بسم الله الرحمن الرحيم

An-Najah National University

Faculty of Engineering and Information Technology

Computer Engineering Department

Graduation Project II

Health Monitoring System

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Disclaimer

This paper was accomplished by Wa'ad Khalifa and Aseel Bustami. Any error in this paper would be the authors' fault. All ideas, recommendations, results, and opinions expressed in this paper are the authors' own and don't reflect the view of An-Najah National University.

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Chapter 1

Abstract

With the recent rapid technological progress, technology has had a significant and noticeable impact in various fields. The Internet of Things (IoT) has successfully dominated most of the industrial sector, particularly automation and control, as well as the health and biomedical industries. In normal cases, doctors carry out medical examinations of patients, so it begins with recording preliminary reports for patients and then conducting examinations. It takes time and effort, especially if there are cases that are more important than others, so the fear is that some cases will be neglected at the expense of others. To solve this problem, a solution was found so that the patient is monitored remotely and the necessary examinations are performed for the patient using modern technology. These examinations are almost equivalent to the traditional examinations that are conducted face to face, as they have several advantages as they are less expensive, effective, and comfortable for the patient and achieve satisfactory results.

With the increasing use of the Internet and the increase in dependence on mobile phones and devices in general, it has become possible to manufacture health monitoring devices that can be worn or carried to any place and used at any time and anywhere, and sending the results to the doctor, for example, without the need to go to the hospital and do repeated examinations, So that the doctor is constantly informed of the results to inform the patient, if necessary, to come to the hospital.

In this project, a model was designed to monitor the patient's health status. This system facilitates the process of diagnosis and examination for the patient as the body temperature, heart rate, blood oxygen and ECG signals are measured, using the following sensors respectively: DS18B20, MAX30100, and AD8232. In addition to an alarm for medicine times.

In addition to a bracelet to detect the patient in the event of a sudden fall by notifying family member and sending them a message immediately upon its occurrence via WiFi module.

This will be done by building fall detection device using NodeMCU and MPU6050 sensor module which will be used as microcontroller and Wi-Fi module, to connect with IFTTT to send messages.

This project consists of two parts, consisting of two devices. The first device is for measuring the vital signs of the body. This information is shown directly on the Nextion screen (touch screen) and at the same time it is sent to the Blynk application(website and mobile app). The second device, which is the bracelet, which works as a fall detection system with a sensor to measure the heartbeat, so that the information is sent directly by message via IFTTT to one of the patient's family member to alert them to the patient's condition.

Chapter 2

Introduction

2.1 Problem

According to the World Health Organization(8), heart disease remains the leading cause of death globally, and it kills more people today than ever before, so new solutions for patient health management are a must.
Aged people or patients, in general, typically require more frequent health checks, which puts additional strain on the current medical systems, which constitutes a huge burden on hospitals as well as large costs for the patient, so it was important to find a solution to this problem so that medical examinations are performed without the need to go to the hospital frequently.

According to the Centers for Disease Control and Prevention(2), about 36 million falls among older individuals are reported each year, leading to more than 32,000 deaths. Additionally, one in five falls results in injuries such as broken bones or head injuries. Falling is not a normal part of aging, so the health condition of the elderly person must be disclosed and an alert sent to a family member of the elderly person if he is exposed to a sudden fall.

2.2 Objective

Our main objective is to implement a system to monitor and measure the patient's vital signs remotely, which reduces costs for the patient, reduces pressure on the hospital, and protects the patient from injury as a result of a sudden fall.

- Health monitoring system device to measure:
  - Heart rate.
  - Blood oximetry.
  - Body temperature.
  - Electrocardiogram.
  - Medicine reminder.
- Electronic bracelet: The bracelet will be able to detect the patient suddenly falling to the ground.
  - Heart rate measurement.
  - Sending an alert or an SMS to a patient's family member.

2.3 Scope Of the Work

Our devices focus in general on the patient's health, we give the patient and their family the ability to conduct self-examinations quickly in order to check on the patient's health.

2.4 Importance

Heart disease is one of the worst illnesses that can currently endanger human life. When a patient and a provider are not physically present with one another, this approach is known as telemedicine. It combines information and communication technology for medical use, and it offers a new method of providing medical care. This device will be also beneficial to rural areas. One aspect of telemedicine that can constantly be improved is patient monitoring. A patient monitoring system has the benefit of lowering the risk of infection and other complications to keep patients comfortable. Additionally, the implementation of patient monitoring in hospitals may result in lower maintenance costs.

