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Smart Bed Health Monitoring based on ECG and Body Temperature using Lab VIEW and IoT

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Abstract: ***Heart disease remains as the major cause of death encompassed by Malaysians over the past ten years starting from 2005 until 2014. There are many factors that influenced this statistical measurement. One of the most influential factors is due to insufficient space for medical placement provided by the hospitals. The purpose of this study is to develop a smart bed health monitoring system based on electrocardiography (ECG) and body temperature sensors. Arduino IDE software was used for Internet of Things (IoT) and LabVIEW software for real time monitoring. Data can be seen through a website, which can help the doctors to monitor their patients' data from a long distance. The result of the project was compared with existing monitoring devices used for heart rate (Hand Wrist Heart Monitoring and Galaxy Watch) and body temperature (Rossmax Monitoring TG380 Thermometer) which available in the market. These comparisons were conducted by several experiments to analyze its accuracy and reliability. The comparison of data between real time monitoring and IoT was analyzed to check for the effectiveness of data via internet. The result showed that the highest percentage of error for both parameters of heart rate and body temperature were less than 4.2%. This system able to interpret an individual's level of healthiness such as bradycardia, tachycardia and fever which can be monitored in real time monitoring.***

Index Terms: ***Smart bed health monitoring, Electrocardiography (ECG), LabVIEW, Internet of Things (IoT).***

I. INTRODUCTION

In recent years, there has been an increasing interest in health monitoring devices. All parts of body include the interior organs such as lungs, heart, brain and exterior organ like skin must be in a good health condition.

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The research to date has intended to focus on the interior part rather than the exterior part. This is due to the limitation of human eyes, which is difficult to see the interior organs with their bare eyes. However, many devices can be used to monitor the interior organ such as the heart rate of a human with the development of technology [1]. These devices include heartbeat pulse sensor and electrocardiogram sensor. Heartbeat pulse sensor uses a bright LED indicator, which detects the pulse of blood through blood vessel when blood is pumping from the heart. This method uses plethysmography where the signal pulses that are similar to the heartbeat pulses due to the heart rate pulses. Then it will decide the flow of blood volume when the light is absorbed by the blood. Another device to detect human heart rate is via electrocardiogram sensor particularly used in this project.

According to the Statistic Department of Malaysia (2018), heart disease stayed as the major cause of death encompassed by Malaysians over the past ten years starting from 2005 until 2014. In 2014, 13.5% of cases have been recorded for heart disease. This number was the highest record in ten-year time from 2005 to 2014. In addition to the finding, it showed that gender showed as one of the significant factors contributed to heart disease where male has the highest percentage compared to female.

II. LITERATURE REVIEW

A. Smart Bed Innovation

Relax can be defined as causing someone to become less active, calmer and happier which make some parts of the body become less stiff. One of the ways to have the higher level of relaxing is by having a sleep or rest on a bed. Furthermore, Brand et al. [2] has stated that different level of sleep deepness was a well-known for each person. Moreover, the deepness of sleep depends on the position of their sleep and type of relaxing object used like chair, bed etc.

In recent years, several works of the literature have suggested to use smart beds for different purposes, where different kinds of sensors and information related to smart beds have been introduced. Hart et al.[3], has proposed a smart bed that used a contact-free method to monitor respiration by capturing their movements. In addition, Park et al. [4] has suggested using smart beds to decrease stress among healthy people by capturing the preferred sound, temperature and light settings while waking them up.

i. Smart Bed for Pressure Ulcer Prevention

One of the smart beds that has been developed was aimed to prevent pressure ulcer among people. Pressure ulcers also called as bedsores is the injuries to underlying tissue and skin that caused from prolonged pressure on the skin. However, this bedsore (see Fig 1) was developed because of pressure caused by lying in bed in one position.

Fig. 1 Bedsore injury

An experimental test of smart bed to prevent the pressure ulcers for patients was designed and simulated in many hospitals. This smart hospital bed was used to upgrade the process of "turning" that was performed by health care workers. This process was done to ensure that patients were turned consistently and reducing the job requirement for caregivers. In another study, Yousefi et al. [5] has stated that someone who was experiencing pressure ulcers will extremely cost due to increases of the length to stay in hospital as well as it was very labor intensive. Therefore, a smart bed that can help to prevent the pressure caused by the ulcer especially critical ulcer must be invented in other to reduce money and time spent by the patients for medical treatment.

ii. Smart Bed for Heartbeat, Respiration and Movement Detection

Sivanantham [6] has mentioned that the system with contactless measurement would be the most suitable method to analyze the sleep stage pattern, to measure body parameters such as heart rate, breathing pattern as well as the body movement. The method uses Ballistocardiography (BCG) which cardio ballistic force was applied near the thorax region when blood was being pumped out of heart by the left ventricle, to measure a heartbeat. Furthermore, breathing effect that caused by a slightly slower frequency variation in the same thorax region was measured to get the respiration signal.

