Heartbeats measurement prototype development based on internet of things

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Abstract. Physical fitness is very important for athletes. It is because by knowing the physical fitness, an athlete can do excellent physical exercise, such as running exercises that can lead to physiological changes in athletes and physical fitness. Ganesha Sport Center (GSC) is a business unit developed by Universitas Pendidikan Ganesha (Undiksha), which is managed by the Faculty of Sport and Health (FOK). However, based on observations made by the research team to the GSC, tools for monitoring athlete’s fitness, especially heartbeat are not available in the GSC. Based on discussions with GSC administrator, the need to develop a tool for monitoring the heartbeats of athletes, so that trainers can monitor athletes’ condition, especially the athlete’s heart condition. Based on this, it is deemed necessary to conduct research on the development of a tool to measure the heartbeats of athletes in the GSC. This research is an applied research in Science and Technology field to support sports facilities in GSC which is a business unit and also a lecture facility at Faculty of Sport and Health, Universitas Pendidikan Ganesha. Based on the result of Blackbox testing that has been carried out, the heartbeats measurement prototype development based on IoT can be declared successful and feasible to be implemented. Beside using blackbox testing, the prototype was also tested by measuring the sensor voltage requirements in measuring heart rate and temperature. From that test, it can be concluded that any increase in temperature or heart rate requires a greater voltage, and vice versa. This is because the sensor requires more power when the temperature or heart rate increases.

1. Introduction

Physical fitness is very important for athletes. It is because by knowing physical fitness an athlete can do very good physical exercise, such as running exercises that can lead to physiological changes in the athlete and his physical fitness [1]. Athletes have limited capacity for adaptation to training loads before fatigue [2]. Excessive fatigue during exercise can hamper the performance of athletes and require a long time in the recovery process [3]. Athletes’ fitness is an important part of all sports, especially to support other aspects such as technique, tactics and mentality [4]. Physical conditions are very decisive to support the task of athletes in the match in order to perform optimally. Physical condition training must be well planned, clear and shown to improve physical fitness, thus allowing athletes to achieve better performance.
Based on the results of an interview on February 24, 2018 with I Nyoman Sudarmada, S.Or., M. Or, it was stated that “the heart condition is very important for the athlete itself because with a healthy heart condition, it can perform various activities especially running”. In addition to physical endurance, heart rate is one indicator of athlete’s assessment both for the selection of matches and for lecture practice activities. But all this time, the process of measuring the heart rate by the trainer is still done at the end of the training, so it does not get the right accuracy / according to the conditions when practicing. Besides that, I Nyoman Sudarmada, S.Or., M. Or. stated that the level of dehydration is an important indicator in athletes’ fitness measurement [5]; [6]; [7]. Measurement of the level of dehydration can be done by measuring the body temperature of the athlete [8]; [9].

Currently the tools for measuring heart rate have been developed. The most popular ones are called Polar and Forerunner. Polar is a belt in which a heart rate sensor is placed which is used to monitor the condition of the body, especially the condition of the heartbeat. While the Forerunner is a watch. Both of these tools are very ergonomic and easy to use. But this tool can only monitor the heart rate via a smartphone device with a Bluetooth connection. Beside that this tool has not been able to measure the body temperature of athletes [10]. Moreover, both Polar and Forerunner have special features to measure athletic fitness levels.

Along with the development of information technology in the field of sports which is increasing rapidly, it has allowed athletes during physical exercise, especially when running to be monitored specifically in terms of the heart rate by using tools, such as the Internet of Things (IoT). IoT is a technology that can connect various things, both physically and virtually through the internet [11]; [12]; [13].

Based on this, it is deemed necessary to conduct research on the development of athletes’ heart rate gauges. This research is an applied research in the field of science and technology to support sports infrastructure in the GSC which is a business unit and a lecture facility at the Faculty of Sports and Health, University of Education Ganesha.

2. Methods and Procedures

This study will be divided into 2 stages, namely the first stage which will be the development of heart rate sensor devices and the second stage which is the final stage where it will integrate the heart rate sensor device as a whole. The integrated system will monitor athletes based on athletic fitness levels.

