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Development of monitoring and hospital patient alert systems using smartwatch application

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Abstract. Health is particularly important family. When a person is sick and hospitalized, the number of family will be limited to just one or two from the patient's family. The family often responds slowly to the critical situation due to the distance traveled from home to hospital far enough. It would be easier if they able to monitor the condition by using a smart watch. it sends the current condition through the API displayed in the mobile application. The Android mobile app will process any data retrieved from the watch then decide the real condition of the patient. This research could support the Internet of Things in the field of health, may improve the chances of life of patients by providing a quicker and accurate information.

1. Introduction
Hospitals provide inpatient services for patients who should receive intensive care with a doctor's monitoring. Most hospitals only allow some family members to assist patients during the treatment period. During the treatment time, if family members want to know the condition of the patient they should ask the doctor or nurse who can understand how to read the health monitor device. This method is impractical because not every time the doctor or nurse is willing to serve the family questions. An intelligent device that connected to the internet, would notify the family about the patient's health condition in real time. A smart watch as a potentially wearable device may become a solution.

As one of the wearable devices, smartwatch holds great potential to improve the health of human life. Currently, smartwatch has been supported by various sensors that can display the user's body condition in real time. Sensors are like accelerometer, gyrometer, motion tracking, temperature, humidity and more. Integration sensors supported by Big Data technology, and AI (Artificial Intelligent) will further bring smartwatch usability to a higher level, especially in health. At least in the future smartwatch can contribute in the field of preventive health monitoring, disease therapy, aids for patients with specific diseases and digital medical record technology. With the ever-evolving sensor technology, smartwatch has a great hope of revolutionizing a healthy human lifestyle in the future.

The initial phase of research is making mobile applications that will retrieve health data from the API provided by smartwatch vendors. The purpose of this research is to develop a mobile application which can real-time present the patient's health condition as seen from the parameters of heart rate and blood oxygen level.

This research is expected to generate a new perspective in monitoring the development of patient recovery through mobile applications. The smart watch used in this study should have at least the features of heart rate reading, blood oxygen levels, GPS, Recovery advisors, and provide APIs to be developed by third party applications. The data retrieval technique is done by integrating vendor smartwatch's API into Android app. Further Android Applications will translate raw data taken from smartwatch in real time into a description of health conditions and divided into several alerts from normal to emergency levels. In addition to being a tool to monitor the patient's health, the application will also tell the patient's family if the patient's condition worsens through the notification mechanism. This paper is divided into chapters. The introductory chapter contains the background of the study. In the second chapter contains the method used in the research of the Requirement Prototyping model,
while in the third part is the installation stage and system configuration to get the expected objective. The fourth section contains the analysis of the research data, and in the last section is the conclusion of the research results along with the suggestions for further research to get another better one.

2. Research Methods

The research method used is a method of Design Science Research Methodology (DSRM) [9]. In this method, there are six stages to be performed, i.e., problem identification, goal setting, design and development, case studies, evaluation, and communications. On this research will only be carried out up to the stage of the evaluation. It can be shown by the DSRM methods Figure 1.

![Design Science Research Methodology](Figure 1)

In Figure 1 above, the identification of problems is made by monitoring the health of patients in hospitals, while the development of smartwatch technology using heart rate sensors, oxygen levels, GPS and heart health monitoring modeling is done through a literature study. Regarding the technology solution, the smartwatch API is used to build an alert system application from the patient’s heart rate if it changes to an abnormal condition. Moreover, with the integration of Android technology and API provided by smartwatch vendors, the heartbeat condition of smartwatch users (the patient) is accessible via smartphone. The process of measuring the success rate of the application functionality that has been built will be tested directly through the measurement of the heartbeat of patients who have high blood pressure disorder in Banjaran Health Center.

