. (2) Requests Notification to Relevant Agencies is a system that categorizes the requests and sends it directly to the responsible agency to resolve problems for the residents, allowing the resolution to be completed in more timely manner.

Fig. 11   Example of UI

1) Basic infrastructure

An example of providing basic infrastructure service is; in the event the roadside illumination is damaged and the citizen who sees it reports this issue through available channels, the information will be recorded in the system and the responsible officer will be notified. The responsible officer will then perform an inspection and analyze data from the GIS database. The database has two data layers consisting of geographic data and the location of roadside illumination, for which the information can be used for immediate repair. When the issue is resolved, the system will notify the citizen of the results instantly. This gives a positive impact to road users and pedestrians in terms of maintained safety.

2) Promoting Quality of Life

An example to services that promotes quality of life is; In the event where there are patients / people with disabilities / the elderly requesting for a shuttle service to a medical facility through the platform, notifications will be recorded in the system and alerted to the responsible officer. The officer will then be able to access 7 layers of related information consisting of database of patients with hypertension, diabetes, nursing homes, bed-ridden patients, elderly database and the disabled database. This is then taken to the staff to prepare the transportation of patients to a medical facility specific to either regular patient / disabled / elderly to be handover to. This is helpful to the family of patients / the disabled / the elderly and the hospital and municipal officials, which also the information can be useful to long term plan for providing care.

3) Planning for Investment Promotion, Commerce and Tourism

An example of services in the area of Organization of community, society, and maintaining peace and order is; In the event that there is an accident in the area, the officer of the municipality's safety and administrative center can be informed via CCTV and notify the emergency medical staff for immediate help. The coordinates are also recorded as a layer of accident point data, which can then plan the route to the accident scene. It can also be analyzed to prevent risks being repeated, find ways to prevent further accidents. The citizens or victims can report their concerns through the service center and can request the footage to be used as evidence if should be needed.

4) Management and conservation of natural resources

An example of Management and conservation of natural resources is; the information layers of forest areas in national parks can be utilized by the park staff or citizens to check the territory and the surrounding boundaries. This can then be used for natural disaster prevention planning, such as in the event of a wildfire, the park staff, the disaster prevention and mitigation staff, and related agencies can travel along the designated route and can reach the disaster site in a short amount of time.

5) Religion, Arts, Culture, Traditions and Local wisdom

An example of Religion, Arts, Culture, Traditions and Local wisdom is; in Education, when a student in the department requests an educational certificate through various channels, the notifications will be recorded in the system and alerted to the responsible officer. Staff are processed through two layers of information: the student information layer and the school information layer. The information is then inspected used to issue a certificate. This can also benefit teachers to plan teaching and classes to students

C. Online Government Permit

Government licensing is a legal process that requires citizens to obtain a certificate of authorization prescribed by the law, before they are entitled to proceed with their act. The process has always been time consuming and lacking in efficiency. Due to this, the municipality has been proposed to improve this process in order to meet the demands of the citizens, by

designing and creating a platform to support the application of two tasks; Application for residential construction permits with a size not exceeding 150 square meters, and application for public health permit for businesses up to 200 square meters in size. This allow people to obtain their licenses faster, reduce cost, and reduce service flaws from staff at the service counter.

1) Online residential construction permit system

In 2018, from the gathering of issues, it is found out that residents asking for permission to build houses took approximately 45 days to obtain a construction permit, which is considered slow by all. The municipality has therefore devised a solution to the problem by creating a platform of online construction permit which shortens the time of issuing a construction permit of buildings not exceeding 150 square meters. The time was shortened to no more than 24 hours or equals to 98% the rate of time reduction. The service process works by having a staff recording the request information and preparing the computer files, forwarding them to relevant staff then proceeding to authority level. The files are the GIS data sets, including drone images and GIS data relating to utility and public land area that has been requested. The issuance of residential construction permits adopts digital signature in accordance with the Electronic Transactions Act, as well as monitoring the building's construction results until completion. The system also records the construction progress and its effects including noise, light, air pollution and others. The evidences are recorded in the platform.

Fig. 12   Show case: Request a construction permit online within 24 hours.

1)   System for requesting public health certificate

After finding the online permit application system effective, the municipality has therefore expanded the method to other missions. In 2019, a platform for the issuance of business operation certificate for food distribution centers or food collection centers have been developed, since the outlets where food is sold and accumulated must apply for a certificate to operate their business. Although the Public Health Act allows the process duration to take up to 30 days, the utilization of online platform and GIS data for licensing allowed the license to be issued within 1 day. Moreover, citizens can make the request at their own outlet. [6]

Fig. 13   Show case: Issuing public health certificates online

Issue – Originally, obtaining a public health license are experienced with delays and time consumption, with complex operational procedures. Officers need to inspect facts, and granting permission is subject to complex legal procedures that are further faced with difficulties in the follow-up process. Applications for permission must be considered through several hierarchies, causing a delay in performing duties.

New operation method – The online construction permit platform became popular and has achieved satisfaction from service recipients. This leads to the development of online health permit application system, which citizens can submit online requests by themselves via smartphones or internet browsers. They are able to follow up on the results at every step of approval, and acknowledge the results via SMS. Staff can perform their duties in considering license issuance at any place and time online.

Results – The duration of license application is shortened, and citizens can operate their businesses more efficiently.

D. Paradigm shift

For vulnerable groups consisting of bed-ridden patients and those needing assistance, besides standard public service is the need for special public service that provides equality and reduced restrictions. The reduced restrictions are such as access to medical facilities and traveling to therapeutical or rehabilitation centers. Therefore, in the year 2016 a "Center for promoting and restoring the quality of life for vulnerable groups" is established to provide people with access to state welfare and able to receive public services with equality. It utilizes the surveyed data and GIS data in the quality-of-life promotion dataset for the activities in the center. The established "Center for promoting and restoring the quality of life for vulnerable groups" draws in healthcare workers or physical therapists. Adding to that, community volunteers, namely Care giver, joins the operation facilitating the delivery of patients to medical facilities for treatment. This improves the dependence of vulnerable groups on others and as a result, the groups are being helped in various aspects for better quality of life.[7]

(1) Organizing physical rehabilitation activities for bed-ridden patients by providing physical therapy to bed-ridden patients in Maehia Sub-district with a team of 15 physiotherapists, volunteer doctors and Care Giver volunteers trained in a rehabilitation program. The operation is carried out at the rehabilitation center where the

municipality provides a shuttle service for the patients to their home. The caregivers or the doctor in charge can notify the schedule in the online public service platform to request a shuttle service. The rehabilitation programs will be provided in specific ways for each patient according to different illnesses.

Fig. 14   Shown operations on-site

(2) Home visits to bed-ridden patients by team of medical volunteers and community Caregiver volunteers. Aimed towards patients with severe symptoms that are not able to travel to the center, the municipality collaborates with a team of medical volunteers, physical therapists and community caregiver volunteer to visit the patients' homes and organize a treatment program according to the symptoms of the patients. The patients' children or relatives can also be advised on how to provide proper care, as well as giving encouragement and improving mental health for their patients.

Fig 15   Shown home visits to bed-ridden patients by team of medical volunteers and community Caregiver volunteers.

(3) Training for patients' caregivers and promoting recreational activities for the elderly. The rehabilitation center organizes intensive training activities for the caregivers, including their own mental health management in order to reduce stress of from caregiving. The caregivers will be trained how to record the patient's symptoms each day to support symptomatic assessment and treatment plan formulation.

Fig. 15   Training for patients' caregivers and promoting recreational activities for the elderly.

V.   RESULTS AND ACHIEVEMENT

Following the initiation of smart technology to Maehia Municipality to improve its efficiency, in year 2020, the online public service satisfaction was assessed. It was assessed based on the online construction permit service and the Online notification of food distribution and collection

locations by internal municipalities and external agencies. The assessment results are as follow.

(1) Maehia Municipality has been assessed for its public satisfaction by the Academic and Planning Division. It appears that the public service receivers are very much satisfied with the channel which the municipal has provided them with the scores of 98.40 over 100.

(2) Chiang Mai University has assessed the public satisfaction in applying for online construction permit. The results show that 95% of the subject gives a score of 9, reflecting that the public is satisfied in the management of the service system and the public facilities.

(3) Chiang Mai University has assessed the public satisfaction regarding one stop service by the Excellence service center. The results show that 95.4% of the subject gives a score of 10
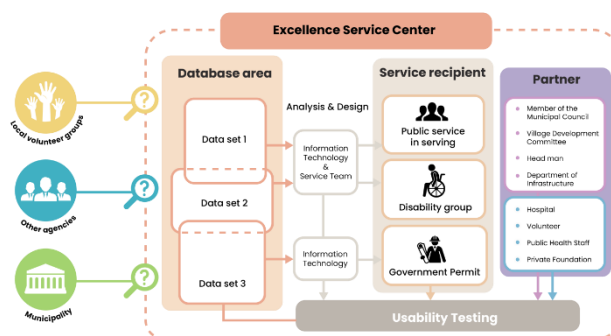
Fig. 16   Excellent service center framework
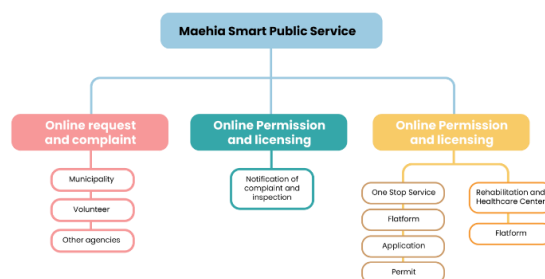
Fig. 17 Maehia smart public service flow chart

VI.   SUMMERY

Having a clear perception of what were really the problems from both the service receivers and providers through a public hearing meeting, attended by many concerned partners. The network group then became a mechanism for managing and ad ministering the public service plan. After the network was firmly established, together the group begin to survey and collect local data into 6 categories all together 83 layers of databases was collected. The data were put together in the GIS to be used as tools to relate each group of data to one another so that it would be convenient and also to increase the efficiency of the public service as a whole. Afterward, the networking group analyzed problems, analyzed data base and an analysis of limited budget was conduct.   Form and functions of public service were established in order to increase the quality of the service itself.   Electronic platform online was launched. The municipality designed and created this platform to accommodate all those data and to use them as tools in

providing and delivering the require services that come from local people and community. It was clear that the launch of this platform was well received and every concerned party were happy and satisfy with the outcomes.

In addition, The Municipality made a fundamental change in work values and ethics for the personnel's to comply with and these changes would be convenient and appropriate for both the online platforms providers and users. The total of 26,591 local people indicated that online platforms had made great impact on their lives in regard to receive public service from the municipality.

Later on the municipal analyzed the data about people requesting permission to build a home and construction of their choices , also studied an existing law and regulations about construction and home building and decided what would be a good mean to short cut the present procedures. So an addition platform is launched to promote construction workers and home builders request online. The permission can be issued for an area less than 150 square meters. In the past the request to build took almost 45 days to get approval or get a permission paper but right now it takes only a day. This is more possible because all data linked together with GIS inside the municipality. Another matter is that if you want to set up a storing and selling store or restaurant in the area less than 200 square meters. The request can be submitted online, and it will link straight to public health and infrastructure department along with the database from the GIS. The time to receive permission is a lot less than it is used to be.

For the vulnerable group, including disadvantaged that needs special care in public service health. The municipal organized a special service general toward this group. Setting up a rehabilitation center and healthcare team, to combine the assistance from various sources such as volunteer doctor team, professional nurses and physical therapists. The center offers public health care, physical rehabilitation to the disadvantaged patients. There are 87 cases that received the treatment both at the center and home visit. For those who are older than 60 years old, there are many recreation session for them to choose and the center also provides a class room online for them to attend. All the activities main focus is that to have elders enjoy their living and live happily in the community

All the public service activities either to general or the vulnerable group, data gathering would be conducted and analyzed to find out and to design proper means to carry out the activities which would be suitable and meet the needs of each group.

The sustainable of project

1. The administration of both online and offline service would be updated in real-time each day. When local people, volunteers other outside agencies and staffs would phone in and give report in certain aspect of each task. They would identify problems and make recommendations about what should be done or corrected in regard to information service and the platform. The municipal would get a team along with other local volunteers to adjust and modify whatever that is necessary to make a platform workable for any users to test it regularly and continuously (usability test) so the service would be provided with efficiency and accuracy and that sustainable would be intact at all time.

2. The Municipality had clearly identified personnel who are responsible for certain service so when this organization put on a fundamental change in the modern world. It is obvious that working culture, values and ethics would become main features for the staff to accept , follow and conduct themselves according to the new paradigm shift.

3. New technology which was brought in, had provided convenience to offer public service. The simple technology is cheap and the budget is small. The municipal IT team can adjust and adapt the program very easily.

4. At the present, Maehia Municipal becomes a learning center for other local government to visit and learn about public service features. In the year 2019 there were 250 groups to visit on study tour program at Maehia Municipal. The visit news is widely spread to other local agencies.

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Artificial Intelligence Maturity Model for Government Administration and Service

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ABSTRACT — Artificial intelligence (AI) is becoming more prevalent in various sectors. Based on rapid AI technology development, the understanding of strategies for implementation is necessary, especially in government administration and services. Despite the current trend, uncertainty in the process needed to build the capacity of artificial intelligence is a major concern for senior management in government sector. The purpose of this study is to develop a maturity model of artificial intelligence for government organization, which is a gap in the knowledge in this area. The results of this research will help government organizations understand the methods of applying artificial intelligence successfully. Including the linking of the AI system with other work systems, and can be used as the theoretical foundation for future research

Keywords — AI Framework, AI Government, AI Maturity, AI Maturity Model

I. INTRODUCTION

Artificial intelligence (AI) is a technology that empowers machines and computers with algorithms and statistical tools to create intelligent software that able to imitate complex human abilities. Such as remembering, distinguishing, reasoning, making decisions, anticipating, communicating with humans, etc. In some cases, it may even go to the point of self-learning. [1]

AI is a key element in helping governments transition to digital government. Government sectors must be ready to develop, deploy and implement systems that can be applied to take advantage of AI very well. This readiness includes the ability to be an AI project initiator and operator, as well as being aware of the nature of the system and the underlying technology of AI. It can check whether the AI-powered system is feasible or not. In an era where there are many technological solutions, the ability to use operational logic must be based on a pre-defined basis. Before deciding on a topic, can see the big picture. Included is the capacity to evaluate the initial artificial intelligence project's success, which is required to urge government agencies to comprehend concepts such as data usage experiments and process transformation.

Government agencies need to be aware of their AI capabilities and maturity that covers both organizational strategy, organizational structure, organizational information readiness and appropriate technology for the organization.

Including knowledge and understanding of artificial intelligence fundamentals, both the ability and responsibility for choosing artificial intelligence that will be the deciding factor in the selection For example, there are different types of artificial intelligence that can match the current maturity of an organization. In the following studies, what AI is and how it can help governments achieve digital transformation. Additionally, the study describes maturity levels and how to initiate and operate artificial intelligence at a certain level and maturity of artificial intelligence of government agencies.

On another topic that is widely discussed. That is the topic of ethics with artificial intelligence. This raises challenging questions about both fairness and fairness. Understanding, Responsibility and Ethics of Artificial Intelligence. The following points of interest include managing bias in data and algorithms, how the system is used fairly and without discrimination, creating complex algorithms and recommendations. That is likely to be understood by the user, reassuring users of the human ability to control and responsible for human artificial intelligence. and on issues of great importance That is to control the ethical use of artificial intelligence systems. all of which said artificial intelligence maturity model It can help government agencies to assess their comprehensive and comprehensive readiness to promote the use of artificial intelligence. to be both efficient and effective.

II. DEVELOPING A MATURITY MODEL

The concept of a maturity hierarchy is that an entity has had some experience in a matter for some time. Various efforts have been made to develop maturity models. In this part of the study, the majority of development principles were compiled into a four-step development framework. The model development process step-by-step is shown in Fig.1

A. Problem Identification Procedure

Stage activities: Identify the problem, its origins and rationale, define the concept of maturity level, narrow the scope needed to assess maturity.

Techniques used: literature review, interviews with subject matter experts.

B. Review Process

Stage activities: Define definitions of maturity model requirements, identification and evaluation of existing artificial intelligence maturity models and related topics, model development strategies.

Techniques employed: Structural literature review, evaluating existing artificial intelligence maturity models based on desired maturity boundaries.

C. The process of Developing a Maturity Model Review Process

Stage activities: Round 1 considers the concept of artificial intelligence maturity boundaries; Round 2 considers concrete concepts of maturity division.

Techniques Used: Case Study Research with Interviews with Experienced Persons

D. Maturity Assessment Process

Stage activities: Round 1 examines the scope's ability to be used in maturity assessments; Round 2 examines the usability of the maturity division.

Techniques Used: Case Study Research with Interviews with Experienced Persons
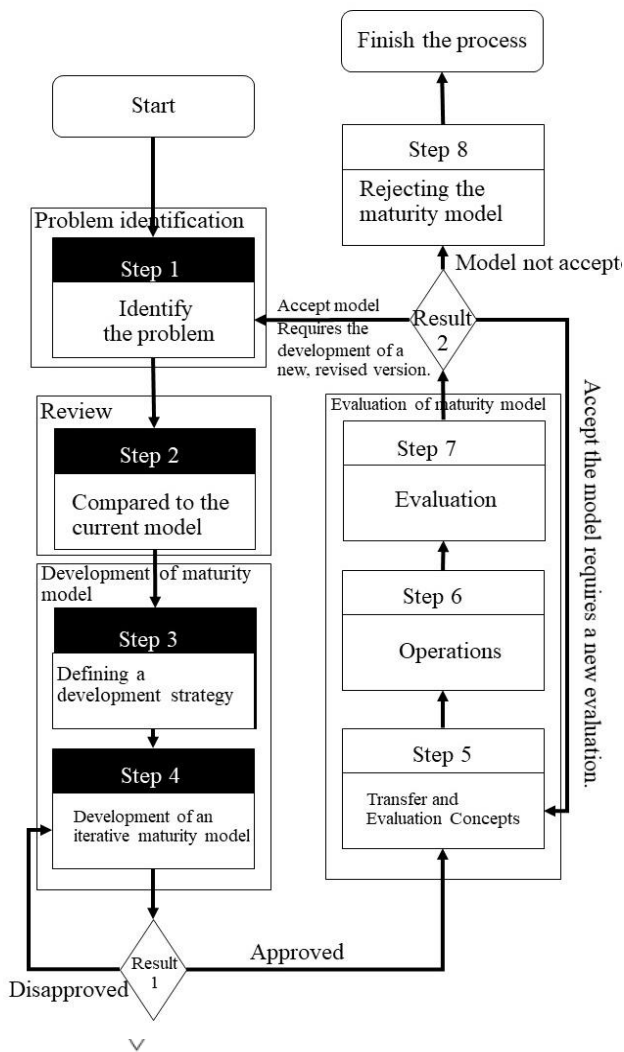

Fig.1 Diagram showing the process of developing a maturity model

TABLE I. SUMMARY OF STUDY SCOPE AND INDICATORS

Scope	Sub boundary	Indicator
Strategic	Strategy	Strategy
	Ethics	Strategy
Organization	Organizational stru	Data analysis, Process
	Corporate culture	Analyze data
	Executive vision	Data analysis, Personnel
	Staff skills	Data analysis, Personnel
Information	Resources	Information
	Data management	Information, Process
Technology	Structure	Information, Infrastructure
	Tool	Data, Infrastructure, Process

III. OVERVIEW OF THE CURRENT MATURITY MODEL

From Table II shows the current maturity model study. of artificial intelligence and related topics such as education on data management (Data management) and business intelligence (Business Intelligent), which is divided into 3 levels: 0 = not defined in that topic; 1 = defined. only partially 2 = fully defined which can analyze the indicators out of six components:

1) Strategy, which is almost always the key factor in determining the success of an operation.

2) Data analysis The use of corporate data for analysis when analytics is used in conjunction with other organisms can provide a wide range of metrics.

3) the process of cultivating an understanding of the systematic operation is another important factor for success.

4) Personnel, the heart of the operation Clear metrics of personnel quality can make project management direction more likely to be successful.

5) information; Not only is it necessary to have a lot of data to be successful in using artificial intelligence, but it is also necessary to manage it well. are ready to use and

6) infrastructure; If there is a lack of good preparation in planning and preparing the structure in operation It will cause problems later as the artificial intelligence project expands. Therefore, it is imperative to have a professional take action to cover it.

IV. SCOPE OF STUDY AND MODEL CLASSIFICATION OF ARTIFICIAL INTELLIGENCE MATURITY

A. Grouping of Regions that Affect Maturity Model Grading

ELEMENTAI [5] has released a report on the maturity framework of artificial intelligence. which studies about strategic approaches to operations

Prophet [21]   Consulting firm with expertise in technology transition The scope of evaluation is divided into 1) Strategy 2) Data Science 3) Product and service development 4) Organization and corporate culture 5) Ethics and good governance.

P. Gentsch [3] The organization is divided into three types: Organizations without automation Organizations that have automation with humans and organizations that use automation primarily But still focus on five main themes. The weight of importance is adjusted according to the type of organization. The five topics consist of 1) Strategy 2) People and Organization 3) Decision Making 4) Data and 5) Analysis

which can be summarized from the study as shown in Table I

Six indicators are used to define four boundaries as follows: 1) Strategic aspects, consisting of strategy and ethics. as indicators 2) Organizational aspect has four sub-components namely organizational structure, organizational culture, executive vision and employee skills, using data analysis, processes and personnel as indicators 3) Information, data sources and data management using data and processes as indicators 4) Technology aspect consists of structures and tools using data, infrastructure and processes as indicators.