2.1. Analysis Step

The first phase that will be carried out in this research is literature study and needs analysis. This stage is intended to examine existing problems, and design a system model that will be developed.

2.2. Design System Step

This research will use the Waterfall model, following the Waterfall model stages.

![Waterfall Model](image)
The method in this research uses the System Development Life Cycle (SDLC) method approach to the waterfall model. The details of each stage in this research are:

2.2.1. Analysis. In the analysis phase several activities are carried out including:

- **Study Literature**, This activity is carried out by doing theoretical and journal studies related to the research that will be conducted. This activity has been carried out in the chapter of state of the art.
- **Position / effective analysis of the measurement of heart rate and body temperature.** This stage will be conducted in form of interviews with heart and blood vessel specialists (SpJ.P) and literature studies to several book sources.
- **Analyse the athlete’s training pattern,** this activity is carried out to determine the athlete’s training pattern for each sport. The analysis will be carried out at several sports training centre in several sports branches.
- **Data collection of athlete training patterns,** after determining the athlete’s exercise pattern analysis for each sport in several sports, the next step is to develop training stages and determine athletes’ assessment criteria for each sport. This data will be used as ranking criteria for athletes’ fitness levels.

2.2.2. Design. Based on the research road map for the first year, it will be designed a heart rate sensor device for indoors. Details of this activity are as follows:

- **Designing a heart sensor device architecture.** The results of the position / effective analysis of the measurement of heart rate and body temperature will be used as a reference in the design stage of the heart sensor architecture. At this design stage, specially designed heart sensors are used indoors. The following is the architectural design and general workings of the heart rate sensor.

![Figure 2. Prototype Design](image-url)
Following explanation of figure 2:

- Number 1 (In Figure 2), it is a tool on the user side or on the athlete side. In this section ESP Module namely ESP8266 NodeMCU acts as a microprocessor that receives data on two sensors mounted on an altitude body namely the heart rate sensor and body temperature sensor. Besides acting as a microprocessor, this tool has also been equipped with a GSM Module (ESP8266) which is the main functional as a good tool used in making IoT projects. Through the GSM module, this device can transmit and receive cellular networks.

- Next, Number 2 (Figure 2) explains that the equipment installed on the side of the athlete communicates with the GSM module. Communication is carried out in the form of sending sensor data. The data sent is the result of sensor detection in athletes (Sensor Heartbeat & Body Temperature).

- In number 3, this is a part of MIFI. In this section, the GSM module will check the connection itself to the provider. When it is connected to a GSM signal, it will provide service to the detection device installed on the athlete's body.

- In number 4, it is explained that sensor data that had been received on the detectors in the athlete's body was transmitted to the cellular network, where it is sent based on the cellular network used.

- Number 5, that is the last part because it is the part where the data has been processed and produces the output that the athlete's heart beat rate and body temperature is displayed before monitoring. Monitoring here can see these results through various tools, such as directly using a PC or smartphone. The output is in the form of an athlete's heartbeat, and the athlete's body temperature is carried out by an application that has been integrated or connected to a cellular network connected to the prototype where the heart rate sensor data and body temperature are processed. In other words, both output devices (monitoring devices) must be connected to cellular networks.

- Designing IoT devices supporting heart rate sensors This stage is done by assembling the equipment in accordance with the design of the system architecture.

- Design the application interface In this activity the design of the system interface is carried out, according to the needs of each entity (Athlete and Coach).

2.2.3. Implementation. At this stage the development of the design phase was carried out, including: 1) Development of athletic heart rate sensor devices for sports. 2) Develop athletes’ heart rate monitoring applications on computer monitors and phone cells.

2.2.4. Testing. System testing is done by using User Acceptance Testing which is Black Box testing the functionality of a single system, so that it suits the user’s needs.

2.2.5. Maintenance. Maintenance phase was not carried out in this research.

3. Result and Discussion
In this section, it will be explained the results of the implementation and discussion of making prototypes.

3.1. Implementation
This IoT-based athlete’s heart rate measuring prototype system was developed based on hardware only, and has been able to receive and send text messages to determine the heart rate, body temperature and body condition status of athletes. The results of the implementation of the Prototype Development Measuring IoT-Based Athlete’s Heartbeat are in form of the
prototype containing sensors to measure heart rate, sensors to measure body temperature and also a GSM module which sends information on heart rate and body temperature from the use of the prototype. The results of the implementation are shown in Figure 3.