Moreover, in order to measure the respiration signal, other methods from previous researchers were implemented. According to Azimi et al. [7], he proposed to apply one of the non-invasive methods to calculate respiratory effort is in-bed pressure sensor arrays. In addition, in-bed pressure sensor arrays can be used to interpret important signals such as respiratory effort of users in smart homes and hospitals [8].

iii. Smart Bed for Transferring Patient

When a patient is admitted to a hospital, there is a possibility for the patient to be transferred to a different Health Care Facility in order to get better treatment. A patient may be transferred for a variety of reasons such as for diagnostic purposes and availability of specialists. Diagnostic purposes included CT Scans, MRI's, radiation treatments, dialysis sessions or cardiac diagnostics.

Patients with disabilities may cause huge liability to a hospital. Lui et al. [9] has stated that patients with disability that suffered from stroke or serious trauma have led to an increasing burden to the hospital staffs especially when monitoring disability patients. Besides, patient transferred has unsatisfactory effects to the hospital staff. Ismail et al. [10] has mentioned that a musculoskeletal disorder (MSDS) and back injuries will be experienced by the hospital staffs especially nurses when after transferred overweight paralyze patients. Thus, these activities give more challenges to the staffs.

Sonntag et al. [11] has proposed an intelligent and automation bed system for hospital to help the staffs, which has been emphasized and focused in recent years. A smart bed for transfer was designed to deal with the nurses' issues by assisting them to transfer their patients from warded bed to medical bed so that the nurse can easily bring the patient to another location. This design used an actuator and ball transfer method.

B. Health Monitoring

Health monitoring nowadays has become one of an important application that can help people to monitor their healthy level. In 2003, Disease Control and Prevention Center (DCPC) which is located at United State of America (USA) stated that life expectancy has been increasing worldwide due to significant improvements in healthcare, medicine as well as due to growing consciousness about personal and environmental hygiene. This statement showed that health awareness are important in prolonging life expectancy.

According to Deen [12], health monitoring system will allow people to continue staying at their house rather than spending time and money at healthcare facilities. The medical expert can monitor their health using online system, thus providing a cost-effective and r efficient way for on-site clinical monitoring. Nevertheless, this system will be implemented with unobtrusive and non-invasive wearable sensors that applicable to use at diagnostic tools for healthcare monitoring system. Personnel healthcare that monitors some vital physiological signs from body often implementing the usage of sensors as its diagnostic tools in real-time from a distant facility.

C. Sensor Development

For a long term health monitoring systems, non-invasive and non-intrusive sensor are considered as of the necessary components. These systems show that every sensor will acquire or receive signal based on that sensor has built to be and transfer that signal to a processing data, then will execute it as an output. In short, when technology improves, the sensor development increases..

According to Ring and Jones [13], normal body temperature lies within a range of 36.2 ºC to 37.5 ºC, which is not constant and varied in both healthy and unhealthy individuals. Fringe temperature was recorded in tissues, for example, the skin, where ecological elements and an absence of protecting connective tissue influence temperature. Kim (2016) [14] has stated that larger magnetic field strength and a lower in the heart rate will be resulting to higher temperature of body.

Mohrman and Heller [15], have stated that the function of the heart is to pump blood throughout the body that is realized by means of contractions. Besides that, cardiovascular system (CVS) is responsible for supplying the human organs with blood that composed by the heart, the arteries, and the veins. Al Ghatrif [16] added that the introduction of electrocardiogram provided objective information about the heart's function and its structure.

III. METHODOLOGY

A. Research Methodology Structure

In this venture, a study on the system's functionality and the design of the project was conducted to fulfill the objectives. The process started with the development of electrocardiogram sensor and temperature sensor to detect signals from the human body. After the detection of the signals, the data received were transmitted to the microcontroller and were displayed using LabVIEW graphical user interface (GUI) system for real time display. Moreover, the data sensed by sensor were also transmitted to the other microcontroller and then to the Favoriot middleware platform for cloud computing system to display the data based on IoT.

