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Pregnancy Monitoring and Mapping Using Integrated Mobile Application and Geographic Information System

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ABSTRACT

Pregnancy care is an important task in public health. Birth health and rate ensure the sustainability of a nation and therefore, many countries put highly attention to pregnant woman. Scheduled medical assessment is a common way to monitor the pregnancy risk. This task, however, need the role of doctor or midwife to carry out several physical assessments. Pregnant women have to come to the health service facilities in certain period of time. It is therefore, lead to unmonitored duration between medical check up periods. Currently, smartphone has a number of sensors embedded in most low-cost device. The geo positioning sensors (GPS), accelerometer, camera and video recorder has become standard gadget facilities. In this research we propose a simple method to monitor pregnancy risk by using an application in a smartphone. We provide an integrated mapping to plot the member of the pregnant women under surveillance on the map with their risk status and their real time position. The mobile application automatically records walking activities and position. Pregnant woman can voluntary submit their weight and consumed food to the system. We implement this system in a pilot study to 30 pregnant women and a public health facility in central Java Indonesia. According to our user experience survey to the respondent, the application working but still need improvement in many user interface aspects. According to the recorded data during the implementation, we found that the main function of the mobile application and mapping successfully record the necessary monitoring data.

Key words : Mobile application, Geographic Information System, Mobile Health, activity detection, accelerometer

1. INTRODUCTION

Currently, communication technology takes important role in many business processes. The user based of smart phone in Indonesia for example nearly reach half of the population. The quality keeps improving while the price inherently cheaper. At the same time the coverage of the internet becomes wider. Those fact pave a way to provide technology for many tasks including health related activity. Mobile health has been rapidly developed in the last decade.

There are some health conditions receive attention from research and industry such as diabetes, mental health, elderly as well as pregnancy. Internet of things and the advancement of the mobile device technology has provided an opportunity for a researcher as well as industry to develop many health wearable sensors [1]. Some initiatives utilize mobile device to monitor patient health such as for the elderly [2], diabetics [3], [4], mental health patients [5], [6] as well as pregnancy. Some application aims to educate the patients with knowledge, asking user entry to monitor and in more advance the application utilize some installed sensors such as camera, voice recorder, accelerometer, and geo-positioning system (GPS). For example, [7] utilizes accelerometer sensors to measure user activity such as walking and running. An application uses a camera to record a user's diet [8]. In [9] researcher propose an online skin diseases prescription.

Pregnancy management aims to ensure all pregnant women receive enough care from the public health provider in certain regional area. Health pregnant woman lead to lower risk not only for the subjects but also for the next generation child. It is an important aspect of nation sustainability in general. In many countries, the threat of population declining has become a major concern. The woman fertility index under 2.1 lead to shortage of productive ages citizen in the future generation. Therefore, promoting pregnancy for young woman and keep their health is an important task. Common pregnancy risk monitoring and treatment carried out by medical assessment in regular basis. This method needs sufficient medical doctor and midwife available as well as health facility. Secondly, there are a blank spot where the midwife does not have any data or contact to the patient between health assessment schedule. Although this condition normally assumed has similar condition from the latest medical assessment, abnormal condition might happen. This

research aims to propose a real time pregnancy risk monitoring to alleviate those limitation.

Mobile application plays important role in health sector. There have been several applications in the market to tackle real time health monitoring. In the google play for example, there are a number of pregnancy and birth related application. Pregnancy related mobile health attracts researchers in interdisciplinary field to work on it such as [10] and [11].

