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Heart rate monitoring system for patient with coronary heart disease with IoT: initial idea

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ABSTRACT

Technological innovations in the field of disease prevention and maintenance of patient health have enabled assessment to be done using a monitoring system. Heart rate is a very important health parameter that is directly related to the human cardiovascular system. The main objective of this project is to develop a heart rate monitoring system for coronary heart disease patients via IoT. IoT-based heart rate monitoring consists of an ECG and a temperature sensor integrated with the Arduino IDE. The developed module is connected to an Arduino which is responsible for calculating beats per minute and body temperature. The Arduino then shares the serial data to the Blynk platform so that the data can be used by physicians or patient caregivers. The study involved thirty normal subjects who contributed to testing the usability, design, and operation of a heart rate monitoring system. To obtain the accuracy of the calculation, readings are formulated using HR Reserved or Karvonen Formula. The result achieved with this approach is the reduction of errors from the readings and the accuracy of the sensors with simultaneous data acquisition applied to the two sensors. During this research, evaluations performed on heart rate monitoring systems for coronary heart disease via IoT were observed based on sample experiments. The results showed that the cardiac data was successfully transferred via the Wi-Fi module. It is a major help for patients who need a heart rate monitoring system because the data can be accessed faster anywhere, at any time using the android application system with notifications.

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Introduction

There are so many people in the world whose health may suffer because they do not have proper access to hospital and health monitoring. Due to the latest technology, small wireless solution which are connected to IOT, can make it possible to monitor patient remotely instead of visiting the physical hospital.

The quality of life of residents is an important objective of a smart cities, and the daily mobile health-care service becomes more and more important for the solitary people, such as the disable and elderly people. Chronic diseases such as cardiovascular and cerebrovascular diseases influence the health of the people living alone in daily life, such as cardiovascular and cerebrovascular. These diseases effect the corresponding motor, sensory and cognitive function could have been lost. or compromised, real-time remote monitoring service is

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required. In Malaysia, chronic heart failure (CHF) has become a very serious problem. This is gradually affecting an ever-growing segment of population leading to represent one of the major causes of hospitalization for patient with heart attack risk. The current healthcare model is mostly in-hospital based and includes periodic visit that has turned as a tedious job for the patients.

Health Monitoring System proven to be the major advantage that reduces human error (Parvez & Mumbai, 2018). Health monitoring is the process by which the Patent Data (Temp of body, Heartbeat, E.C.G, Respiration etc.) is continuously updated on the internet website or application via the sensors connected to the patient. Using IoT the patent data is easily accessed by doctors and can treat well according to the risk level. In this study, a complete and integrated healthcare model is described enabling Chronic Heart Failure (CHF) patients to daily collect vital signs at home and sending them using Internet of Things (IoT). A set of five parameters has been identified that are Electrocardiogram (ECG), Pulse rate, Weight, Temperature and Position detection by using wearable sensors (Kajaree & Behera, 2017).

Learning that a monitoring system is an essential part of pervasive healthcare service, and multi-parameter monitoring systems are more helpful than those that only monitor one sign however, data transmission for multiple parameters is the major concern. Although the current resampling methods can lighten the remote server's burden, it also experiences loss of the data accuracy. In health applications, data accuracy is crucial to the overall performance and may even affect patients' life. Therefore, this study proposes a multi-parameter monitoring system which keeps all sensor data but uses a flexible transmission scheme to reduce communication and computing cost (Mallick & Patro, 2016). Patients' risk level is used as the key to transmission control. Patients with higher level risk will send data more frequently, while ones with lower risk level only send data during important periods.

Method

The two purposes of this study are, first to facilitate heart rate check every day without interfering with daily activity, secondly to generate interactive health monitoring utilizing modern technology. The proposed system is mainly divided into three stages: the transmitting section, the processing unit, and the receiver section. The transmitting end mainly consists of biological sensors which are used to pick up the bio potential signals from the patient's body (Devices, 2013).