There were nine elements used as an important role to ensure the system will operate well as planned. The elements use in the study include Arduino Mega, Arduino Uno, Cytron Wi-Fi shield, AD8232 Heart Rate Monitor sensor, LM35 Body Temperature sensor, Favoriot Platform, structure of the bed, Biomedical Sensor Pad and Electrode Pads. The interconnection between these elements were presented in term of block diagram as shown in Fig 2. In this project, the bed structure played as the base to place all the other elements Arduino Mega and Uno that acted as the microcontrollers that assisted the two type of sensors for data readings. The heart rate sensor was attached to the human body using biomedical sensor pads and electrode pads. The temperature sensor was placed under the armpit. The data was monitored using LabVIEW monitoring environment and Favoriot middleware platform.

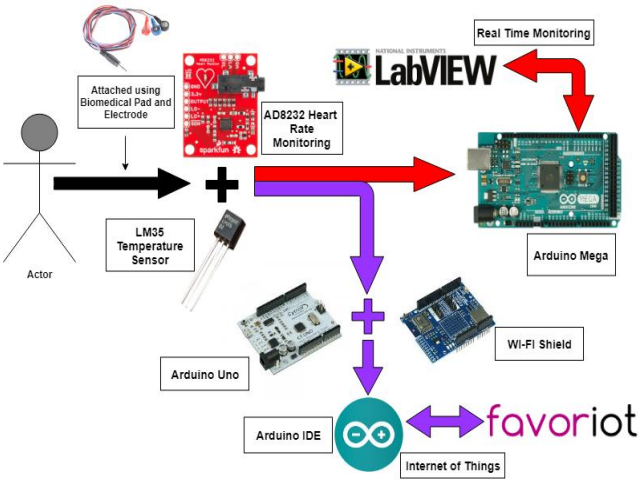


Fig. 2 Block diagram of the system

B. Project Flow

Fig. 3 shows the process flow for the project system. The flow starts when the user puts the temperature sensor and heart rate sensor, which connected with electrode pads to the body. These sensors read perimeters from human body and sent it to microcontrollers to read the signals. The electrode pads were placed closer to the heart to get the electrical impulse and the temperature sensor was put under the armpit to get the temperature from the body.

The sensors transmit signals to the Arduino Mega and Uno respectively. These signals were displayed using LabVIEW software for monitoring purpose in real time. In the monitoring software, there will be some codes based graphical language to calculate all factors that have to be analyzed which related to the objectives of the project such as the heart rate. The buzzers will be on if the reading reached emergency threshold. For Internet of Things, the data get from the sensors on Arduino Uno will be sent to the Favoriot platform through Wi-Fi shield. In this case, the Favoriot platform works as the middleware in cloud computing system from the device to the application of this system.

C. Wiring Diagram

The design consists of an actual wiring diagram of overall project (Fig 4). The wiring diagram showed on how the main components of this project were combined and connected. This design was done at early stage in order to make sure that there will be no mistake in wiring a prototype of this project. For this design, a software called as Fritzing was implemented where this software composed of many of electronic parts for easily design. The design of wiring diagram was illustrated in Fig 4.