![Prototype of Athlete’s Heart Beat and Temperature Gauge](image)

**Figure 3.** Prototype of Athlete’s Heart Beat and Temperature Gauge

In order to know the heartbeat, athlete’s body temperature, and also how the athlete’s body condition, it can be done by sending a text message to a number that has been previously registered. This way, the coach can easily know how the athlete is doing.

3.2. Testing

This test is intended to evaluate the truth of the system that has been developed. In addition, this test is not solely used to check the correctness of the results, but to ensure that the hardware or software developed is in accordance with the needs of the user. The following will be elaborated on several things related to testing, namely the purpose of system testing, the design of the case of system testing, the implementation of testing, and evaluation of test results.

3.2.1. Purpose of System Testing. Testing the prototype measuring heart beat and temperature of the athlete is done by using Blackbox testing. Blackbox testing is intended to find out whether the input and output functions of both software and hardware are in accordance with the required specifications, without testing the design and program code.

3.2.2. Case Designing System Testing in Blackbox Testing. For Blackbox testing, it focuses more on the functionality of each sensor whether it is able to operate properly or not. The sensor tested is LM35 to measure temperature, Pulse sensor to measure heart rate, and the GSM module to receive and send text messages. As for the results of testing the functionality of the LM35 sensor, the sensor to the GSM module can be seen in Figure 4(a), 4(b), 4(c), 4(d).
Figure 4 (a) is the result of testing the sending of a text message "Help" to find out what information I can get from the prototype. From the test, it can also be seen that the relationship between the GSM module and the Arduino runs well. From the trainer’s process of sending a message until receiving a reply, the average time is 13 seconds. Figure 4 (b) is the result of testing the text message "Jantung" which serves to determine the heart rate of athletes. In testing the sending of text messages "Jantung", it can be seen that the relationship between the GSM module, Arduino with pulse sensor goes well. The average response time from sending a "Jantung" text message to receiving a reply is 9 seconds.

Figure 4 (c) is the result of testing the sending of a text message "Suhu" which has a function to determine the body temperature of an athlete. From testing sending text messages "Suhu", it can be seen that the relationship between the GSM module, Arduino with LM35 can work well. The average time from sending a message to getting a reply is 8 seconds. The last in figure 4 (d) is the result of testing the sending of a "Status" text message that serves to determine the athlete’s heart rate, body temperature to the athlete’s body condition. In this test it can be seen the relationship between the GSM module, Arduino, pulses sensor and LM35 sensor can run well. From attempting to send a "Status" text message to receiving a reply, the average time is 11 seconds.

In addition to testing with the sending of text messages, testing is also carried out by measuring the voltage that can be used for each sensor. Voltage testing results are expected for sensors can be seen in Figure 5. From the graph which can be seen in figure 5 (a) it can be said that the higher the heart rate correlate with the increase in voltage with an average increase of 0.05 volts voltage for an increase of 1 bpm. The graph of the correlation between temperature and voltage can be seen in figure 5 (b). From the graph, it can be said that the higher the temperature the greater the voltage value.
3.3. Discussion
At the system development stage, the programming language is used by processing to connect the microcontroller with the sensor and the GSM module. Based on Blackbox testing that has been carried out, the heartbeats measurement prototype development based on IoT can be declared successful and feasible to be implemented. Beside using blackbox testing, the prototype was also tested by measuring the sensor voltage requirements in measuring heart rate and temperature. From that test, it can be concluded that any increase in temperature or heart rate requires a greater voltage, and vice versa. This is because the sensor requires more power when the temperature or heart rate increases.

4. Conclusion
Based on the research on the development of heart Beat measurement prototypes based on IoT, it can be concluded that the developed prototype can be declared successful but still constrained in the process of sending text messages that still take a long time because it is still depending on GSM signals.

For future development the thing that can be designed is that the prototype which is integrated with clothing so that it is easier for athletes to use. Prototype can be connected to cloud service so that data processing becomes faster, and automatic ranking is added to know the condition of the most excellent athletes

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