Sport, and leisure activity has been observed positively related to pregnancy health. According to [12], aerobic exercise between 30-40 minutes 3 to 7 times a week will reduce the risk of pre-term birth delivery (PTD). Supporting sports activity and leisure time known as reducing factor of the preterm birth risk [13]. Moreover, moderate exercise activity does not cause a risk of preterm birth as reported by [14]. Unfortunately, according to [15] most pregnant women do not achieve the suggested level of physical activity during gestation and leads to risk pregnancy risk. Walking, in particular, has proven correlated with reducing pregnancy risk as reported in [16]–[18]. According to [18], walking during pregnancy reduces the risk of pre-term delivery (PTD). A comparison between stretching and walking for pregnant women has been reported by [16] in measuring the possibility of risk of pre-eclampsia on sedentary pregnant women. Both activities have the same effect on the weight gain but stretching more effective mitigating the risk of pre-eclampsia. Less walking woman during pregnancy tend to have a symptom of depression and a higher risk of preterm birth [17]. According to the previous reported finding, this research propose an automatic walking activity monitoring tools with a mobile application.

Geographic information system, now days play an important role in presenting data on the top of a map. For instance [19] develop a framework of geodatabases to improve a spatial data with richer information. In the healthcare management, researchers use GIS to improve the quality of public health such as in [20], [21]. The distribution of healthcare professional is defined by considering spatial and nonspatial factor in an integrated geographic information systems [21]. While in [20] researcher use GIS to asses the need of primary heath care in certain area. In this paper we present the pregnancy data on the top of GIS in order to help the healthcare management monitor the patients.

Application development need an evaluation in order to ensure the application meet the user need. There are some methods available such as unified technology acceptance and use of technology (UTAUT) and user experience questionnaire (UEQ). Security assessment for mobile payments apps in Indonesia has been reported in [22]. They adopt unified technology acceptance and use of technology (UTAUT) proposed by [23]. User experience questionnaire (UEQ) on the other hand has been developed originally in German language in 2005 [24], [25]. UEQ aims to reveal user experience during the use of a particular application. UEQ has been implemented to asses many application such as [26]–[28]. [28] evaluate an android application using UEQ and SUS. In [27] an evaluation of UEQ reported for web based online exam application. In this paper we adopt UEQ to evaluate the web and mobile application towards user experience in order to understand the weakness of the application and improvement needed for the current version.

The contribution of this paper as follows :

Proposing an integrated application for walking activity monitoring and mapping through thematic geographic information system (GIS).

Provide user evaluation of the mobile application and web based GIS.

The remaining of this paper is structured as follow, section 2 discuss the design of the application and evaluation methods. Section 3 present the result which are the application, the evaluation result and collected data from the application. Section 4 present the discussion regarding to the result and conclusion presented in section 5.

2. METHODS

This research is divided into some main tasks. First task is defining the software user requirements, followed by an implementation. Once the application ready, a black box testing is carried out. Mobile apps installation is carried out on user smartphone, 30 respondents involved in the pilot project. The web-based application installed in a local health facility (PUSKESMAS). After six months using the application, user ask to answer a user experience questionnaire to assess the mobile application and web application. We analyze the questionnaire to understand the weakness and strength of the application. Figure 2 explain the entire research framework.

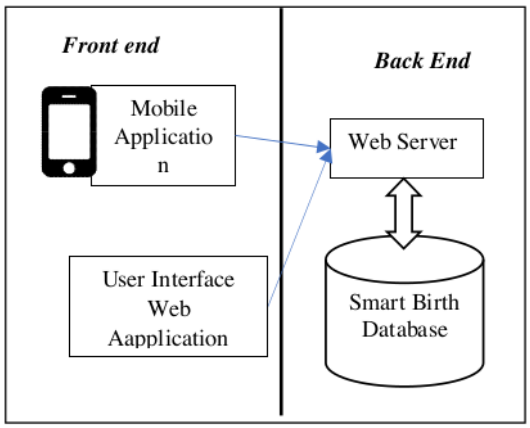

Figure 1 : Application architecture

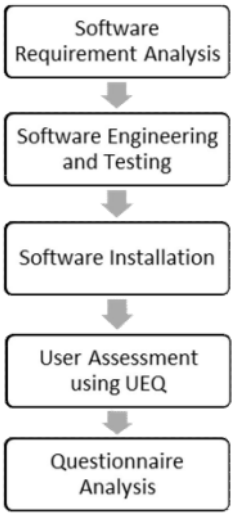

Figure 2 : Research Design

The overall application architecture consists of mobile application, web based GIS application and back end. Figure 2 presents the high level presentation of the architecture.

