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DEVELOPMENT OF ELECTROCARDIOGRAPH (ECG) TRAINING KIT SYSTEM BASED ON INTERNET OF THING VIA THINGSPEAK APPLICATION

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Abstract

The Electrocardiograph (ECG) training kit is an instrument used to record the electrical activity of the heart. Due to the difficulties for teachers to teach provide a description of each subtopic taught more accurately in terms of concepts and situations, therefore there is a need for a training kit as a learning aid to improve students' understanding of ECG. This makes it tough for students to comprehend the information related to ECG in detail. Therefore, the objective of this study was to develop an ECG training kit and design a practical laboratory application-based 6-lead ECG sensor kit. Besides that, to evaluate the effectiveness of the use in the learning and teaching process using ECG training kit for a topic related to ECG. The ECG sensor detects the produced ECG signal from the simulator in the ECG training kit. The entire circuit will be operated and processed by the ARDUINO UNO. On Thingspeak, a simulation of the heart rate (BPM) and ECG wave procedure is presented. The output of BPM is also presented on LCD in the ECG training kit. The application-based simulation aid in-class collaboration during practical lab experiments. The project generally consists of two parts, namely hardware development and IoT implementation to prototype boards. For hardware development, an ECG prototype board will be developed using ESP8266 as a microcontroller and Wi-fi module. The ECG sensor module is the AD3282 ECG Sensor kit. ECG data transceiver site will be developed using a ThingSpeak application on a laptop. After successfully performing ECG data capture, the application software will display real-time ECG simulations such as heart rate and output waveform based on a 6-lead ECG electrode. The ECG training kit was considered usable by students and suitable for educational purposes by the lecturer. Future research using this

training kit will be required to assess students' learning and retention of information about ECG interpretation.

Keywords: Training kit, ESP8266, AD3282, ThingsSpeak, Learning

1.0 Introduction

The process of learning and teaching is a type of communicative activity that involves both the lecturer and the student in the educational process. Communication between those parties is primarily the process of communicating knowledge from one to another, as is common between a lecturer and a student. The learning process is mostly carried out in the classroom, where the knowledge is supplied by the lecturer and the student serves as the recipient (Kob, Abdullah, Shamsuddin, 2019). In addition, practical activity or hands-on learning is a component of the learning process, which is typically carried out in a laboratory. According to, laboratory experience while completing the practical lab is designed to improve student comprehension of certain facts and concepts as well as the scientific organization of the facts and concepts. As a result, theory and practical classes are very important in the learning process. Learning aids are a significant tool for enabling information transfer between lecturer and student at the polytechnic, particularly among engineering students, where student-centred learning is viewed as a useful strategy to improve learning effectiveness (Kob, Abdullah, Shamsuddin, 2019). This project is to create an ECG training kit that can be utilized as a learning aid to improve student knowledge reception. The intended learning aids will be created using a practical learning approach.

Biomedical Engineering students also learn medical instruments such as ECG machines. As is well known, the current ECG training kit technologies are costly to be purchased individually either by students or lecturers to support the learning and teaching process in topic related with ECG (Kiak, Ibrahim, And Ramli,2020). Besides, the teaching and learning process, especially for the topic related to ECG, focuses on two-part namely theoretical and practical. Therefore, it is difficult for teachers to provide a description of each subtopic taught more accurately in terms of concepts and situations, which makes it difficult for students to understand the content in more depth (Kob, Abdullah,Shamsuddin, 2019).

The objectives of this project are to develop a kit for 6-lead ECG trainer kit for learning aids with IoT via the ThingSpeak application. To design an ECG Training Kit System for the practical lab from the 6-leads ECG by using the ThingSpeak Application and to improve

students' understanding of ECG signals with easy-to-understand methods when performing practical activities. The main function is to detect the heart rate of 6 lead ECG electrodes. This project will focus on the education sector. This training kit is helpful to biomedical engineering students to do their practical work and also to the lecturer for the teaching materials.