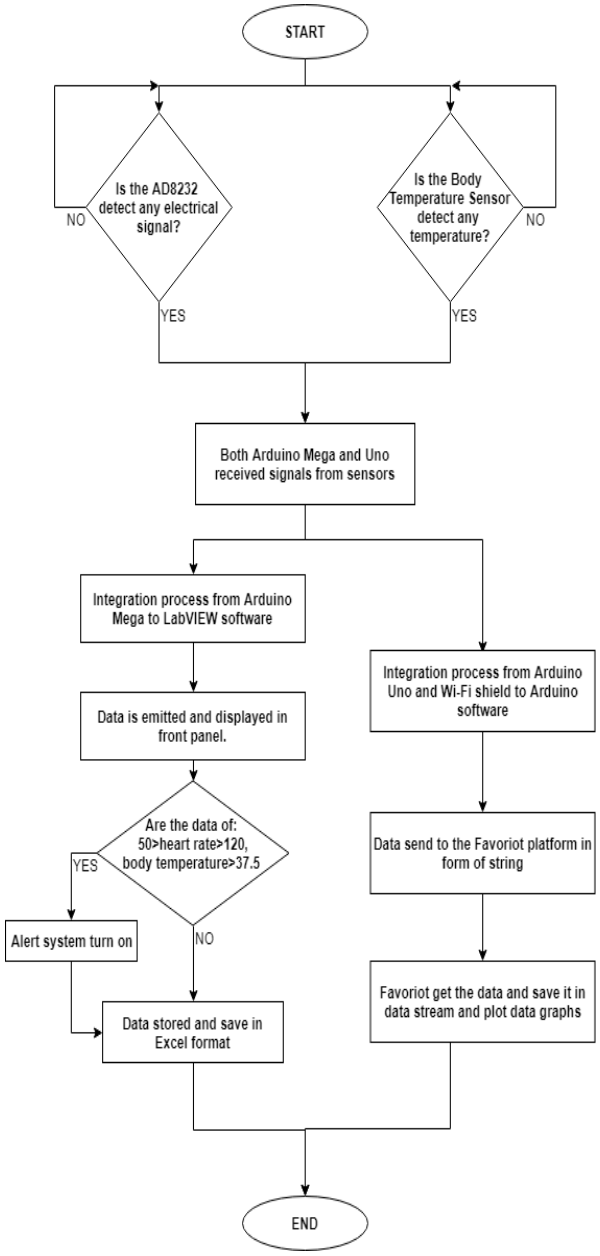


Fig. 3 Flow chart of the system

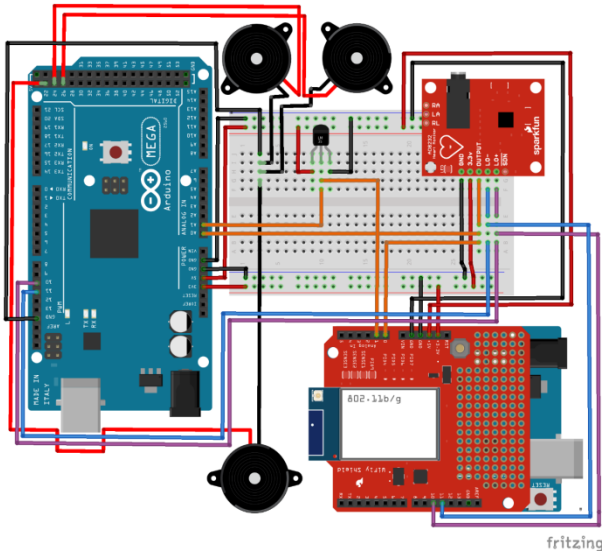
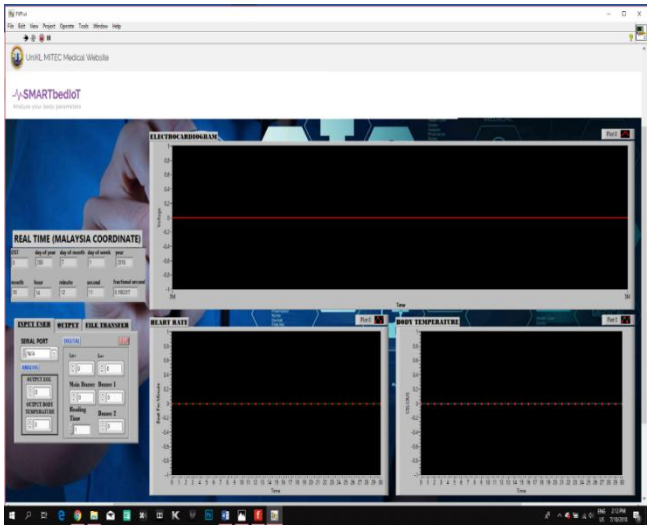


Fig. 4 Wiring diagram

D. System Design

This system was designed in LabVIEW 2016 for real time monitoring and Arduino Integrated Development Environment for Internet of Things. Fig 5 shows the design of this system in LabVIEW for real time monitoring. The front panel of the LabVIEW showed graphs of three important parameters of this system, which were heart electrical signal, heart rate and body temperature. User will key in the input of serial port, digital input and analog output as well as the interval of reading time.