The mobile application responsible for monitoring the pregnant woman walking activity and location. The mobile application also has an optional feature to records the food intake and the weight.

On the other side of the systems, Medical doctor, midwife and public health facility staff interact with the system through a web user interface. The system responsible for medical assessment data entry. Displaying the position and the risk category for each patient under surveillance is also the role of web-based application. This user interface is installed in health facility.

Thematic map responsible to plot the pregnant women under surveillance on the geographic map. This map aims to help the public health manager and medical doctor to locate and identify the patient, their location and last risk known risk status. The icon in the map can interactively provide an interface for the medical staff to locate and browse the detail of the patient such as their weight, statistic of walking activity and medical assessment data.

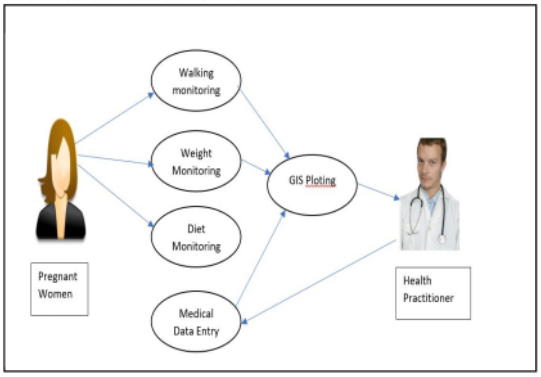

Figure 3 : Use Case

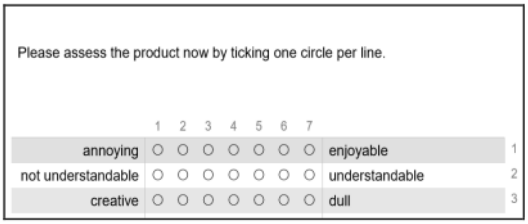

Figure 4 : a piece of UEQ Questionnaire [25]

The software requirements presented in the use case. There are two group of users in this application which are the pregnant women, medical staff. Medical staff consists of medical doctor, midwife and administrative staff. Figure 3 shows the complete use case of the integrated application.

The implementation of mobile application in the pilot project, we select 30 pregnant women in the Temanggung Central Java. We install the application in order to test the functionalities of the application and also user satisfaction of the user interfaces.

We adopt a user experience questionnaire to asses user satisfaction in using the application. After six months of using the mobile application, respondent answer use experience questionnaire. To assess the web-based user interface we ask the medical staff to answer UEQ.

UEQ measure six variables which are Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. Each variable indicated by negative and positive words. For instance, the Attractiveness indicated by Annoying for negatives and Enjoyable for positive score. Between negative and positive words, respondents ask to choose their answer in 7 level scored -3 to 3. An example of a item in the questionnaire demonstrated below.

The structure of UEQ is divided into three groups of indicators which are attractiveness, pragmatic quality and hedonic quality. Pragmatics quality consists of Perspicuity, Efficiency, and Dependability. Hedonics Quality consists of Stimulation and Originality.

3. RESULT

Mobile application is designed as far as possible can be used without any training. It start from user registration where user need to entry their data personal data and more importantly locate their home location with the help of geo positioning system (GPS). Inside the application, three main menus provided which are statistic of user walking activity, weight entry and food intake entry. The mobile application automatically record the user walking activity using the accelerometer. Figure 5 shows the user interface of the mobile application.

