Development of a Healthcare Monitoring Diabetes Mobile Application for Community

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Abstract: The purpose of this project is to develop the mobile application, by applied Machine learning, for analyzing, collecting, monitoring, and retrieving information between patients with diabetes especially diabetes type 2 and village public health volunteers and to study the impact of using mobile application based on self-learning and self-management in diabetes information. This is a research and development mobile application and the sample consisted of 30 diabetes patients and 5 village health volunteers participated in this research. The project has demonstrated the effectiveness of using mobile application to support patients and village health volunteers. The results showed that user satisfaction has a high level.

Keywords: Diabetes type 2, village health volunteers, mobile application, personal health, machine learning
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1. Introduction

Diabetes is a persistent disease in which levels of glucose in the blood has higher than normal levels. The high blood glucose, Hyperglycemia, is the result of a lack of the hormone "insulin" or the performance of "insulin" is decreased, causing too much sugar in the blood normally. Diabetes can be divided into two major types. Type 1 diabetes, called insulin-dependent or juvenile diabetes, occurs when the body is unable to flight inflection to attack and destroy cells in pancreas that make insulin. Type 2 diabetes is the most common type of diabetes and approximately 95% of patients with diabetes in Thailand, known as adult-onset diabetes. Type 2 is usually occurred in older adults and some children with obesity [1]-[2]. With type 2 diabetes, the pancreas still produces insulin but it may be produced in insufficient quantities that causes the level of glucose in the blood to become too high.

Nowadays, the International Diabetes Federation (IDF) reported more than 460 million people worldwide have diabetes and it is expected to increase to 578 million by 2030. The diabetes cause of the leading of death in the world and contribute to health expenditure accounting for 10% of total health expenditure worldwide [3]. The World Health Organization (WHO) has declared COVID-19 as a serious epidemic worldwide. It is important to take preventive care in proper behavior especially patients with diabetes. With the COVID-19 pandemic, the effects of diabetes are even more pronounced because diabetic patients have usually to postpone regular appointments and with uncontrolled of glucose levels and prevention of diabetes, it might be crucial for people with diabetes at higher risk from COVID-19. Moreover, patients with diabetes have increasingly infected the chance of getting seriously ill from COVID-19. Therefore, diabetes is a chronic disease that causing an impact on both the lives of patients and their families and a lot of medical expenses from the family to the national level.

According to the President of the Diabetes Association of Thailand, there were around 5 million of Thai population aged over 15 year suffering from diabetes and the estimated diabetes prevalence was 9.6% (2.4 million Thai people), which included 4.8% previously diagnosed and 4.8% newly diagnosed. Also, obesity and lifestyle habits are due to the increasingly prevalence rate of the diabetes disease problem especially working age population. Therefore, it is important to educate patients on diabetes to control and treat diabetes at right time.

Village Public Health Volunteers (VHVs) play a crucial role in promoting health and changing health behaviors of people in the community. Patients should be supervised by Village public health volunteers, which will be a part of risk reduction from complications. A follow-up home visit by village public health volunteers is useful to patients and their families to support people in the community. Hence, VHVs should be trained and educated their knowledge to support local health staff in immunization, and help to taking in simple tasks like temperature measurement, blood pressure measurement, first aids and etc.[4]. Consequently, village health volunteer is a bridge between patients and health staff to drive a public health of community. Today modern communication and internet technologies have emerged and developed continuously and advance technology has dramatically revolutionized in daily life. The smart phone acts as the smart device used to access the knowledge and to communicate among people. Nonetheless, there are few health mobile application for diabetes mellitus patients and Village Public Health Volunteers.

The aim of this study were 1) to develop the health mobile application to serve diabetic patients and volunteer staffs and 2) to observe the impact of using mobile application based on self-learning and self-management in diabetes information between patients with diabetes and village public health volunteers.