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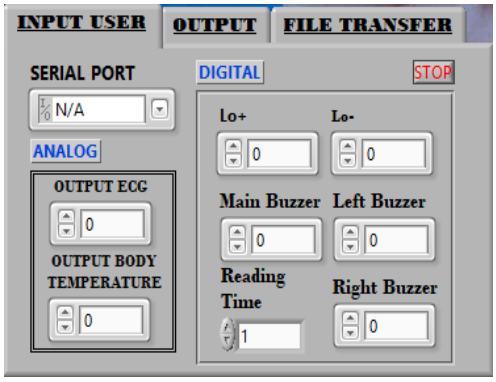

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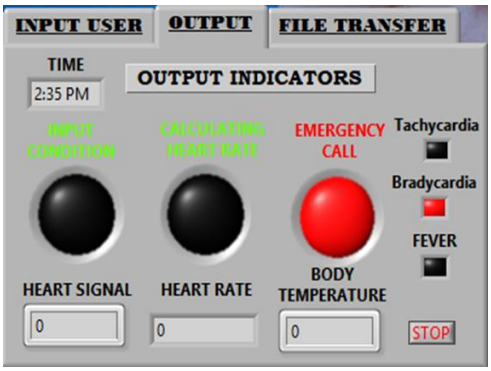

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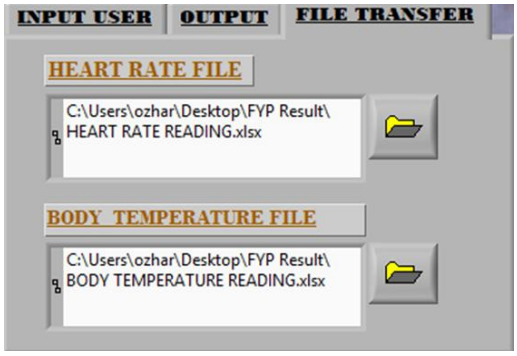


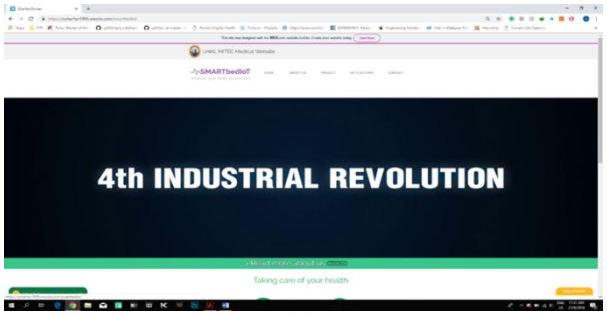
(d)

Fig. 5 (a) Real time monitoring design (b) Input user (c) Output (d) File of data transfer location

E. Internet of Things (IoT)

Internet of things in this system was designed via Arduino IDE where it used C language to communicate from the Wi-Fi to the Favoriot cloud system. In this project, a UniKL MITEC Medical Website called as SMARTbedIOT has been created to ease the users to open the Favoriot platform. This website was designed to meet readers satisfaction where the website itself explain about the overview of the project. Besides, readers also will learn a bit of basic information regarding UniKL MITEC, the sensors function such as normal sinus rhythm as well as a short explanation about IoT. The website was addressed as https://ozharfan1996.wixsite.com/smartbediot.

Fig 6 (a) illustrates the website home page that has been created using WIX. By clicked "analyze" data button on IoT platform section as shown in Fig 6 (b) at SMARTbedIOT website, user will directly open to the Favoriot account to analyze of data via Internet of Things.



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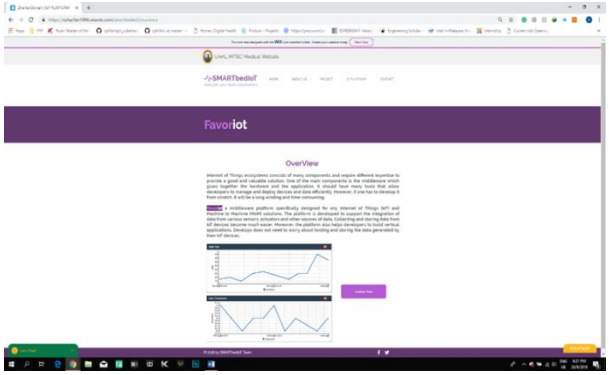

(b)

Fig. 6 (a) SMARTbedIoT Homepage (b) IoT Platform section Favoriot

F. Project Prototype

Prototype of smart bed health monitoring based electrocardiographic and body temperature sensor with real time and IoT has been developed. The base structure of this prototype was made from wood. The microcontrollers with all the sensors were attached on the side of the base structure to make the prototype more creative and well designed. Fig 7 illustrate a picture of the system prototype.