2.0 The Important of Using Training Kit Materials Among Students

The importance of a training kit in the teaching and learning process cannot be overstated. Learning kits can make the process of exchanging knowledge among students on subjects taught more clearly easier. The objective of the training kit is to make it easier and more systematic for students to comprehend the topic. In reality, it may be used to stimulate a student's interest in learning about the ECG machine and ECG signal, as well as to assist them in learning about the ECG machine and ECG signal through a manipulative experience (Kob, Abdullah,Shamsuddin, 2019).

The teaching and learning process, particularly as it relates to topics involving ECG machines and ECG signals, is divided into two parts: theoretical and practical. These two divisions play a vital role in ensuring that students are able to understand the topic in line with the specified objectives, according to the Ministry of Education's curriculum. The emphasis on this topic related to ECG machines and ECG signals is on an application in the form of hands-on work (Kob, Abdullah,Shamsuddin, 2019).

Furthermore, the topic of ECG machines and ECG signals not only need theoretical but also practical knowledge. Because they are more quickly aware of a lesson through hands-on experience than through theoretical understanding alone, most students are very weak with this technology. As a reason, lecturers must apply effective learning kits for students in order to improve their knowledge of a topic while also saving time and retaining student interest. Making teaching and learning easier and more effective than verbal explanations with the suitable selection of learning kit for the topic related to ECG machine and ECG signal (Kob, Abdullah,Shamsuddin, 2019).

3.0 Previous Study

3.1 ThingSpeak Cloud Computing Platform Based ECG Diagnose System

Figure 3 shown there are two main parts to the IoT ECG health monitoring system based on the ThingSpeak platform. The ECG sensor nodes are used to collect raw ECG data using a Node-MCU with a Wi-Fi built-in module and a central broker. The data is

collected, saved as a text file, and delivered to the central broker via an online MATLAB program. For categorization purposes, the software reads and analyses stored data using the PCA technique (Mohamad,Et Al.,2019).

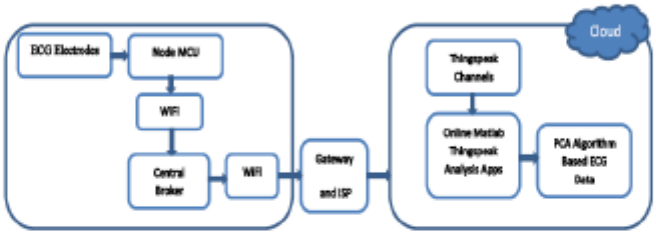

Figure 1: Structure of proposed system

3.2 Designing ECG monitoring Healthcare System Based on Internet of Things Blynk Application

At figure 2, the proposed ECG healthcare system enables the doctor to monitor the patient's remotely using IoT Blynk application installed on his smartphone. The system consists of a set of hardware and software components that are interacted together. These components can be divided into four units, the data collecting unit, Arduino Uno microcontroller, ESP Wi-Fi module and Bynk IoT application (Hasan and Ismaeel, 2020)

Figure 2: Flow diagram of ECG Monitoring Healthcare System

4.0 Method

This system consists of the design of the project, the flow chart and block diagram on how the device works, the sensors that are used, and more.

4.1 Design Project

Figure 3 shows the project's design. It's a description of the project in progress. The overall training kit system is built, including software, hardware, and even a laptop that shows output simulations such as the 6-lead ECG wave, heart rate, and heart rhythm conditions.

(a) (b)

Figure 3: (a) ECG Training Kit. (b) Software Design ECG Training Kit via Thingspeak Using Laptop

This project used some sensors and Node-MCU to design and implement the ECG training kit system based on IoT. The system senses the ECG signal from the ECG simulator (the ECG simulator is not included in the idea of this project) or the human body (respondent) through 6 – leads ECG electrodes via AD8232. This sensor was used to measure the heart's electrical activity called ECG signal. In this project, Arduino UNO is used to convert the analog signal to digital data and transfer the signal via Node-MCU ESP 8266 to the laptop through the ThingSpeak Application.