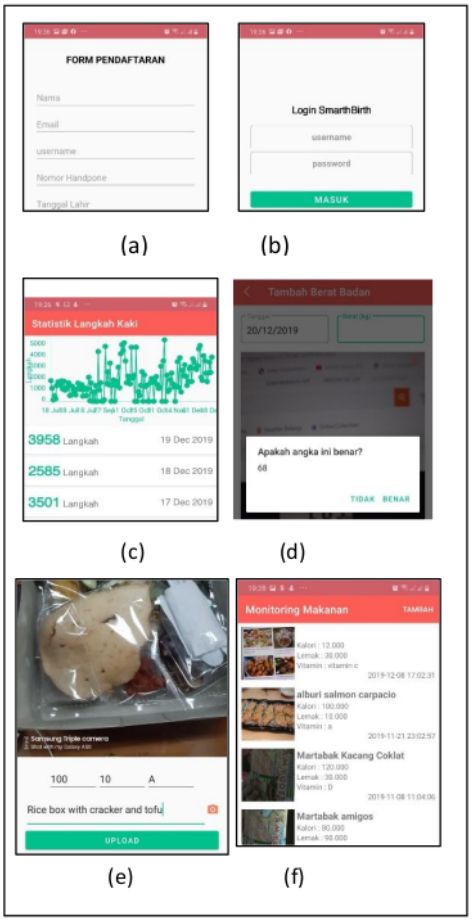

Figure 5 : Mobile Application Interface

The mobile application interface in figure 5. The login and user registration presented in 5.a and b. The mobile apps enable the user to monitor their daily activity and provide the graphics, it is shown in 5c. The application is also capable to capture the weight from digital scale, it shown in 5d. The diet monitoring interface shown in 5e and 5f.

The main feature in web based interface consists thematic geographic information system and entry of medical check-up. Figure 6 shows the GIS where the pregnant women under surveillance plot on the map with their status. The color of the icon identifies their risk status.

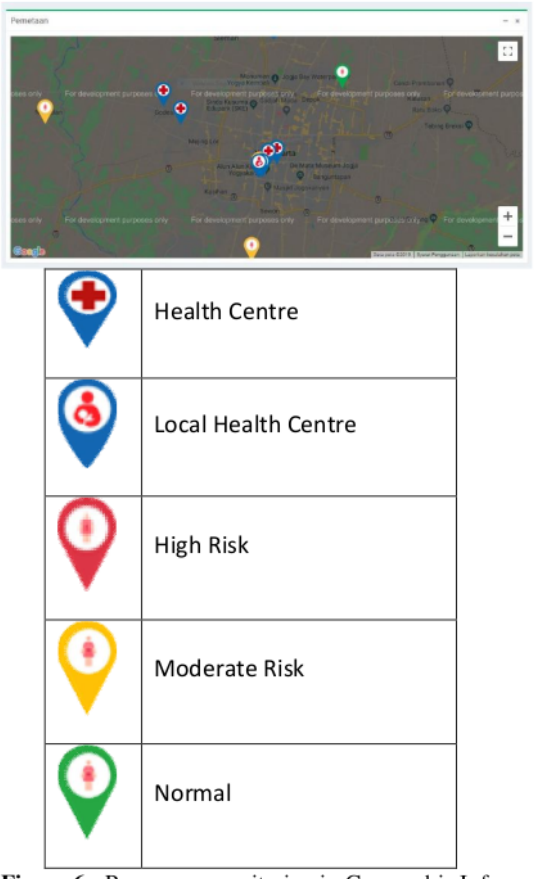

Figure 6 : Pregnancy monitoring in Geographic Information system

The UEQ for mobile application indicate the user use the application but some part of the mobile user interface needs an improvements. Figure 7 shows the overall result of the UEQ assessment to the mobile application.

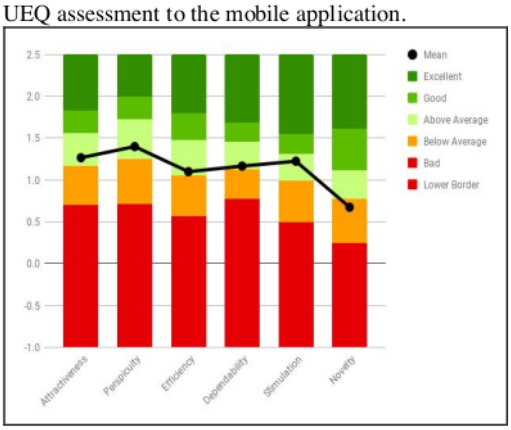

Figure 7 : : UEQ Result for "Smartbirth" Mobile Application

According to figure 7 the novelty scored the lowest. It is below average compare to the benchmark. The efficiency achieved second lowest of above average.

