

mHealth: A Design of an Exercise Recommendation System for the Android Operating System

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Abstract

For healthiness and wellness, exercising is one of the key factors. Therefore, this paper aims to present the first phase of a mobile health application developed to recommend healthcare support referring to exercises on an Android smartphone. This application has been designed to provide exercise advice depending on Body Mass Index (BMI), Basal Metabolic Rate (BMR) and the energy used in each activity or sport (e.g. aerobic dancing, cycling, jogging working and swimming). Also, this application has been designed to present special exercise advice for patients with health issues. Moreover, it has been designed to store information in a database and to have the ability to produce reports to users. After designing, this proposed mHealth application has been evaluated by 30 subjects who have computer programming skills. It has been found that all diagrams, including use the case diagram, sequence diagrams and overall were assessed as 'good', except the part of user interfaces that was assessed as 'fair'. Therefore, this design can be used to implement in the next phase of this application development with minor revision concerning the user interfaces.

Keywords: eHealth, mHealth, expert system, exercise recommendation system, Android mobile application

Introduction

Mobile phones have a significant impact on consumers and their lifestyle because the phones can work as small computers. Therefore, lots of applications and services have been developed and provided on mobile phones. One such area is healthcare applications. Gartner reported that 'mobile health monitoring' would be ranked as no. 5 of 'the top 10 consumer mobile applications for 2012' [1]. It is consistent with 'the top 10 strategic technology trends for 2013' that includes 'mobile device battles' and 'mobile applications and HTML5' [2]. Moreover, it has been predicted that the market value of mobile health will increase to be more than 11 billion USD by 2018 [3]. For medical applications, the industry of medical applications is predicted to grow by about 23 percent annually over the next 4 years, whereas, it has been estimated at 150 million USD currently. Nevertheless, by 2015, more than one third of the *ca.* 1.4 billion smartphone users will have at least one mobile health application [3].

Besides, consumers have more concerns about their health. Thus, healthcare is increasingly considered for better quality of life, with the active approach focusing on prevention of their health, instead of the passive approach focusing on treatment [4]. Exercise is a major option to prevent disease and illness, to gain better health and to maintain it. However, to do exercise, there are many kinds of sports, for example, aerobic dancing, jogging, walking, swimming, tennis and yoga. It is questionable,

how long should one who has different body characteristics take for each kind of sport. Therefore, this mobile health application called the mHealth application, has been designed to provide appropriate time expense with each activity or sport, for not only normal users/consumers but also patients with health issues. This application is based-on Android, which occupies more than 70 % of the smartphone market worldwide [5].

Background

This section presents the background information about 3G networks, mobile health and healthcare information (e.g. BMI and BMR and recommended exercise for patients), related technology, and related research works, as follows:

Evolution of mobile devices

The convergence of technologies provides many advantages to consumers. Due to the combination between advanced mobile phone technology and computer technology at present, mobile phones are not just telephones, they have become smartphones, see their history in **Figure 1** [3]. Particularly, after the 3rd Generation International Mobile Telecommunications or 3G mobile networks were officially launched in Thailand in May 2013, smartphones and other mobile devices can be used efficiently because the transmission speed of data increases significantly.

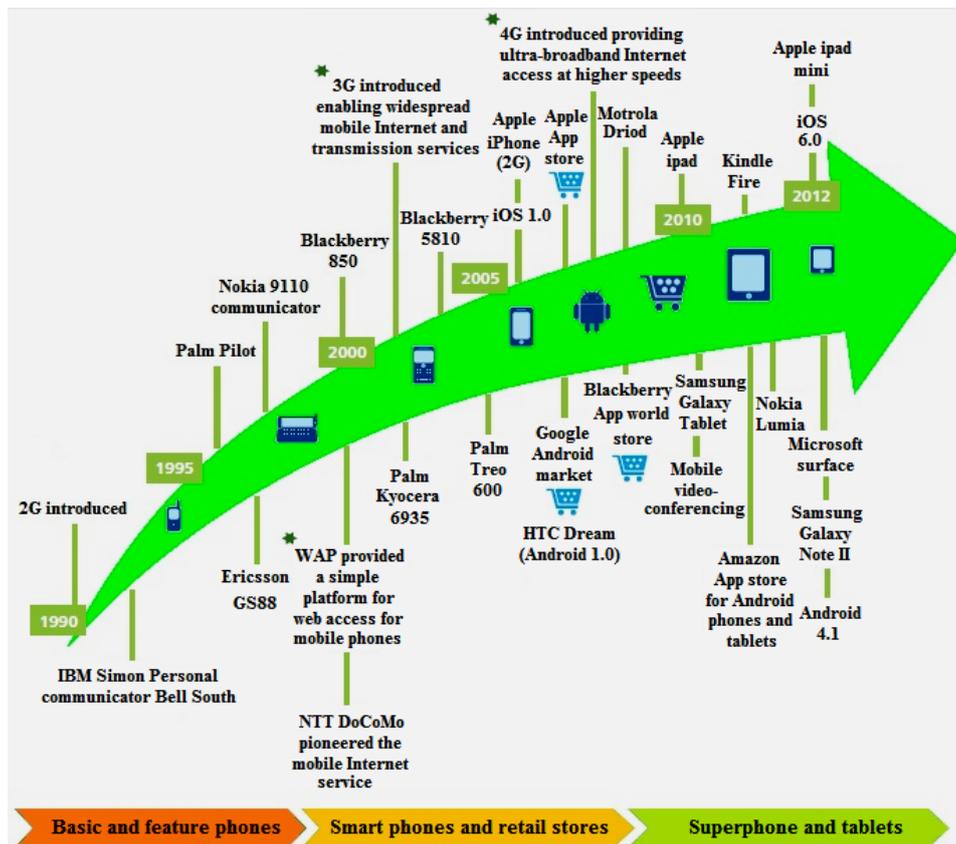


Figure 1 The history of smartphones and mobile devices [3].

mHealth

‘mHealth’ can combine health and mobile device technology, especially smartphones. It can be defined as ‘medical and public health practice supported by mobile devices (e.g. mobile phones, patient monitoring device and wireless devices)’ [1], whereas, for 10 years ago, it has been defined as wireless telemedicine involving the use of mobile telecommunications and multimedia technologies and their integration with mobile healthcare delivery systems [6].

To clearly understand ‘mHealth’, understanding of the mHealth ecosystem is required. As shown in **Figure 2** [7], the mHealth ecosystem overlaps several dynamic spheres, consisting of health, technology and finance, whereas, government is the influencer that has power to set regulations, policies, and strategies that can affect all spheres throughout the development and use of mHealth inventions. The stakeholders in mHealth influence the drivers, as shown in **Figure 3** [7], so that mHealth can help consumers to have better health.