B. Hierarchical division of maturity model

In each study, a different method was used to rank the maturity model hierarchy. by focusing on the suitability of

TABLE II.   TABLE OF MATURITY MODELS CURRENTLY AVAILABLE.

Article	Author	Work group	Strategy	Analyze data	Process	Human resources	Data	Infar
Measuring data management practice maturity: a community's self-assessment	Aiken et al. (2007)	Data management	0	0	0	0	2	0
Understanding big data analytics capabilities in supply chain management: unravelling the issues, challenges and implications for practice	Arunachalam et al. (2018)	Data analytics	0	1	0	1	2	1
How organisations leverage Big Data: a maturity model	Comuzzi & Patel (2016)	Data analytics	1	2	1	0	2	2
Towards a business analytics capability maturity model	Cosic et al. (2012)	Business Intelligence	0	2	1	2	1	1
Big data, analytics and the path from insights to value	LaValle et al. (2011)	Data analytics	0	1	0	0	1	0
Defining analytics maturity indicators: a survey approach	Lismont et al. (2017)	Business Intelligence & Analytics	1	1	0	0	0	0
Assessing business-IT alignment maturity	Luftman (2000)	Business Intelligence & Analytics	2	2	0	2	0	1
Business intelligence maturity: the economic transitional context within Slovenia	Lukman et al. (2011)	Business Intelligence & Analytics	1	0	0	0	2	2
Updating business intelligence and analytics maturity models for new developments	Muller & Hart (2016)	Business Intelligence & Analytics	2	1	0	2	1	2
Using quantitative analyses to construct a capability maturity model for business intelligence	Raber et al. (2012)	Business Intelligence & Analytics	1	1	0	0	0	2
The maturity model of corporate foresight	Rohrbeck (2011)	Business Intelligence & Analytics	0	2	1	1	0	0
Big data analytics in logistics and supply chain management: certain investigations for research and applications	Wang et al. (2016)	Business Intelligence & Analytics	0	0	2	0	1	0
Data warehousing stages of growth	Watson et al., 2001	Data management	0	1	0	2	1	1
			8	14	5	10	13	12

specific areas that are important, for example Microsoft [4] presents the AI Maturity and Organizations report. To describe the maturity of artificial intelligence, four levels of maturity are categorized into four levels. The second level is The advent of artificial intelligence There are expectations and hypotheses for use. three levels of inspiration Artificial intelligence trials and applications have begun. The highest level is the fourth level. Maturity level with the use of data science and outstanding operational capability. Gardner [6] has an AI Maturity Model that identifies five stages of AI maturity hierarchy as follows. There is interest but not defined in the use of functional artificial intelligence. The second stage is implemented. At this stage, it is an informal implementation of artificial intelligence, such as an artificial intelligence experiment in the Jupyter notebook, and possibly some models from the Jupyter notebook. The TF.js library is used in the current workflow, the third level, the level used to operate the company. That is, artificial intelligence is integrated into the current work, for example, using machine learning in the work. At this level there may be a group of Machine Learning Engineers to perform specific tasks. Level IV Systematic implementation. is to use artificial intelligence to replace the old system harmoniously It can be used continuously and smoothly. Really understand how to apply artificial intelligence to work today. and the highest level transitional stage Can make the most of the development of artificial intelligence. There have been changes caused by artificial intelligence that has evolved to the point where new innovations have emerged.

Becker[22] concluded that the model was divided into levels 0-5, where level 0 was incompetent. There is no administrative control and audit. And at level 5 is the level with the best practice. That is to use good practice as a model in management. Able to control and manage technology projects according to the goals set Details are as follows:

0) Nonexistent; no strategy technology No top management tracks technology-related activities. to take advantage of technology 1) Initial/Ad hoc; No official supervision Follow-up is project-specific, as is the case. Governance is not fixed, but based on the experience of the tech team. by collecting information from other executives in the organization In addition, senior management will be involved only. Only when there is an emergency is necessary. Measurements are determined only on technical and workload measurements. 2) Repeatable but intuitive; At this level will begin to have a more formal understanding of the technology. There is a division of management responsibilities supported by senior management. Oversight practices are shown periodically. depending on the technology team Participants are stakeholders only and are voluntary participation; 3) Define process; There is a step-by-step process. Determine the timeframe for monitoring the framework. A committee was set up to devise rules and regulations. whether in the matter of normal goal setting performance review Assess capabilities with necessary plans, project plans, and budget management to improve required technology. There is an official rule of thumb. But the technique used in the evaluation is still a simple method. uncomplicated and straightforward 4) Managed and measurable; Use action goals to determine the direction of work. Measurement principles are definite and mutually understood. There is a comprehensive performance report presented to the management. The organization's management team aims to manage in the same direction, which is to make the most of information technology at the lowest risk. There is also an evaluation of completed projects to be used for further improvements in new projects. 5) Optimized; At this level, there will be a need for more sophisticated information technology supervision. with techniques that are both efficient and effective Activities in the implementation of information technology are defined.
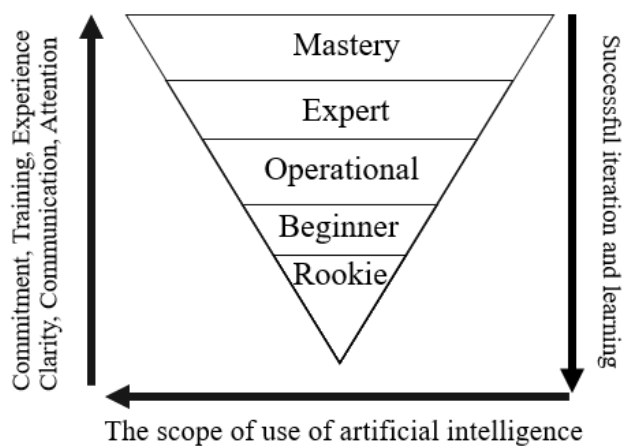
Fig. 2. The grading of the maturity model.

Appropriately Set up a committee to work on the technology strategy formulation. Activities are scheduled to be carried out in accordance with the organization's main action plan. Can measure the performance of technologies that deliver value to the organization. There are steps to prepare in case of unexpected events in a timely manner. There is risk management in accordance with risk management standards. Comparisons of competency with external agencies have been established. Able to control technology costs There is a continuous improvement plan.

When summarizing from the study Able to define artificial intelligence maturity model rating by considering together with agency commitment, training to enhance staff skills, execution experience, executive clarity internal communication and the attention of people in the organization, including the reproducibility and learning of artificial intelligence projects in the organization. So it can come out as level 1-5 starting from new beginner level > beginner level > operational level > proficiency level > proficiency level.

V. ARTIFICIAL INTELLIGENCE MATURITY MODEL FOR GOVERNMENT SECTORS

In this study A five-level, four-aspect, artificial intelligence maturity model for the public sector has been presented.

A. The scope used to assess the maturity of artificial intelligence

The scope of assessment in the maturity model is divided into four sections, the details of which are as follows:

1) Strategic

Strategic implementation of artificial intelligence, which is the focus of the strategic dimension. artificial intelligence maturity framework It is not the same as the corporate strategy used. Artificial Intelligence, however, is linked to the long-term vision for how organizations will operate and compete in the future using artificial intelligence Plans to focus efforts on artificial intelligence applications should be communicated. The challenge for leaders is the ability to spot meaningful strategic moves with artificial intelligence. That

requires knowledge of artificial intelligence. It is a foundation to begin understanding how to judge good artificial intelligence alternative opportunities from bad.

2) Organization

A recurring question for business leaders is how will AI affect their jobs, in fact, no one knows what will happen. But research supports the view that self-directed choices play a key role in action. For example, AI solutions can be used for automation including human-machine collaboration and even when used for AI automation. no need to replace workers but it can fill and increase the demand for their work, meaning leaders can find the use of AI to better enhance people, culture and organizational values. For more information about AI's impact on jobs
In this study A five-level, four-aspect, artificial intelligence maturity model for the public sector has been presented.

3) Technology

In contrast to the software, the rules are configured with step-by-step instructions. Modern AI solutions are configured by setting goals or objectives that define the process of machine learning. This is the reason that AI solutions need to be trained and repeatedly tested during development as well as tracked and trained in production.

When the business environment changes over time Machine learning models can degrade if they are not retrained. This problem can be solved by constantly designing the model to adapt to new data. But at the expense of the increasing complexity of AI governance, including techniques for validating AI models used in production.

B. Level of artificial intelligence maturity

At the first level, the AI is not recognized as a level of incompetence. The strategy was not executed. No organization preparation the data is not in a ready-to-use format. and no technology the fifth level is the level at which best practices are implemented by the organization in which the framework of good practice is guided by its management. Able to control and manage projects according to the goals set the maturity model has the following measurement scales:

1) *New Entry Level :* No Artificial Intelligence Cognition
2) *Elementary Entry Level :* Knowledge and understanding but no practice problems
3) *Operational Level:* Artificial Intelligence has been tested but not yet implemented.
4) *Proficiency level*: Artificial intelligence is applied to certain tasks.
5) *Proficiency level:* Use artificial intelligence as the core of work.

VI. SUMMARY

From the study of factors that are important in the maturity model can be summarized as follows: 1) Strategic placement between IT and business 2) Organizational factors for big data analysis 3) Organizational process incubation 4) Employee skills consideration 5) Differentiation of data and information technology 6) Specificity of Industry and processes 7) Considering the existing IT infrastructure

TABLE III.   SUMMARY OF STUDY SCOPE AND INDICATORS

	Strategy	organization	information	technology
Rookie level	There is no strategy yet. and ethical framework artificial intelligence	No responsible person has been defined in the organizational structure, management lacks knowledge and understanding, employees lack interest and specific skills.	Most of the inside information used but can not meet all the data requirements Information management and related policies are closed and not formally defined.	IT architecture exists but cannot combine new data sources, only use standard IT tools.
Beginner level	There have been some strategies for artificial intelligence. But it is not included in the corporate strategy.	The project has a wide range of responsibilities. No responsible person is defined in the organizational structure, executives are interested but have not yet started to develop, skills employees are interested but cannot develop skills.	Most information needs can be satisfied with inside information. Data management is muted. But there are attempts to identify what information is useful and necessary for artificial intelligence tools.	Network planning kits are not merged with new data sources. Using the network planning application's basic functions for a separate step of the network planning process.
Operational level	Artificial intelligence strategy has been put in place. and is integrated with the organization's strategy But the ethical aspect has not yet been determined.	Specific responsible person(s) has been established but no responsible person(s) has been assigned in the organizational structure, at least one senior management aware and supportive, staff with basic skills	Most information needs can be satisfied with internal or external data. IT functions decide according to current needs together what information should be obtained and stored.	Use periodic aggregate of new data sources in each case. Using the Network Planning Application Pack for most planning steps
Expert level	Artificial intelligence strategy has been put in place. and is integrated with the organization's strategy Ethical arrangements have been made. but not yet integrated with corporate strategy	Responsible people are defined in the organizational structure, most executives are comprehensible and supportive, skilled employees can develop on their own.	Sufficient internal and external data sources are selected to meet all data needs with at least one data type. The IT department periodically reviews the usefulness of the information currently stored in relation to its usage and collects data based on estimated data needs.	Flexible integration of new data sources on demand Use one app for every network planning process. but lacks advanced analytical capabilities
Mastery level	Strategies are clearly and measurable. including setting up a framework for ethics and good governance in the implementation of artificial intelligence that is integrated with the organizational strategy	Responsible people are defined in the organizational structure, executives understand and deliver specific policies, skilled employees. (Consider both permanent and temporary employees)	There is a wide selection of internal and external resources available to meet all your data needs with the best possible information. Resources and data types and policies are periodically reviewed to assess their usefulness and practicality, as well as periodic reviews of data limitations. such as any lost data and future opportunities.	A fully event-driven network planning architecture can add the resources needed. Using a single application for all relevant network planning and data analysis steps.

Once the organization knows the level of artificial intelligence maturity to the desired extent. can be applied in laying out guidelines, planning and organizing systems and maturity levels in each scope process more appropriately. Make the organization know that the organization may still have problems in various aspects. Therefore, various standards and conceptual frameworks have been established. used to supervise artificial intelligence and knowing the obstacles to the use of artificial intelligence in the organization This enables organizations to identify obstacles and find ways to eliminate them. so that organizations can benefit from artificial intelligence as much as possible. and limiting the risk to an acceptable level

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Preparedness of Blended Education prior to SARS-COV-2 Pandemic via Google Classroom for the fifth Year Medical Students, Otolaryngology Rotation.

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Abstract *Background:* Generally, we use face-to-face manner as a main method for teaching while some flipped classroom applied online to get more achievement. The Department of Otolaryngology, Phramongkutklao College of Medicine has introduced the online Google Classroom (GC) to the fifth-year medical students, in the academic year of 2019. The main purpose of the online GC may be applied to the flipped classroom for the fifth-year medical students. Due to the SARS-COV-2 pandemic situation at the time of this academic year, each rotation should get a different learning method. Therefore, it appeared that the second to the seventh rotation from total 8 rotations learned by blended education. Face to face manner of teaching was applied first then it was switched to online GC. After that, the eighth rotation came at the same time of the SARS-COV-2 pandemic, they were switched to the online GC only. It may be very hard if the online teaching has not been prepared before the time comes. The purpose of this study was to report the result of the application of GC and difference between group of the second to seventh rotation and the group of eighth rotations. How, the first rotation was not included in the study since they had opportunity to learn only face to face procedure. *Methods:* This is a descriptive prospective study by data collection from 86 medical students of the second to eighth rotations while the eighth rotation studied 100% online. The variable data, including a general information, satisfaction, and tools for accessing the GC were obtained from the questionnaires given to the second to the eighth rotation of the fifth-year medical students. Besides, the daily quiz (DQ) created and evaluated by the second-year residents were preformed and analyzed for the relationship with multiple choice question marks, slide quiz marks, objective structured clinical examination marks and practical marks. Moreover, the questionnaires regarding the comparison between the Google Classroom and the Moodle (MD) were also given to the sixth to eight rotations. *Results:* From evaluation (of the full mark of 5) of satisfaction and usage, it was found that the satisfaction was 4.7, difficulty to access was 3.2, suitability of DQ was 4.5 as well as the content of pedagogy, bedside teaching and OPD teaching conform with DQ was 4.5. Information through GC was useful by 4.2. Convenience to do SDL through GC was 4.5. Preferring to do SDL through GC was 4.5 and believe that GC could reduce paper consumption was 4.8. Comparison between GC and MD, there were 66.7% (26/39) of students who answered the evaluation with 96.1% preferred GC. Among these, 80.8% thought GC was easier to access, and 76.9% thought GC was more user friendly than MD. Correlation analysis by Pearson correlation, it was found that rotation was related to slide quiz (p = 0.010) and PBL marks (p < 0.001). Those who had more numbers of answering quizzes would gain higher quiz marks (p < 0.001). *Conclusion:* Using of the blended education to familiarize students, faculty and support staffs with learning management system are important since if 100% online teaching is needed. The change from face to face to online could be easily performed. Almost of student preferred Google Classroom to Moodle.

Keywords—Blended education, Google Classroom, SARS-COV-2, Online Teaching

I. INTRODUCTION

Phramongkutklao College of Medicine (PCM) is the first military medical school in Thailand where the academic military medicine has been conducted [1]. The principle of this military medical school is to provide the good medical care in the straitened circumstances. Due to the SARS-COV-2 pandemic at the moment, all schools and other educational institutes have to be closed in order to create the social or physical distancing. Therefore, it is inevitable to provide some online education.

Since all of the teacher staffs would like to give the best education to all medical students, especially the fifth-year medical students registered the otolaryngology, the Otolaryngology department considered to give 3 weeks per rotation for 3 credit study. This program covers 3 main organs comprising ear, nose, and throat. Although in the whole 3 weeks, the contents are still overwhelming, many more holidays may reduce the studied time in each rotation. The teaching teams include faculty as well as the first to third year residents of the Otolaryngology department.

Traditional methods used for teaching include lectures, practice in the outpatient department (OPD) and

inpatient department (IPD), operative theatre, problem-based learning (PBL), self-directed learning (SDL), manikins, physical exam instruction, patient care with residents. Grading tools are composed of multiple-choice question (MCQ), practical work mark, slide quiz, and objective structured clinical examination (OSCE). At the same time the aptitude evaluation is done by residents and faculty while the practical work marks come from patient reports, SDL and PBL.

There are many tools for online teaching and how to choose appropriate tools depends on many factors such as level of students, faculty's preference, and policy of the institution. However, the best tool for faculty may not be the best for students. In one meta-analysis by Leisi Pei and Hongbin Wu (2019) concluded that no evidence that the offline learning worked better than that of the online learning. Comparing the offline learning, the online learning had advantages to enhance undergraduates' knowledge and skills [2]. The Characteristic of the useful tools for educational technologies perceived by Students were multimedia tools, scheduling tools, communication tools, collaborative authoring tools, learning management systems and electronic health records [3].

The flipped classroom was lately introduced to the medical education with main principle of utilizing of the education technology and brainstorm activities. As the time in the class is limited for students to understand concepts therefore learning from other tools made by faculty is recommended. These tools could be both online and offline with additional reading online discussion with other friends or faculties. This could be done outside the class. In the classroom, faculty may arrange an appropriate environment for the designed activities to let students work on. Faculty will explain difficulty issues and problems that students encounter find. By this mean the medical students will understand and link all the matter much better. Anyway, Aggarwal *et al*. (2019) concluded that even mean assessment scores in the flipped and traditional classroom were not statistically significant but flipped classroom teaching method could be used in the transitional period [4]. In contrast to the work of Blair *et al*. (2019) who studied in resident, the results showed that residents expressed great satisfaction and engagement with the flipped classroom curricular model which might improve the clinical behavior and patient treatment outcomes [5].

The PCM Otolaryngology Department has recently selected the Google Classroom (GC) as the teaching tool in making the flipped classroom since it has a friendly user interface (UI). Most people have been familiar with the Google already which can easily get access by the Gmail. However, after utilizing GC with the second rotation, it was found that Google Drive (GD) space was abruptly full, therefore it was switched to PCM's account. This is a part of Google Suite for education which has more, and no space limit features. PCM has its own Moodle (MD), but our faculty are still familiar with the Google, so GC has been chosen, Login is needed before use. Faculty and appointed second year residents will set the daily quiz (DQ) 4 days a week along with questions and answers for 3 consecutive weeks.

The topic of DQ, resources, SDL, bulletin board and evaluation are set. Resource topic is used to keep all media such as pdf files and YouTube playlist for physical examination instruction to study prior to class. SDL topic includes questions, clips, YouTube, and answer sheet. Students are allowed to write on pdf file and then upload or print out on the answer sheet, write with a pen, taking photograph or scan to upload for submission. The bulletin board is used as the web board for announcing the additional class from those in the LINE application. Evaluation topic is used for evaluation of teaching in various topics. In 2017, Harvard Medical School introduced a form of flipped classroom, called case-based collaborative learning (CBCL), for preclinical curricula [6]. From this study, 90% of faculties found the CBCL peer observation and debriefing to be extremely helpful or helpful. Therefore, we generated DQ as a tool for flipped classroom. The second-year residents play an important role to prepare the DQ. As the third-year residents have more responsibility mainly on inpatient and outpatient service as well as operation while the first year residents have the paperwork service and may not get involve extensively into the content of otolaryngology as those of the second year.

In addition, since 2019 all residency training institutes have needed to be evaluated by the World Federation for Medical Education (WFME) which is the international organization that accredit all medical curriculum globally. For this formally evidence is needed to be monitored those residents as the assistants for medical student teaching and GC is the obvious evidence.

In January 2020, there was a pandemic of SARS-COV-2 and all institutions were closed to mitigate the spread of the virus. However, as the teaching is needed to continue, GC with Google Meet (GM) could be used as a crucial tool for lecture and examination.

Without preparation of the flipped classroom, no online and no application practice before online teaching during the SARS-COV-2 pandemic would have been very hard to manage.

The purpose of this study is to report the result when GC was used as a tool for conventional teaching and online teaching for the fifth year medical students of the 2019 academic year during both normal and SARS-COV-2 pandemic situations. The effects of daily quiz (DQ) by the MCQ, Slide quiz (SQ) and OSCE will also studied.

II. MATERIAL AND METHOD

In academic year of 2019, there were 100 (60 males and 40 females) fifth year medical students who registered for otolaryngology at PCM. These students were divided into 8 rotations with about 11-14 students each. Each rotation lasted 3 weeks and were taught by different tools depending on the SARS-COV-2 pandemic situation. Since, the first rotation of 14 students learned at the time of normal situation, the conventional face to face teaching procedure was conducted. Therefore, they were not included in the study.

Regarding on the purposes of the study concerning the online GC teaching tools, 86 participants of the second to eight potations were included. The 73 students of the second to the seventh rotations were manipulated in the blended education with both conventional face to face and then switched to online GC tools. The eight rotations of 13 participants started learning in mid-March 2020 which was the same time of the severe SARS-COV-2 pandemic, so the

teaching procedure was switched to the online GC feature only.

After applying the online GC teaching tool, general information and satisfaction were accessed by questionnaires. Besides, the questionnaires regarding the comparison between GC and MD were also given to the sixth to eighth rotations. There were 5 full marks for each question. The DQ marks evaluated by the second-year resident were analyzed for the relationship to the MCQ, SQ, OSCE and practical marks.

III. DATA COLLECTION

The data were collected from June 2019 to April 2020 in the Department of Otolaryngology, Phramongkutklao Hospital and College of Medicine, Royal Thai Army Medical Department, Thailand. This study protocol was reviewed and approved by the Institutional Review Board of the Royal Thai Army, Medical Department (S032q/63_Xmp). The consent forms for participation and publication were obtained and signed from all participants according to the Declaration of Helsinki.