2. Literarture Reviews

The smart devices has widely increased to manage diabetes in recent years and there are much of research to conduct in this field. In the previous review, it revealed that currently most research also focuses on the use of mobile application [5]. The diabetic management app for patients with type 2 diabetes helped to enhance glycemic control and diabetes self-efficacy in a Chinese community hospital by a randomized controlled trial [6]. The lifestyle of patients with diabetes can be improve diabetes mellitus self-management by focusing on food and physical activity [7]. Providing the mobile app for type 1 diabetes mellitus (DM) assists the patients in their daily treatment routine [8]. The mHealth has been proposed by WHO to support healthcare systems delivery worldwide and assessed the utilization of mhealth in the management of patients with DM in Africa [9]. Droobi, a diabetes management app for self-management of diabetes in Qatar, served an efficient and convenient approach for communication between health workers and patients [10]. Self-management is a crucial factor in glycaemic control and mobile application improve self-management and health of patients. Also, there are many mobile application for self-management of diabetes [11]-[16].

Machine learning and data mining techniques were applied to conduct research in almost aspects of diabetes [17]. An intelligent mHealth application was proposed to assess his/her possibility of being diabetic, prediabetic or nondiabetic without the assistance of any doctor or medical tests [18]. Deep learning-based for predicting diabetes mellitus, a mobile application developed to build the diabetes prediction model and the deep learning approach presented considerable accuracy of 93% [19]. mHealth app was adapted machine learning to increase physical activity in diabetes and depression [20]. An expert system based on fuzzy logic was used to diagnose with diabetic neuropathies with a sensitivity of 89%, a specificity of 98%, and an accuracy of 93% [21]. Machine learning exploits the explosion of medical information and it improves health quality for people with diabetes. Most research has utilized several ML algorithms to improve in detection and diagnosis, self-management and personalization respectively [22].

3. Methodology

The project was the Research and development (R&D) approach, which generates new knowledge, products, services, or systems by using quantitative method and qualitative method. In this section, we will describe the detailed methodology adapted to conduct this project.

3.1 Data Collection

The sample consisted of 30 diabetes patients and 4 village public health volunteers. The mobile app was installed to participants' mobile phone and patients were trained to use the mobile app. The training includes how to install app, how to monitor blood glucose, how to communicate with health volunteers, and how to use other functions of application. To prevent the spread of COVID-19, 1) questionnaire will be collected via online survey and 2) telephone interview was applied to obtain additional new information for collected enough data.

To implement in prediction module, the data acquired from UCI repository (PIDD) was used to analyze classification algorithms [23].

3.2 System Design

To implement this project, feasibility and requirement analysis was the first step to gather the requirements based on the user's point of view. This project was designed and implemented using flutter framework, a free and open-source mobile UI framework created by Google. Firebase database has been used to store data and information. UX design and UI design are crucial tools to support the first stage of the design mobile application process. The main steps of creating the user centered design are: creating user-journey map, building UX wireframe, building prototype, graphic design and usability testing [24]-[25]. The mobile app has 6 parts as following: health monitoring, appointment, education, medication, healthy eating, and prediction. Health monitoring module is responsible for monitoring blood glucose levels and overall health like blood pressure, and weight. Patient can reserve and manage online appointment scheduling through the appointment module. Patients can search and learn information based on the disease in education module and medication module notifies patients to specify amount of medication taken with the time and shows the patient's drug list. Healthy eating module recommends users to self-control of diabetes and prediction module shows data based on a collected user data.

Fig. 1. Example of mobile application

3.3 Machine Learning Techniques

Machine learning is a subfield of computer science that evolved from the study of pattern recognition and computational learning theory in artificial intelligence .Machine learning explores the construction and study of algorithms that can learn from and make predictions on data. [26].

K-Nearest Neighbor (KNN): KNN is a non-parametric supervised machine learning algorithm used to solve both classification and regression problem and classifies the new data point based on a similarity measure [27]. The KNN procedure is described by figure 2.

K-Nearest Neighbour

Determine (k, distance)

Classify ($\boldsymbol{X}$, $\boldsymbol{Y}$, x)

// $\boldsymbol{X}$ is training data, $\boldsymbol{Y}$ is labels of $\boldsymbol{X}$, x is unknown sample

for i = 1 to n do // n is all the training data

Compute distance d($\boldsymbol{Xi}$,x)

end for

Compute set I containing indices for the k smallest distance d($\boldsymbol{Xi}$,x).

return majority label for {$\boldsymbol{Y}$ where i ∈ I}

Fig. 2. KNN Procedure

Support Vector Machine: Support Vector Machine is a supervised machine learning algorithm used to both classification and regression problem [28]. The algorithm separates a data point into class attribute using hyperplane and the goal of the line is to maximizing the margin between the points on either side of the so called decision line. The training phase of SVM estimates the parameters W and b for a hyperplane from a given training data.

$$W.x_i + b \geq 1 \qquad \text{if } y_i = 1 \qquad (1)$$

$$W.\ x_i + b \leq -1 \qquad \text{if } y_i = -1 \qquad (2)$$

where $X_i = (x_{i1}, x_{i2} \ldots\ldots x_{im})$ and $Y_i \in [+,-]$ denotes its class label.