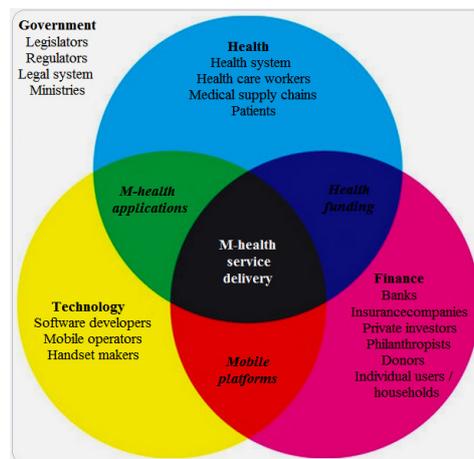


Figure 2 The ecosystem for mHealth (adapted from [7]).

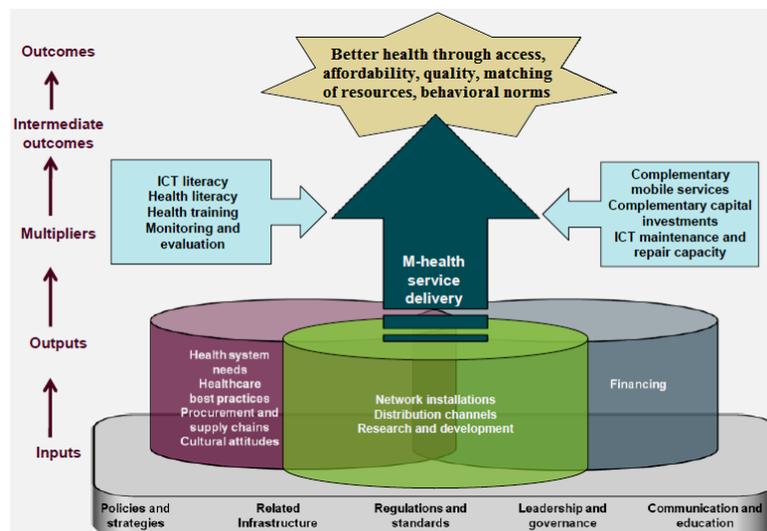


Figure 3 Framework for mHealth outcomes (adapted from [7]).

Exercise and related indexes

Exercise is any bodily activity that enhances physical fitness and/or maintains overall health and wellness. There are several reasons for exercise, for example, strengthening the cardiovascular system and muscles, weight loss, honing athletic skills and enjoyment. However, to evaluate and indicate the changes in the body after performing exercise, there are few indexes to be considered, as follows:

1) Body Mass Index (BMI): is a measurement of body fat based on height and weight, as shown in formula (1) [8]. It is calculated as weight (in kg) divided by height squared (in m²). This index is classified into 4 groups, based on WHO Asian BMI classifications, as shown in **Table 1** [9,10]. However, this index is mainly for men and women who are 18 - 65 years old.

2) Basal Metabolic Rate (BMR): is calculated from the variables of height, weight, age and gender [11]. This index is more accurate than calculating calorie needs based on body weight alone. However, each gender uses different formula to calculate, as shown in (2) and (3) [12].

Table 1 WHO Asian BMI classifications.

Category	Weight (kg/m ²)	Meaning
1	< 18.5	Underweight
2	18.5 to < 23	Normal-weight
3	23 to < 27.5	Pre-obese
4	≥ 27.5	Obese

$$BMI = \frac{M}{H^2} \tag{1}$$

where BMI is body mass index (kg/m²), M is body weight in kilograms and H is height in meters.

$$BMR = C_1 + (C_2 * M) + (C_3 * H) - (C_4 * A) \tag{2}$$

where BMR is basal metabolic rate (kcal./day), C₁ is 665 for women or 66 for men, C₂ is 4.35 for women or 6.23 for men, C₃ is 4.7 for women or 12.7 for men, C₄ is 4.7 for women or 6.8 for men, M is body weight in kilograms, H is height in meters and A is age in years.

$$kcal = 0.0175 * MET * M * T \tag{3}$$

where kcal is caloric expenditure in kilocalories, MET is metabolic equivalent of task or activity in METs, M is body weight in kilograms and T is time of the activity in minutes.

3) Metabolic Equivalent of Task: is a unit used to estimate the amount of oxygen used by the body during physical activity. One metabolic equivalent (MET) is defined as the amount of oxygen consumed while sitting at rest and is equal to 3.5 ml O₂ per kg body weight × min. [13,14]. The formula to calculate for caloric expenditure can be shown in (3), while the estimated METs for some kinds of exercises are shown in **Table 2** [15,16].

Safe exercise for patients

There is a misunderstanding that patients with diseases should do nothing, he or she cannot do exercise. In fact, each patient can do regular exercise at least 150 min per week (30 min per day at least 3 days a week), except patients with heart diseases who need consultation from the doctor. The benefits of safe exercise for patients include [17]:

- Strengthening heart and cardiovascular system.
- Improve circulation.

- Helping body use oxygen better.
- Improving heart failure symptoms.
- Lowering blood pressure.
- Improving cholesterol.

Nevertheless, each patient must check or consult the doctor first before starting an exercise program because the doctor can help to find an appropriate exercise program for each level of fitness and physical condition. In addition, he or she must stop the exercise immediately and contact the doctor if any bad signs or symptoms occur [17].

Table 2 Examples of MET values for cycling, jogging and walking.

Activity	MET value
Cycling 16 - 19.2 km/h	6.0
Cycling 19.2 - 22.4 km/h	8.0
Cycling 22.4 - 25.6 km/h	10.0
Jogging 8 km/h	8.0
Jogging 9.7 km/h	10.0
Jogging 11.3 km/h	11.5
Jogging 12.9 km/h	13.5
Walking 4.0 km/h	3.0
Walking 4.8 km/h	3.5
Walking 5.6 km/h	4.0
Walking 7.2 km/h	4.5

Selected technology for system development: Android operating system and Adobe flex framework

Android or Google Android is a platform for handhelds or mobile devices (e.g. smartphones). It was developed based on the Linux Operating System [18]. Its architecture is shown in **Figure 4** [19]. According to the 3 major parts, the application part is the highest that consists of the major application, such as E-mail, SMS, browser and others. The application framework, covering activity manager, content providers, telephony manager and resource manager, is also important. It helps programmers to access hardware and to run background services using the application programming interface, and also helps developers to create applications with convenience. Moreover, the next important part is the libraries; consisting of, for example, the system C library, the media library and the surface manager.

In order to create the interactive web based application, Adobe flex framework is an option to develop the user interface of the system with motions, due to the collection of Flash files (*.swf).