IV. STATISTICAL ANALYSIS

The information from the questionnaires were analyzed using a statistical program. The descriptive statistics, containing the number, percentage, mean, standard deviation, minimum and maximum were reported. Categorical data were analyzed using chi-squared test, while continuous data were analyzed by independent t-test. Logistic regression analysis was used to identify variables independently correlated with daily quizzes. The results were presented as the means ± SD and adjusted odds ratios with corresponding 95% confidence intervals. Statistical significance was inferred at $P < 0.05$.

V. RESULT

From 100 students with 14 students with regular teaching, 73 students with blended learning environment and 13 students with online environment, among the 86 students studying by the GC, there were the percentage of 68.6 (59/86) that answered the evaluation form. At the same time, 39 participants of the sixth to eight rotations which answered the questionnaires concerning the comparison between GC and MD returned the forms at 66.7% (26/39). More details, including the business day, submit quiz, quiz mark, MCQ, slide quiz, OSCE, report, PBL and ethics are shown in the Table 1.

After evaluation of the data obtained (of the full mark of 5), the results found were in the Figure 1. Those were as followed. The satisfaction and usage were 4.7, difficulty to access was 3.2, suitability of DQ was 4.5 as well as the content of pedagogy, bedside teaching and OPD teaching conform with DQ was 4.5. The information through GC was useful by 4.2. Convenience to do SDL through GC was 4.5. Preferring to do SDL through GC was 4.5 and believe that GC could reduce paper consumption was 4.8 (Fig. 1).

Regarding to the electronic devices used, for GC it was found that 71.2% of the students used tablet or iPad only, 23.7% used only smartphone, 3.4% used only (Personal Computer)PC, (Notebook)NB, or (Macbook)MB and 1.7% used both iPad and smartphone. To submit reports, homework, or diagram, 83.1% preferred to do them on a tablet/iPad and upload than doing them on the paper and sent the scanning or photo (16.9%). Meanwhile the type of the connection used for GC showed that 67.8% used college's, 13.6% used personal Wi-Fi and 15.6% used their mobile networks.

Table 1 Demonstrating all summary data obtained from 86 students in 7 rotations, including business day as well as the percentage of submit quiz, quiz mark, MCQ, slide quiz, OSCE, report, PBL and ethics

	Mean	SD	Median	Min	Max
Business Day	14.7	0.7	15.0	13.0	15.0
Submit Quiz (%)	87.4	22.0	100.0	11.1	100.0
Quiz Mark (%)	76.4	22.2	82.7	8.9	100.0
MCQ (%)	74.7	12.5	77.3	37.9	91.9
Slide Quiz	79.4	14.4	81.6	16.6	100.0
OSCE (%)	85.6	6.1	86.3	67.5	97.7
Report (%)	87.2	6.2	88.5	70	98
PBL (%)	90.0	7.5	93.3	63.3	100.0
Ethics (%)	94.4	5.2	95.8	56.9	99.7

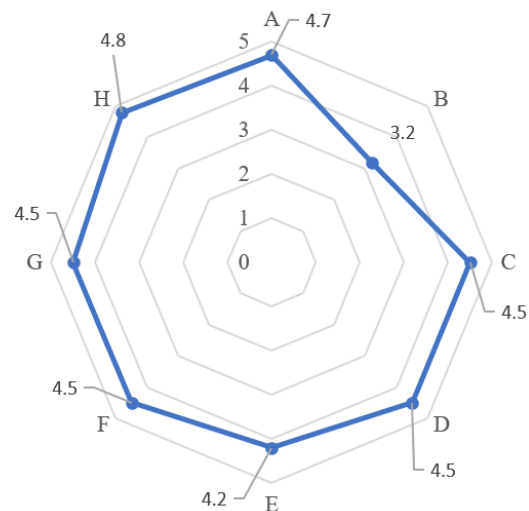Google Classroom Overall Evaluation

Figure 1 Showing the overall evaluation of the Google Classroom. Satisfaction and usage (A), difficulty to access (B), suitability of DQ (C), content of pedagogy, bedside teaching and OPD teaching conform with DQ (D), information through GC is useful (E), convenience to do SDL through GC (F), preferring to do SDL through GC (G) and believe that GC could reduce paper consumption (H).

Table 2 From 86 students in 7 rotations howing the correlation of all variables with the rotation. Pearson correlation coefficient, significant at p < 0.05.

	Rotation		
	n	r	p-value
Submit Quiz (%)	86	0.200	0.065
Quiz Mark (%)	86	0.136	0.211
MCQ	100	0.135	0.182
Slide Quiz	100	0.256	0.010
OSCE	100	-0.036	0.722
Report	100	-0.181	0.071
PBL	100	0.452	<0.001
Ethics	100	0.041	0.688
Grade	100	-0.192	0.056

Table 3 from 86 students in 7 rotations isplaying the correlation of all variables with the percentage of the submit quiz. Pearson correlation coefficient, significant at p < 0.05.

	Percentage of the submit quiz		
	n	r	p-value
Quiz Mark (%)	86	0.894	<0.001
MCQ	86	0.094	0.388
Slide Quiz	86	0.082	0.452
OSCE	86	0.131	0.228
Report	86	-0.051	0.640
PBL	86	0.027	0.808
Ethics	86	0.122	0.262
Grade	86	-0.092	0.399

In the aspect of the comparison between GC and MD, there were 66.7% (26/39) of students who answered the evaluation with 96.1% preferred GC. Among these, 80.8% thought GC was easier to access, and 76.9% thought GC was more user friendly than MD.

Quality of the video and sound from GM in terms of lecture-type teaching, appeared that 13 students from eighth rotation taking only online lectures during the end of March 2019 owing to SARS-COV-2 pandemic. There were many lecture sessions by GM but only 3 of them were evaluated during the early period of the rotation performed. However, there were only 34 (instead of 39) evaluations for these issues. The participants graded the video and sound quality as 4 and 5 of the full marks of 5. Concerning the video quality, 20.6% and 76.5% of them gave the mark as 4 and 5 respectively. At the same time in the sound quality, 23.5% and 73.5% of the participants gave the mark as 4 and 5 respectively.

The correlation analysis of all variables with rotations and percentages of the submit quiz by the Pearson correlation are presented in the Table 2 and Table 3 respectively. The significant difference was accepted at p < 0.05. Therefore, in the table 2 is showing that the rotation significantly correlated with the slide quiz and the PBL at p of 0.010 and < 0.001 respectively while that of the percentage of the summit quiz showed significant correlation with only the quiz mark at p < 0.001 (Table 3).

VI. Discussion

Our study is the first study that uses GC with medical students who were studying Otolaryngology. GC could be used in both blended education and 100% online tool. Evaluation feedbacks from students, faculty, and support staffs of the department were ranged from good to excellent. However, evaluation of various education methods performed showed no significant difference among the two groups of students studied.

A study in Australia identified four key concepts that would influence the likelihood of success of a learning platform which was ease of access, collaboration, student voice/ agency and pace [7]. Our college provided GC training for faculty and support staffs during the start of first Otolaryngology rotation, therefore the first rotation missed the chance to use GC. The eighth rotation was at the time of SARS-COV-2 pandemic during mid-March 2020. With the government's order to lockdown and performed 100% online education so the eighth rotation used GC as the only mean of both the study and some types of examinations. MCQ was done by MD which normally used for the preclinic students at the PCM.

User experience (UX) is an advantage for GC since the students are Gen Y and Gen Z which make it easier for them to use electronic devices. In addition, user interface (UI) of the Google which people are so familiar with such as Gmail, Google Map and Google Drive make it easier for students, faculties, and support staffs to easily use in performing the GC. Since the college provides free G suite for education now being as the Google Workspace, it makes the chance to online education possible quite instantly. Therefore, there is no red tape to find a means for online education. This is consistent with Dash (2019)'s study in Indian students who learned the Biochemistry [8]. The students preferred to use GC by mobile phone and reported that GC was easily to access for being a learning resource. Furthermore, GC is free of charge so, it is appropriate for any countries with low to mid income.

Moodle is also a good tool, but the students think GC is easier either through a tablet/iPad or a smartphone. Although MD has applications both in android and iOS, the students are more convenient with MD used through web browser in PC, NB, or MC. This makes it difficult to use outside the establishment. For faculties, MD is an important means for MCQ examination especially when is used with safe exam browser (SEB), it could minimize exam fraud.

Even one systematic review and meta-analysis regarding blended learning in medical education concluded that blended learning demonstrated consistently better effects on knowledge outcomes compared with traditional learning in health education [9]. From the analysis, it showed that the rotation was correlated with the SQ (p < 0.010). The latter rotations would get higher quiz marks. In addition, the rotation was also correlated with the PBL (p < 0.001). The explanation could be that the students had got experiences from other subjects and then applied those to the Otolaryngology made them get higher marks than that of the first rotation. The more students answered the quiz, the more higher quiz marks obtained (p < 0.001) which is straight forward. The more they answered could give a better chance of more marks than those who did not ever answer. Although DQ cannot yield higher mark in MCQ, SQ or OSCE but the researcher believed that this was an important tool for learning improvement. The medical students could learn how to do differential diagnosis, treatment, and laboratory interpretation more than those of conventional teaching methods as well as building relationship with the second year residents who helped creating questions and giving detailed answers to all participants. This was an evidence-based practice that the residents had a good chance to really teach the medical students.

Although, there are many learning management systems, our department chose GC since the students, faculty and support staffs are familiar with UX and UI which cost nothing more. In the future many more LMS may be chosen such as Microsoft Teams. For the reason is that the MT has feature Insights that helps analyzing student participation through the activity data collection such as grading, work submission and announcement. The data will be collected as a dashboard for analysis. Using MT with application of Dugga can help minimizing exam fraud which may rely only on LMS, and any MD will not be needed at the exam.

Learning management system selection depends on the tools existing at each college, potential of students, faculty and support staffs, bandwidth, budget, and many other factors. One study in the United States indicated minimum infrastructure to support e-learning within medical education included repositories or digital libraries, to access to e-learning materials and consensus on technical standardization [10]. This study shows that GC is our best tool for online education. The blended education makes it is easier to switch to 100% online. There was no difference with the education result, but it was unpredictable to tell that upon graduation those doctors could do potential history taking, physical examination as well as proper management and medical ethics.

VII. CONCLUSION

Using the blended education to familiarize students, faculty and support staffs with learning management system is important. If 100% online teaching is needed the change from face to face to online could be easily performed. Almost of student preferred Google Classroom to Moodle.

AUTHORS' CONTRIBUTIONS

AP was a composer of this article while SN helped to interpret the analysis and SR was a research consultant. All authors have read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE.

This study protocol was reviewed and approved by the Institutional Review Board of the Royal Thai Army, Medical Department. Informed consent was obtained from all participants according to the Declaration of Helsinki.

CONSENT FOR PUBLICATION

Written informed consent was obtained from the person for publication of this review and any accompanying images.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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A Predictive Model for Student Academic Performance in Online Learning System

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Abstract— **As COVID-19 has brought a major disruption in educational system, online learning has replaced the traditional classroom learning during the pandemic in many parts of the world. One of the inferior point of online learning is that it has less interaction between the instructors and the learners. Therefore, closed and active monitoring of the students' academic activities is especially required in this mode of learning. The predictive model becomes one of the main tool for active monitoring that allows the instructors to forecast the final performance of the students to determine appropriate guidance or attention for each student. In this study, predictive models based on machine learning models for student performance are proposed using the log files that record student activities in online learning system. Different sets of features are used to determine the most suitable machine learning model. Several preprocessing methods are employed to improve the performance prediction including handling imbalanced data with Synthetic Minority Over-sampling Technique (SMOTE) and choosing relevant features by XGBoost model. The model with the highest performance yields the prediction accuracy as high as 83.95%.**

Keywords— Online Learning System, Student Academic Performance, Machine Learning, Data Science

I. INTRODUCTION

Many educational institutions have adopted a Learning Management System (LMS) for teaching and learning which can record the student's activities and scores. It is also a platform for teachers to create teaching topics, tests. LMS has become an absolute necessity under the epidemic situation of COVID-19 when traditional classroom teaching cannot be conducted. However, in online teaching, students and tutors have less interaction with each other. Without face-to-face connection, teachers require a more effective and proactive monitoring system to track students' progress to provide timely support and guidance.

In this study, we aim to actively predict student performance, that is to predict student's grades before the end of the semester, using the learning behavior of each individual student recorded in the LMS as well as some parts of the scores the students obtained during the semester. We use the log file that recorded various activities of users, including participation time, assignment scores, quiz scores as dataset for building the models. Several models are developed based on different techniques to determine the most suitable techniques for the dataset.

II. LITERATURE REVIEW

Many researchers have studied and published the topic of educational data mining using machine learning, including predicting student academic based on learners' assignment submission behavior in the learning management system [1], predicting student dropouts from general information and student academic performance [2] and prediction of cumulative grade point average (GPA) based on course grades and general information [3]. There are many researches aimed at predicting the student's academic performance by using machine learning techniques. For example, the researchers in [4] proposed a model that can deal with imbalanced data using SMOTE techniques. In [5], the researchers used ensemble models that can achieve best performance with the accuracy of 85%. In [6, 7], the authors used feature selection to improve performance of the model. It was found that the models with features selection have better performance that those without feature selection. The authors in [8] proposed a model that incorporates clustering technique to improve the prediction performance. The authors reported the best predictive performance with the accuracy of 80.1%. The article [9] performed the experiment by dividing the dataset into two sets, one dataset using the data of six weeks, while another used the data of ten weeks. The researchers achieve the accuracy of 60.5% with the Random Forest for six weeks dataset and the accuracy of 82.18% with the same Random Forest for ten weeks dataset.

III. PROPOSED METHODOLOGY

Fig. 1 shows a synopsis of the research process for a predictive model for student academic performance in online learning system. We acquired the information from the LMS system, then we used Excel to pre-process the dataset. We used SKlearn library in Python to build the models in the experiments.
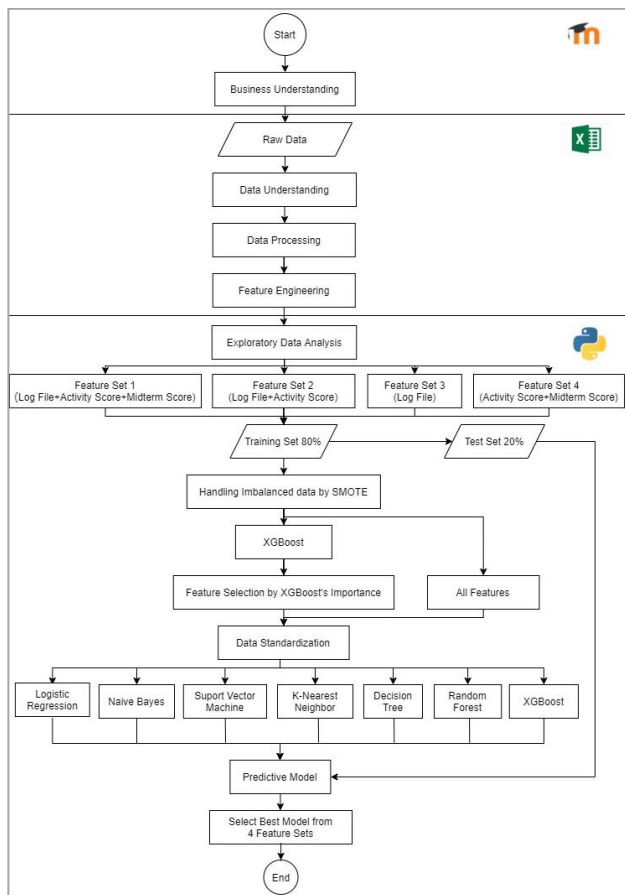
Fig. 1. Flow work diagram

A. Business Understanding and Data Preparation

In this study, we used the dataset from the course SWU 141 Life in a Digital World delivered by Innovative Learning Center, Srinakharinwirot University in the first semester of 2021. The course has been conducted in full online mode using Moodle platform as the learning management system. The course consists of eleven learning materials with six quizzes. The final grade is evaluated from four parts of the scores shown in Table I.

TABLE I. EVALUATION SCORE OF THE COURSE

Learning evaluation score	Assessment proportion
1. The first half of the semester	
1.1 Classroom activities score	30%
1.2 Midterm score	30%
Total	**60%**
2. The second half of the semester	
2.1 Project score	30%
2.2 Participation behavior score	10%
Total	**40%**
Grand Total	**100%**

The course is a university–wide course where 405 first-year undergraduate students have been enrolled. We used Excel to extract the information from log file into a tabular form. Then, the students who have dropped the course were removed from the analysis. Finally, there were 403 students who properly obtained the final grade that we used in this study.

B. Feature Engineering

In this study, we created features that reflect several aspects of the students. For example, we extracted the features that represent the study behaviors of the students, such as the frequency of accessing the system, the frequency of accessing learning materials. The features related to the sense of responsibility which includes the punctuality of submitting the assignments and the length of time the students took to submit each assignment. Another features include general identities of the student such as gender and faculty. Finally, we created the features from the score of the students that include the classroom activities score and midterm score which were scores obtained in the first half of the semester. Note that as we want to build the model that can make early prediction, we did not use the score obtained at the second half, which were project score and participation score. As a result, we used at most 60% of the score in order to make the prediction. In making the prediction, we divided the students into three classes according to their final grades. The students who received grade A and B+ are labelled as Excellent, those with grade B and C+, labelled as Good, and those who received C and lower labelled as Need improvement. There were 185 students who were labelled as Excellent, 174 students labelled as good, and 44 labelled as Need improvement.

C. Handling Imbalanced Data

We divided the dataset into training set data and test set data at the ratio of 80% to 20%. The training set had 322 instances while the test set had 81 instances. Among 322 instances in the training set, we found that there were 141 instances with label Excellent, 147 with label Good, and 34 with label Need improvement. To deal with the imbalance in the training set, we used Synthetic Minority Oversampling Technique (SMOTE) by upsampling the instances in the imbalance class. The distribution of the classes after applying SMOTE is shown in Fig 2 where all classes are balanced at 147 instances.
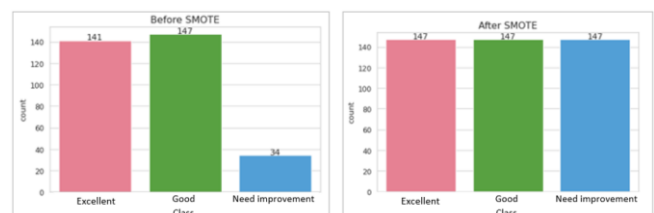

Fig. 2. Number of students at each grade level before and after SMOTE

D. Classification Modeling

After dealing with imbalance training set, we built the prediction models. In this study, we compared seven popular and highly effective models in machine learning: Logistic Regression, Naïve Bayes, K-Nearest Neighbor, Support Vector Machines, Decision Tree, Random Forest, and XGBoost. We created four sets of models using different sets of features from the training set to compare the predictive performance of the models in different scenarios. In the first sets of models, we employed the whole features, totally 115 features. In the second set, we excluded features related to midterm score, leading to 111 features. Then, in the third set, we omitted the features

related to all scores, including quiz and midterm scores. The remaining features in the third set, totally 99 features, were related to the study behavior only. Finally, in the fourth set, we used only the features related to scores, totally 18 features, to create the models. The datasets used in each set of models were denoted as Dataset 1, 2, 3, and 4 respectively. The details of the features in each set are shown in Table II.

The objective of comparing the models using Dataset 1 and Dataset 2 is to investigate the predictive performance of the models during different stage in the semester. As Dataset 1 contains all features, this dataset would become available after the midterm examination is conducted. On the other hand, not requiring midterm scores, the models which use dataset 2 can make the prediction earlier, which could lead to earlier response from the teacher.

For Dataset 3 and 4, we want to compare the influence of two sets of factors, i.e., the study behaviors in Dataset 3, and the scores in Dataset 4, on the predictive performance of the models.

TABLE II.   DESCRIPTION OF FEATURES USED FOR PREDICTION

Features used for prediction	Dataset 1 (115 Features)	Dataset 2 (111 Features)	Dataset 3 (99 Features)	Dataset 4 (18 Features)
1) General information				
- Faculty	√	√	√	√
- Gender	√	√	√	√
2) Students' behavior in using the system				
- Accessing the system	√	√	√	X
- Viewing learning materials	√	√	√	X
- Doing quiz	√	√	√	X
- Submitting assignment	√	√	√	X
3) Scores				
- Classroom activity score (30%)	√	√	X	√
- Midterm score (30%)	√	X	X	√

IV. RESULTS AND DISCUSSION

We used accuracy score as the performance metric for evaluating the predictive performance of the compared models. After training the models using different datasets, we also built another sets of models with feature selection to compare the benefit of using feature selection in this setting. The results are shown in Table III.

TABLE III.   ACCURACY COMPARISONS OF MODELS

Model	Accuracy (%)			
	Dataset 1	Dataset 2	Dataset 3	Dataset 4
1. Logistic Regression				
Full features	62.96	65.43	56.79	74.07
Features selection	74.07	69.14	66.67	59.26
Change[a]	11.11	3.71	9.88	-14.81
2. Naïve Bayes				
Full features	65.43	60.49	48.15	64.20
Features selection	65.43	66.67	48.15	60.49
Change[a]	-	6.18	-	-3.71
3. K-Nearest Neighbor				
Full features	62.96	62.96	55.56	**77.78**
Features selection	72.84	64.20	64.20	70.37

Model	Accuracy (%)			
	Dataset 1	Dataset 2	Dataset 3	Dataset 4
Change[a]	9.88	1.24	8.64	-7.41
4. Support Vector Machine				
Full features	71.60	58.02	55.56	71.60
Features selection	72.84	66.67	62.96	59.26
Change[a]	1.24	8.65	7.40	-12.34
5. Decision Tree				
Full features	65.43	58.02	46.91	69.14
Features selection	54.32	58.02	46.91	59.26
Change[a]	-11.11	-	-	-9.88
6. Random Forest				
Full features	69.14	69.14	**67.90**	76.54
Features selection	74.07	77.78	60.49	59.26
Change[a]	4.93	8.64	-7.41	-17.28
7. XGBoost				
Full features	**83.95**	**79.01**	65.43	76.54
Features selection	74.07	**79.01**	66.67	61.73
Change[a]	-9.88	-	1.24	-14.81

[a.] The percentage change in accuracy after performing feature selection.