2.5 Report Organization

The first chapter is the abstract. The second one is about the introduction. The following chapter is chapter three, it will discuss the limitations we faced when developing this system will be covered in more detail, and will also highlight the courses required to complete it. Chapter 4 is the literature review, it talks about applications that are similar to our project or in the same field. Chapter 5 is the methodology, it will describe the method required to complete this work, as well as the tools and technologies employed to develop this system. Chapter 6 is the results and discussion, it will discuss the outcomes of the project. Finally, chapter 7 will discuss and talk about the conclusion and recommendation.

Chapter 3

Constraints and Earlier coursework

3.1 Constraints and limitations

1. **Electronic components**: Electronic components are very sensitive and easy to burn or damage, so we had to deal with them with caution, and also due to our lack of experience in dealing with some of them in terms of electrical connections.

2. **Time limit**: This is the first time that we are making an integrated performance device from scratch, consisting of hardware components that we do not have sufficient knowledge about, we had to identify the components and know how to use them, and identify the connections, as well as get to know the Arduino and write codes for the hardware, and then build a complete system works properly. It was a little difficult because we did this under the pressure of a normal semester, where we had other commitments like subjects projects and assignments.

3. **Internet connection**: Both devices that we manufactured need to connect to Wi-Fi in order to send information to the computer or mobile phone, so we suffered from an interruption of the internet and we must always be in a place where Wi-Fi is present because the components mainly depend on Wi-Fi, such as ESP32 and NodeMCU ESP8266 (Wi-Fi module).

3.2 Earlier coursework

During our education phase in computer engineering, we took several courses such as digital design, microprocessors, electrical circuits, electronic circuits, and microcontrollers, which helped us build this system. Moreover, we have taken some online courses for our needs to get the work done and we learned several basics about Arduino and writing codes.

Chapter 4

Literature Review

We reviewed several previous works used to monitor the patient's health status and reviewed them to take advantage of them in building this project.

- There are many applications available now that use smartphones for health monitoring such as Sinabro which is a mobile electrocardiogram (ECG) monitoring system that keeps track of the user's ECG while they use their smartphone on a daily basis. It is a prototype ECG sensor that may offer physiological status related to the ECG and be integrated with a smartphone and the Sinabro system. With the use of prototype-based experiments and monitoring of phone usage, they demonstrate the approach's fundamental viability based on daily smartphone usage. it will enable the daily detection and prevention of heart problems such as arrhythmia and heart attack. (5).

- Sometimes the goal of designing such applications is to improve the lives of patients and not just to monitor them. Here, a patient monitoring system was developed, which is an alternative to help patients with chronic diseases. For example in this paper (3), the aim was to develop an ontology-based solution with the ability to monitor health status and exercise recommendations with chronic disease architecture. A sample was made on 16 people who used the system for a month to verify the efficiency of the system used in patients with diabetes and arrhythmias. In addition to having the smartphone application, each measuring sensor had diabetes, and EGC, Bluetooth audio devices to broadcast audio guides were created to take readings and exercise programs.

- Another IoT-based method for ECG monitoring, a wearable monitoring node is used to collect ECG data, which is then wirelessly sent to an IoT cloud (10). The proposed system is reliable in gathering and showing real-time ECG data, according to experiment results, which can help in the initial detection of several heart diseases.

- This paper (6) applies a patient's heart rate monitoring system which is an inexpensive ECG data acquisition system, where a new monitoring system of the Lead I electrocardiogram (ECG) signal by using a wireless steering wheel has been developed, and then the results were presented using MATLAB and Raspberry Pi.

- This paper proposed an IoT-based ECG monitoring system with an integrated ECG sensor (1). The system computes the patient's heart rate and sends the value, expressed in beats per minute (bpm), to a cloud-based database. All of the crucial patient health-related parameters may be collected and transferred to the cloud using this technology, which can be connected to an ambulance. This system's main goal is to collect physiological parameters using sensors and upload them to the cloud.

- In this paper (9), a wearable device with a single triaxial accelerometer was used to construct a fall detection system. The system's extremely effective algorithm and low power-consumption hardware design may help the wearable device last longer. The development of technology opens up more opportunities for protecting the elderly. The elderly's declining physical fitness and falls always result in major health problems. Due to the great impact of most falls, the fall itself is the primary cause of injuries. The faster the salvage comes, the less risk the elderly will face.