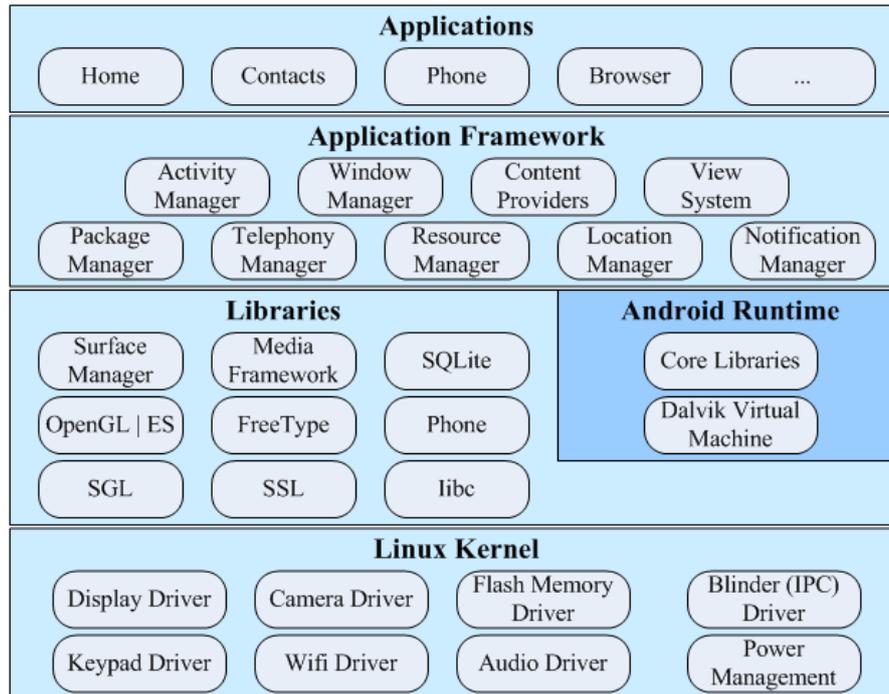


Figure 4 The architecture of Android [19].

Selected system development solution: Object-oriented approach and unified modeling language (UML) [20,21]

At the point of view of the object-oriented approach, each system does not consist of processes, programs, data entities or files. It consists of objects which are things in the system that are capable of responding to messages. Object-oriented analysis (OOA) describes all of the types of objects which do the work in the system and shows what user interactions are required to accomplish tasks because the object-oriented approach views information systems as collections of interacting objects. Object-oriented design (OOD) describes all of the additional types of objects necessary to communicate with people and devices in the system. Also OOD shows how the objects interact to accomplish tasks, and refines the definition of each type of object.

UML is a language and notation for specification, construction, visualization, and documentation of models of software systems. It is a modeling language, and as such pre-destined for translation into programming languages, that is, for code generation. Nevertheless, its high expressiveness puts high demands on CASE tools and makes reverse engineering more difficult, on the other hand, it offers extensive modeling capabilities. It includes many types of model elements and details. The following diagrams provide detailed explanations of all model elements of UML, ordering by the types of diagram in which the elements are used. Some elements can be a part of different diagrams; these are explained in the context of the diagram in which they primarily occur.

1) Use case diagram: shows actors, use cases and their relationships. A use case defines a set of activities of a system from the point of view of its actors, which lead to a perceptible outcome for the actors. A use case is always initiated by an actor. In all other respects, a use case is a complete, indivisible description.

2) Class diagram: to show classes and their relationships with each other. A class is the definition of the attributes, the operations and the semantics of a set of objects. All objects in a class correspond to that definition.

3) Behavior diagrams:

- Activity diagram: to show activities, object states, states, state transitions, and events. An activity diagram describes the procedural possibilities of a system with the aid of activities. It is a special form of a state diagram which mostly or exclusively contains activities.
- Collaboration diagram: to show objects and their relationships, including their spatially structured message exchange. A collaboration diagram shows a set of interactions between selected objects in a specific, limited situation (context), focusing on the relations between the objects and their topography.
- Sequence diagram: to show objects and their relationships, including their chronologically structured message exchange.
- State diagram: to show states, state transitions, and events. A state diagram shows a sequence of states an object can assume during its lifetime, together with the stimulus that cause changes of state. It describes a hypothetical machine which at any given time is found in a set of finite states.

4) Implementation diagrams:

- Component diagram: to show components and their relationships when a component represents a physical piece of program code, either as source code, binary code, or executable program.
- Deployment diagram: to show components, nodes, and their relationships. Deployment diagrams show which components and objects run on which node (processes, computers), that is, how they are configured and which communication relations exist between them.

Related previous research works

The previous work based-on eHealth research that are similar to this research, are as follows:

Mattila *et al.* developed a mobile application ‘TuneWalk’ to provide guidance to the patients during home exercise using heart rate and physical activity analysis. This application is also able to gather information about the progress during the periods of the rehabilitation program. The gathered data are also sent for remote exercise performance analysis and consultation by the trainer or the physical therapist. The major advantage of this application is to help patients to exercise at homes [22].

Säreälä *et al.* proposed a home-based care model for outpatient cardiac rehabilitation. This mHealth application is able to gather and send the data of a user’s movements (steps) and several parameters (e.g. weight, exercise, eating, stress level, working/sleeping hours, blood pressure, fat percentage, blood sugar, waist circumferences). The major advantage is the analysis data that have been sent to the server by a doctor. However, it is unable to record heart rate data [23]. Another heart disease system based-on a smartphone has been proposed recently by Watanabe *et al.* who developed the wearable heart disease monitoring and alerting system, called ‘Dentan’. It consists of a wireless electrocardiogram (ECG) sensor and a smartphone. It can continuously monitor patient’s ECG and issues, and then alert the patient and surrounding people if it detects abnormal heart behavior [24].

Haghighi *et al.* [25] presented a prototype of an intelligent healthcare support system using data mining techniques (Fuzzy logic). This mHealth application consists of an ECG biosensor and a mobile phone with a health monitoring application. The biosensor sends information, systolic and diastolic blood, and heart rate via Bluetooth. Therefore, a doctor can analyze the data and evaluate the situation of a patient.

Also, there are 2 mobile health monitoring solutions developed in Europe and Australia, reported by Jones *et al.* [26]. In each system, the biosignals of a patient are measured and transmitted to a remote location to be monitored by a remote health professional. Each system has been developed for clinical application (e.g. cardiac rehabilitation and pregnancy).

Hernandez Munoz *et al.* [27] proposed a mobile health device that can help patients with life-threatening allergies to manage their health, particularly in emergency situations, the alarms can be activated. However, this application focuses on patients with allergies only.

One interesting mHealth application is ‘SapoFitness’, which is developed for dietary evaluation. After a user inputs weight, weight, age and sex, this application will calculate the daily calories consumed and a weekly weight loss. Also a user can input daily meal data, to see the energy statistics [28]. Another interesting system for healthcare is the expert system for diet recommendation that was developed by

Kovasznai [29]. For menu construction and dietary analysis, this system has been developed using an interesting approach called a cased-based approach, based on ripple down rules (RDR).

Recently, Pamanto *et al.* [30] developed and implemented a novel mHealth system to support self-care in management of complex and chronic conditions (e.g. individuals with spina bifida), called 'iMHear'. It is interesting that this system supports two-way communication.