A. Comparison of the predictive performance with differenet sets of data

From Table III, we can see that the set of models using Dataset 1 yield best performance, compared with those using other dataset. This is in accordance with our expectation that with more information, the models should perform better. The XGBoost model yields the best performance with the accuracy of 83.95% without performing features selection. It is noted that although XGBoost model performs better without feature selection, some other models such as logistic regression and K-nearest neighbor models yield better performance with feature selection.

TABLE IV.   PRECISION AND RECALL OF THE XGBOOST MODEL OF DATASET 1

Grade	Precision	Recall
Excellent	0.93	0.86
Good	0.76	0.81
Need improvement	0.73	0.80

The Precision and Recall scores of XGBoost are shown in Table IV. We can see that despite the fact that the number of students in class Need improvement is less than those of the other classes, Recall score of this class is as high as 0.80 which is on par with Recall scores of the other two classes. This result ensures us that XGBoost model can be a highly competitive choice for our application, as our main objective is to predict the students who perform not very well so that the teacher can provide more support early.

When comparing the predictive performance from the models using Dataset 1 and that using Dataset 2, we find that adding the features related to Midterm scores can improve the overall performance of the model averagely 4.06%. Considering our best model XGBoost, although the accuracy score from Dataset 2 is slightly lower than that from Dataset 1, Recall score of the students in class Need improvement remain the same at 0.80 which indicate that this model can be used to perform early prediction, that is before the midterm examination, without compromising too much performance.

When considering only the students' behaviors without the information of the scores, we find that the models trained by this dataset yield the worst performance. Compared with the results obtained from Dataset 1, the accuracy score of models trained by Dataset 3 drop almost 12.17% averagely. In addition, Recall scores in all classes drop below 0.60. From this result, we can conclude that training the models by the features that reflect only the behaviors of the students is not sufficient to enable the models to perform accurate prediction. More features are required to improve the accuracy score of the models.

In contrast, using the features related to score alone yields better predictive performance. In term of accuracy score, the models using Dataset 4 yield averagely 15% higher than those using Dataset 3. This result is not surprising because the socre should be the better reflection of the final academic performance that the activities of the students in the platform. However, we can notice that the average performance of models obtained from Dataset 4 is 4.06% less than that from Dataset 1. Especially, in XGBoost case, the model using Dataset 1 yields 7.41% better performance than that using Dataset 4. This figure indicates that the student behavior can improve the predictive performance considerably.

B. Impact of feature selection over predictive performance

TABLE V. NUMBER OF FEATURES BEFORE AND AFTER FEATURE SELECTION

Feature selection	Dataset 1	Dataset 2	Dataset 3	Dataset 4
Before feature selection	115	111	99	18
After feature selection	36	33	41	5

We performed feature selection by using the function *SelectFromModel* which is the built-in method in SKlearn. We used XGBoost as the based model for performing feature selection. In each dataset, after perfoming feature selection, the number of the resulting features are shown in Table V.

We find that performing feature selection improves the performance of some models, while other does not. For models with relatively high complexity such as XGBoost, using full featured data yields better performance. However, for low complexity models such as Naïve Bayes or Logistic regression, feature selection can improve the performance. This could result from the fact that the model with high complexity can learn from high dimensional feature effectively, whereas for low complexity models, high dimensional featured data might be too complicated for the model. As a result, for low complexity models, reducing the size of information through feature selection can improve the predictive performance of the models.

V. CONCLUSION AND FUTURE WORK

This research created a predictive model for student academic performance in online learning system with SMOTE data balancing and feature selection. The student's academic performance is divided into 3 levels which are Excellent, Good and Need improvement. Datasets for predicting academic performance contained

several types of features, including general information, system usage behavior, quiz and midterm score. This dataset was divided into 4 cases, based on different study periods and the types of features are: Dataset 1 uses all data for every feature, Dataset 2 doesn't use midterm scores, Dataset 3 uses only student system behavior, and Dataset 4 uses only all scores. The performance of the various models was assessed by considering accuracy values from the comparison of the behavioral features with score and only score model and comparing the performance of all features and feature selected, it was concluded that 1) XGBoost using students behavior data with score in dataset 1 had better predictive performance as compared to a model that uses only score 2) XGBoost in dataset 1 has the best performance as compared to other models that use all features and some features, XGBoost uses all features, which has an accuracy of 83.95%.

In future, we plan to extend this study into two directions. In the first direction, we will improve the performance of the model by testing other state-of-the-art models and techniques to boost the predictive performance of the model. In the second direction, we will conduct the study in a more holistic fashion, by applying the models in real online environment and study the effectiveness of the models in real situation.

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Visual-based Confusion Detection using a Cooperative Spatio-Temporal Deep Neural Networks

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Abstract— Confusion is one of the most frequently observed emotions in daily life and can greatly affect the effectiveness and efficiency of communication. Especially in education, detecting learners' confusion and resolving it timely is crucial for effective teaching. Most research on facial expression recognition has only focused on detecting six basic emotions that do not include confusion. Even though the problem of detecting confusion has recently received more attention from researchers, analysis of both the spatial and temporal information with sufficient data is still short. In this study, we present a spatial-temporal network for detecting confusion in video images that was trained on the BAUM-1 database that collected by Zhalehpour et al. in 2017, which is, as far as we know, the largest public video dataset of labelled confusion images. The model includes the ResNet-18 Convolutional Neural Network for learning spatial information from facial images, and a Long-Short Term Memory (LSTM) recurrent neural network (RNN) for learning temporal information. By cascading two deep learning structures, our method reaches a more accurate result (73%) on the BAUM-1a database than the baseline LSTM network (67%). We also tested with our CUPIC-Confusion video dataset, which was collected from recording 15 participants' faces while they were watching a confusing video in an uncontrolled environment. The proposed model predicted one instance from 30 consecutive facial images within 0.04 sec. with 66% accuracy, while the baseline model took 0.02 sec. with 47%. Our method can be applied to any task that gains benefit from the automatic detection of confusion, such as supporting teachers or speakers to recognize confusion in their audience without manually observing them, improving human-machine interaction tasks, and supporting those who have difficulties with confusion perception.

Index Terms—Facial Expression, Confusion Detection, Emotion, Deep Neural Network

I. INTRODUCTION

One emotion that is commonly found in human communication is confusion It usually occurs when people facing a hard time trying to understand something and they may have to invest a lot of time to comprehend unfamiliar information. In some cases, if people cannot turn their confusion to understanding fast enough, they might have to take actions or make decisions based on an incorrect understanding, which might lead to a misunderstanding or lack of detail that causes more time and effort to correct later.

In face-to-face conversation, a person can recognize the others' confusion based on their appearances and reactions, such as facial expressions, body languages, or even questions from the listeners. We then can instantly noticed and resolved the confusion in time. However, this natural way of confusion detection still has some limitations. First, the speaker must be able to visually observe their listeners' appearances. Second, When the communication is in large scale, such as a public speaking, it is almost impossible that the speaker will be able to recognize confusion of the whole audiences. Third, the accuracy of confusion recognition depends on personal experience and culture.

To overcome all these limitations, a system that can automatically detect audiences' confusion is needed. Especially in today when the pandemic has changed many things dramatically including education with the peculiar rise of e-learning, whereby teaching is undertaken remotely and on digital platforms. Moreover, most office workers have made the abrupt shift to working from home and having meetings online through video conferencing systems. An automatic confusion detection capability will be very beneficial in such online communications. It will increase the efficiency of communication by letting the speakers know when their audiences get confused and be able to respond more suitably and on time, which is very essential for good communication and learning.

Recently, many researchers have proposed methods to detect confusion automatically. Their methods range from measuring electroencephalograms from the brain (EEG) [1], electromyography from facial muscles (EMG) [2], and Facial Expression Recognition (FER) from images. With the current technology, EEG and EMG still require a specialist to set up and install sensors on the subject's body. While the FER uses only a camera to record the subject's appearance which makes this approach more practical in many use-cases. However, there are still many challenges to be solved. Most of the researches in the past had focused on classifying six basic emotions [3], which confusion was not included. Until recently, some researches have begun to address the detection of confusion, however, most of them did not take full advantage of deep learning techniques or used too limited amounts of data. These led to our motivation to find a method that can detect confusion from videos and feasible for real-life implementation.

II. RELATED WORKS

Most of the research on FER has focused on the classification of six basic emotions (happiness, sadness, disgust, surprise, fear, and anger) and not confusion, but the methodology and challenges are similar enough to mention. Initially, it was proposed to train two deep neural networks (DNNs) separately and then combine them at the decision level [4]. The first network was the Deep Temporal Appearance Network, which is used for capturing the temporal changes in the input image sequence's appearance using a three-dimensional convolutional neural network (CNN) structure. The second network is the Deep Temporal Geometry Network for capturing the temporal changes in the facial landmarks with a fully connected network structure.

This study achieved 97.3%, 81.5%, and 70.2% accuracy in the classification of six basic emotions on the well-known CK+ [5], Oulu-CASIA [6], and MMI [7] facial expressions datasets, respectively.

An alternative approach was to train two DNNs separately and then combined them at the decision level to classify the same six basic emotions too, but with a different methodology [8]. In this approach, the first network was a part-based hierarchical bidirectional recurrent neural network which took sequences of facial landmarks as the input. The second network was a multi-signal CNN, which took grey-scale static images as the input and fed them through four convolutional layers, one fully connected layer, and a softmax layer, respectively. The predicted probabilities of both networks were then combined using a fusion function to provide the final predicted probabilities.

Compared with the aforementioned six basic emotions, there are fewer datasets and algorithms that have focused on detecting confusion, but some research has begun to study this topic. In one study [9], they recorded both videos and audios of participants while they were watching stimuli images and videos. They performed a comprehensive experiment to create classifiers from visual features and/or audio features. Using only the visual features, their pipeline started with cropping only the part of the detected face region that was relevant to expression and then selecting six peak frames from each video clip, assuming that the peak frames contained a high intensity of expression. The images were then classified by Support Vector Machine (SVM) with a linear kernel. However, the accuracy for confusion detection was not explicitly mentioned, but rather was reported as the average accuracy (25.2%) for classifying the thirteen emotions and mental states of: anger, disgust, fear, happiness, sadness, surprise, boredom, contempt, unsure (including confused and undecided), neutral, thinking, concentrating, and bothered. They performed well on data collection gaining a decent quality and volume of data. In total, 1,457 acted and spontaneous videos from 31 subjects were recorded and annotated with 13 emotions/mental states by five annotators. This dataset greatly encouraged other researchers to study FER in addition to the six basic emotions.

Indeed, some methods to specifically detecting confusion have been proposed [10]. Video data were recorded from 82 students while they were studying an online course and they also labeled when they were confused on their clips. Then, the videos were separated into still images and processed by face detection, size normalization, rotated to be perpendicular, and cropped again to obtain the facial expression area. The pre-trained CNN VGG16 [11] was applied as a feature extractor and classification was performed by the SVM classifier. Thereafter, an image sequence-based classification method was proposed [12]. After recording videos of instructor-follower dyads engaging in a map directional task, the videos were analyzed at 15 frames per second (fps) with a 2-sec duration. The intensity level of activation from 20 action units (AUs) of the Facial Action Coding System [13] was extracted from each frame. Thus, each instance representation is comprised of 20 action unit's activation intensity from 30 consecutive frames. Then, a neural network with a 32-cells LSTM layer, fully connected layer with 64 nodes, and softmax layer with four classes (positive, negative, neutral, and confusion) was trained. For confusion class, the accuracy, recall, precision, and F1-score of the network were found to

be 87.07%, 84%, 78%, and 81%, respectively. This research [12] started training the model that detects confusion from features of image sequences, which is more realistic for spontaneous confusion expression than still image classification.

Furthermore, from the IEMOCAP visual-audio dataset [14], [15] proposed the multimodal emotion classifier constructed from 1D CNN and LSTM to extract features from speech data, and 2D CNN to extract features from the facial image, then combine both speech and facial expression features by using fully connected layers before classifying instance into 4 emotion classes (angry, excited, neural, and sad) with softmax layer. The multimodal classifier achieves more accurate result, when compared to each single modal classifier. Besides, In the user interface field which focuses on human-computer interaction, [16] proposed a confusion dataset with mouse and eye movements data, collected from the interaction of 60 participants with travel agency web application. While the participants were performing an experimental instructed task, they reported when they were confused by clicking confusion button that had been integrated on the web application. this dataset might be beneficial for combine with visual feature to improve the performance of confusion detector further.

III. SCOPE AND CONTRIBUTIONS

This study focused on detecting confusion from human facial expressions. The thinking state is considered as part of confusion, since we assume that people do not fully understand the situation while they are still thinking. Confusion in this study only covers that which occurs by comprehending new concepts or information with normal health conditions and does not include confusion that is caused by injury, illness, drugs, or loss of situation awareness.

The first contribution of this paper is the proposed spatial-temporal network (STN) that considers both the spatial features of each frame and the temporal relationship of them in a video sequence that achieves comparable accuracy to the chosen recreated baseline on, as far as we know, the largest public video dataset in which confusion is labeled. We also report the inference speed of the model, which is considered to be very important when real-time implementation is required. The second contribution is our exploration from testing the proposed network with our self-collected confusion video dataset. This dataset was collected from an uncontrolled environment, which is the most challenging and most realistic dataset ever used for confusion detection. The details and testing procedure are described in the following section.

IV. DATASET

We used the spontaneous part of the BAUM-1 database (BAUM-1s) as the main dataset for training, validating, and testing the baseline and the proposed model. The acted part of the BAUM-1 database (BAUM-1a) was used as a second testing dataset for a fair comparison between the proposed and baseline model. Moreover, we also collected our own CUPIC-Confusion videos dataset to test the performance of the models on the most realistic use case.

A. BAUM-1 dataset

1) Data Collection: This dataset was first proposed by [9] and is comprised of 1,457 videos at a 30 fps frame rate containing only one emotion/mental state per video of a

subject's expression from watching a stimuli video or image are annotated with a majority vote from the five annotators. Every video was recorded in the same controlled lighting condition, background, and camera angle.

Fig. 1. The sample images from the BAUM-1 database.

2) Data Preprocessing: For both BAUM-1s and BAUM-1a, we split every video into frames and labelled each frame with its original video's emotion/mental state. After that, the facial detection algorithm, adapted from the object detection algorithm proposed in [17], was applied to crop only the facial area from each frame. Then, from the original emotion/mental state of BAUM-1, we created our target binary class (called confusion) by grouping "Thinking" and "Unsure" into confusion, which is represented by 1, and 0 is used as the group of other emotions/mental states. Another preprocessing step will be explained in the training section of each model later because the proposed model and the baseline model used different formats of input data. This frame-level dataset was used to create the video-level dataset on the training step later.

B. CUPIC-Confusion video dataset

We wanted to test the proposed model with the most realistic data possible. Unfortunately, we could not find any public facial expression video datasets that label confusion, except for the BAUM-1 database that we used as the main dataset for this study. Therefore, we decided to collect our own confusion video dataset to fulfill this need.

1) Data Collection: We asked participants to send us a video of their faces while they were watching confusing videos. Participants were allowed to watch any video they wanted or to watch the video about a hard logic puzzle that we prepared for them. Then, they reported whether they were confused from watching the video or not. Participants were also allowed to record the video of their face from any environment with any device. Therefore, the lighting condition, background, camera angle, and video quality were different among each of the videos. In total, 50 videos were collected from 15 participants.

2) Data Preprocessing: After collecting the videos from the participants with their self-reported labels, we annotated the time that confusion was recognized on every video as pair of start and stop times. For some videos, confusion was recognized at more than one time, while we could not recognize confusion in some videos even though it was reported as confusion. We decided to annotate the part of the

video as confusion only when the video had been reported as confusion and we also recognized it. After the videos were annotated with the confusion time, we converted the confusion time to a start and stop-frame on each video by multiplying the time with the video frame rate. Other frames, except on the confusion interval, were labelled as non-confusion.

Fig. 2. The sample images from the CUPIC-Confusion video dataset.

V. SPATIAL-TEMPORAL VIDEO CLASSIFICATION MODEL

Each step and details of creating our proposed STN are explained respectively as follows.

A. Choosing a clip with at least 2-sec. length

Because BAUM-1s from the preprocessing process is a frame-level dataset, each instance represents the data of one frame from the original clip. We created a video-level dataset by choosing every other frame from the first 60 frames of each original video. This resulted in each instance of our video dataset being represented by a sequence of 30 frames at a frame rate of 15 fps from the first 2 -sec. duration of each video clip. Therefore, we could select only video clips that had at least a 2 -sec. duration to equalize the number of frames on each video instance.

B. Choosing a clip without a missing frame

Some videos might have 60 or more frames, but the video duration might be longer than 2 sec. and have some missing frames from an error in splitting the video to frames, or face region cropping, or features extraction. Therefore, choosing only a clip that contained consecutive required frames was necessary to make sure that every instance did not have a missing frame that differs from other clips.

C. Balancing and splitting the video dataset

From our two criteria, the chosen video dataset was unbalanced, with the number of non-confusion videos being significantly more than confusion videos. Therefore, we balanced the dataset by randomly selecting a non-confusion video to obtain the same number as the confusion video. Then, we split the video-level dataset to be training, validating, and testing datasets at a 80:10:10 ratio to maintain the same balance between confusion and non-confusion in every dataset.

D. Training the ResNet image classification model

The training and validating video-level datasets from the previous section were merged. Each instance was then split into a frame-level dataset and re-split into a frame-level training and validating datasets at a ratio of 80:20. The target classes were balanced between the confusion and non-confusion parts in both datasets. We used PyTorch's pretrained ResNet-18 on the ImageNet dataset to perform transfer learning with the dataset. The last fully connected layer of ResNet-18 was modified from 1,000 output features to be only one output feature. We also set an 80% probability that the training image will be transformed with eight image augmentation techniques (random rotation between -15 to + 15 degrees, left to right flipping, contrast adjustment, brightness adjustment, saturate adjustment, salt & pepper noise, gaussian blur, and gaussian noise).

After that, every frame was rescaled to 224 x 224 pixels, the pixel value was normalized in the RGB channel by subtracting the means (0.485, 0.456, and 0.406) and then dividing them by the standard deviation (0.299, 0.224, and 0.225, respectively), and fed into the network. Binary cross-entropy with logits loss function was used to evaluate the confusion classification of this model along with the adaptive moment estimation optimization technique, and the learning rate was scheduled to decrease 90% when five consecutive epochs gave no improvement in the validation loss. The training process ended when 10 consecutive epochs did not improve the validation loss. The weight of this model was further used as the initial ResNet weight for the video classification model.

E. Training the ResNet-LSTM video classification model

Inspired by the result from combining the spatial and temporal information to classify the six basic emotions that archived a competitive performance in the related literature, we propose a cascade spatial-temporal deep learning model for classification of confusion at the video-level. The structure of the STN model consisted of the two main components of (i) ResNet-18, for capturing spatial information of the facial image, and (ii) a LSTM recurrent neural network, for capturing the temporal information. The initial weight of the ResNet-18 model was acquired from the image classification model as explained in the previous section. The last layer with one output feature was cut off. The 512 features that had been used as input features for the last layer became the output features of the ResNet-18 network. Then, the output features were fed as the input into the LSTM network.

Each instance of the data represents one video that contained 30 frames from 2 sec. of the original BAUM-1s video. Each frame that passed through the ResNet-18 model was transformed into an array of 512 features, and each array was fed to each LSTM cell in the frame order. Therefore, the LSTM network consisted of 30 cells to match with the number of frames per instance. Each cell of the LSTM network used the cell state and hidden state from the previous cell along with the array of features from the ResNet-18 to predict the label of the next frame. Dropout with a probability of 50% was applied on the LSTM network output before feeding to a fully connected layer with 64 output features. Then, a second dropout with 50% probability was applied again, and the output layer of the whole cascade network was a fully connected layer with 64 input features and one output feature. The structure of the model is illustrated in Figure 3.

Each video instance was also augmented, rescaled, and normalized using the same process as the ResNet-18 image classification model. Every frame of each instance was applied with the same augmentation technique. Training strategies, such as loss function, optimization technique, learning rate schedule, and early stopping criteria, were all the same as those used in training the ResNet-18 image classification model.

VI. BASELINE AND EXPERIMENTAL RESULT

We recreated the baseline model to be as close to the original work [12] as possible. However, because the dataset is not the same, we had to adjust the last layer of the original work from the four classes softmax layer to be a fully connected layer with one output feature, and the sigmoid activation function to compatible with the BAUM-1 dataset that was focused only on classifying confusion and non-confusion. The facial action unit activation intensity extraction is another part that did not follow the original work. We used the "OpenFace 2.0" software [18], which can extract activation intensity from 17 action units, while the original work used 20 action units extracted by the "Face Reader" software. Moreover, the training strategy details were not stated in the original work, so we used the same strategy as our proposed method to compare the results from the different model structures. All of the results reported in this study were tested on the same computer with an AMD Ryzen 7 3700X 8 cores 16 threads CPU, 16 GB of RAM, and Nvidia RTX 2060 super GPU, which had windows 10, python 3.8.2, torch 1.7.0 with cudnn 10.1, and torchvision 0.5.0 installed.