The training data are linear kernel. $K(X_i, X_j) = < X_i, X_j >$:

$$\min_{w} \left(\frac{1}{2}\|w\|^2\right) \qquad (3)$$

subject to

$$y_i(w \cdot x_i + b) \geq 1,\ i = 1,2 \ldots m \qquad (4)$$

equivalent to

$$max L_d(\alpha) = \sum_{i=1}^{m} \alpha_i - \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \alpha_i\, \alpha_j y_i y_j (x_i \,.\, x_j) \qquad (5)$$

where $\alpha_i \geq 0$

Performance Evaluation: To judge the performance of the classification model, we applied a confusion matrix, calculated using the predictions of a model on a data set. There are four probable outcomes (TP, FP, FN, and TN):

- True Positive (TP): the number of positive examples correctly classified.
- False Positives (FPs): the number of negative examples incorrectly classified as positive.
- False Negatives (FN): the number of positive examples incorrectly classified as negative.
- True Negatives (TN): the number of negative examples correctly classified as negative.

Accuracy: The formula for calculating accuracy, based on (TP+TN)/ (TP+FP+FN+TN).

Precision: The measure of true positives over the number of total positives, based on TP/ (TP+FP).

Recall: The measure of true positive over the count of actual positive outcomes, expressed as: TP/ (TP+FN).

F1 Score: The harmonic mean between precision and recall, expressed as: 2(p*r)/(p+r) where 'p' is precision and 'r' is recall.

4. Results

To achieve the goal, data preprocessing tasks have been used to the diabetes dataset. This step is one of the most crucial process in the machine learning approach.

	Accuracy	Precision	Recall	F1-Score
KNN	72.05	88.20	73.58	79.56
SVM	73.55	79.23	79.65	79.35

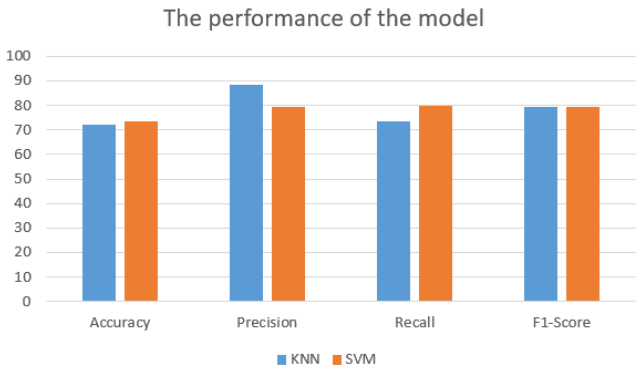

Fig. 3. The performance of the model

To assess the performance of the mobile application, questionnaire included the properties as follows: Usefulness (14 topics), Ease of use (10 topics), Ease of Learning (10 topics) and Satisfaction (10 topics). The results of the performance of mobile application for diabetic patients were summed up and presented as table I.

TABLE I. THE RESULTS OF THE PERFORMANCE OF MOBILE APP

	$\bar{x}$	SD
1. Usefulness	4.8	0.45
2. Ease of use	4.6	0.55
3. Ease of Learning	4.4	0.50
4. Satisfaction	4.8	0.45

The study shows that the overall level of assessment satisfaction of all dimensions was higher than level of expectation.

5. Conclusion

The use of smart technologies increasingly prevail a promising field of research to improve the quality of life for the patients and their families. The development of a diabetes monitoring application has powerfully supported patients with diabetes and community health volunteers to enhance clinical cure and self-management behavior. Consequently, it was found that the satisfaction with the application of patients had a high level of overall with the application which is caused the ability of the application to conveniently use and connect with caregivers or medical personnel in a timely manner. Due to the COVID-19 outbreak, the application was used to

communicate with patients for online consultation, and arrange for Regular Check-Ups. However, further studies are needed to applied wearable technologies, IOT and machine learning to enhance this project.

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