The ECG monitoring system is also integrated into the training kit system, reading and displaying the cardiac simulation generated by the ECG Simulator. The ECG monitor

will define and show measurements such as pulse rate (bpm) and display a waveform from 6 – leads ECG electrode. Finally, in this training kit, ThingSpeak application software is used to display the whole functioning of the training kit system.

4.2 Block Diagram

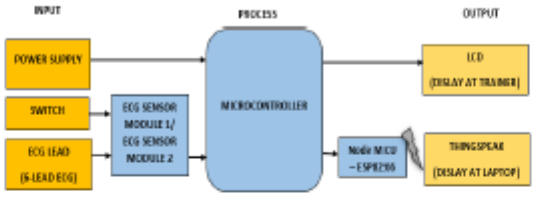

Figure 4: Block Diagram of IoT ECG Trainer kit

Figure 4 shows the input in designing this training kit, its circuit is powered by a direct source which causes the circuit to start operating and has a switch of selection ECG sensor 1 and ECG sensor 2. This project included an aspect of the ECG training kit. Sometimes known as an ECG machine. In showing the signal the ECG signal used by The ECG simulator (the ECG simulator is not included in the idea of this project) or the human body (respondent). The 6 – leads ECG electrode will collect the raw ECG data (analog signal) from the ECG simulator or human body.

The data from 6 – lead ECG electrodes is received by the ECG sensor module (AD8232), which is then sent to the microcontroller (Arduino UNO) and converted to digital data by the microcontroller and the output will display through LCD. While, the Wi-fi module (Node-MCU ESP8266) delivers the digital data to the laptop through the ThingSpeak Application.

A bpm is presented through LCD on the ECG training kit. The output simulation of the ECG is also presented on the Software Application through a laptop when synchronizing it. The software will show a graph from the 6-lead ECG sensor kit and initialize the heart rate value (BPM). The application-based simulation aids in-class collaboration during the practical lab.

4.3 Flow Chart

4.3.1 Flow Chart of IoT ECG Training Kit

The flow chart in Figure 5 is the operational implementation of the project. It is the procedure of the project. This procedure shown steps on how the whole device work:

i. Place on the 6-electrode ECG leads to an ECG simulator or human body.
ii. If the switch is low ECG sensor 1 will detect the signal for lead 1 until 3, while if the switch is high ECG sensor 2 will detect the signal for lead 4 until 6 and measure the electrical activity heart generated from ECG simulator or human body The heart rhythm condition will be analyzed depending on the PQRST value. If the ECG signal cannot be detected, check the connection AD8232 ECG sensor kit with lead.
iii. The data will be processed by ESP8266 and connected to the access point. If it is not connected, check connection with ESP8266 to the access point.
iv. After getting a connection, the ECG signal is sent to the ThingSpeak application.
v. The output simulation from the simulator will display on the LCD (ECG trainer kit) and the ThingSpeak application (laptop).

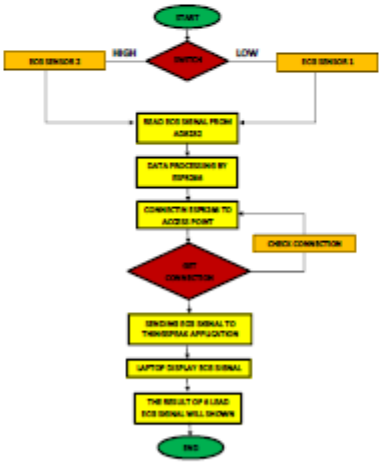

Figure 5: Flow Chart of IoT ECG Training Kit

4.3.2 Flow Chart for SOP of ECG Training Kit

Figure 6 depicts the flow Chart for SOP of ECG Training Kit. This is a project process that displays the wave from a 6-lead ECG electrode, as well as the heart rate and rhythm

condition. Respondents can learn or practice on a laptop using the ThingSpeak application's display.

i. Use a search engine to find a ThingSpeak Application.
ii. Log in to the ThingSpeak App and enter the username and password.
iii. ECG electrodes with 6 leads should be placed on the ECG simulator or responder.
iv. The data will be sent to the cloud through API, and a wave from 6 lead ECG will display in a few seconds in ThingSpeak Application.
v. The heart rate is measured in beats per minute (bpm).