Nevertheless, to the best knowledge of the authors from previous work at this moment, most of them focus on patients with diseases (e.g. heart disease, allergies) or individuals with chronic conditions (e.g. spina bifida and pain) [23-30]. There are some applications which have been designed for health promotion with exercise but these are limited to only a few kinds of sports (e.g. running), whereas some applications have been developed for dietary purposes [22,28]. Therefore, there is room to develop a mHealth application for healthcare promotion with many kinds of sports for both general users and patients who require safe exercise.

System design - Part I: Structure, use case diagrams and sequence diagrams

To design the recommended exercise system, firstly the conceptual framework was provided. Then the system diagram, use case diagram, sequence diagram and user interface were designed. As shown in **Figure 5**, the mobile application is an important part that functions on a smartphone. This system was designed based on the Android operating system and used Adobe Flex to create the user interfaces. It consists of several functions, including BMI calculation, BMR calculation, exercise caloric calculation, recommended exercise, diary and profile. There is also an important part called the provider service. Its main function is data processing. However, both parts require the HTTP protocol for interfacing.

After planning and analysis activities and selecting the algorithm, the system design was conducted. In this design phase, the system process diagram was presented in **Figure 6**. Inside the recommended exercise part, instead of using genetic algorithms, it has been designed by using a case-based approach called a RDR tree that was applied in the dietary expert system as presented in [29] as shown in **Figure 7**, whereas the most important diagrams of the object oriented approach (OOA) called the use case diagram, shown in **Figure 8**. Then the sequence diagrams of the major functions, consisting of BMI calculation, BMR calculation, exercise caloric calculation, recommended exercise, diary and profile were provided, as shown in **Figures 9 - 11**.

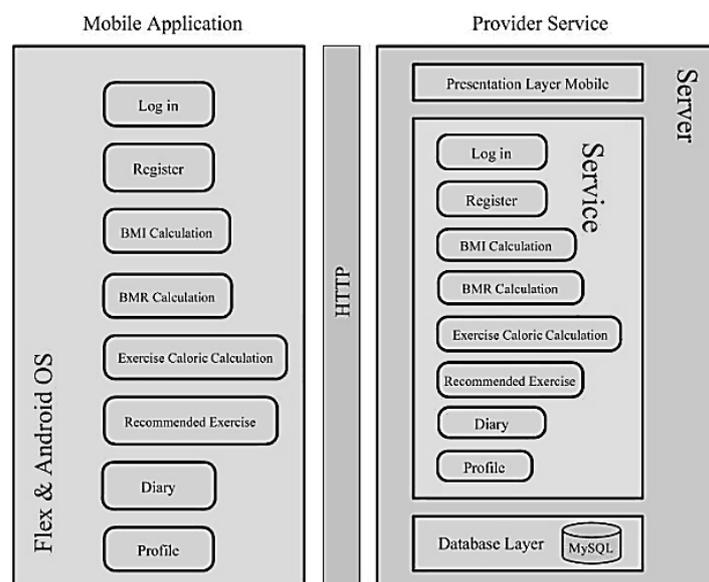


Figure 5 The conceptual framework of the exercise recommendation system.

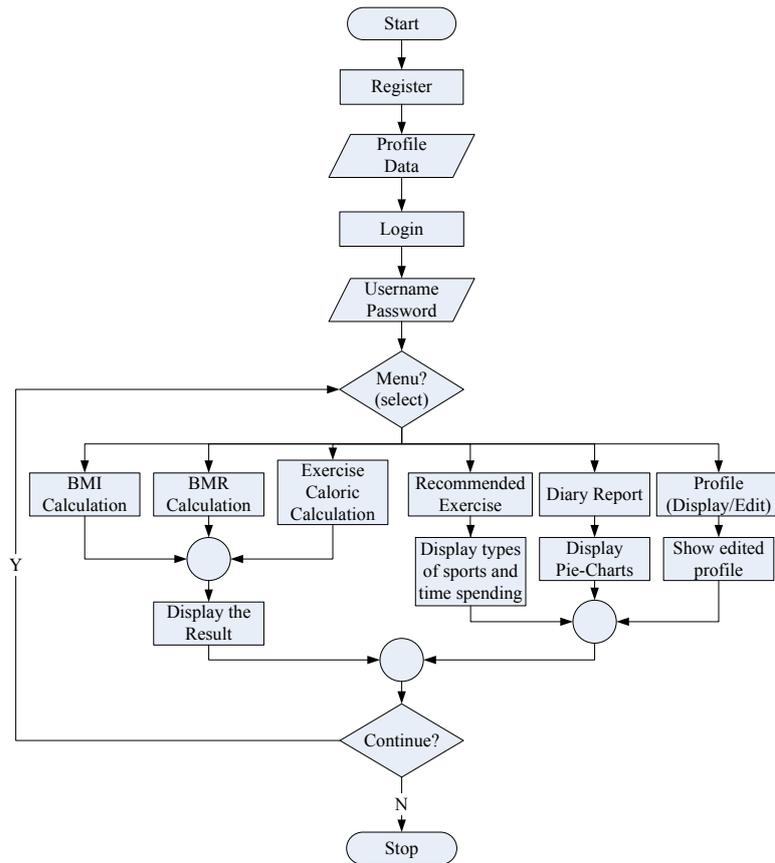


Figure 6 The system process diagram.

As shown in **Figure 7**, each node stored a logical condition and a conclusion (e.g. a partition). There are 2 types of links. The first link is a ‘true’ link that is directed to one child node, whereas the second link is a ‘false’ link that is directed to the other child node. Using a RDR tree for recommended exercise, three aspects are defined as follows:

1) The attributes to use for the cases

They have been designed to describe each user, as follows:

- height (integer)
- weight (integer)
- BMI (automatically calculated from height and weight)
- BMR (automatically calculated from the variables of height, weight, age and gender)
- age (integer)
- sex (string or enumerated, e.g. ‘m’ and ‘f’)
- disease (this is not an attribute, but rather a function that returns a Boolean value when takes the name of a disease as an input parameter).

2) The kind of conditions to use in the nodes

For this aspect, they are rules’ conditions that are calculated from the above-mentioned attributes. For example, one can be restricted that his or her age must be not less than 18 years old or disease must not be ‘heart disease’.

3) The kind of partitions to use

Each partition is illustrated as a set of actions, consisting of:

- Add-action. The action adds a new constraint on a certain component (for example, aerobic dancing, badminton and cycling). Such a constraint must specify the following data:
 - exercise (the name of the certain exercise, such as, ‘aerobic dancing’ or ‘badminton’)
 - direction (the way the above-mentioned exercise is constrained. There are four values, consisting of ‘prohibited’, ‘not recommended’, ‘recommended’ and ‘highly recommended’)
 - calories (floating-point number)
 - period (Number of minutes, the default value will be calculated based on multiple factors).However, in the case of prohibition, calories and period are not taken into consideration.
- Delete-action. It deletes all constraints on a certain component.
- Replace-action. When there is a constraint added on a certain component, the user may substitute another for it. A replace-action can be consisted of a delete-action and an add-action.