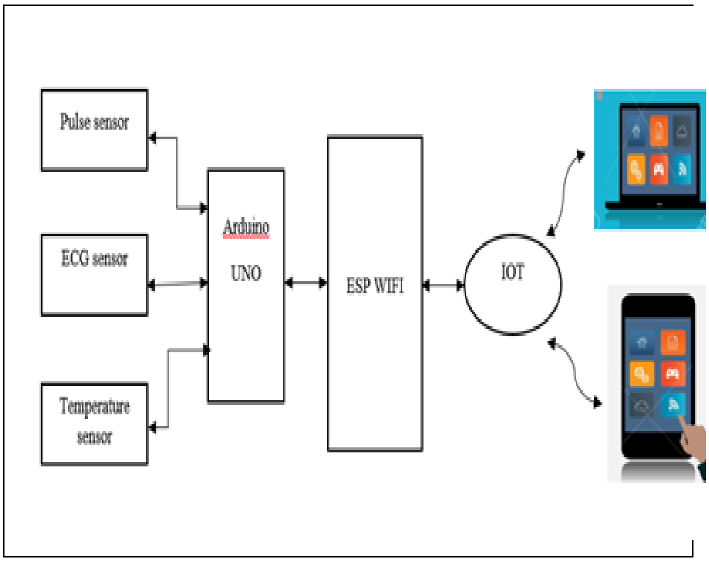

Figure 1 <Initial Idea of the Project>

Figure 1 show the scenario for idea of the project used IoT technique, ECG, pulse, and sensors' data that can be shared and analyzed effectively and efficiently. With the aid of an IoT cloud, computation-intensive data process and analysis tasks can be carried out in powerful servers, which greatly eases the burden of smart devices or web ("Design of a low Cost Portable Heart Beats Monitor Using," 2013).

Flow chart in Figure 2 shows the flow of work process, starting with literature reading development, block diagram of project, hardware and software development, technical data analysis and performance evaluation.

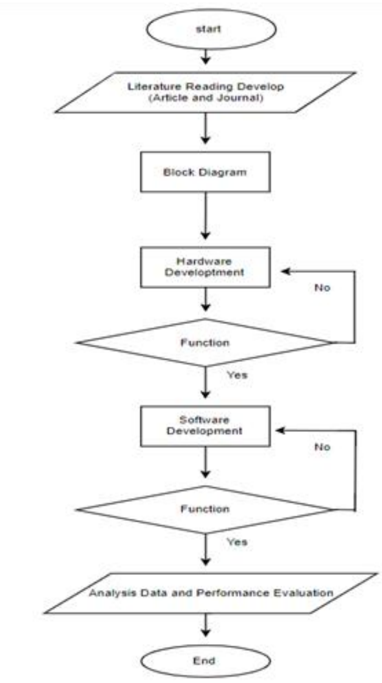

Figure 2 <The Flow of Work Process>

The Figure 3 shows block diagram of project can be dividing into two section one consisting of hardware part and the other part is software.

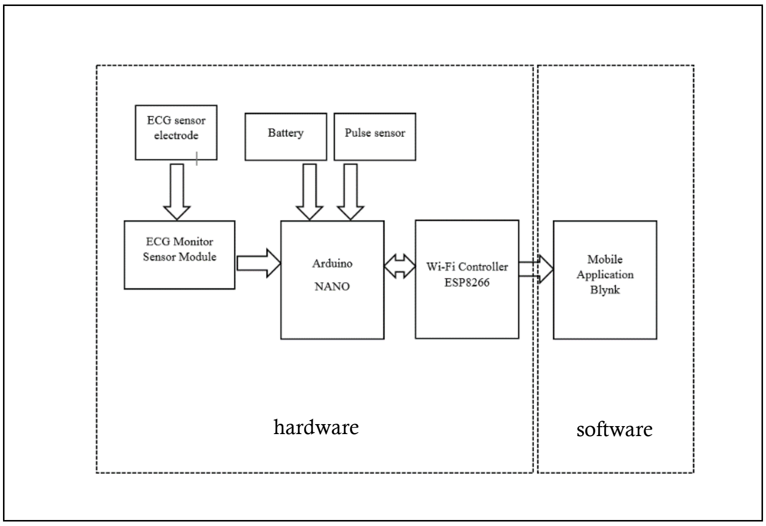

Figure 3 <Block Diagram>

In this proposed system it is constrained the process, working space and simplified the gadget to show the ECG and pulse output. In this system there is a simplified interface for two other parameter ECG and pulse sensor detection. The sensors are placed for secondary parameter detection and are directly interfaced with Arduino processor. The processes input data from the sensor and concludes the final information using program code. It is finally display on LCD. It has sensed the patient's ECG through three lead electrode system via AD8232 which amplifies minor and small bio-signals to the Arduino.