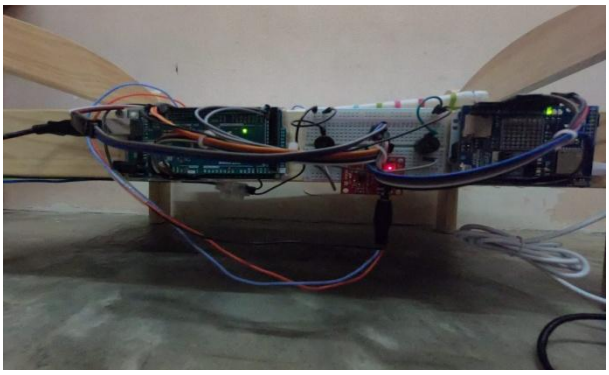

Fig. 7 Project Prototype

IV. RESULT AND DISCUSSION

A. Result for Real Time Monitoring (Using LabVIEW)

LabVIEW software was used to monitor the data in real time. The data will appear in three different graph charts as shown in Fig 8, which named as Electrocardiogram, Heart Rate and Body Temperature graphs respectively. A Boolean indicator was used to show the conditions of the system are met when the system is still running. The condition was based on the digital inputs of leads-off detect positive (LO+) and lead-off detect negative (LO-) of the heart rate sensor. The graph chart of the electrocardiogram will interpret the data logging of one millisecond while both graphs of heart rate and body temperature interpret the data longing of one second.

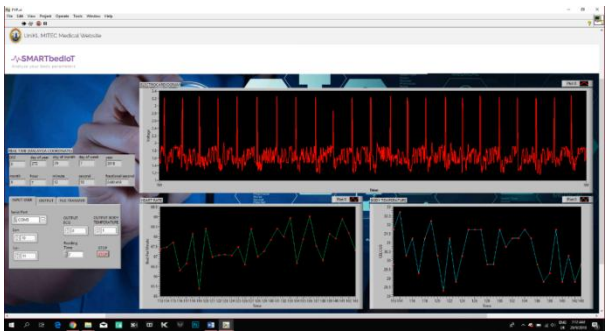

Fig. 8 Real Time Monitoring System in LabVIEW

B. Data Analysis between System and Available Devices

From the experiments, data were compared from development system with the existing devices. For heart rate data, the available devices used were the wrist heart rate monitor device and galaxy watch meanwhile for body temperature data, the available device used was Rossmax Monitoring TG380 Thermometer.

The purpose of this data analysis was to determine the reliability of this project by measuring the error between the system data and the available device data as shown in Fig. 9 and Fig. 10.