A. Result of analysing the BAUM-1s dataset

The BAUM-1s dataset was used to train both the baseline and the proposed model. Since OpenFace 2.0 cannot extract the action unit activation intensity from all the images of BAUM-1s, the 217 instances that we could use to train the baseline model were significantly lower than the 342 instances for the proposed model. After the training process was completed, the results of testing each model on their testing dataset showed that our proposed model achieved a higher accuracy level (74%) than the baseline model (68%). Moreover, the precision and F1-score of the proposed model were also higher, with only the recall being lower than the baseline model. However, because we chose the testing dataset randomly from all the available data for each model, the testing dataset of each model is not the same, which we consider to be an unfair comparison.

B. Result of analysing the BAUM-1a dataset

Since we wanted to compare our proposed model and the baseline model fairly, we decided to preprocess the BAUM-1a dataset with the same process as the BAUM-1s. For fairness of testing both models on the same set of video clips, we used only videos that OpenFace 2.0 could extract the facial action unit activation intensity from to test both models. We consider this method as a fair comparison. The result showed that our proposed model still had a higher accuracy level (73%) than the baseline model (67%), but the precision, recall, and F1-score of the proposed model were all lower than the baseline model on this dataset (Table 1). It is interesting that, for both models, the precision, recall, and F1-score were all significantly lower than the testing result from BAUM-1s, which indicates that the confusion expression in the acted expression of the BAUM-1a dataset is not similar to the spontaneous expression in the BAUM-1s dataset.
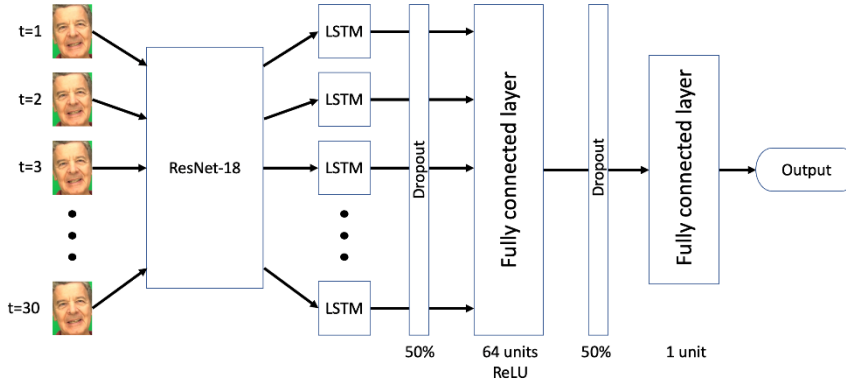
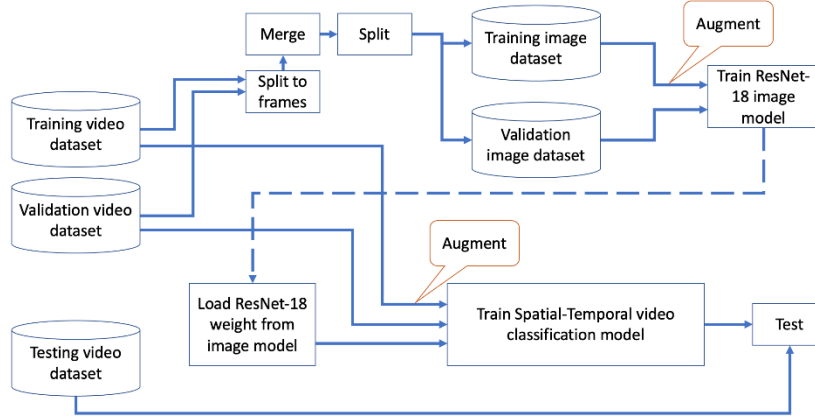Fig.3. Spatial-Temporal confusion detection network structure.

Fig. 4. Training process for the STN.

TABLE I. TEST RESULT OF THE PROPOSED AND BASELINE MODEL.

	Accuracy	Precision	Recall	F1-score
Proposed Model				
BAUM-1s	74%	75%	71%	73%
BAUM-1a	73%	15%	27%	20%
CUPIC	66%	4%	37%	7%
Baseline Model				
BAUM-1s	68%	65%	79%	71%
BAUM-1a	67%	19%	53%	28%
CUPIC	47%	3%	66%	5%

C. Result using the CUPIC-Confusion video dataset

Unlike the BAUM-1 dataset that each video was labeled with one class, the CUPIC-Confusion video dataset was labeled with confusion interval within each video. Therefore, the testing procedure is different. The testing process on each video started with reading every other frame of the video and then detected and cropped the face region. The facial image was stored on an instance array and repeatedly read the next frame until the last one. On each reading loop, if the instance array was stored with 30 facial images, the instance array was fed as an input of the confusion detection network. The network predicted whether the input instance was confusion or not and led all of the frames that were represented by the input instance with the predicted result. The instance array was then cleared after the predicting step to prepare for storing facial images from the next frames.

From the results in Table 1, our proposed model achieves higher accuracy, precision, and F1-score. Even though the performance of the baseline model is calculated only from frames that AUs can be extracted which is intuitively similar to choosing only frames that emotion is clearly expressed. And the overall speed of the proposed model at 6.5 fps is considerably faster than the baseline model at 1.7 fps. Although the inferencing time of the baseline model (0.02 sec. per instance) is faster than the proposed model (0.04 sec. per instance), but the AU extraction process which took 0.8 sec. per frame is the bottleneck of the whole process.

VII. CONCLUSION

We presented a new deep learning STN for confusion detection from a sequence of facial image data. Our proposed model includes ResNet-18 CNN to capture spatial data from each frame and LSTM RNN to capture temporal features through a sequence of frames. By using the BAUM-1s, BAUM-1a, and CUPIC-Confusion dataset, the proposed model gave higher accuracy in all testing datasets, while only BAUM-1s and CUPIC-Confusion dataset that F1-score is higher than the baseline model. It is noteworthy that the baseline model predicted an input to be confusion class more often than the proposed model which makes it got a higher recall on every testing dataset. Our hypothesis is the proposed model, trained with more numbers of data and augmented by various techniques, has more generalization than the baseline model which lost part of training data from the failure of AU extraction. We also wonder that CNN or AUs is a better spatial feature for confusion detection. But because the AU extraction

issue makes it difficult to compare fairly. However, this issue makes the proposed model can be implemented more conveniently.

The processing speed on the CUPIC-Confusion dataset of the proposed model at 6.5 fps is significantly faster than the baseline model at 1.7 fps which was caused by the AU extraction that took 0.8 sec. per frame and the second most time-consuming task is facial detection with 0.29 sec. per frame. Moreover, we consider another two aspects as noteworthy for future study. First is the duration of confusion expression. In this work, we only studied a 2-sec. duration while the average duration from BAUM-1 and our dataset were 6 sec. and 6.5 sec., respectively. Second is the audio data of the content or information that confuses a subject could possibly support visual data to achieve better detection accuracy.

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Design of A Curriculum for Online Competency-Based Training

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Abstract—**The concept of making occupational standards as a framework to develop a workforce has been adopted in many countries. Each occupation requires certain skills and capabilities necessary to pursue that profession. However, occupational standards are only a description of those desired skills. A curriculum is an important part of developing an effective and productive workforce. Therefore, this research presents a method/concept for designing a competency-based curriculum using the principles of Outcome-Based Education (OBE) and use the National Occupational Standards (NOS) as a source of basic information for development by converting competency units into the curriculum, The goal is to be a competency-based curriculum for online competency-based training because due to the current situation, learning is more likely to be online platforms. The occupational standard of data analyst is used to demonstrate the process of this work. The conceptual framework was assessed using the Delphi technique by 10 experts. The results show that the proposed framework is suitable for developing a competency-based curriculum. As a result of this method, the curriculum is complete and consistent with occupational standards.**

Keywords— National Occupational Standards, Outcome-Based Education, Curriculum Design, Online Training

I. INTRODUCTION

Nowadays, technology is changing rapidly, which makes the work process change according to the development of technology. Therefore, personnel development is important in every organization. Therefore, the curriculum for personnel development should collect important information from each occupation to develop related competencies [1]. These processes could take a significant amount of time. Moreover, the data collected may not provide a complete picture of the competency requirement for the professional standards.

Therefore, to obtain skills of the professional, occupational standards have been established, which is the concept of determining the ability of professionals to ensure that a person can do a career. The occupational standardizations have been adopted in many countries also known as the National Occupational Standards (NOS). However, the occupational standards are only a description of competencies, which may be insufficient to develop and upgrade the workforce. Personnel development should create suitable learning programs. It must be designed by considering all related factors. Therefore, this work proposes a curriculum design framework using the Outcome-based education (OBE) technique in cooperation with NOS to make the personnel development process more efficient.

As a result of the challenges mentioned above, the curriculum was designed by adopting units of competencies to the online competency-based training. In addition, the current Covid-19 pandemic has forced all levels of education to conduct lessons online causing online learning to rapidly become more prominent.

II. LITERATURE REVIEW

A curriculum is an important component of a training program. To develop a curriculum, several factors must be considered. In this section, the related factors of curriculum development are reviewed as follows.

A. National Occupational Standards

NOS is the collection of essential competencies for each occupation. Competence is defined as the capability of an individual to be able to complete a task successfully and efficiently. It is a skill that can be developed for a person to improve work performance or meet certain criteria [2]. Creating a collection of competency or occupational standards takes time and resources. These occupational standards can apply to develop the assessment and curriculum. Erica Smith [3] implemented competency-based training (CBT) in vocational education for ten years and discovered three key points of competency training. First, competency training focuses on outcomes. Second, the outcome is measured against specified standards (not against other trainees). Third, the focus on standards is industry-related.

B. Outcome-based education

OBE means educational management through curriculum development, which focuses on the outcome from the learning program. The content and application of learning processes are aimed at developing specific competencies. There are 3 important components, which are learning outcomes, assessment, and learning activities [4]. The principle of OBE has been applied to learning programs at various levels such as under-graduation, graduation, and post-graduation levels. It becomes a standard process of curriculum development for today.

C. Online learning

Online learning is a means of communicating content, photographs, videos, and multimedia in conjunction with conversations and concept discussion using electronic devices and current technologies [5]. The most common issue with online learning is the reliability of the internet connection for both students and professors. Due to this, students and professors, as well as students and other students, may have a difficult time interacting within the online course session [6]. To keep students engaged, instructors should urge students to turn on cameras from their computers or mobile phones during the course session. This will allow for more interaction during the class. Students can ask questions in a manner that is similar to a traditional classroom and instructors can assign group discussions and direct questions to individual students. Before the conclusion
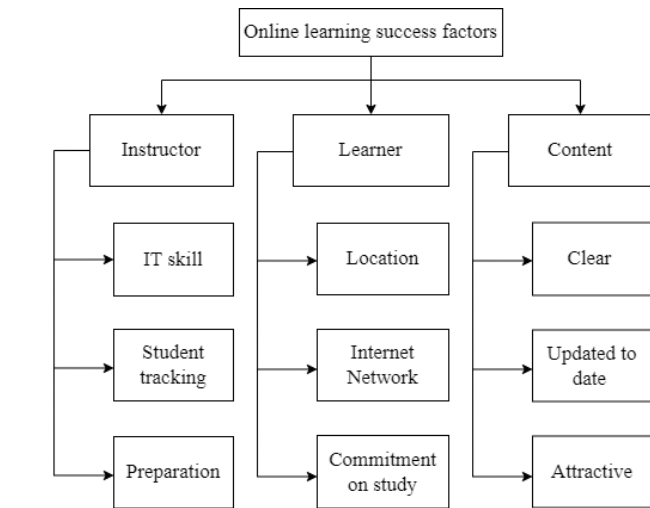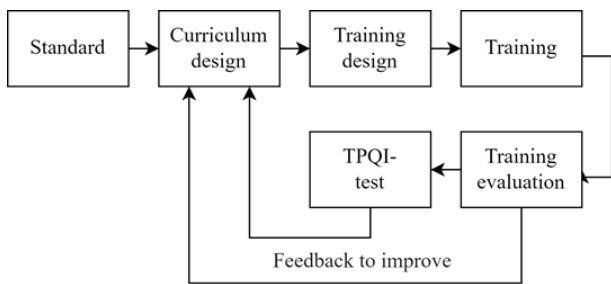
Fig. 1. Online learning success factors.

Fig. 2. The training program development framework

TABLE I. FUNCTIONAL ANALYSIS OF DATA SCIENCE OCCUPATIONAL STANDARD.

Key Function		Unit of Competence (UOC)		Element of Competence (EOC)	
Code	Description	Code	Description	Code	Description
702	Collect and study to understand the data	70202	Collect Initial Data	70202.01	Draft requirements and data requirements
				70202.02	Check data availability
				70202.03	Determine the criteria for selecting data
		70203	Describe Data	70203.01	Specify data details
				70203.02	Save detailed data
				70203.03	Define data descriptions
		70204	Explore Data	70204.01	Examine the definition and meaning of the data provided
				70204.02	Check the received data attributes
				70204.03	Summarize the results of the data survey
				70204.04	Communicate during data surveys

of the research topic, the teacher must have proficiency in using information technology (IT), monitor students' attendance regularly, and prepare before teaching by learning how to utilize the system and testing online teaching to identify difficulties, impediments, and solutions. Furthermore, the curriculum plan must be concise, easy to comprehend, and constantly updated. Teaching materials must be interesting to attract and stimulate students' learning [7]. From this review, we can conduct the online success factors as shown in Fig. 1.

D. Data Analyst Occupational Standard

In this work, the occupation standard of Data Analyst Level 3 by Thailand Professional Qualification Institute (TPQI) is used [8]. Data Analyst is an occupation in Data Science Domain. The standard gives information about the competence with development from the Functional Analysis (FA) Technique [9]. To explain the occupation standard, the functional analysis of data science is selected and shown in Table I.

From Table I, we can see that the standard consists of Key Function, Unit of Competence, and Element of Competence.

• Key Function: The scope of duties and responsibilities of a specific workgroup within the occupational group. It is expected that personnel will be able to achieve their key roles.

• Unit of Competence: The scope of the work (Outcome) with a beginning and an end. It can be done alone by an individual or a group of people in a professional group.

• Element of Competence: Subcomponents of the Unit of Competence

This is a short form of occupation standard. The detail of each UOC can be found in [10].

III. RESEARCH METHODOLOGY

A. Research Framework

To perform this work, the framework needs to be created According to the literature review, the framework of developing the training program is depicted in Fig. 2. We can see that it consists of six processes and the details of each process are given below.

1) Standard Selection

An occupation standard is selected for developing the curriculum. It will be used as the initial information of the second step. For this work, the occupational standard of the data analyst level 3 by TPQI is selected for this study.

2) Curriculum Design

The selected occupational standard is analyzed and converted to a curriculum. The related factors are studied and collected from the literature review. The diagram of this process is shown in Fig.2. For more detail, it will be explained in the next section.

3) Training Design

The training program is designed according to the curriculum from the previous process. The training activities are created depending on the type of competency, i.e., skill, knowledge, and attitude.

TABLE II. SUMMARY OF EXPERT CHARACTERISTIC.

Expert Number	Experience (years)	Field of Expertise
No.1	20	Computer Science
No.2	15	Information Technology
No.3	20	Computer Science
No.4	10	Competence Development
No.5	10	Data Science
No.6	20	Information Technology
No.7	15	Information Technology
No.8	15	Data Science
No.9	10	Information Technology
No.10	10	Competence Development

Fig. 3. Curriculum Design Framework.

4) Training Implmentation

The implantation of a competency-based curriculum is applied to competency-based training at this stage.

5) Training Evaluation

The satisfaction of trainees is measured during training evaluation. The outcomes of trainees' assessments can be used to improve and develop the curriculum's design to increase its efficiency.

6) Competency Assessment:

Evaluating the curriculum is using examination results from the TPQI to gauge the success of the design. However, if the trainees received poor results, then the curriculum must be redesigned with the purpose of improvement.

B. Evaluation Process

After we complete each process such as curriculum design, curriculum, and training program, the evaluation needs to be performed. Delphi technique is selected to complete this task.

1) Experts for Evaluation Process

The experts in the related field are invited to this evaluation. The summary of the expert information is given in Table II. Most of them are related to computer science and information technology. Two of them have experience in competence development.

2) Delphi Technique

Due to the Delphi technique, the experts have the freedom to give any idea to the given questions. The evaluation process is set as a private evaluation to prevent the influence of another expert. The initial questionnaire is created due to information from the literature review, which is submitted to the experts to complete independently. The replies from the first round of the questionnaire will be used to create the second round, which is a rating scale questionnaire (5 levels). The questionnaire is submitted and documented for decision-making of the rating, allowing the experts to write their suggestions freely. Finally, the questionnaire will be evaluated using the median and interquartile range.

3) Data Analysis

Five levels of Likert scale questionnaires are used to determine the opinion of the experts. The interquartile range and median values were used to analyze the consistency of
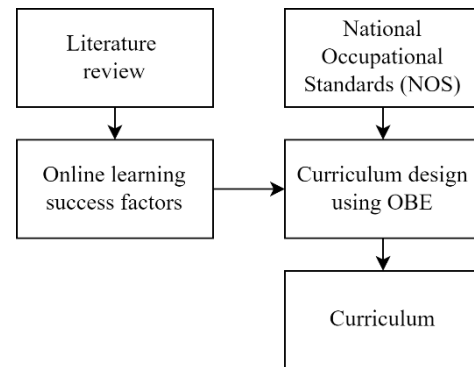
the expert group. The Delphi method is commonly used to calculate central tendency metrics like mean and median. Because mean values are easily influenced by extreme values (Outlier), they are not appropriate for data with outliers because they can be easily skewed, therefore the median is used in this research.

If the opinions of the expert disagree, the third questionnaire must be created for the experts to answer. In In this round, the experts will also be required to give justifications for their responses. If the opinions remain the same, around 4 questionnaires must be created. For this final round, the statistics of the third round include mode, median, and mean to indicate the group's opinion level in an accumulated manner. There should be no more than four rounds of questionnaires. If a consensus cannot be reached, it may be necessary to create a new questionnaire.

IV. RESULT AND EVALUAITON

This section presents the results of this work. It consists of 4 parts, i.e., curriculum design framework, evaluation of curriculum design framework, DA3 curriculum, and evaluation of DA 3 curriculum. The details of each part are given as follows.

A. Curriculum Design Framework

The curriculum design of the work is based on Outcome-based education (OBE) principles, which focus on the characteristic outcome of the learner. The proposed framework is shown in Fig 3. In terms of Outcome, whether it is PLO (Program Learning Outcome) or CLO (Course Learning Outcome), according to OBE principles, will be developed using NOS as a source of data for developing and designing a curriculum instead of the OBE original method. Because NOS has already developed the necessary competency units of each professional standard. This will reduce the time required to collect the competencies needed to pursue a career. The key performance criteria for each step are clearly stated. In addition, the online teaching method must be taken into account in the development of this curriculum. Its uses of literature review to collect factors that will affect online learning or training to be considered in the design of a curriculum. Therefore, in the design of this curriculum, there are two primary components: A review of the online learning success factors and NOS. It will demonstrate an example of a Data Analyst Level 3 (DA3) curriculum design with the following steps.

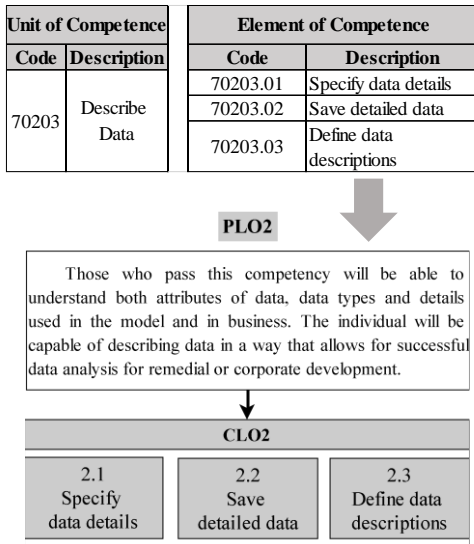| Unit of Competence		Element of Competence	
Code	Description	Code	Description
70203	Describe Data	70203.01	Specify data details
		70203.02	Save detailed data
		70203.03	Define data descriptions

PLO2

Those who pass this competency will be able to understand both attributes of data, data types and details used in the model and in business. The individual will be capable of describing data in a way that allows for successful data analysis for remedial or corporate development.

CLO2

2.1 Specify data details	2.2 Save detailed data	2.3 Define data descriptions

Fig. 4.   Development of PLO and CLO for DA3.

Fig. 5.   Content rearrangement for DA3.

1)   Develop PLO and CLO from NOS.

As shown in Table I, the FA of NOS consists of Key Function, UOC, and EOC. This information can be used to create the PLO and CLO depending on the level of the analysis. For example, the occupation standard of DA3 can be created in the PLO and CLO as shown in Fig. 4. We can see that UOC is mapped as PLO and EOC is mapped as the CLO of this curriculum.

2)   Design Learning Content.

After we obtain the PLO and CLO from the previous step, the learning content is created by analyzing the performance

criteria (PC) of each UOC [10]. PC is an important outcome of performing a task that can be measured or indicated. An example of learning content designed by analyzing the data from the PLO2 is shown in Table III. We can see that each learning content does not organize in a way that can be used as a teaching plan directly. Therefore, one more step needs to be done to complete the curriculum design.

