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Development of Electrocardiogram (ECG) Monitoring System using IoT

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Abstract: This work aims to develop and produce the design of an Electrocardiogram (ECG) system that uses IoT to facilitate the output signal data of the patient's heartbeat flow to be sent to the smartphone of the person in charge for observing the condition and health of the patient's heart, which the limitations of typical ECG systems provide only a snapshot of heart health at a specific moment and limit mobility, the solution is develop ECG system that uses IoT that enables continuous remote monitoring to get real-time normal ECG signal and comprehensive long-term assessment of a patient's heart condition. This research is to develop an electrocardiogram (ECG) device based on module AD8232, to develop and integrate IoT-based ESP8266 and to analyze ECG signal and real-time monitoring system, which uses the ECG module sensor AD8232 and use the Durian Uno with ESP8266 Wi-Fi then will view the result in Blynk application. The experiment was to observe three volunteers with different weights and heights and also different ECG lead placements. Multiple tests using the created ECG device and the laboratory ECG were used to corroborate this. In the final stage of this work, the result for the real-time signal of the ECG that develops is the same as the ECG signal of normal people. However, it was challenging to achieve these goals, which suggests in the future, some filters for the ECG signal result to get excellent output can be more accurate and relevant to use in hospitality.

Keywords: Development Of Electrocardiogram (ECG), Iot-Based System, ECG Signal And Real Time Monitoring System

1. Introduction

An ECG is a simple and valuable test used to determine the trends of one's heartbeat. Sometimes it can diagnose a heart problem. However, a normal ECG does not rule out serious heart disease. For example, the patient may have an irregular heart rhythm that 'come and go', and the recording can be normal [1].

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Electrocardiogram (ECG) system that uses IoT to facilitate the output signal data of the patient's heartbeat flow to be sent to the smartphone of the person in charge for observing the condition and health of the patient's heart. With this system it can improve the ability to diagnose heart problems and improve the quality of medical devices in hospitals to overcome the limitations of manual operations with the use of applications based on IoT. This mobility ECG was recommended wherein the patient constantly records the patient’s heart rhythm. A wearable mobility ECG could be a helpful tool in remote monitoring of the heart condition of the patient in which patient has the freedom of movement and stress free since the patient is no longer connected to the ECG recorder or computer with cables. It could be used at home while watching television, sleeping and others while the patient’s heart pulse and rhythm was recorded and monitored. It will improve the delivery of healthcare and the quality of people’s lives [2].

The previous researches related to ECG and IoT show different findings in measure the ECG signal of people. Some of the findings do not get accurate real-time ECG signals, and other than that needs to address the long-term monitoring capabilities so that the IoT result can be monitored. In this work, an electrocardiogram (ECG) device that allow the user to view the measurement in the IoT platform is developed.

2. Materials and Methods

The requirements are divided into three phases to ensure a smooth implementation. The first phase involves thorough research of relevant papers and websites. In phase two, circuits are constructed, and hardware components are assembled based on identified parameters. The sensors undergo calibration, and their performance is assessed through output results. Phase three focuses on developing hardware that takes the input signal from the heart rhythm when electrical activity happens. Then, the amplifier will amplify the signal before entering the microcontroller, and the next microcontroller will process the data and then display it via Arduino IDE or Matlab before the data becomes IoT. After that, the data will be transferred to the smartphone using IoT. The output data on the smartphone can be displayed in the IoT platform in smartphone software called Blynk.

Figure 1 shows the block diagram of the proposed system. The proposed system will take the input signal from the heart rhythm when electrical activity happens. Then, the amplifier will amplify the signal before entering the microcontroller. Next, the microcontroller will process the data and display it via Arduino IDE or Matlab before it becomes IoT. After that, the data will be transferred to the smartphone using IoT. The output data on the smartphone can be displayed in the IoT platform in smartphone software called Blynk.