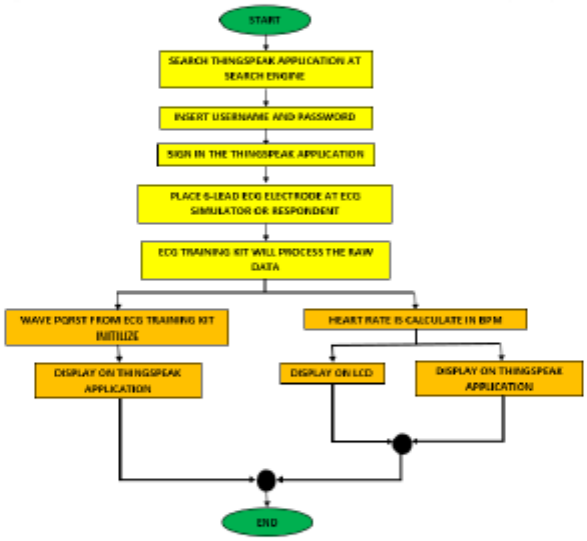

Figure 6: Flow Chart for SOP of ECG Training Kit

5.0 Result

5.1 ECG Training Kit System

The ECG Training Kit system as shown in Figure 7 is developed which comes with elements of ECG training kit and software (ThingSpeak Application). The ECG simulator

(not included in this project) acts as ECG signal generation and provides the heart rate generation, while the ECG training kit and Software is to display output simulation of ECG such as Heart Rate and Heart Rhythm. The main objective in developing an Electrocardiograph (ECG) training kit system as for learning media is achieved and the physical development outcome as shown in figure 7.

Figure 7: ECG Training Kit System with IoT via ThingSpeak Application

5.1 ECG Training Kit Application

Figure 8 is referred to. In implementing the software-based ECG training kit system, the application software is built to display the output simulation. The ThingSpeak Application is used to create application software. Few main elements are designed to be displayed on the front layout (of Application software) such as heart rate and ECG Waveform visualization. The side elements such as time, reset save /export data are also

have on the application for display. The function of every designated element is as follows:

- Heart Rate: displays heart rate value in beats per minute
- Heart Waveform Visual: displays the heart waveform depending its heart rate.
- Time: displays time
- Reset: deletes all data
- Save /export data: the data will save into Microsoft Excel

Figure 8: ECG Training Kit Application

6.0 ECG Training Kit Application

6.1 Questionnaire

Figure 9 shows the survey about the development of an ECG training kit system based on the Internet of Things via the Thingspeak application. There are 8 questions have been asked to 25 respondents involved.

The impact of the implementation of the ECG Training Kit system was evaluated from the survey feedback. The feedback data is processed and graphed as in Figure 36

for this study. The data analysis of the survey was conducted from a questionnaire which distributed to respondents. For question one (Q1), 91% of the respondents agree that the ECG training kit can improve students learning process. For question two (Q2), 82% of respondents agree that the ECG training kit can help students learn and understand topics related to machine ECG quickly, the rest 18% disagree that the ECG training kit can help students learn and understand topics related to machine ECG quickly.

For question three (Q3) in the product design/features section, 82% of the user think the features in this ECG training kit device and the ThingSpeak application are easy to use and 91% of the user think the devices is a portable or easy-to-carry device in the question four (Q4). For question five (Q5), 73% of the respondents love the software-based features implemented in the ECG training kit.

In the third section, the learning material is applied to the questionnaire. In question six (Q6), 100% of the respondents respondent satisfied with the implemented learning material of ECG in the training kit. In the second last question (Q7), 91% of the respondents believe that the presence of a display on the ECG application software (e.g.: PQRST wave) on the system is very beneficial to students in completing practical lab in the face -to -face or online. Lastly, in question eight (Q8), 100% of the respondent understand the concept of electrocardiogram (6-leads ECG placement). Most of the respondents were able to analyze and recognize the output simulation generated through the ECG training kit. Overall, the majority of respondents that have tried the ECG training kit system are giving positive feedback. The majority of the respondents agree that this product can improve their knowledge of electrocardiographs (ECG).