A normal heart rate beat between 60 and 100 beats per minute (bpm), while resting. However, the rate will vary depending on when it is measured and what activities that has been done before the reading (Foundation, 2015). For example, the heart rate for a subject will be higher when measure after a walk compared to when the subject sits or rest. This is because subject's body need more energy when active hence the heart must work harder. The maximum heart rate depends on the age. The heart rate can be identify based on the heart the heart rate reserved or Karvonen formula.

HR Reserved or Karvonen Formula

- The Karvonen formula factors in Resting Heart Rate (HR rest) to calculate Target Heart Rate (THR)
- Its unit is the same with the VO2max whereby,

HR reserve = Maximal HR-Resting HR

(HRR) = (220 – AGE) – HR rest

Target Heart rate

To find the zone, HRR value is then multiply by 0.50 and 0.85 to get the 50% and 85% range followed by adding the resting heart rate value, as follow:

Target Heart Rate = Heart Reserve (*50%~**85%) + Resting Heart Rate
*50%: low end of heart rate, **85%: high end of heart rate

Resting Heart Rate

The most accurate resting heart rate per minute can be obtained by taking the radial pulse in early morning [6]. TABLE 1 shows the resting of heart rate reading based on the difference gender.

Table 1 <Analysis the RHR based on Gender>

Age	**20 - 29**	**30 - 39**	**20 - 29**	**30 - 39**
Excellent	<58	<58	<64	<62
Good	59 - 63	59 - 63	65 - 66	63 - 65
Fair	64 - 70	64 - 72	67 - 78	66 - 75
Normal	71 - 81	73 - 81	79 - 82	76 - 81
A bit high	>82	>82	>83	>82

In perspective of constancy and openness, the ECG is the unmistakable business standard concerning heart checking (Heart & Monitor, 2015). This also makes it the most by and large attempted base contraptions for compact heart watching, while it empowers customers to have a broad point of view of the heart executions, in any case it incorporates unfaltering, direct skin contact remembering the ultimate objective to work.

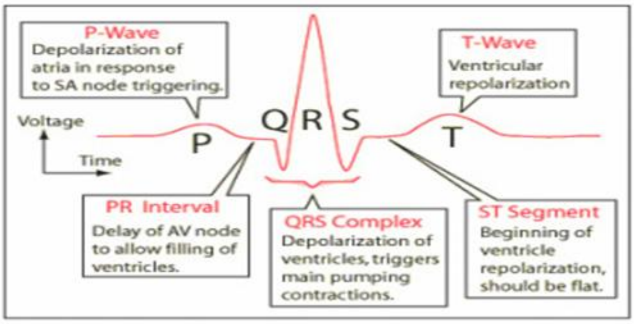

Figure 4 <The Basic Pattern of Electrical Activity Across the Heart>

Table 2 show the parameter of electrocardiogram in heart rate monitoring system thought IoT. There are difference types of waves that can be identified by the using of electrocardiogram sensor.

Table 2 < The Parameter of Electrocardiogram in Heart Rate>

P - Wave	**0.06 – 0.11**	**0.05 – 0.25**	**Produce left and right atrium signal**
Q - Wave	<0.03 – 0.04	<R ½ - 1/4	Deliver left and right atrium signal
R - Wave	-	< 2.5	Deliver left and right atrium signal
S - Wave	0.06 – 0.11	-	Deliver left and right atrium signal
T - Wave	0.05 – 0.25	0.1 – 1.5	Electrical potential of ventricular repolarization
P - Wave	0.06 – 0.14	Coplanar with the baseline	Between P – wave and QRS-Wave
PR interval	0.12 – 0.20	x	Deliver to ventricular
ST - Wave	0.05 – 0.15	Line	Process of ventricular restoration
QT interval	<0.4	x	Process of ventricular repolarization

Results and Discussions

The heart rate monitoring system for patient through IoT is wear by the user at home. The temperature sensor straps are attached at the finger and the electrocardiography sensor are attached in body through 3 lead electrode system via AD8232 which amplifies minor and small bio-signal to the Arduino. Both sensors can be detected and are directly interfaced with the Arduino processor. The processes input data from the sensor and concludes the final information using program code. It is finally display on a LCD.