3)   Rearrange Content:

Fig. 5. shows the content rearrangement which can be categorized into 3 main categories because the content from the course design is not arranged or categorized accordingly. Therefore, should be to categorize the content and arrange the teaching from basic to advance. In some cases, if the content requires some basic knowledge or prerequisite, the

TABLE III.   LEARNING CONTENT OF CLO2

PLO2	
CLO2	Learning content
2.1 Specify data details	1. Definition and benefits of data dictionary 2. Characteristics of data 3. Data Restrictions
2.2 Save detailed data	1. Information details 2. Data analysis techniques
2.3 Define data descriptions	1. Techniques for presenting information 2. Meaning of Entity- Relationship Diagram 3. Elements of Entity- Relationship Diagram

TABLE IV.   CURRICULUM DESIGN METHODS VALIDATION
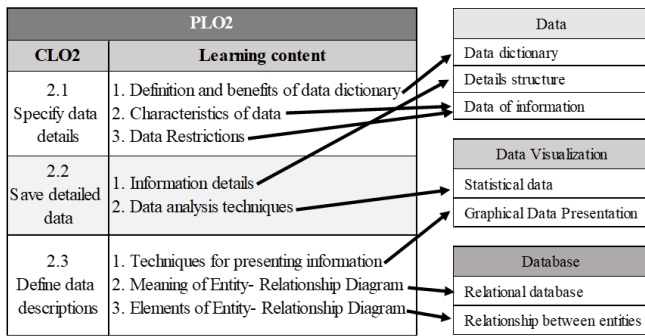
No.	The Assessment items	Median	Interquartile range	level of consensus
1	Appropriateness of the application of NOS and OBE in Competency-based curriculum design.	4.67	0.95	Highest level
2	Appropriateness of using online learning success factors in Competency-based curriculum design.	4.50	1.12	Highest level
3	Complete curriculum design method.	4.50	1.00	Highest level
4	The method is clear.	4.67	1.08	Highest level

the curriculum must provide that content or reference for future curriculum development.

B. Evaluation of Curriculum Design Framework

To evaluate the framework, the Delphi technique is used. The details of experts performing this evaluation are given in TABLE II. The evaluation is performed according to the Delphi technique. A questionnaire is created according to 4 dimensions and the result of this evaluation is shown in

TABLE III. It was founded that the experts agreed, the four assessment items were at the highest level, the expert opinions were also consistent based on the Interquartile range. From this result, we can imply that the proposed framework is suitable for designing the curriculum for competency-based online training.

C. DA3 curriculum

To demonstrate an output of the proposed framework, the DA3 curriculum is created, which is shown in TABLE V. We can see that the curriculum consists of 4 modules including basic data science, data, machine learning, and database. Each module has a learning topic that should be covered in a training program.

TABLE V.   DA3 CURRICULUM

Curriculum	
1. Basic data science	1.1 What is data science? 1.2 System overview 1.3 The importance of data science 1.4 Careers in data science 1.5 Competency in data science
2. Data	2.1 Definition and meaning of the data 2.2 Metadata 2.3 Data structure 2.4 Details of information 2.5 Data item details 2.6 Basic data analysis techniques
3. Machine learning	3.1 Machine learning type 3.2 Introduction to rapid Miner 3.3 Linear regression 3.4 Classification 3.5 Decision tree 3.6 K-mean
4. Database	4.1 Components of a database system 4.2 Data management 4.3 Type of Database 4.4 Entity-Relationship Diagram 4.5 Relational Database 4.6 Terminology related to database 4.7 Relationships between entities 4.8 Basic SQL 4.9 Multidimensional Database4. 4.10 Data Warehouse

TABLE VI.   EVALUATION OF DA3 CURRICULUM

No.	The assessment items	Median	Interquartile range	level of consensus
1	The curriculum is compliant with TPQI standards.	4.88	0.63	Highest level
2	Content is complete by the core competency of TPQI standards.	4.88	0.63	Highest level
3	Appropriateness of content ordering.	4.67	0.95	Highest level
4	Appropriateness of the content amount.	4.75	1.26	Highest level
5	Curriculum modernity.	4.79	1.47	Highest level

D. Evaluation of DA3 curriculum

To evaluate the DA3 curriculum, the Delphi technique is used. The details of experts performing this evaluation are given in TABLE II. The evaluation is performed according to the Delphi technique. Questionnaires are created according to 5 dimensions and the result of this evaluation is shown in TABLE VI. We can see that the experts agreed, the five assessment items were at the highest level, the expert opinions were also consistent based on the Interquartile range.

V.   CONCLUSION

The curriculum design framework based on NOS and OBE is proposed in this work. The occupation standard of data analyst level 3 is used for demonstration. The results show that the proposed framework is a suitable method for applying to competency-based curriculum design because NOS has already developed the necessary competency units of each professional standard. It can reduce the time required to collect the competencies needed to pursue a career. In addition, experts agree that the application of NOS and OBE will enable effective teaching and learning and have clear guidelines. The proposed framework can apply directly to another occupation standard to create a competency-based training program.

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A Flexible Water Monitoring System for Pond Aquaculture

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Abstract— **Water quality is the most important factor for pond aquaculture. Farmers must be able to control a water quality to be within the appropriate range for each kind of aquatic animal, which needs both skill and knowledge. This work proposes a flexible water quality monitoring system for pond aquaculture, which can be configured to fit with a particular aquatic animal. Three types of sensors are applied to measure the water quality including pH, temperature, and dissolved oxygen sensors with 2 types of wireless connection, i.e., WiFi and NB-IoT. A microcontroller is used to process these sensing signals and send data to a cloud server. The system monitors the water quality all the time. If the water quality is not within the controlled range, the alert message will be sent to the farmers. The dashboard is also provided for real-time system monitoring. Systems can be selected as three kinds of aquatic animals including white shrimp, white sea bass, and tilapia. The controlled range will be changed according to the type of aquatic animal that the user selected. As the result, we found that the proposed system can perform as designed and the accuracies of the prototype are 98.5%, 97.6%, and 95.1% for pH, temperature, and dissolved oxygen, respectively, when compared with the standard tools. The proposed system can support both connections, i.e., WiFi and NB-IoT.**

Keywords— *water quality monitoring system, aquaculture, IoT, NB-IoT*

I. INTRODUCTION

Aquatic products are an important food source for both domestic consumption and export market, which can be obtained from nature and aquaculture. However, according to the overfishing problem, fish stocks from nature were rapidly depleted. On the other hand, aquaculture tends to increase considerably. In general, aquaculture will look like a closed system. The water does not circulate. Climate and sludge directly affect the water quality, which has many risks to the quality of aquatic animals. Water is an important growth factor for aquaculture. If the water quality value is in the inappropriate range, the productivity of aquaculture will be decreased.

A water quality measurement system has been introduced to assist in the management of aquaculture. The information on water quality is gathered via several techniques and recorded in the database for further analysis. Moreover, these systems can manage the water quality remotely. Fig. 1 shows an overview of general water quality measurement systems. We can see that it consists of four main parts including a water quality sensor, microcomputer unit (MCU), GSM module, and cloud server.

There are several factors of water quality that affect aquatic animals, such as pH, temperature and dissolved
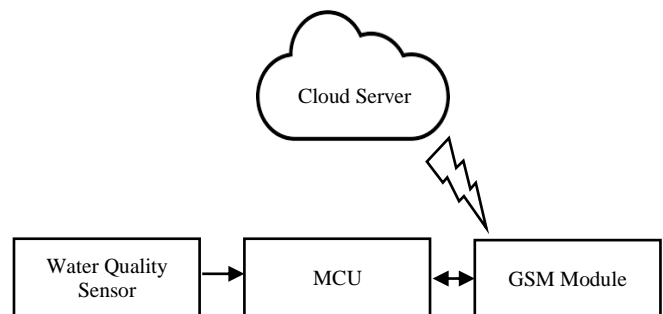

Fig. 1. An overview of general water monitoring systems.

oxygen. Different species of aquatic organisms require a different value of these parameters. Normally, farmers must have all of this knowledge to control the pond culture. Different configuration of water monitoring is needed for different aquatic species.

This work proposes a flexible water quality monitoring system for pond aquaculture, which can be configured to fit with a particular aquatic animal. Three types of sensors to measure water quality: pH, temperature, and dissolved oxygen (DO) sensors. Two types of wireless connections can be selected including WiFi and NB-IoT. The system monitors the water quality all the time and sends alert messages to the farmers when it detects abnormal conditions. A dashboard is provided to present real-time water quality data and suggest basic solutions to farmers. To reduce the work process and facilitate farmers, it can also support many areas of use. The details of implementation and experimental results are shown in the following sections.

II. LITERATURE REVIEW

Aquaculture is one of the channels that can generate income for farmers. Normally, to operate the aquaculture, famers have to regularly measure water quality. This task consists of many steps, takes a long time, and is difficult to perform in some situations such as rain. For water quality control, farmers must have the knowledge and skill to solve these problems. Moreover, by raising different species, the treatment process will be different.

Important economic aquatic animals such as white shrimp, sea bass, and tilapia are popularly cultivated by farmers. Each species requires different water quality values. Table 1 shows the appropriate water quality values for aquaculture. A farmer needs to control the water quality in the culture pond to be at an appropriate level at all times. Especially white shrimp, they are difficult to cultivate aquatic animals because it is easy to

Aquatic Type	Water Quality		
	pH	*Dissolved Oxygen*	*Temperature*
White shrimp	7.5 - 8.0	> 5 mg/L	28 - 32 °C
Sea bass	7.5 - 8.5	> 4 mg/L	28 - 32 °C
Tilapia	6.5 - 8.0	> 4 mg/L	28 - 32 °C

Water Quality	How to fix basic problems	
	Lower than standard	*Above standard*
pH	Dolomite, Hydrate lime	Vinegar 5 %
Dissolved Oxygen	Paddle Wheel, Oxygen powder	
Temperature	Add warm water to the mix or perhaps lower the water level early in the morning.	Add water to raise the water level.

panic and sensitive to changes in water conditions. During aquaculture, if the water quality is not within the proper range, farmers can control water conditions by using the suggested solution as given in Table 2.

In aquaculture, information technology has been introduced to enhance the performance of water quality control systems. Early automation systems were used to monitor water quality in water sources by installing water quality sensors at various points to reduce the process and time of operation [2, 3]. A GSM communication model was utilized to allow monitoring of water quality from a distant center. A notification message is sent when the water is in an abnormal state. This method can help to reduce costs and travel time to collect samples [4]. As a result, it can help the farmer to solve problems promptly [5].

Wireless sensor networks have been applied to these applications. The water quality data is sent and stored in a central system, which can be performed the analytic process easily [6, 7]. Moreover, the system was developed to reduce the process of taking care of the pond. It uses an automatic aeration system to control dissolved oxygen and an automatic heating system to control the temperature.

In addition, the remote data communication system by using the telematics system was proposed [8]. Internet of Things (IoT) technology was introduced to reduce the cost of the whole system so that information can be accessed from anywhere over the internet network [9, 10]. However, taking care of water quality is one of the main duties that farmers must be done. If the water quality is within the desired range, it will be a positive factor for the productivity of the pond culture. Therefore, using the proper technologies is an important factor for pond culture.

III. THE PROPOSED SYSTEM

The basic diagram of the proposed system is shown in Fig. 2. We can see that there are three parts of the proposed system. The first part is the measuring units which are installed at the ponds. The second part is the cloud unit and the last part is smart devices. The measurement units are responsible for measuring the water quality. After that, the data are sent to store on the database. The cloud unit is responsible for processing water quality and managing the
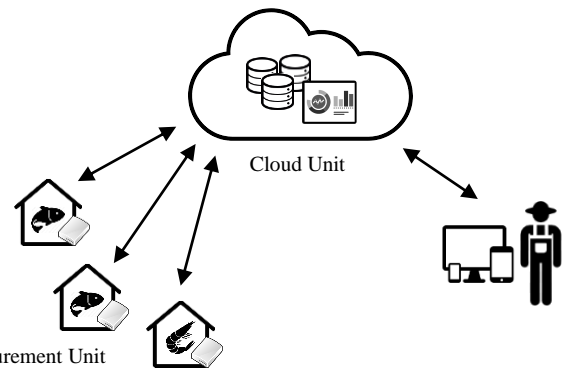

Fig. 2. An overview of the water quality monitoring system for flexible aquaculture.
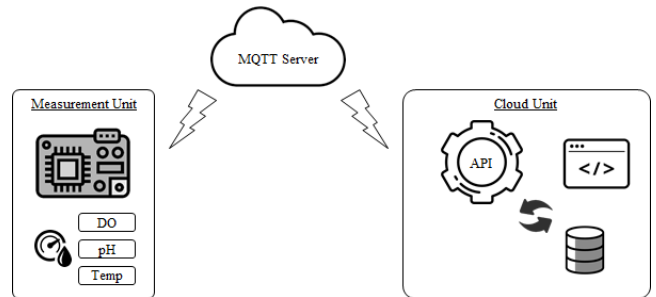

Fig. 3. A diagram of the water quality monitoring system for flexible aquaculture.

core data of the system. The status of the ponds is presented in a dashboard, which a farmer can monitor by using smart devices. No specific software need implement in the smart device because the generic web browser can display the dashboard.

Fig. 3 shows more technical details of the proposed system. Starting from the measurement unit, the water quality is captured by three sensors. These analog data are converted to digital data by MCU and sent to the cloud unit via MQTT protocol. Then, the cloud unit retrieves the transmitted data and store it into the database by a dedicated API. The dashboard is also implemented in the cloud unit. The details of each part are described as follows.

A. Measurement Unit

From Fig. 4, we can see that the measurement unit consists of two parts, i.e., sensor and processing parts. There are three types of sensors including pH, temperature, and DO sensors. The status of the water is detected by three sensors, where the sampling rate can be set from the cloud unit. These signals are converted to a digital signal by the analog to digital convert inside the MCU of the processing part. Then, the MCU conducts MQTT messages to send these data to MQTT broker, which is a web service for MQTT communication. There are two selectable communication interfaces for the proposed system, which are WiFi and NB-IoT. WiFi is suitable for the small coverage area while the NB-IoT can cover the large area, which users can be selected to fit with their application. This system will be installed close to the pond. The power consumption needs to be further considered when the system needs to be operated using a battery system. Low power design techniques need to be applied to both software and hardware.
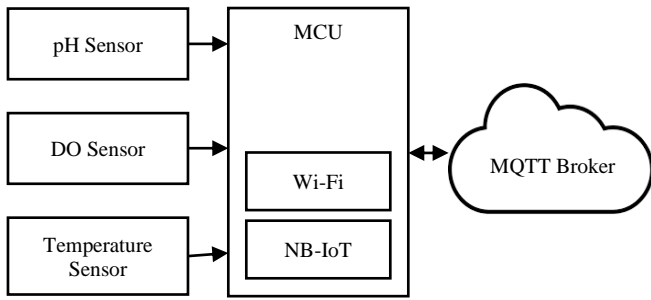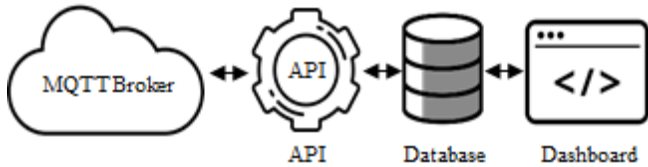
Fig. 4.   A diagram of a measurement unit.
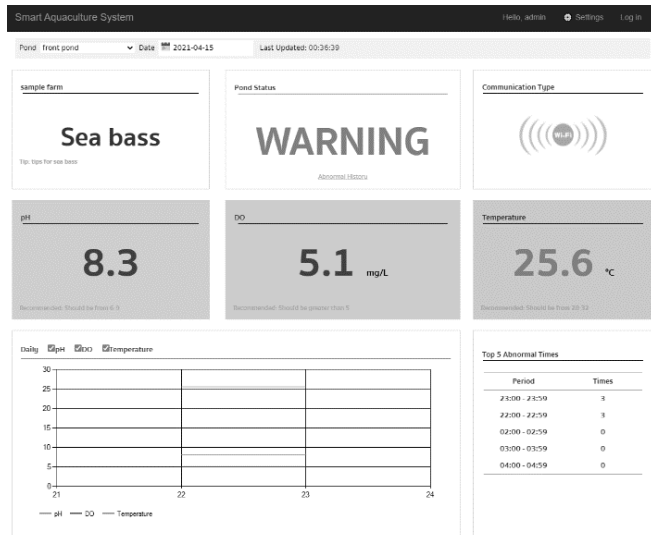

Fig. 5.   A diagram of a cloud unit.

Fig. 6.   An example dashboard page.

B. Cloud Unit

Cloud unit consists of 3 parts that are API, database, dashboard. The system is responsible for managing the main data of the system and displaying dashboard data in the form of a website. Starting from an API, the water quality data are received from MQTT Broker, then it is compared with the specified water quality criteria set by the cultured aquatic animals. If it is not within the specified criteria, the notification message is sent to the farmers and also recode to the database. Then, the dashboard will retrieve the data from the database and display the data in various formats. The interface of the dashboard is shown in Fig. 5.

The dashboard is developed in the form of a website to display the information about the pond. Farmers can use various information to analyze problems, including types of aquatic animals, current status and water quality values of the pond, transmission format of measurement unit, daily water quality values in graphs, and the top 5 times when ponds enter abnormal states most often as shown in Fig. 6.

IV.   EXPERIMENTAL RESULTS AND DISCUSSION

To evaluate the performance of the proposed system, several experiments are set up including sensor reliability tests, data transmission test, and notification message test. The details of each test are described in the following.

A. Water quality measurement test

As described in the beginning, there are three types of water condition sensors including pH, temperature, and DO. The reliability tests for these sensors are conducted as follows.

1) pH Sensor Reliability Test

For the pH reliability test, we performed the experiment using a small simulated aquarium. Then, add pH4 buffer solution which is the standard solution, immerse pH sensor and standard measuring instrument. The results were recorded every minute for 30 minutes. After that, we repeated the other 2 tests by replacing plain water and adding pH7 and pH10, respectively.

From the experiment, we found that the prototype can obtain the pH close to the standard measuring instrument as shown in Fig. 7, where the x-axis is pH from the standard instrument and the y-axis is pH from the sensor of the proposed system. Some variation of results that obtains from the sensor can be computed and the accuracy of this sensor, when compared with the standard instrument, is about 98.5%.

2) Temperature Reliability Test

For the temperature test, we prepared a water supply into a small simulated aquarium. The test is similar to the pH test except that the hot water is used to change the condition of the water in the state of the pH solution. For the first round, nothing was mixed in and the temperature was captured by the sensor of the quality measurement unit and the standard measuring instrument. The measurement results were recorded every 1 minute for 30 minutes. The second round was done by mixing hot water and repeating the same process. For the final round, more hot water was mixed to the plain water to have a higher temperature than the second round and then repeat the same process.

From the experiment, we found that the prototype can show a similar value of temperature to the standard measuring instrument as shown in Fig. 8, where the average accuracy was about 97.6%.

3) Dissolved Oxygen Reliability Test

For the last test of the sensor, a similar method was conducted in this test. We prepared water supply into a small simulated aquarium. The dissolved oxygen sensor of the quality measurement unit and the standard measuring instrument are then immersed in it. The measurement results were recorded every 1 minute for 30 minutes and then repeated by changing the water using water from aquarium 1 and aquarium 2, respectively.

From the experiment, we found that the prototype set was able to measure close to the standard measuring instrument. For water supply, water from Aquarium 1 and Aquarium 2. The average accuracy was 95.1% as shown in Fig. 9.
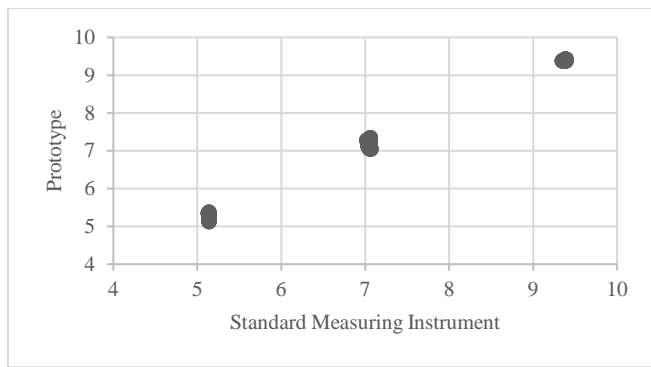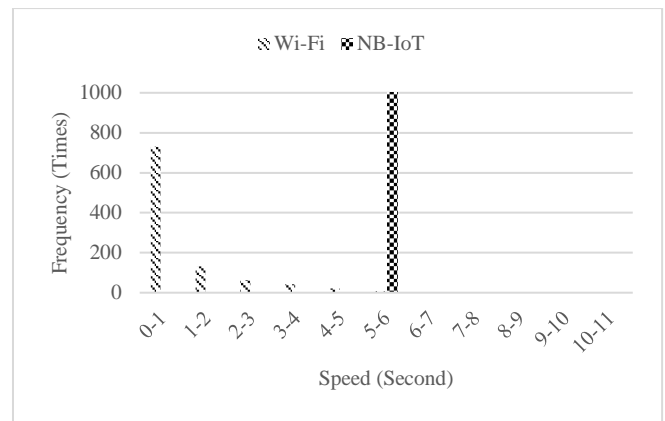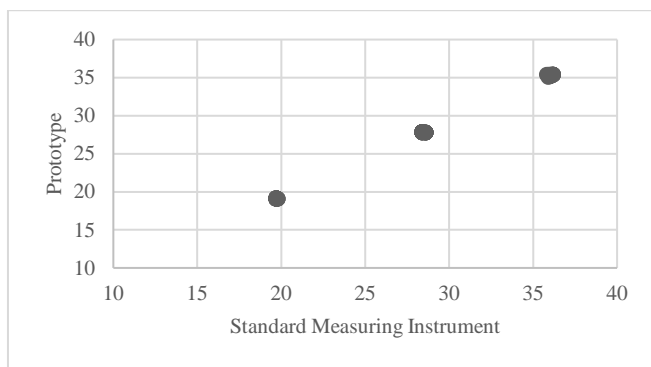
Fig. 7. Experimental result of pH sensor test.