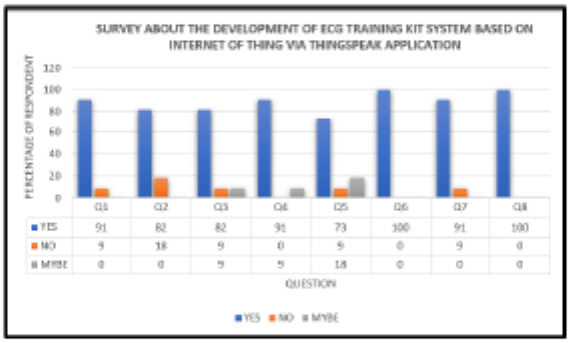

Figure 9: Survey about development of ECG training kit system based on internet of thing via thingspeak application.

6.2 Data Analysis for Transmission Data and Connection Test

Testing of data transmission was carried out to determine any disturbances or errors during the data transmission process. The sensor data from the database (displayed on the ThingSpeak Application) compared with data from the LCD display. The results are presented in Table 1, shows heart rate in bpm data from AD8323. The data on ThingSpeak Application and the data on the LCD display are all the same. It revealed that the transmission data and connection test between data display at ThingSpeak Application and LCD is a success since the data is transferred directly, supported by the connection which it is stable with 0 % of error for normal, tachycardia, ventricular fibrillation, atrial fibrillation and bradycardia.

Table 1: Transmission Data and Connection Test on LCD and ThingSpeak Application for Heart Rate

Subject	Heart Rate(bpm)		
	LCD Display	ThingSpeak Apps	Error (%)
Normal	80	80	0
Tachycardiac	108	108	0
Ventricular fibrillation	36	36	0
Atrial fibrillation	120	120	0
Bradycardia	46	46	0

6.3 Comparison ECG Measurement Between ECG Wave (Theoretical) and ECG Wave from Training Kit (Project)

Table 2 tabulates the number of subjects their reading of value PQRST wave. In general, it found that each value from both theoretical and ECG training kits had a significant difference. The P amplitude for the theoretical value is 0.15 mV while the measured value from the ECG training kit is 0.17 mV and the percentage error is 13,3%. The QRS height in theoretical is 1.5 but at ECG training kit is 1.8 with the percentage of error is 20%. At the ST level, the theoretical is 0 same value as the ECG training kit. So that the percentage of error is 0% for the ST level. Lastly, the T amplitude in theoretical is 0.3 while the ECG training kit measure is 0.32 and the percentage of error is 6.7%.

Table 2: Data Collection between ECG training kit and theoretical for value of PQRST wave

Subject	PQRST wave (mV)		
	True value	Measured	Error (%)
P amplitude	0.15	0.17	13.30
QRS height	1.50	1.80	20.00
ST level	0.00	0.00	0.00
T amplitude	0.30	0.32	6.70

7.0 Conclusion

The development of an electrocardiograph (ECG) training kit system based on the Internet of Things via the Thingspeak application is successful done in this project. The developed training kit system is significant as its benefits overcome the issues faced by biomedical

students and lecturers. It also achieves its' objective when it analyzed when an ECG training kit has been developed for learning materials, a software-based training kit system to facilitate students doing practical lab via online learning or face-to-face. Lastly, to improve students' understanding of ECG signals with easy-to-understand methods when performing practical activities.

8.0 Recommendation

This project leads to various promising topics for future investigations. Many elements have to be implemented and improved in the training kit system. For example, using a better application or system there is no delay to get real-time PQRST waves. This will give the real-like experience of the user in performing the ECG. This also will increase the improvement in gaining knowledge among the students.

Secondly, produce a smaller or half size from the developed life-size ECG training kit. It will be easy for users to bring anytime and anywhere. Thirdly the addition of 12-leads ECG also can be improvised to make it varied and add more ECG learning material in it. Lastly, The ECG wave can produce for each lead.

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