The percentage of error is calculated to determine the differences between counting heart rate with using HRM based IoT and manually counting the heart rate with stopwatch. Figure 4.7, show the randomly collected data for 30 subjects uses the ECG Sensor that is display on the graph of the measured value versus the accepted value. Based on the graph above, 96.18% indicated the accuracy readings between IoT based IoT (measured value) and manual measurement (accepted value). Where is the percentage error reading calculated is low that is 3.82%. This proves the accuracy of this project in measuring patients' heart rate.

In this study, to measure the HR reading the ECG sensors were attached to the patient's body for collect the health data from the patient. The body temperature which attached to the patient's hand is the part for collect the reading from body temperature from patient and then store to the Arduino Nano and start reading. When the ECG and body temperature sensor have done and got the output, then the data from two sensor must send to the main module by using Arduino Nano interfaced with Node MCU ESP8266. Then, Blynk is open source IoT application where the application we can build directly from smartphone. Therefore, the setup of the measurement can be conducted by a family to monitor the patient condition and doctor. TABLE 4.3 shows the baseline characteristics of population participant among the 30 subjects.

Table 3<Baseline Characteristics of Population Participant>

	Participants (n=20)
Male	18 (60%)
Female	12 (40 %)
Pre-existing condition	
Cardiovascular disease	1 (5%)
Stroke disease	0
smokers	6 (20%)

In this study, the data was collected for a month using Heart rate Device vs. Smart watch by average overall. The finding is as shown in the table below:

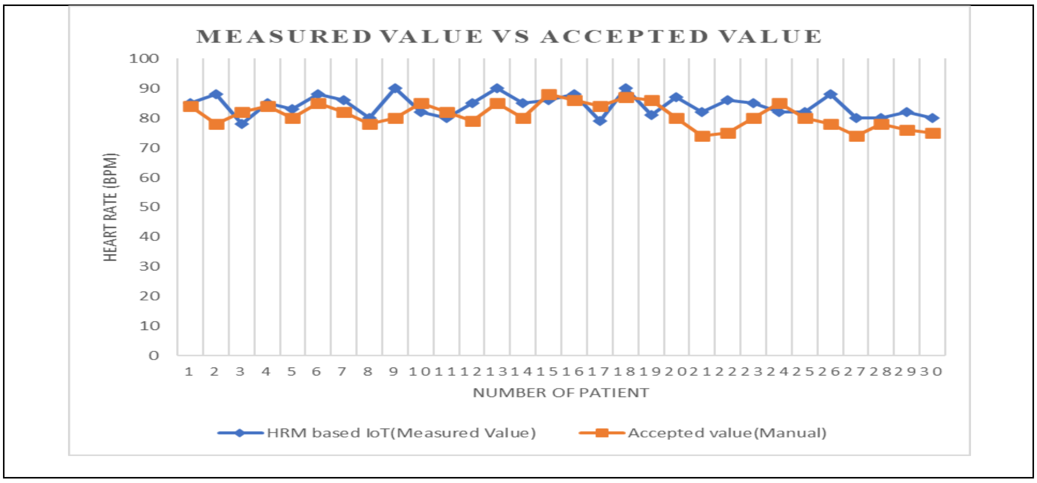

Figure 5 <The Graph of Measurement Value Vs Accepted Value Using ECG Sensor>

The researcher then compare data that been received using temperature sensor to the manual digital thermometer and the results were analyze in percentage of temperature error as per below:

% Error = (measured Value – Accepted Value / Accepted Value) x 100

% Error = (36.9 – 36.82 /36.82) x 100
= 0.21%

Whereas, the percentage of accuracy is,

% Accuracy = 100 – 0.21
= 99.79 %

Average Measured Value (Celsius) = Sum of values / Number of values
= 1107.1 / 30
= 36.9

Average Accepted Value (Celsius) = Sum of values / Number of values
= 1104.6 / 30
= 36.82

This able to show that the measured using this temperature based IoT method able to obtain small differences compared to manual measurement method. The measured data were shown in a graph at Figure 4.8 below.