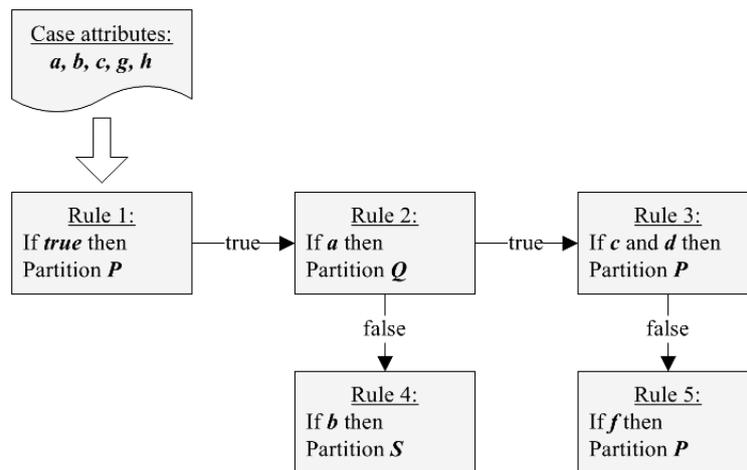


Figure 7 The RDR tree algorithm.

System design - Part II: User interface

According to **Part I** which covered the structure, use case diagrams and sequence diagrams, this section highlights services provided by the system. Particularly, following **Figure 12**, this section mainly presents user interfaces for BMI calculation, BMR calculation, exercise caloric calculation, recommended exercise and dairy, as shown in **Figure 13**. Therefore, it is easy for a developer or a programmer to communicate with stakeholders about each display that should be shown to users by the system.

System design evaluation

In this phase, subjective evaluation has been selected as the methodology to assess the design. There is a general guide recommended that subjective evaluation requires 30 subjects. Therefore, 30 volunteer subjects have been asked to evaluate the outputs of the design as follows:

- 1) Use case diagram
- 2) Sequence diagrams
- 3) User Interfaces
- 4) Overall

A 5-point scale was applied, 5 = excellent, 4 = good, 3 = fair, 2 = poor and 1 = bad. Then, the individual score was gathered from 30 subjects (consisting of 20 master degree students in Information Technology Faculty, KMUTNB, and 10 IT workers in 2 companies in Bangkok), who have computer programming skills (**Table 3**). However, the algorithm that has been used inside the system was not evaluated because this issue is too specific and too detailed for these subjects.

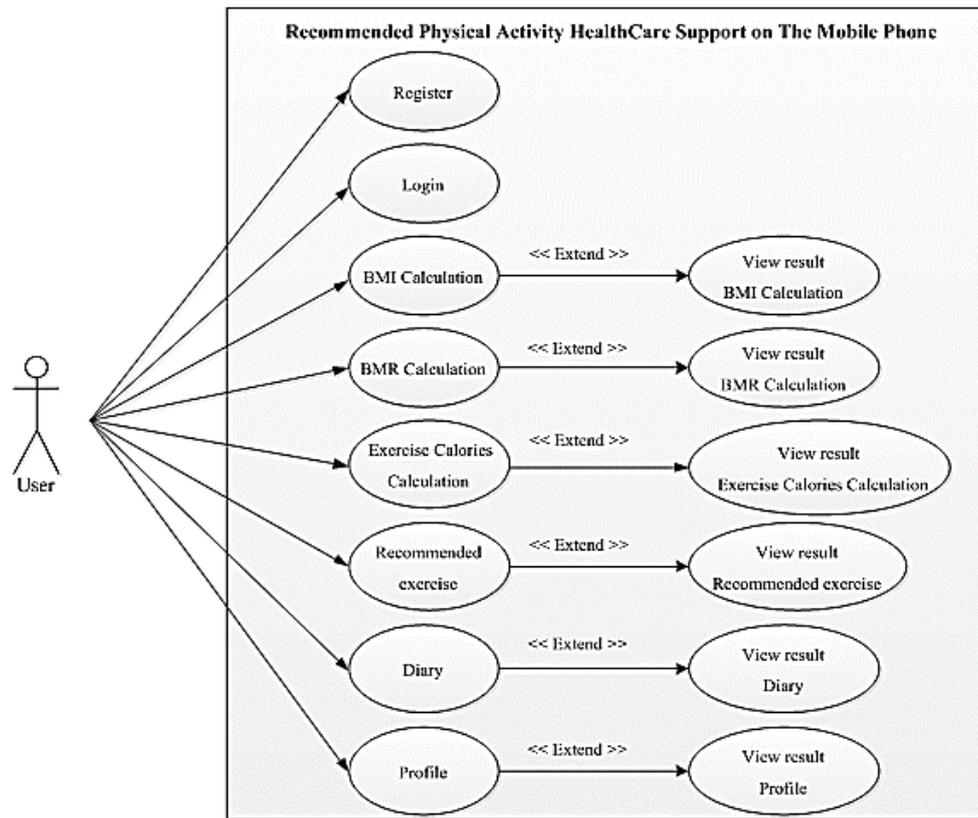


Figure 8 Use case diagram.