The mobile apps and web based user interface collect the data during their operation. The main function of the mobile application is collecting the daily walking activity automatically. Table 1 shows the piece of data collected by the mobile apps. Table 2 shows the data collected by web based user interface.

Table 1 : Health Center Check-ups Data

Subject	Pregnancy Age	Systole	Diastole	Lila	Tfu	Djj	Status
A	182	110	80	28	24	130	normal
B	84	100	70	21	2	120	normal
C	224	110	80	30	29	123	normal
..							

Table 2 : Mobile Application Monitoring Data

Date	Subject	Pregnancy Age	Mobility Steps	Record Length
01-Nov-18	A	182	1001	92
04-Jan-18	B	84	992	159
29-Nov-18	C	224	1056	57
….				

The result of UEQ for the web-based user interface presented in figure 8.

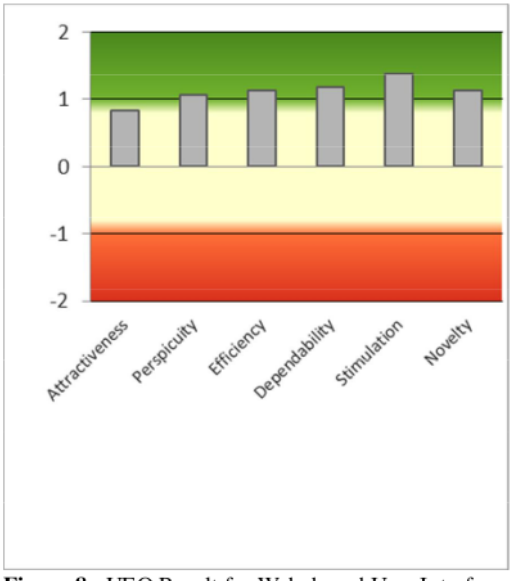

Figure 8 : UEQ Result for Web_based User Interface

As can be seen, user suggest that web user interface need massive improvement in most of the dimension, attractiveness scored the lowest among all parameters.

4. DISCUSION

The mobile application and web application has been tested. The main functionality of web application to monitor the user walking activity successfully collect the daily data. The accelerometer as movement sensors has been successfully exploited in the mobile application to record the user movements. It is therefore, require the user to bring their smartphone in the walking activity. It is mean that when the respondent walking without their smartphone, the activity would not be recorded. Table 1 proof the scenario of recording the activity work. In fact, we collect more than 2900 records during our pilot project from 30 respondents.

The web-based user interface responsible to capture the medical assessment data. Table 2 proof the result of this function. During the pilot project, we collected 150 medical assessment record from 30 patients.

The user evaluation to the application indicated that we still have to put attention to some user interface aspects. In mobile application assessment no dimension achieved good category. The highest score is achieved in perspicuity at 1.40 and consider as above average. The worst score recorded on novelty at 0.675. According to the result a major improvement still need to be done in all dimension of the application. The second lowest is the efficiency at 1.100, the score is just slightly above the lowest border of above average. Therefore, efficiency is also need attention to be improved.

The assessment of the web user interface shows the same results. Most of dimension are bellow average, and only two parameters yields a good compare to the benchmark. The web user interface needs a big improvement to achieve better user experiences.

5. CONCLUSION

In this paper we demonstrate our pilot project of an integrated application for pregnancy monitoring application. According to the collected data by the application, the main functionality of the application is working properly. However, the quality of user interface still needs major improvement. Both mobile based application and web-based application still need improvement in attractiveness quality. This research however still in an early stage, therefore, massive improvement of the application needs to be done to ensure it meet user expectation. An automatic prediction of the pregnancy risk can be done with machine learning algorithm. The algorithm can learn with medical check-up data and the monitoring data.

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