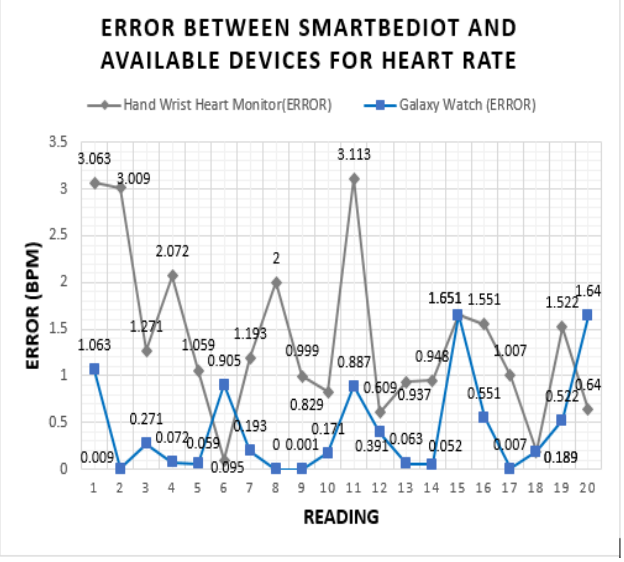

Fig. 9 Error of the data for heart rate parameters

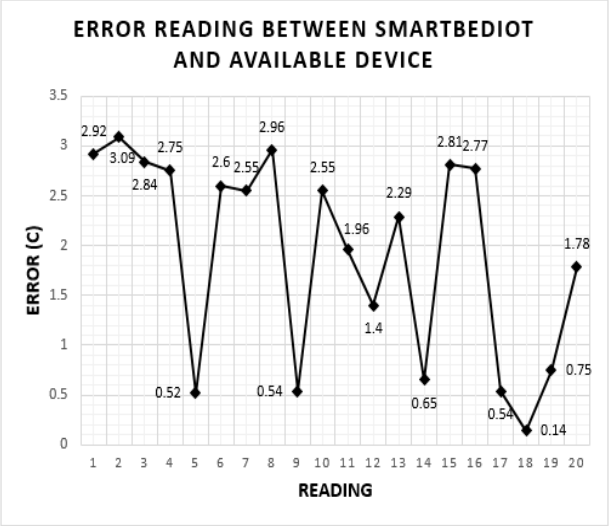

Fig. 10 Error of the data for body temperature parameter

C. Result for IoT (Using Arduino IDE)

For Internet of Things, three elements need to be considered which were the Application Programming Interface Key (API key), Service Set Identifier (SSID) and Java Script Option Notation (JSON). API key usually provided by the cloud platform.

In general, the data generated from Arduino IDE which was on the left side of Fig. 11 will be sent to Favoriot platform meanwhile the data generated from LabVIEW for real time monitoring system which was on the right side will be saved and stored in excel format automatically. Based on the time and date of the data executed on the data stream at Favoriot platform, the time and date matched on the Microsoft Excel that stored the data for real time monitoring on LabVIEW were highlighted so that both of the data can be compared and analyzed. The purpose is to check the effectiveness of IoT of this system.

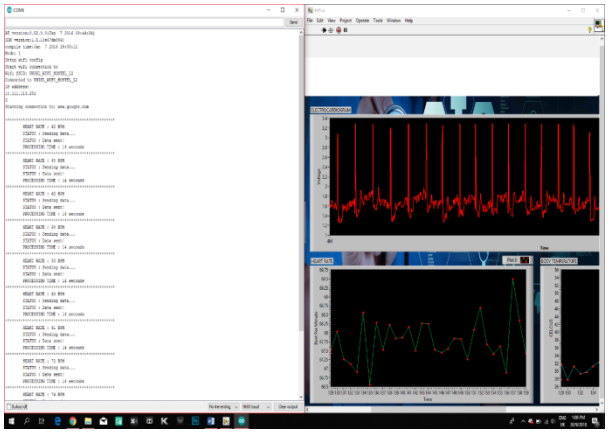

Fig. 11 System running both LabVIEW and Arduino IDE softwares

D. LABVIEW Website for Local Host

LabVIEW software from National Instrument provided a tool used to monitor the front panel on the website called as the Web Publishing Tools. Figure 4.17 illustrated the real time monitoring via website. However, a module called runtime and google plug in were needed to run this tool. Data showed via the website was 1 second delay compared the real time monitoring on LabVIEW.

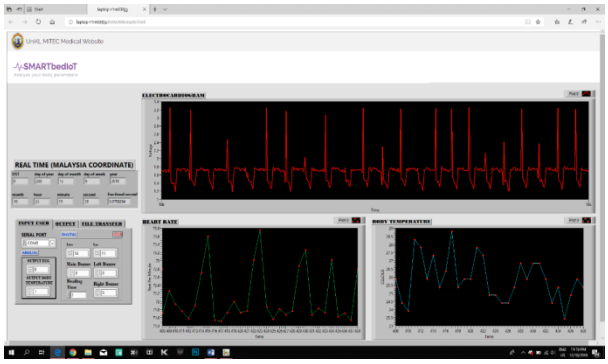

Fig. 12 Web publishing tool

V. CONCLUSION

Smart bed system has been developed to measure ECG and body temperature patients. The system also able to provide wireless monitoring for the doctor to monitor patient from a long distance. This study can give a lot of benefit to patients, doctor and to the society. Data of this project has been conducted and analyzed. The analysis of data consisted of the data analysis between this system and the available devices as well as the comparison of data between real time monitoring and internet of things. Besides, the heart electrical signal (ECG) has been calibrated to get the best result. Both data showed that this project was high in accuracy and good precision that made this project a reliable to be developed. In addition, a high performance of specification computer was needed in this project due to requirement to run many software. Finally, this project has introduced important procedures of conducting a research.

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