2.1. Smartwatch

The saturation conditions of smartphone usage and sales are influenced, for one reason, by wearable devices market - especially smartwatches - across the globe, which offers users new interaction experience in the digital world. One of the things is its ability to monitor and display data related to user health. Smartwatches resemble watches have been embedded with powerful processors, memory subsystems and various sensor variations such as Accelerometer, gyroscope and optical sensors [2]. Sensor support on smartwatch has opened up opportunities for smart devices to improve the quality of Accelerometer and sensor Gyroscopes, for example, are ideal for gait-based biometric: [3] with the ability to send data and calculations via Bluetooth, or with the help of smartphone via the internet [3], making smartwatch more reliable in monitoring human health than smartphone.
In Figure 2 above GodsTale [4] created a smartwatch consisting of Arduino Microcontroller with ATmega328 chipboard and 2Kbytes RAM, Bluetooth module HC-06 equipped with status, low power display with 1-inch size supporting I2C, SPI compatible with board Arduino and Lithium Polymer Battery. This Smartwatch has a minimum specification that can run the Android v4.3 operating system and supports notification services.

2.2. Health data and heart rate
Health is one of the most important factors in life, and one of the benchmarks is the heart rate condition. Heart rate is the number of heartbeats per unit of time, usually minutes. The pulse rate is the propagation of the heart rate calculated per minute by repetition count (times/min), generally represented as bpm (beats per minute). The condition of a person's heart rate will affect the volume of blood and oxygen that flows throughout his body. This condition is critical to be observed at any time, especially someone who has a history of heart disease. Significant changes in the status of heart rate at any given time can cause death. The monitoring of heart rate at all times is crucial both for the sufferer and his family. Table 1 below shows the heart rate and associated conditions.

| Category | Heart Rate (bpm) |
|----------|-----------------|
| Low      | < 60 bpm        |
| Normal   | 60 – 100 bpm    |
| High     | > 100 bpm       |

2.3. Android SDK
Android Studio SDK is an IDE (Integrated Development Environment) for Android application development. In addition to being a powerful code editor and developer tool, Android Studio offers more features to improve productivity when creating Android apps [5].

2.4. ANT+
ANT + is a wireless technology that allows other electronic devices to communicate with each other on condition that the device supports ANT + communication or embedded ANT + technology. ANT + technology is widely used by smartwatch manufacturers to detect heart rate to retrieve data for health monitoring applications easily. ANT + also provides APIs for developers to create similar applications.
3. Data and Analysis

Testing aims to see the functionality of the system built. The system uses two devices that are smartwatch and smartphones that have mobile applications installed and both support ANT+ technology. The ANT+ protocol can communicate without further adjustment. Mobile apps can take heartbeat data from the smartwatch. Through the process of parsing API smartwatch, it can display patient's heartbeat data. The built-in flowchart system is shown in Figure 5 below.

**Figure 3. Flowchart System**

Figure 3 illustrates the process of integrating smartwatch data into Android apps, which the smartwatch owner data can be displayed on Android smartphone. First, the login view to know the patient's name and number. The second is the smartwatch device search field. Thirdly, mobile apps display health information. Health information features such as patient identity, time, device status, real-time value and average heart rate. By leveraging the existing ANT+ APIs in the smartwatch, the mobile app allows taking heart rate data.

The testing process is done through 3 stages:

3.1. Test of heartbeat data retrieval from a smartwatch.

Intake of heartbeat data from smartwatch can be done by using ANT+ communication where previously have added library from ANT+ API so that smartwatch heartbeat data can be processed using a smartphone. The results of this test are shown in Figure 5.

**Figure 4. Test of heartbeat data retrieval from smartwatch**
Figure 5 shows that smartphone managed to take heartbeat data from smartwatch through ANT + technology.

3.2. Heartbeat data processing.
Heart rate data processing aims to determine the average heart rate of patients. Average is obtained by using the formula (1).

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n} \quad \cdots (1)$$

The mean value of the patient's heartbeat test results repeatedly performed in a minute will be searched according to equation one above. Furthermore, this average value will be displayed and categorized into the patient's heartbeat health status consisting of Low, Normal, or High. This health categorization of the heartbeat is done through heartbeat testing after the patient performs walking, jogging, and running activities. Also, the category testing process carried out on patients who have a history of high blood disease. Table 2 below shows the patient's heartbeat category.