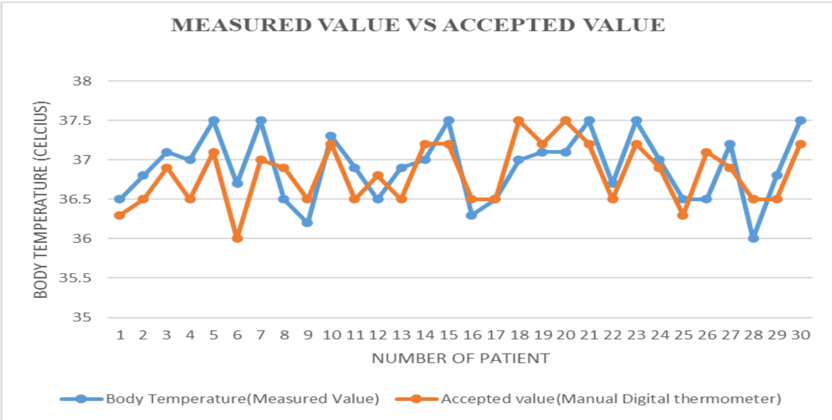

Figure 6 <The Graph Of Measurement Value Vs Accepted Value Using Temperature Sensor>

The data was collected for a 7 days per week for a month for patient A using Heart Rate Based IoT, thermometer and smart watch. The finding shows that on the 1st week, smart watch take reading more accuracy than heart rate device due to lack of electro pad replace on heart rate device. The 2nd week of the month show higher accuracy reading heart rate device due to new pad replacement. On the 3rd week show slightly improve reading of accuracy of heart rate device than smart watch. The last week of the show a declined accuracy in reading due some patient health in abnormal. However, based on the calculation of measured acceptance versus accepted value, the heart rate monitoring system showed high reliability throughout the 7 weeks of the study. All the finding were shown as per graph below.

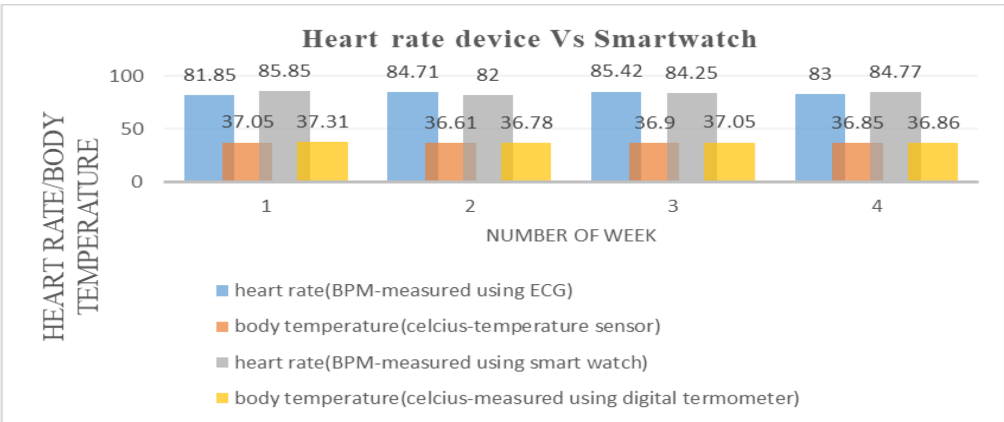

Figure 7 <Heart Rate Device vs Smartwatch>

Conclusions

The proposed healthy monitoring system is useful mainly to improve patient's health care and the quality of life of individuals. It builds for easy accessibility and monitoring by family members for heart rate monitoring system. This system is believed suitable for patient with Chronic Heart Failure (CHF) that need continuous care at home.

This study was successfully implemented of heart rate monitoring system involving low cost and effective. The data transmission from Arduino NANO to smart phone via Wi-Fi module was also achieved. It is very efficient system and very easy to handle and thus provides great flexibility and serves as a great improvement. Here according to the proposed system, doctor does not need to be present while monitoring the heart rate. Patient examination will be easier because this system been developed to be portable and suitable for longer distance data transmission. Once the reading is done, a notification will be sent to guardian and doctor. This enabling them to monitor the patient condition should any reading raise from normal heart rate reading.

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