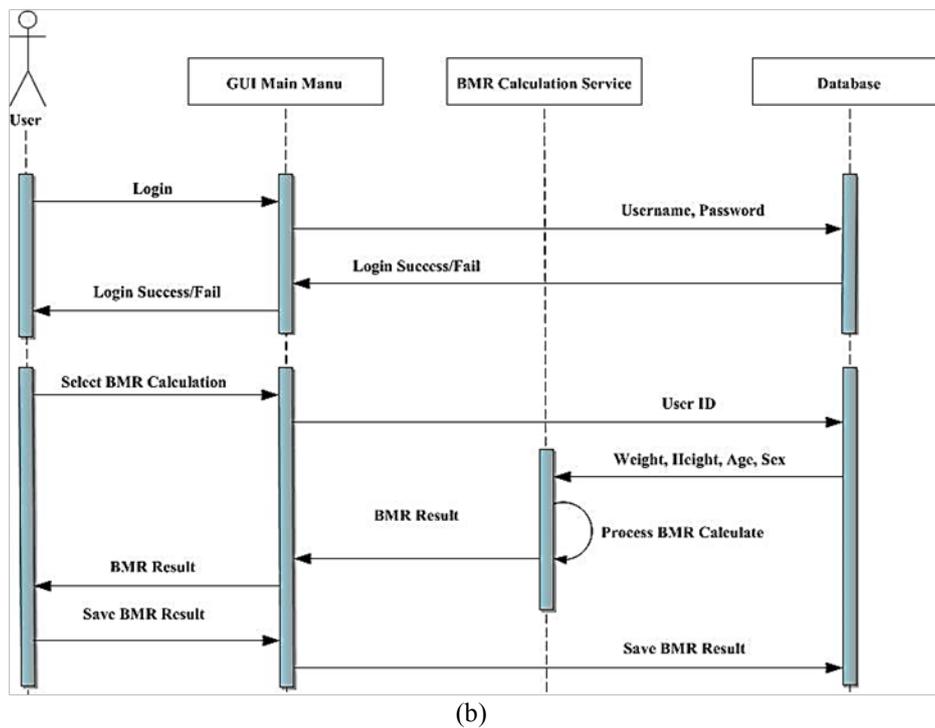
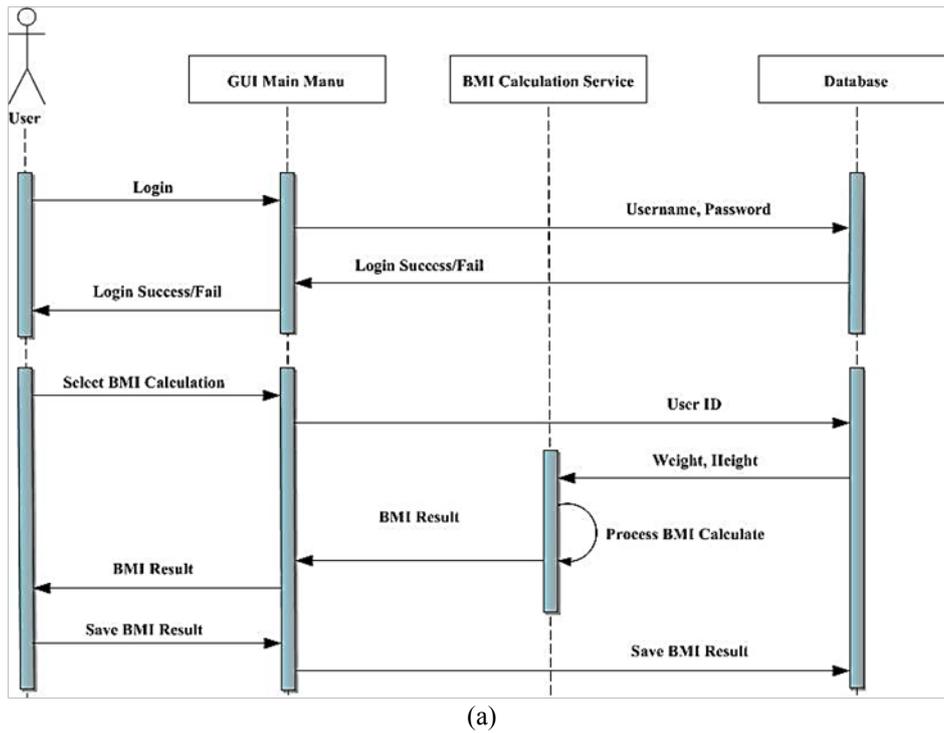
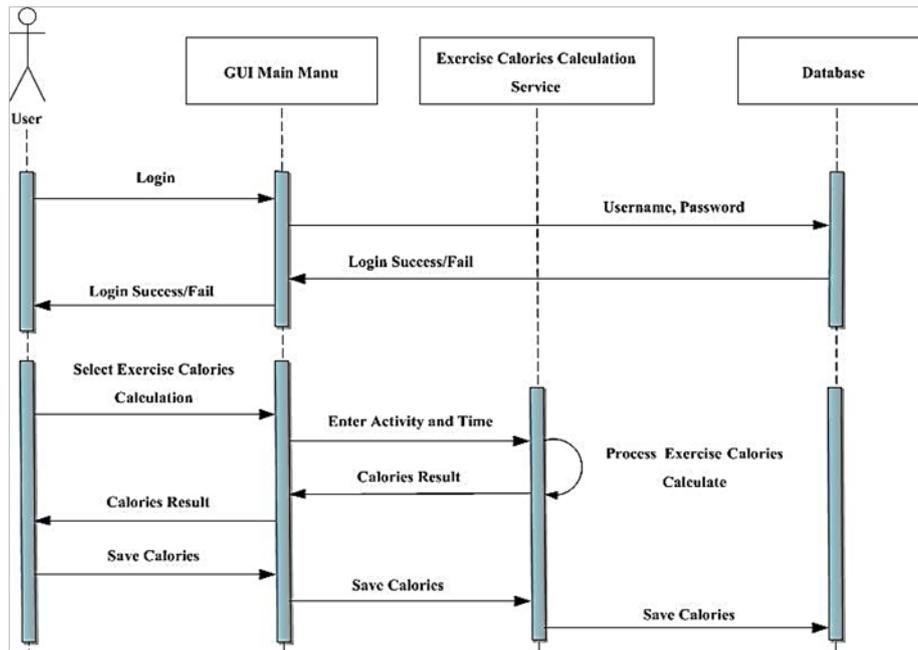
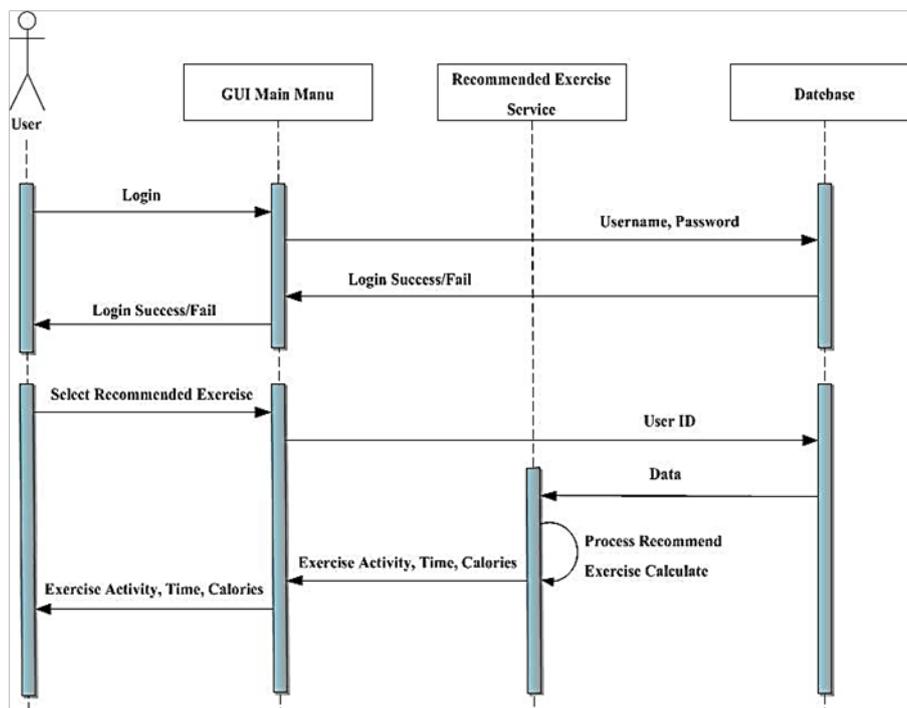


Figure 9 The sequence diagrams for (a) BMI calculation and (b) BMR calculation.