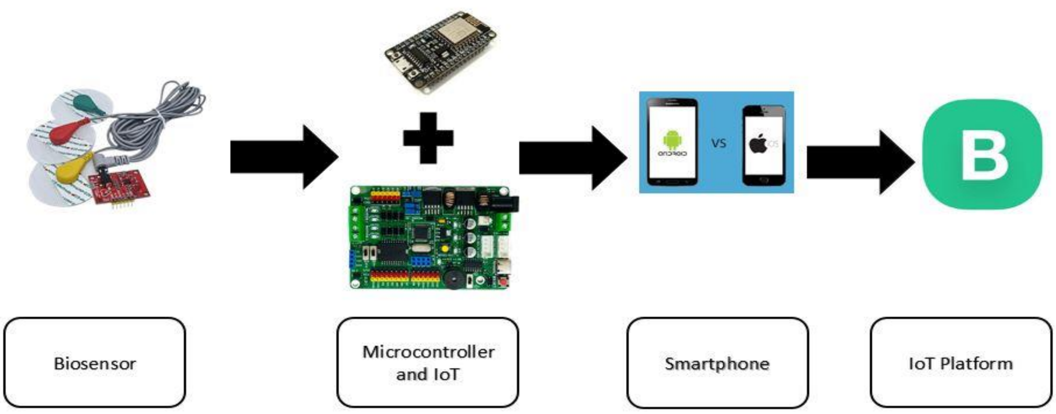

Figure 1: Block diagram for ECG monitoring system base IoT

Figure 2 shows the flowchart for the proposed system. The system will begin with input collected from the ECG Module as a sensor, and then the amplifier will amplify the signal before entering the microcontroller. As a microcontroller, Durian UNO will process the data and then transfer it to the smartphone using IoT. The smartphone output data can be displayed in the IoT platform in smartphone software “Blynk”.

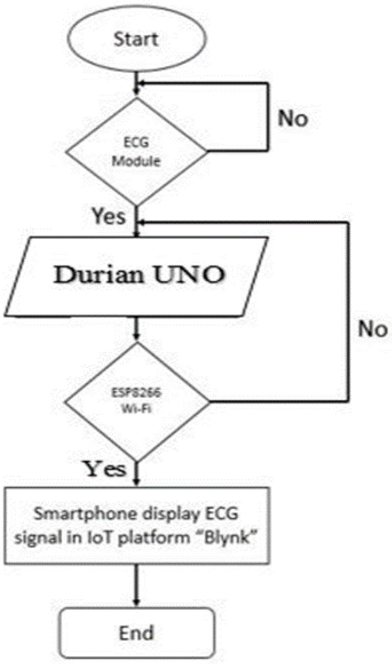

Figure 2: The flowchart hardware of ECG monitoring system base IoT

Figure 3 shows the ECG device that has been developed with IoT. The device has fully functioned well to signal ECG. The device is set to beep the buzzer when any input power is entered, and it also beeps the buzzer when the coding upload succeeds from Arduino Ide, which is the same beep as if any power enters the device. The beep buzzer will make a different beep if the ESP8266 is connected to Wi-Fi. That is, only specific settings of Wi-Fi can connect with this device. After the ECG device made the different beep, the Blynk software was ready to use. Also, only specific Blynk accounts with settings can interact with the device and view the interface inside Blynk software on a smartphone.

Figure 3: The ECG device has been developing with IoT

3. Results and Discussion

The results and discussion of the testing will be discussed. Arduino IDE and Matlab will also perform this result, and IoT results will be displayed in the Blynk IoT platform. The findings will fulfil the objectives of the study. The results obtained from the first experiment Vpp (Max Voltage – Min Voltage = Amplitude of the Voltage) and the results obtained from the second experiment ((Value of vertical box) X (Value of Volt/div) = Amplitude of the Voltage) showed different values of Vpp or amplitude of the signals, indicating that the IoT-based system achieved comparable results to the laboratory ECG that offer the development the near the placement to the heart the longer the Vpp of ECG signal.

3.1 Different ECG leads placement for the develop ECG device with system of IoT

Results can be view on Matlab (refer to Figure 4), and for IoT results is on Blynk (refer to Figure 5), the lead placement has also been adjusted, Lead (RA and LA on hand) and RL on leg, Lead (RA and LA on the chest which distance between them 18cm) and RL on leg.