Fig. 8. Experimental result of temperature sensor test.

Fig. 9. Experimental result of DO sensor test.

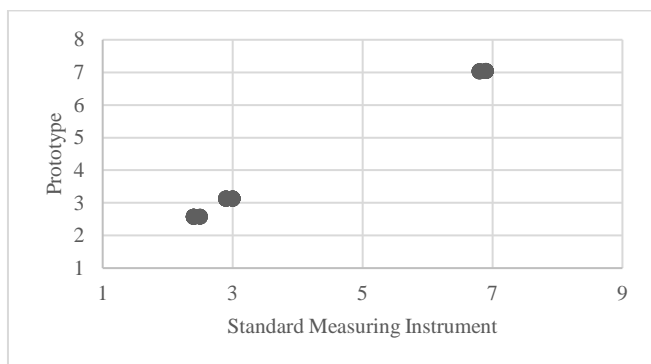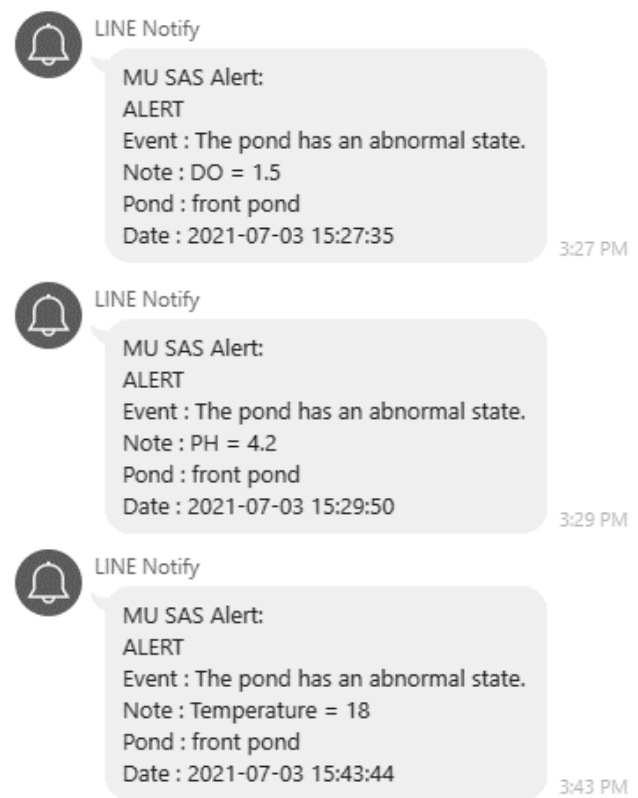Fig. 10. Transmission speed results of WiFi and NB-IoT.

Fig. 11. An example of a message to notify related persons.

B. Data Transmission Test

There are two types of connections, WiFi and NB-IoT. In this test, we experimented to compare this transmission connection. We defined the data set used for each submission as the same data set. Starting from start sending data until receiving an OK response from storage and display data.

From the experiment, we found that in 1000 data transmissions, the WiFi speed was 731 times less than 1 second, and the rest spread from 1-11 seconds. While NB-IoT has a transmission speed of 5-6 seconds, the amount of 1000 times as shown in Fig. 10.

C. Notification Message Test

For the notification message test, we conducted this test by varying those three parameters of water quality. The small simulated aquarium was applied for this experiment. We start with changing the value of dissolved oxygen to be lower than the specified threshold. The data on water quality was sent to the cloud unit to test the alarm. Then the notification message is sent to the farmer via LINE application. After that, we repeated these steps with pH and temperature, respectively.

From the experiment, we found that the cloud unit can effectively monitor and notify the water quality value. Fig. 11 shows an example of the notification message when the system detects that the water quality value is not within the specified criteria.

From the experiment, we found the accuracy of the prototype to measure pH 98.5%, temperature 97.6%, and dissolved oxygen 95.1%, but there was still data fluctuation and slow response compared to the standard instrument. This is because the sensors are selected according to the cost perspective. The prototype is efficient at transmitting both wireless and NB-IoT technologies, although NB-IoT is slower but can be installed over long distances because it is a used mobile network. This makes the prototype more flexible to use.

Limitations of research DO sensor must be recalibrated every 12 months and the pH sensor has a service life of not more than 6 months and cannot be immersed in turbid water or has high acidity or base.

This work was evaluated in the small aquarium. For future work, the field experiment is needed to explore the ability and also the weakness of the proposed system. Several modifications of the proposed system can be done such as adding other types of sensors or integrating with the water treatment system. More sensors can be applied to increase the capability of the system to handle a wider variety of applications. Integrating with the water treatment system can make the system to be an autonomous system.

V. Conclusion

This work aims to create a prototype of a flexible water quality monitoring system for pond aquaculture. The system is designed to be configurable for three types of aquatic life: white shrimp, sea bass, and tilapia. Three types of sensors are used to measure water quality: pH, temperature, and DO sensors with 2 types of wireless connections: WiFi and NB-IoT. All data is stored on cloud servers. The proposed system includes an alert system for detecting the anomaly detection of the water quality. There is also a dashboard that presents real-time data for analysis and decision-making to reduce the process of water quality monitoring and facilitate farmers. In addition, farmers can use the information to analyze and make decisions to solve problems. This will help reduce the rate of loss of productivity for farmers.

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Z-Face Sketch : Automatic Placement of Face Composites for Composite Sketches.

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Abstract—The face composite sketching has been in use as the substitute as well as the complement to the forensic sketches by law enforcement artists. However, it requires manual methods to make proper placements for the various types of face composites which is a time-consuming process. This paper has introduced the Z-Face Sketch for the automatic positioning and scaling of face composites. The mechanics of Z-Face Sketch has taken the proportions and the positions of face composites relative with other types of face composites with human anatomy data into account. Z-Face Sketch also allows the users to readjust the positions of face composites as needed by users. Z-Face sketch has been designed as web application to be used on-line on PC or mobile devices. The image results from Z-Face Sketch are comparable with the photographs of volunteers and the manual results.

Keywords— composite sketch, web application, Face recognition, Law Enforcement

I. INTRODUCTION

Police have to rely on the witnesses' testimonies to perform either manual sketches or assemble the facial composites to obtain composite sketches that reveal the faces of suspected crimes as the critical information for arresting the runaway fugitives. Police even give the basic knowledge to people especially those youths along with children on how to remember and notify the facial information including facial compositions including necessary facial details and accessories like eyeglasses and hats eyewitnesses need to remember along with the behavior of suspected persons who covered their faces or wear accessories such as glasses or hats. However, people have a short-term memory on the suspected persons they have seen. Therefore, it has become necessary to develop a web application to perform facial composition for people to be used soon after witnessing the criminal acts since sometimes people may not be mindful enough to use mobile devices to take a photograph of suspect persons at the crime scenes or even find the right words to describe how the faces of the suspect looked like. Therefore, the idea of creating a composite sketch program people can access with ease has become materialized. However, the composite sketch program should have capabilities closed the desktop versions to make it useful for generating facial composite sketches.

II. LITERATURE REVIEWS

A. Commercial Softwares

For the cases of composite sketches, it has been done by using Photoshop which require expensive licenses to be able to use without the issues of intellectual property infringement. The alternatives are to use the commercial face composite programs to assemble facial composites and generate composite sketches. These commercial software for face composite popular for police and other law enforcement agencies are including Identi-Kit® [1] which generate composite in greyscale as an output. This program has Law Enforcement Agency version and the cheaper Education version along with free demo version by request. Another commercial software for face composition is FACES [2] which has various versions including Single license (Education version for high school students and artists, Pro version with 4400 facial features of various ethnics and facial marks, and Law Enforcement version) and monthly subscription on Web Browser, Cloud, Chromebook (Education version, Law Enforcement version) to meet the different demands and budgets of consumers. SketchCop® Software App [3] which is commercial software for composite sketch based on the skill of police officer who have artist skill for forensic sketches for decades with more than 2000 facial composite pieces of males along with facial details, and accessories to choose with the results of composite sketches in greyscale with high resolution (750 x 1000 pixels) in PNG or TIFF format that look like composite sketches. This program also offers both standalone version as well as SketchCop® REMOTE for online version by special request with annual fees according to the packages. This software also offers free trial version with only five facial components per component category for law enforcement, military, government, security professionals and select licensed private investigators but no free trial version for classroom version. There are also mobile applications for forensic sketches or composite sketches addition to the desktop applications for forensic sketch and composite sketches including FlashFace: Mobile app which has both Android version and IOS version [4] and each version also offer different packages including free version with about 50 face items, premium version at 3.99 US Dollars with more

than 800 face items and female version at 3.99 US Dollars with more than 900 face items. However, the outputs for all versions are the black and white facial sketches. PortraitPad [5] is a web application for creating facial composite using Microsoft Silverlight and .Net frameworks to create this web application which store catalogues of facial features which covered to various ethnics in the real-world applications. The users can use this application in the mobile devices that use Windows 10 operation system. This program has both free version and the commercial version (PortraitPad Pro) which users can purchase by downloading at 49.99 US Dollars with separated upgrading package at 20 US Dollars. The users can export the results as black and white or greyscale images with various tones including sepia tone as demanded by users. Photo-Fit Me [6], a free web application which allow user to select facial features to be changed from the default facial image by selecting the pictures of facial feature according to the types of facial features including the upper part of the head with various hair styles, Eyes with eyebrows, Nose with cheeks, Mouth with or without moustache, Jaw with focus on the chin. Users can move trackbars of currently editing facial features to change widths, height, and tone (brightness). Once the user has finished the selection of facial features and readjustment of facial feature, algorithm in Photo-Fit Me is going to create the face according to the user's specifications.

However, these facial composite sketch applications, whether they are either applications for PC or the smart devices usually have facial features which may not be suitable for the need of Thai people as well as Thai police along with the limitation of the programs which provide the results only as black and white or greyscale facial sketch images as outputs. This has become the reasons for the development of Z-Face Sketch, a web application program to making composite sketches of the suspected persons by the witnesses with facial features and relating accessories separated in different directories in the program.

B. Algorithms behind the Composite Sketch Programs

Computer programs for composite sketches based upon the ideas to emulate the instrument for composite sketches which has received patent in 1973 [7]. Such program has become successfully implemented in 1991 [8] with the assemble of facial features including the forehead section that cover the hair style and a pair of ears, eye sections with a pair of eyes and a pair of eyebrows, nose with cheek section, mouth section and chin section within the assemble area of 178 x 299 pixels and become a basis for Identi-Kit® [1]. Another alternative idea. The alternatives are the idea of encoding facial feature image data and code factor table implemented in 1998 [9] based on parameterized facial feature images based on hierarchical networks implemented in 1995 [10] along with the idea to implement an electronic montage composing apparatus by Casio in 1996 [11] which has become a basis for FACES [2]. The other approach is to apply holistic system such as expert system and artificial intelligence including principal component analysis (PCA), select, multiply, mutate algorithm (SMM) along with facial landmark set of the whole face to construct the whole faces that meet the criteria from the eyewitness descriptions rather than details of faces and choosing features [12][13] which has become a basic building block for EFIT6 [14].

Further improvement for composite sketch outputs to match with photographs could be implemented in various

ways including component-based approach to measure the similarity between composite sketches from FACES® and Identi-Kit® and mugshot photographs by using active shape model to detect facial landmarks on both a composite sketch and corresponding mugshot photograph before applying face normalization and component localization to separate hair and forehead while defining eyes, eyebrows, noses and mouths with the certain widths and heights, before performing multiscale local binary patterns to extract facial components to calculate component similarity for each facial component [15]. Another approach is to use deep learning based on GAN for sketch refinement known as Deep Plastic Surgery by dilation along with coast to fine process to generate the new rough sketch in different radii of dilation. The results from this Deep Plastic Surgery algorithm have given output images with sketch faithfulness with high verisimilitude. Nevertheless, it still needs user interfaces for the cases where errors are larger than dilation radius [16].

III. IMPREMENTING Z-FACE SKETCH APPLICATION

Z-Face Sketch program is a web application with the server section based on Python [17] and Flask [18] to create the web framework along with MongoDB [19] to store face composite images in different categories since it could write the data in the database faster than SQL or SQLite [20] while this database allows the flexible and the client section based on HTML5 [21], CSS [22], JavaScript [23] and Angular [24] as open-source front end framework for web application with separations into different component while using TypeScript files to control the functions of components. For the image data used in Z-Face Sketch, there are 70 male heads, 70 male eyes with eyebrows, 59 male noses, 55 male mouths, and 59 male hair styles along with 117 female heads, 154 female eyes with eyebrows, 155 female noses, 161 female mouths, and 118 female hair styles along with a few more images of mustaches, beards along with accessories such as glasses and hats. Nevertheless, the developers have modified these images to head images without necks and ears, hair styles without forehead skin for better results on automatic locations of facial composite images along with further reduction of facial composite images to the optimal amounts. Z-Face Sketch has used KonvaJS library [25] and mobile-drag-drop library [26] to perform drag drop process with the results shown in Fig. 1.
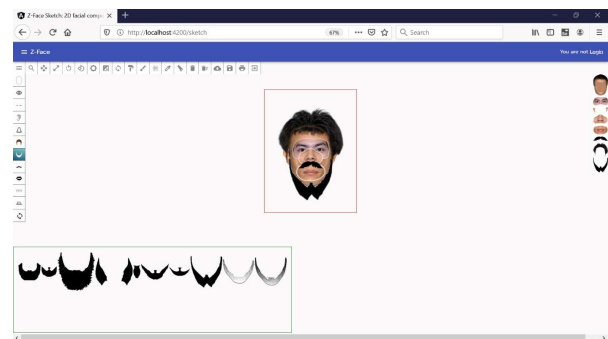

Fig. 1. Resulls after performing drag and drop using KonvaJS library and mobile-drag-drop library.

The mechanics of automatic assembly of facial composite images consists of the following:

- Drag-and-Drop mechanic for moving facial composite images in Various Features.

- Automatic readjustment of width, height and position of facial composite images after drag-and-drop process.

- Mechanic for decorating and exporting the finished facial composite sketch.

This paper is going to focus on automatic readjustment of width, height, and position of facial composite images after drag-and-drop process with focus on the following procedures:

- Automatic readjusting width height and position of facial composite images of head type.

- Automatic readjusting width height and position of facial composite images other than head

The description of details on these procedures will be in the next section.

A. Automatic Readjusting Width Height and Position of Facial Compose Images of Head Type.

The readjustment of head image size and position which is the basis for creating composite sketch image will focus on the following procedures with a flowchart shown in Fig 2:

- Set the head width (W_{Head}) to 150 pixels for a hollow image or head without hair style.

- Next is to check the genders of the head and set the female head width ($W_{FemaleHead}$) to 150 pixels and the male head width ($W_{MaleHead}$) to 200 pixels for the case of original width (W_0) at least 130 pixels. The case of male head less than 130 pixels, $W_{MaleHead}$ will be proportional to A according to (1):

$$W_{MaleHead} = A * W_0 \quad A = (20/13), W_0 < 130 \quad (1)$$

- Calculate the scale from the old width and the new width to calculate the new height.

- Define the position for the head image (X_{Head}, Y_{Head}) using the new width and height of the head image to ensure that the center of head image is at the center of displaying section of the program by taking Center of Display area (X_C, Y_C) into account according to (2) and (3):

$$X_{Head} = X_C - X_{TD}, X_{TD} = (W_{Head}/2) \quad (2)$$

$$Y_{Head} = Y_C - Y_{TD}, Y_{TD} = (H_{Head}/2) \quad (3)$$
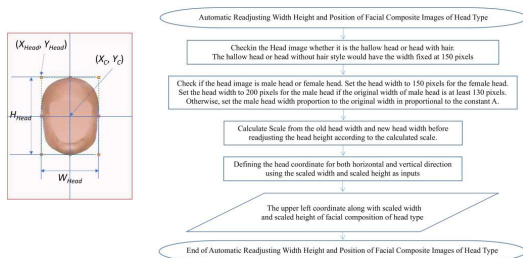
Fig. 2. Flowchart for an automatic readjusting width height and position of facial composite images of head type.

B. Automatic Readjusting Width Height and Position of Facial Composite Images Other Than Head

The readjustment of face composite other than head image size and position is following the procedures with a flowchart shown in Fig 3:
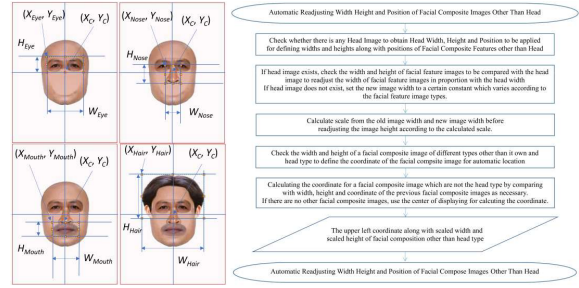

Fig. 3. Flowchart for an automatic readjusting width height and position of facial composite images other than head types.

- Check if head image exists to use Head Width (W_{Head}) and Head Height (H_{Head}) to define the size of face composite other than head image.

- Check the old width of the current face composite image to set the new the new width according to the condition: For the case of a hallow head or head without hair style image exists, set the Eye Width (W_{Eye}) to 73.4% of W_{Head} for the case of a pair of eyes or 36.7% of W_{Head} for the case of either left or right eye. For the case of a head with hair style image exists, set W_{Eye} to 85.2% of the Head Width (W_{Head}) for the case of a pair of eyes or 42.6% of the Head Width (W_{Head}) for the case of either left or right eye. If head does not exist, set the width of the eye image to 110 pixels for the case of a pair of eyes and half of this distance for the case of either left or right eye.

- Nose width (W_{Nose}) must be proportional to head width (W_{Head}) which will be varied according to width to height ratio of nose images which will be in 20 – 33% of W_{Head}. Otherwise, set up nose width to the constant value within in 45 - 80-pixel range according to proportion of nose image and characters of head image.

- Mouth width (W_{Mouth}) must be proportional to head width (W_{Head}) which will be varied according to characteristics of nose images which will be in 20 – 33% of W_{Head}. Otherwise, set up mouth width to the constant value within in 60 - 80-pixel range according to proportion of mouth image and characters of head image.

- For the case of setting up the hair width (W_{Hair}), calculate the hair ratio (R_{hair}) between the original hair width (W_{Hair0}) and the gap between left hair and right hair ($W_{HairGap}$) at the point half of hair height which is the place for put their hair on the head image. Check if the head exists. If head does not exist, set hair width constant value within 159 – 225 pixels. If head exists, calculate the head ratio (R_{head}) between the original head width (W_{Head0}) and head width ($W_{HeadHalf}$) at the point half of the head heigh. The hair width (W_{Hair}) will be proportional to the ratios according to (4):

$W_{Hair} = R_{hair} * R_{head} * W_{head}$

$= ((W_{Hair0}*W_{HeadHalf})/(W_{HairGap}*W_{Hair0})) *W_{head}$ (4)

- Calculate the scale from the old width and the new width to calculate the new height. If calculated hair height (H_{Hair}) is more than 350 pixels, limit the hair height (H_{Hair}) to 350 pixels and set the hair width (W_{Hair}) to have the same proportion to the original hair.

- For the case of Eye Position (X_{Eye}, Y_{Eye}) which relies on the position of head, it would be ensure that X_{Eye} will make the eye image at Center of Display area by taking C_X into account. On the other hand, Y_{Eye} will be sum of head position on y axis (Y_{Head}) and template displacement in y axis (Y_{TD}) which is within the range of 0.267 - 0.422 of head height (H_{Head}) depended on the conditions of the eye whether the eye image is the eye pair with eyebrows or without eyebrows which also need to take genders into account.

- Check the width, height, and position of previously defined facial composite image other than head for defining position of the present face composite image. Example for this case is the Nose Position (X_{Nose}, Y_{Nose}) after defining Eye Width (W_{Eye}), Eye Height (H_{Eye}), Eye Position (X_{Eye}, Y_{Eye}), Nose Width (W_{Nose}) before calculating the nose position (X_{Nose}, Y_{Nose}). If eye image exists, X_{Nose} will be in position that nose image will be in the middle of the eye image while Y_{Nose} must be at the position halfway between eye position and eye height. If eye does not exist but head exists, set the nose position by taking Center of Display area (X_C, Y_C) into account while setting template displacement position (X_{TD}, Y_{TD}) so X_{TD} is at a half of nose image and while Y_{TD} is 0.125 – 0.258 of nose height or 0.333 of head height depended on the ratio between Nose Width (W_{Nose}) and Nose Height (H_{Nose}).

- Another example of checking the width, height, and position of previously defined facial composite image other than head for defining position of the present face composite image is the Mouth Position (X_{Mouth}, Y_{Mouth}) after defining Nose Width (W_{Nose}), Nose Height (H_{Nose}), Nose Position (X_{Nose}, Y_{Nose}), and Mouth Width (W_{Mouth}) before calculating the nose position (X_{Mouth}, Y_{Mouth}). If nose exists, X_{Mouth} will be in position that nose image will be in the middle of the nose image while Y_{Mouth} must be at the position just below the nose with a compensation value. If nose does not exist, but head exists, set the nose position by taking Center of Display area (X_C, Y_C) into account while setting template displacement position (X_{TD}, Y_{TD}) so X_{TD} is at a half of mouth image and while Y_{TD} is within 0.15 – 0.75 of mouth height depended upon the ratio between Mouth Width (W_{Mouth}) and Mouth Height (H_{Mouth}).