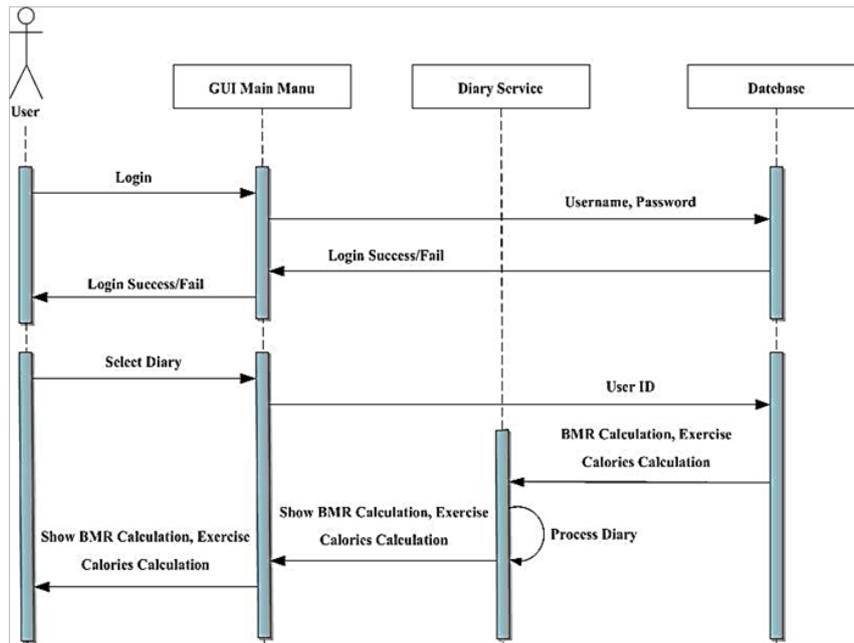


(a)

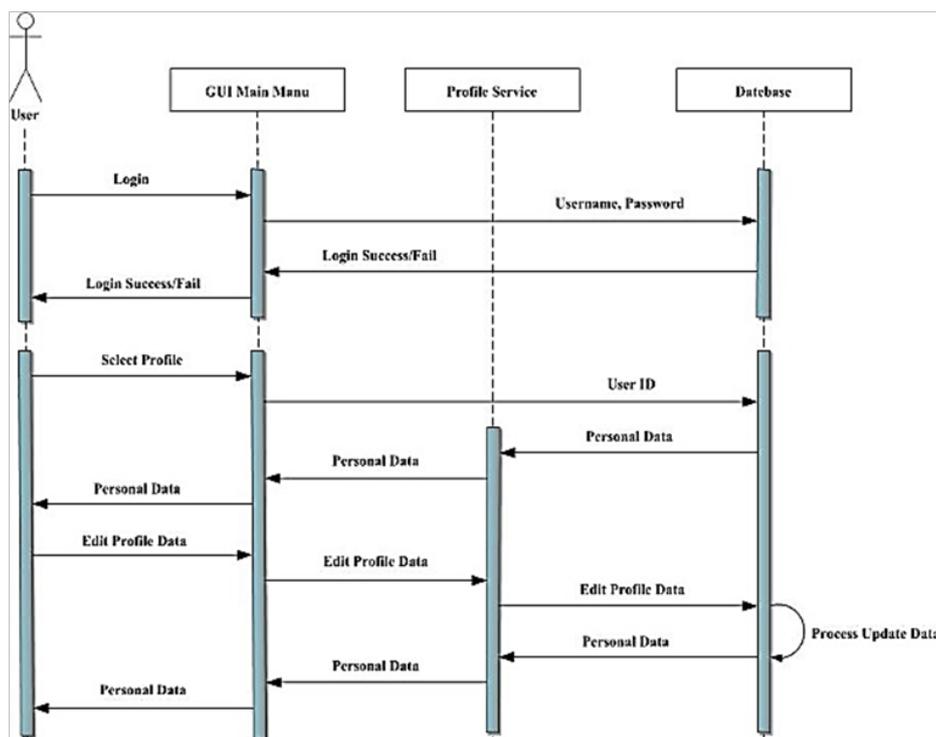


(b)

Figure 10 The sequence diagrams for (a) Exercise Caloric Calculation and (b) Recommended Exercise.



(a)



(b)

Figure 11 The sequence diagrams for (a) Report and (b) Profile.

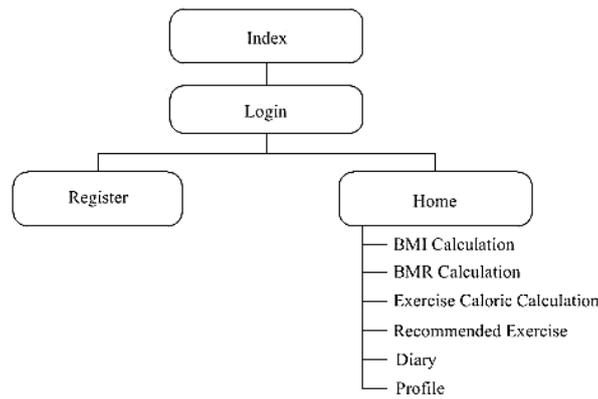


Figure 12 Overview of the exercise recommendation system.



Figure 13 User interfaces (a) Register (b) Main menu (c) BMI Calculation (d) BMR Calculation (e) Recommended sport and time duration (f) Recommended exercise and caloric expedition (g) Diary report.

Table 3 Information about 30 participants who joined the design evaluation.

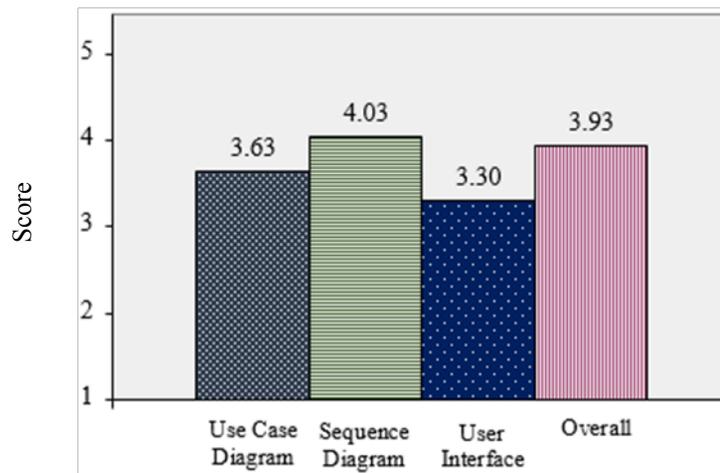
	Description	Statistic
Sex	Male	22 (73.33 %)
	Female	8 (26.67 %)
Age	20 - 24	10 (33.33 %)
	25 - 29	12 (40.00 %)
	30 - 34	4 (13.33 %)
	> 35	4 (13.33 %)
	> Undergraduate	7 (23.33 %)
Education	Graduate	23 (76.67 %)
	0 - 1 year	9 (30.00 %)
Experience	2 - 3 years	9 (33.33 %)
	4 - 5 years	6 (20.00 %)
	> 5 years	5 (16.67 %)
	Expert	5 (16.67 %)
Programming ability	Advanced	12 (40.00 %)
	Intermediate	2 (6.67 %)
	Beginner	11 (36.67 %)