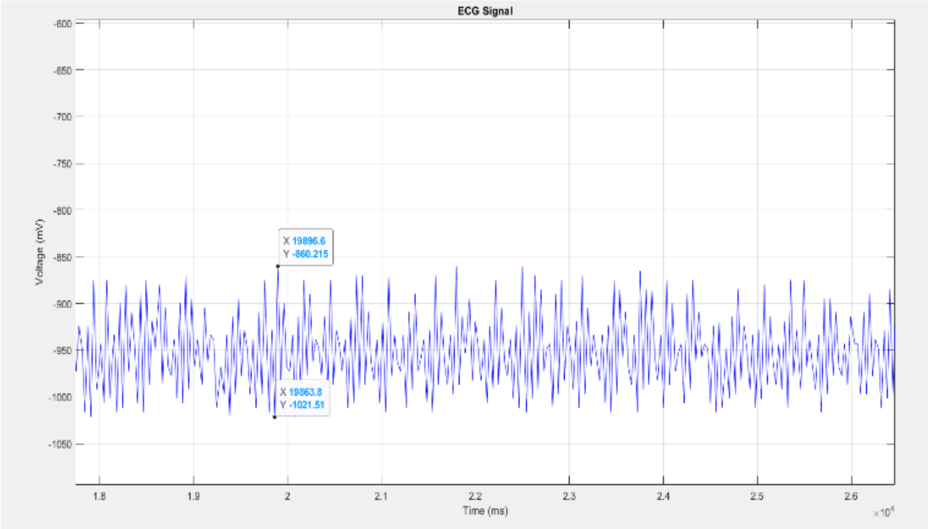

Figure 4: The result of ECG signal view on Matlab

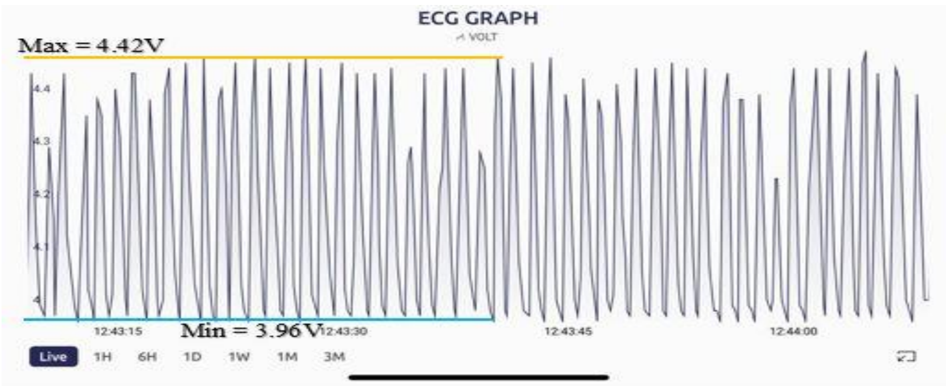

Figure 5: The result of ECG signal view on Blynk

All the figures show the result of volunteer. It can be compared to the finding that the result of the ECG signal when wearing lead RA and LA on the chest and the ECG signal when wearing lead RA and LA on hand that viewed on either Matlab or Blynk. The placement the device near the heart enhances the detection and collection of ECG signals.

From Table 1, the volunteer had to go through the same method of experiment, which was developing an ECG monitoring system device with IoT and wearing the same number of leads, RA, LA, and RL. All volunteers wear leads of two different placements: information (RA and LA on hand) and RL on the leg and lead (RA and LA on the chest, the distance between them is 18cm) and RL on the leg. Then, the volunteer result of the ECG signal will be viewed on three different displays: Matlab, and Blynk. The result is taken from the Vpp or amplitude of the signal result.

Table 1: The result for the experiment 1

Volunteer	Type of display	Result of ECG signal Lead (RA and LA on hand) and RL on leg	Result of ECG signal Lead (RA and LA on chest which distance between them 18cm) and RL on leg
1	Matlab	161mV	268mV
	Arduino IDE	460mV	480mV
	Blynk	460mV	480mV
2	Matlab	58mV	93mV
	Arduino IDE	440mV	500mV
	Blynk	440mV	500mV
3	Matlab	40mV	44mV
	Arduino IDE	480mV	480mV
	Blynk	480mV	480mV

3.2 ECG leads placement for the medical laboratory ECG

From Table 2, the volunteer had undergone the same experiment medical laboratory ECG method and was wearing the same number of leads: RA, LA, RL, and LL. All volunteer wear leads, which is lead RA and LA on hand, RL and LL on the leg. Then the volunteer result of the ECG signal will view on an oscilloscope. The volunteer result displayed view on an oscilloscope is recorded in the table. The value of the result is the Vpp or Amplitude of the signal result.

Table 2: The result for the experiment 2

Volunteer	Result of ECG signal Lead (RA and LA on hand, RL and LL on leg)	Type of ECG waveform refer lab sheet answer on appendix A
1	1900mV	Lead I
2	150mV	Lead II
3	80mV	aVF

3.3 Comparison and analysis between Develop ECG monitoring system device with IoT and Medical laboratory ECG

The comparison was made between the results obtained from the developed ECG monitoring system with IoT on the Blynk view and the results obtained from the medical laboratory ECG on the oscilloscope (refer to Table 3). Both experiments showed different values of Vpp or amplitude of the signals, indicating that the IoT-based system achieved comparable results to the laboratory ECG. However, it should be noted that the signal accuracy was higher in the medical laboratory ECG, which utilized four leads compared to the three leads used in the developed ECG monitoring system with IoT. The medical laboratory ECG also had an ECG module with built-in amplifiers and filtration, enhancing its accuracy. On the other hand, the developed ECG monitoring system with IoT offered the advantage of mobility, while the medical laboratory ECG was stationary. Moreover, the disposable and cost-effective leads used in the developed method were more convenient than the gel-based leads of the medical laboratory ECG, which were difficult to obtain and could become sticky when in contact with the hands. Furthermore, switching between volunteers required placing and cleaning the four leads in the medical laboratory ECG setup.