| No. | Time   | Data                                      | Heartbeat    | Condition | Status |
|-----|--------|-------------------------------------------|--------------|-----------|--------|
| 1   | 16:43  | 90,91,92,96,95,96,95,94,93,94,95,96,97,95,97,96,95,92,91,90 = 1880 | Amount of Data = 20 | Walking   | Normal. |
|     |        |                                           | X=1880/20 = 94                     |           |        |
| 2   | 20:29  | 128,129,130,129,130,131,132,133,132,129,124,114,107,106,105,106,108,109,110,111,112,113,114,2742 | Amount of Data = 23 | Jogging   | High   |
|     |        |                                           | X=2742/23 = 119,21                 |           |        |
| 3   | 20:39  | 142,144,143,141,139,138,141,143,149,152,150,149,151,150,152,153,152,154,146,147,148,149,150,151,150,149,148,147,148,145,5178 | Amount of Data = 35 | Running   | High   |
|     |        |                                           | X=5178/35 = 147,94                  |           |        |

Table 2 above shows the variation in the patient's heart rate repeatedly measured to determine the patient's heartbeat category, while Table 3 below lists the results of system and application testing with different patient activity conditions. This test is intended to find out whether mobile applications can work if user activity varies by displaying status changes from Normal to High and vice versa according to the average heart rate generated based on data from the smartwatch.
Table 3. Testing Mobile Application

| No. | Time | Average Heartbeat | Condition |
|-----|------|-------------------|-----------|
| 1.  | 16:43| 94                | Walking   |
| 2.  | 20:29| 119,21            | Jogging   |
| 3.  | 20:39| 147,94            | Running   |

After doing the activity test, then the next test will be done to the patient at Cikalong Public Health Center, Banjaran. This test is intended to determine the difference in heart rate of patients who have different diseases, ages, and sexes. Table 4 shows direct application testing to the patients of Community Health Centre Cikalong Banjaran, Kab. Bandung.

Table 4. Tests Against Patients

| No. | Identity of Patient | Test Data | Status |
|-----|---------------------|-----------|--------|
|     |                     | Time | Heartbeat |        |
| 1.  | Name: Ase Somdani.  | 10:30| 96        | Normal.|
|     | Age: 75            | 10:31| 93        | Normal.|
|     | Male               | 10:32| 93        | Normal.|
|     | Disease: Maag and Hypertension | 10:33| 92 | Normal.|
|     |                     | 10:34| 90        | Normal.|
| 2.  | Name: Edi Bartas.  | 10:37| 79        | Normal.|
|     | Age: 70            | 10:38| 77        | Normal.|
|     | Male               | 10:39| 77        | Normal.|
|     | Disease: Cholesterol and Hypertension | 10:40| 75 | Normal.|
|     |                     | 10:41| 75        | Normal.|
| 3.  | Name: Wiwik Suciati.| 10:50| 72        | Normal.|
|     | Age: 50            | 10:51| 61        | Normal.|
|     | Female             | 10:52| 63        | Normal.|
|     | Disease: Heart Failure and Hypertension | 10:53| 66 | Normal.|
|     |                     | 10:54| 65        | Normal.|

Based on table 4 above, the process of measuring heart rate data and determining the health category of patients based on smartwatch heart rate data is successfully displayed via smartphone. The data shows the success rate of the system built to reach 100%.

In addition to displaying the user's heartbeat smartwatch data, this application can also display the Geolocation of smartwatch users because the built application integrates the GPS API for user location data retrieval. Figure 8 below shows the smartwatch user position shown through the built application.
Figure 5. Smartwatch application test for location

Figure 6 indicates that the built application successfully displays the location of the smartwatch user, i.e., at Jalan Telekomunikasi No.20 Sukapura Dayeuh Kolot Bandung, West Java 40267, Indonesia. Smartwatch user location retrieval process can be done if the smartphone is connected to the internet.

Figure 6. Information of Testing Location Centre

Figure 7 shows the location information when the built system is tested at the Cikalong Public Health Center, Banjaran.

4. Conclusion
Some of the tests performed indicate that the Smartwatch integration process with Android has been successfully built. The application can display the patient's heart rate in real time. By integrating smartwatch with GPS, the user position can be known directly.

For further research, it is necessary to build a SMS Gateway to inform the patient's health condition to his family. It is crucial that the family can get notified as soon as possible if something terrible happens to the patient.

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