Results, analysis and discussion

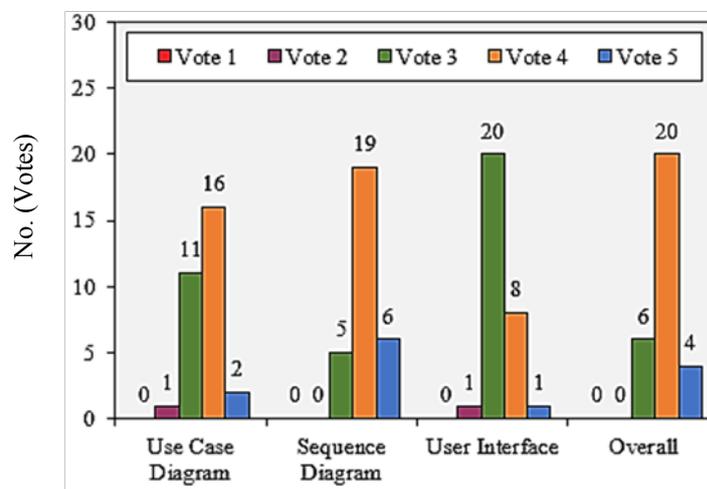
The average score of each item from the evaluation has been calculated. The results are shown in **Figure 14a**. It can be seen that the average score from the sequence diagrams is the highest, 4.03, from use case diagram is 3.63, whereas the lowest is only 3.30, from user interfaces. That means the sequence diagrams and use case diagrams were evaluated as good but the user interfaces were evaluated as fair, where 2.50 - 3.49 = fair, 3.50 - 4.49 = good and 4.50 - 5.00 = excellent [31].

As shown in **Figure 14b**, the average score overall is still good; it is 3.93 with the lowest standard deviation of 0.58. When analyzed from the individual scores, it can be seen that the evaluation result from the use case diagram, sequence diagrams and overall are good. The majority voted 4 (good) for those items as 16, 19 and 20 votes respectively, whereas the majority voted 3 for the user interfaces as 20 votes. One reason for the low scores for the user interfaces could be from the paper-based evaluation, the subjects may not feel like watching the demonstration on the real mobile device. Besides, some of them may require explanation. Nevertheless, the user interface should be improved before development in the future.

Comparing with previous research work, as shown in **Table 4**, it can be seen that most previous work has been mainly developed for patients (e.g. cardiac rehabilitation). This designed system is similar only to the mHealth system by Silva *et al.* (2011) that focuses on dietary evaluation for obsess users. However, the major advantage of this designed system focuses on healthcare promotion with the ability to support not only low-risk patients but also general users who are interested in their health.



(a)



(b)

Figure 14 The results from the subjective evaluation (a) Average score for each (the standard deviation of use case diagram, sequence diagram, user interface and overall are 0.67, 0.61, 0.60 and 0.58 respectively) (b) Raw scores that shows majority for each area evaluated.

Table 4 Comparison of previous work and this research based on major advantage and target users.

Authors & Year	Contributions and major advantage	Target users
Mattila <i>et al.</i> 2009 [22]	<ul style="list-style-type: none"> - A mobile application ‘TuneWalk’ was proposed to provide guidance to the patients during home exercise. - It can help patients to exercise at home. 	Patients without high risk
Särelä <i>et al.</i> 2009 [23]	<ul style="list-style-type: none"> - A home-based care model was proposed for outpatient cardiac rehabilitation. - The analysis data can be sent to the server by a doctor. 	Patients with cardiac rehabilitation
Watanabe <i>et al.</i> 2012 [24]	<ul style="list-style-type: none"> - The wearable heart disease monitoring and alerting system based-on smart phone were proposed. - It can continuously monitor patient’s ECG and issues, then alerts the patient and surrounding people if it detects an abnormal signals. 	Patients with heart disease
Haghighi <i>et al.</i> 2009 [25]	<ul style="list-style-type: none"> - A prototype of a healthcare support system using data mining technique (Fuzzy logic) was proposed. - The doctor can analyze and evaluate the situation of a patient remotely. 	Patients with heart disease
Hernandez Munoz <i>et al.</i> 2008 [27]	<ul style="list-style-type: none"> - A mHealth device that helps patients with life-threatening allergies to manage their health was proposed. - In emergency situations, the alarms can be activated. 	Patients with allergies
Silva <i>et al.</i> 2011 [28]	<ul style="list-style-type: none"> - A mHealth application for dietary evaluation using the data of weight, weight, age and sex was proposed. - It can calculate the daily calories consumed and a weekly weight loss. 	Obese users
Kovasznai 2011 [29]	<ul style="list-style-type: none"> - An expert system for diet recommendation (for menu construction) using a case-based approach, based on RDR tree. - The approach in this research is supposed to be used in the health record management system in Hungary. 	Patients with medical conditions and/or general users
Pamanto <i>et al.</i> 2013 [30]	<ul style="list-style-type: none"> - A novel mHealth system was developed to support self-care in management of complex and chronic conditions. - It supports two-way communication. 	Patients with chronic conditions
Wuttidittachotti <i>et al.</i> 2014, this work	<ul style="list-style-type: none"> - A design of an exercise recommendation system for the Android operating system has been proposed for healthcare promotion. 	General users and low-risk patients

Conclusion and future work

This design of a new mobile health or mHealth application called ‘Recommended Exercise System on the Android Operating System’ has been conducted. It has been designed to recommend exercise for each individual who has different age and physical characteristics (e.g. sex, weight and height). Therefore, he or she can exercise appropriately, not too little or too much, with different kinds of sports that he or she selects. Also, several functions have been included (e.g. calculation of BMI, BMR, caloric expedition and report). Furthermore, this mHealth application has also been designed to be able to support different kinds of patients and exercise (e.g. back pain).

After designing using an object-oriented approach, it was evaluated by a group of subjects who have computer programming skills. It has been found that this mHealth application design graded by a 5-point scale was found to be ‘good’ overall, while use case and sequence diagrams with had an average score of 3.93, 3.63 and 4.03 respectively (average score of 3.50 - 4.49 means good). However, they graded the

user interfaces as ‘fair’ due to its average score of only 3.3 (average score of 2.50 - 3.49 means fair). This means the design of user interfaces should be revised before implementing in the next phase as future work.

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