Table 3: The comparison between Develop ECG monitoring system device with IoT and Medical laboratory ECG

Volunteer	Develop ECG monitoring system device with IoT	Medical laboratory ECG
	3 lead (RA, LA and RL)	4 lead (RA, LA, RL and LL)
	Lead (RA and LA on hand, RL on leg)	Lead (RA and LA on hand, RL and LL on leg)
	Blynk	Oscilloscope
1	460mV	1900mV
2	440mV	150mV
3	480mV	80mV

3.4 Expected Result vs Achieve Result

Refer to Figure 6, the ECG signal graph in the red circle, the ECG signal graph that plots the result achieved from the ECG monitoring device is almost the same as the expected result of signal Figure 7 which normal ECG signal for normal person is 14ms after calculated and the obtained ECG signal from Blynk is 15ms.

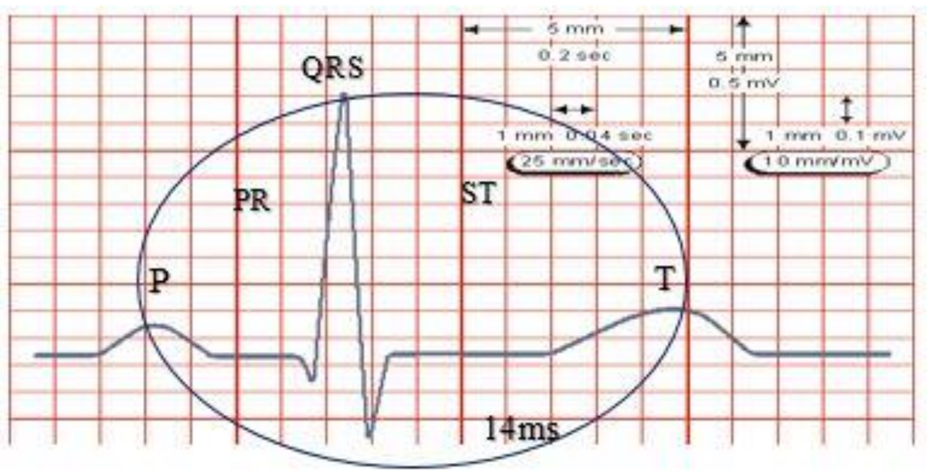

Figure 6: Graph that expected to achieve from ECG monitoring device

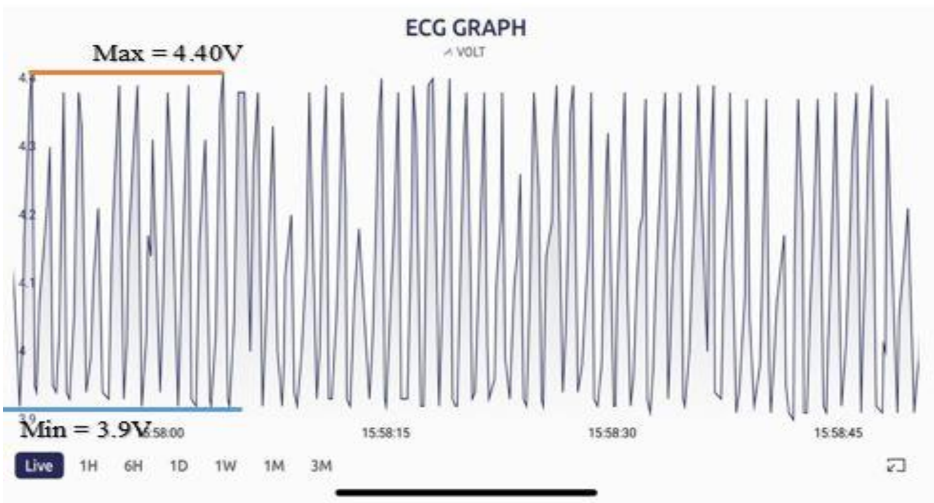

Figure 7: Graph that achieve for ECG monitoring device

4. Conclusion

Finally, Internet of Things (IoT)-based ECG monitoring system was successfully developed. The system enables healthcare providers to remotely assess, identify, and treat patients utilizing telecom technology. Throughout the project, all goals have been met with success. The procedure involves replicating the biosensor's coding to generate a signal and developing the ECG device's hardware. Output signals produced by the assembled device were gathered from the ECG module. To upload the data to the Blynk cloud libraries, the ESP8266 was used to transfer the output signals to a smartphone via an IoT platform. On the smartphone, the Blynk app UI showed the signal data.

Comparisons were done with laboratory ECG signals and evaluated based on their benefits and drawbacks to ensure the produced ECG signal's accuracy. The results were also contrasted using various weight parameter configurations, proving that signal stability rose with more significant body sizes. Multiple tests using the created ECG device and the laboratory ECG were used to validate the measurement. The system had consistent performance in recording and interpreting ECG signals, and it offered real-time data presentation through an intuitive interface. The initiative advances medical technology by improving the usability and effectiveness of ECG monitoring in healthcare settings.

Acknowledgement

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