- For the case of calculating the Hair Position (X_{Hair}, Y_{Hair}), it needs to check whether a head image exists while taking Center of Display area (X_C, Y_C) into account the gender into account. If head exists, X_{Hair} will be in position that hair image will be in the middle of the head image while Y_{Hair} must be at the

position above the head by 0.333 of the Hair Height measured at the center of the hair image.

IV. EXPERIMENT AND RESULTS

A. Experiment

To evaluate the performance of Z-Face Sketch, there are an experiment to compare the results of composite sketch from Z-Face Sketch with the actual photographs of 50 volunteer as well as the composite sketched done by manual methods corresponding to the photograph of 50 volunteers shown in Fig. 4 with the photographs of volunteers shown in Fig 4 (A), composite sketches by manual method shown in Fig. 4 (B) and composite sketches by manual method and Fig. 4. (C) is showing composite sketches by Z-Face Sketch.
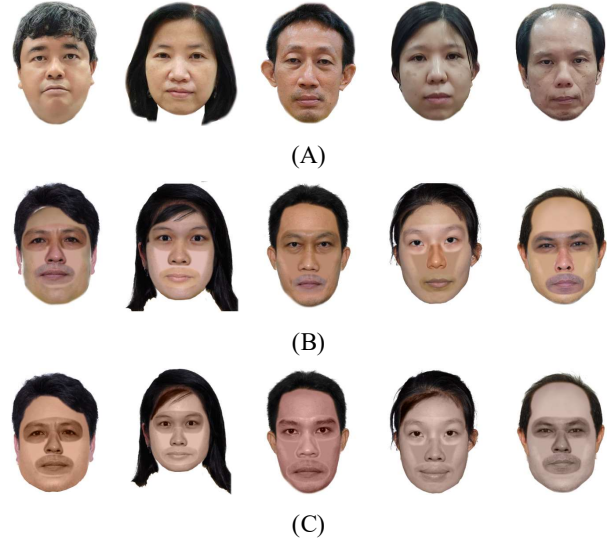

(A)

(B)

(C)

Fig. 4. Comprisons between Photographs of Volunteers and corresponding composite sketches by manual methods and Z-Face Sketch

The researchers have applied K-Mean clustering [27] to select the facial composite templates to 10 male heads, 10 female heads, 10 pairs of male eyes, 10 pairs of female eyes, 10 male noses, 10 female noses, 10 male hair styles and 10 female hair styles while using the K-Mean to compare facial composite images in different categories (heads, eye pairs, noses, mouths, and hair styles) which are closest to the corresponding facial sections of the individual volunteers to ensure that both manual methods and Z-Face Sketch method will use the same facial composite templates while assembling the facial composite sketches.

B. Results

The comparisons of the facial composite sketches by manual method, and Z-Face Sketch methods will be done by identifying the similarity between two images used in [28] even though the images from Z-Face Sketch must be scaled to be the same size as the composite sketches by manual and the photographs which are 1200 x 1200 pixels, and the results are as shown as a plot in Fig. 5. The results have shown that composite sketch images by Z-Face Sketch have given the results closed to the photographs of the volunteers with the maximum percentage for Volunteer36 (90.44%) even tough manual methods are closer to the volunteer

photographs than the composite sketches from Z-Face Sketch with the range of 65.22- 90.76% vs. 51.97 - 90.44%.

Fig. 5. Comprisons between Photographs of Volunteers and corresponding
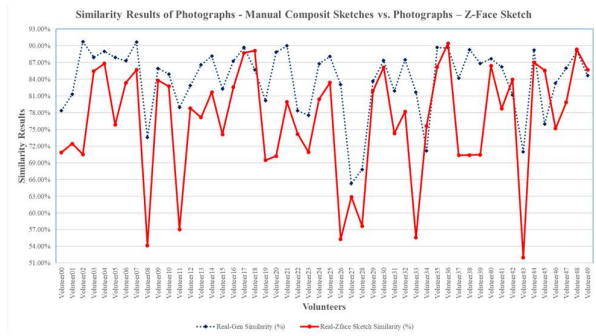
composite sketches by manual methods and Z-Face Sketch

Further improvement for Z-Face sketch to boost the similarity percentage can be done by coming up with better calculation of position that take the real area of eyes, noses, mouths, ears and landmarks of those facial composites into account along with the use of color blending by machine learning and deep learning rather than applying tinting process [29] to get better results of facial composite sketches with a provision to allow user to select the colors to blend.

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A Simple Random-Bit Generator Implemented on FPGA Based on Signum Chaotic Map

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Abstract—This paper presents a simple implementation of random-bit generator. The random source is based on a piecewise-linear signum chaotic map, which provides not only truly random signals but also robust chaotic behavior against parameter changes. Chaotic dynamics are described in term of bifurcation diagram, Lyapunov exponent, cobweb plot and time-domain signals. The randomness of binary sequences is investigated by several statistical analysis, i.e., autocorrelation histogram, entropy, and NIST standard tests suite. Experimental results of digital random-bit sequences have been implemented on FPGA, which realizes speed and compact area. The proposed random-bit generator offers a potential alternative in many applications such as test pattern generator and a robust random bit source for information security and cryptography.

Index Terms—True random-bit generator, chaotic theory, signum chaotic map, FPGA

I. INTRODUCTION

Due to rapid advancements of data computational and communication technology, information security has become a crucial issue under widely consideration for both research and practical applications. Data encryption has consequently been exploited as a general solution for information security where a True-Random-Bit Generator (TRBG) is typically utilized as a source of confidential key generation. Searching for an effective random source for the key generation has still motivated many researchers. Basically, the TRBG is constructed by a software-based algorithm that provides the generation of binary sequences with randomness properties, e.g., Pseudo Random Number Generator (PRNG). Existing hardware-based TRBGs were generally implemented by random physical phenomenon such as the amplification of direct resistor noises [1] or jitter noises of digital clock signals [2]. Despite the fact that such limitations can be conquered through proper custom circuits, extraction of proper randomness source is still a challenging topic in the design.

Chaotic system has been extensively studied during the last decade. The significant properties are extremely sensitive for initial condition and system parameters change and generate a highly random signal. Consequently, chaotic system is employed in various applications such as test pattern generation [3], cryptography [4] or secure communications [5]. Typically, one-dimensional function in a discrete-time is the lowest condition for providing chaotic behavior. Various simple chaotic maps are used as a random-bit generator, involving logistic
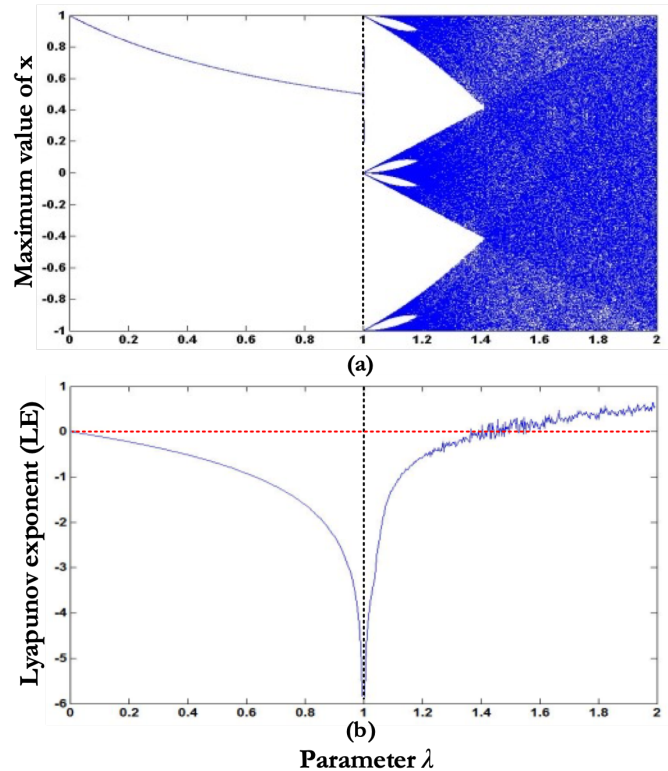

Fig. 1. (a) Plot of bifurcation diagram and (b) LE spectrum versus parameters λ

map [6], tent map [7] and gauss map [8]. However, mostly one-dimensional chaotic maps may not provide enough sufficient complexity. It can be seen that, security is a crucial issue for TRBGs which can be proved by standard NIST tests. The typical from existing chaotic maps may not fully robust for TRBGs and consequently complicated post-processing algorithms are necessarily required.

This paper therefore presents a simple and compact random-bit generator. The signum-based chaotic map has been employed as a nonlinear signal source of the random-bit generator, which providing not only a simple hardware synthesis but also robust chaos against parameter changes for random-bit generation. Chaotic dynamics are examined through a plot of bifurcation diagram, Lyapunov exponent (LE), time-series
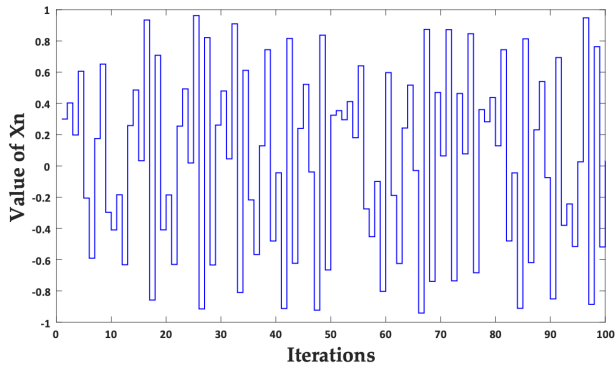
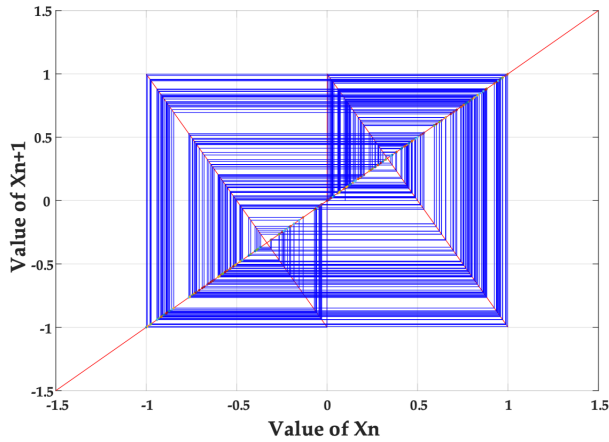Fig. 2. Chaotic waveform in time-domain over 100 iterations.

Fig. 3. Cobweb plots of the signum chaotic map in time-domain over 100 iterations.
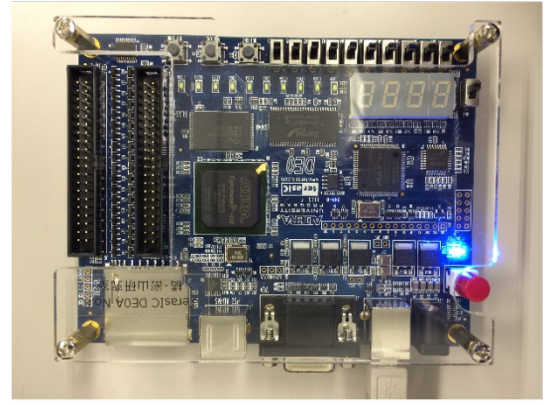

Fig. 4. Altera DE0 cyclone III EP3C16F484C6 uses to generates the chaotic sequence based on (4).
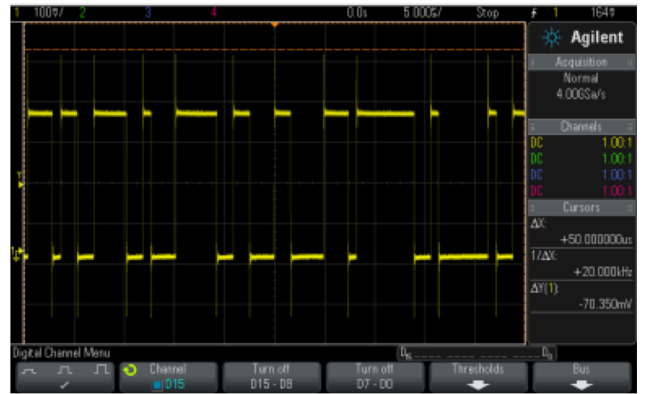
Fig. 5. Measurement of binary sequences generated from FPGA.

signals, and cobweb. Randomness of the proposed generator is also verified by autocorrelation, histogram, entropy, and NIST standard tests suite. A Field-Programmable Gate Array (FPGA) has been used to demonstrate an experimental result through generation of chaotic signal in time-series.

II. SIGNUM CHAOTIC MAP

Many simple chaotic maps have been presented in a first-order, autonomous difference equation of the form

$$x_{n+1} = \pm\lambda x_n \pm f(x_n) \qquad (1)$$

where λ and $f(x)$ are parameter and nonlinear function, respectively.

Of particular interest, the nonlinear functions $f(x)$ that exploits an s-shape curve have been considered. Although many smooth (continuous) functions (e.g., cubic function, hyperbolic tangent function, and sigmoid function) can be used, all of those functions lead to difficulties in FPGA implementation. Further studies

Consequently, this paper proposed a used of nonlinear term as a hard-switching (discontinuous) function i.e. signum function of the form

$$x_{n+1} = -\lambda x_n + \text{sign}(x_n) \qquad (2)$$

where λ is a parameter and $\text{sign}(x)$ is a signum function which is defined by

$$\text{sign}(x) = \begin{cases} 1 & ; x > 0 \\ 0 & ; x = 0 \\ -1 & ; x < 0 \end{cases} \qquad (3)$$

In addition, the nonlinear term in (3) can be alternatively replaced by an absolute value of denominator as

$$x_{n+1} = -\lambda x_n + \frac{x_n}{|x_n|} \qquad (4)$$

The investigation of chaotic dynamics can be achieved by a plot of bifurcation diagram and Lyapunov exponent (LE) as a qualitative and quantitative measurement, respectively. Simulations have been performed by MATLAB with equal initial conditions of 0.3. Fig. 1(a) illustrates the plots of one-dimensional bifurcation diagram versus parameter λ. Such a bifurcation diagram indicates possible long-term values, involving fixed points or periodic orbits, of a system as a function of a bifurcation parameter. The stable solution is represented by a straight line while the unstable solutions are generally represented by dotted lines, showing thick regions. It can be considered that, from the parameter $\lambda = 1$ to $\lambda = 2$ there are no periodic region appears. In additional,

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it is apparent in LE spectrum can be investigated as well, where the value is greater than zero, the output will represent chaotic dynamics as depicted in Fig. 1(b). Fig. 2 shows an unstable chaotic signal in time-domain of proposed chaotic map at parameter $\lambda = 1.9$. A cobweb plot is also illustrated in Fig. 3 in order to investigate the long-term status of an initial condition under repeated application as qualitative behaviors of one-dimensional iterated function. This graphical method indicates a stable fixed point corresponds to an inward spiral while an unstable fixed point is an outward one. A chaotic orbit would show a thick area, indicating an infinite number of non-repeating values. As clearly shown in Fig. 3, the output of signum chaotic map is moving spirally over the points 1 and -1 which suggests highly chaotic signals in time-domain and symmetric for zero-thresholding for random bit generation.

III. FPGA-BASED SIMPLE RANDOM-BIT GENERATOR

The proposed random-bit generator has been implemented on FPGA, i.e., Altera DE0 EP3C16F484C6 as shown in Fig. 4. In order to generate chaotic signal, the FPGA was compiled and synthesized in VHDL through Quartus II 12.1 sp1 program. The IEEE-754 standard is used for operating 32-bit floating point in ALU block. The chaotic values are fed into a zero-trigger comparator block in order to provide a pulse-width waveform within 80 clock cycles. Finally, the output data are transmitted to computer via serial communication port RS-232. The whole design utilizes 49 registers and only 150 out of 15,408 of total logic elements (1 %). Fig. 5 shows the time-domain binary sequences, directly measured from the random-bit generator. It can be seen from Fig.5 that the signal is apparently aperiodic in the whole range of time-domain.

IV. RANDOMNESS EVALUATION

The randomness of the proposed random-bit generator has been evaluated through standard statistical methods i.e., histogram, autocorrelation which represent a qualitative measurement, and NIST standard test suite as a quantitative measurement.

A. Histogram, Autocorrelation and Entropy

Fig. 6. Illustrates the histogram plot of 1,000,000-bit sequences, which clearly indicates an equality distribution between binary "0" and "1". This characteristic suggests that the generated binary sequences have a potential to achieve the TNRG characteristic. Autocorrelation of the 1,000,000-bit sequences is also depicted in Fig. 7 which also verify the randomness of the generated output. Otherwise, the correlation is expected to be unity at zero and close to zero at all other values. It is clearly seen from Fig. 7 that there is rarely occurred the periodic region since the correlations are relatively close to zero for most value. Moreover, the entropy of hundred sets of 10,000 binary sequences have been investigated based on Shannon's algorithm as illustrated in Fig. 8. As expected, the entropy values of the overall sets of the output binary sequences have reached the unity which implies the high randomness property of entire sequences.
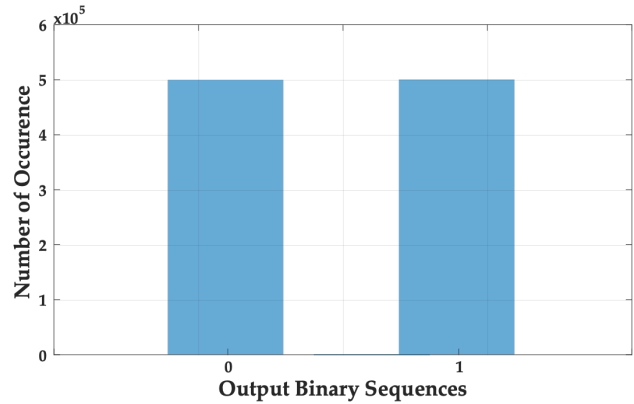

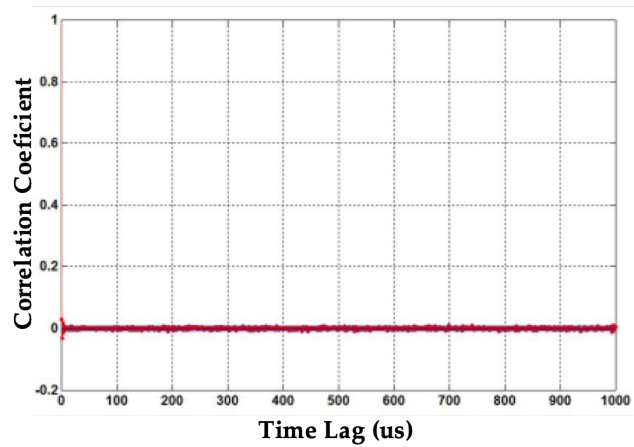Fig. 6. Histrogram of 1,000,000 output binary sequences.

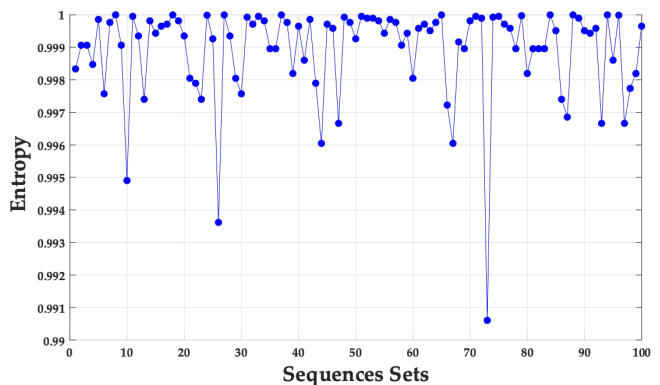Fig. 7. Autcorrelation plot of 1,000,000 output binary sequences.

Fig. 8. The entropy of 100 sets of 10,000 binary sequences.

B. NIST standard test suite

A high-acceptable statistical tests algorithm has been provided by the National Institute of Standards and Technology (NIST) in order to particularly examine the randomness of binary sequences. In this paper, the widely-used NIST test suite from 800-22rev1a [15] is utilized with 1,000,000 random binary sequences. The test suite comprises 15 test methods which imply the random characteristic of the sequences. Where the robustness of the perfect randomness is described by p-value (probability value), for example, a p-value greater than a level of 0.01 suggests that the tested sequences is performing the random behavior with 99% of confidential level. Table 1 summarizes the NIST test results of 1,000,000 binary sequences obtained from proposed generator. The proposed random-bit generator can be passed all the test methods which can be highly considered as the randomness signals source.

TABLE I

NIST STANDARD TEST RESULTS OF 1,000,000 BITS GENERATED FROM PROPOSED SYSTEM

Test Methods	p-values	Results
Frequency Test	0.6287	Success
Block Frequency	0.8128	Success
Runs	0.8147	Success
Longest Run of Ones Block	0.1370	Success
Binary Matrix Rank	0.1270	Success
Discrete Fourier Transform	0.2986	Success
Non-overlapping Template Matching	0.0209	Success
Overlapping Template Matching	0.9144	Success
Universal Statistical	0.3741	Success
Linear Complexity	0.2592	Success
Serial	0.9833	Success
Approximate Entropy	0.9134	Success
Cumulative Sums	0.9563	Success
Random Excursions	0.8128	Success
Random Excursions Variant	0.7193	Success

V. CONCLUSIONS

This paper has presented a true random-bit generator using a signum function-based chaotic map as a randomness source. The robust chaotic dynamics has been verified by plots of bifurcation diagram and LE. The proposed random-bit generator has been fully implemented in Altera DE0 FPGA with 1% of total logic elements. Furthermore, the true random-bit characteristic has been examined by statistical analysis, i.e., histogram, autocorrelation, entropy, and NIST standard tests suite. This system has a highly potential to an alternative random-bit generator for the various applications such as a secure communication or a high-complexity hardware-based authentication.

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