Chapter 5

Methodology

5.1 Technical choices

- **Arduino**
  Arduino is an open-source platform, it is used to create electrical projects. Both hardware and software(IDE) make up the Arduino platform(4). The circuit board of an Arduino contains a variety of parts that interface with one another. There are many pins that can be utilized to link the Arduino to different components which can be divided into two types: 14 digital I/O pins and 6 Analog pins. Also, it contains a power connector and a serial connector. The Arduino's main component is a microcontroller, which you may program to enable it to carry out commands. In addition to a number of additional components(7).

- **Libraries**

  1. HardwareSerial: used for connecting serially between esp32 and Arduino mega.
  2. BlynkSimpleEsp32, WiFi, WiFiClient: used to configure the connection between ESP32 and Blynk application.
  3. OneWire: used to access temperature sensor.
  4. DallasTemperature: used for Dallas Temperature ICs.
  5. RTClib: used for RTC.
  6. Wire: used for communicating with I2C devices.
  7. EEPROM: used for writing/reading EEPROM's bytes.
  8. ESP8266WiFi: used to connect NodeMCU to the internet.
  9. MAX30100_PulseOximeter: used to support the MAX30100 Pulse Oximetry IC.

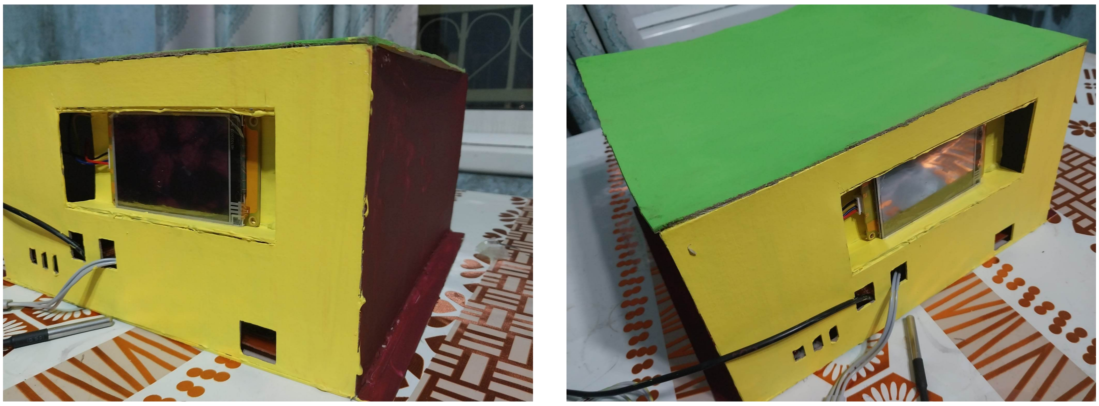
5.2 Methods and techniques

5.2.1 External design

- Health Monitoring System device: The device should be small and light to be carried anywhere and at any time, and its design should be simple so that it is easy to use. When designing it, the following was taken into account:

  - The outer body consists of a cartoon box, the internal connections are hidden and only what is needed to perform a medical examination is shown, as there are several necessary holes in the box.

- The size of the box is small, and the screen is placed on it from the outside.

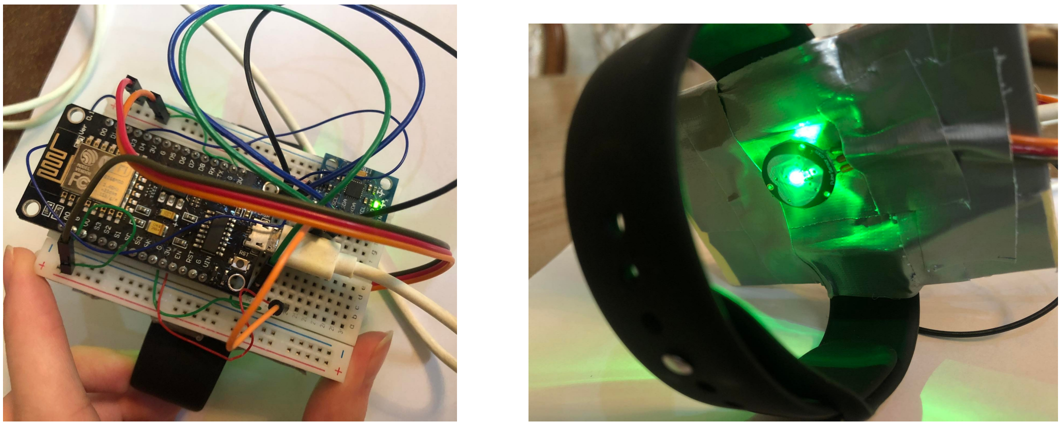


(a) Front side (b) Upper side

Figure 5.1: Health monitoring system device

- Electronic Bracelet:

  - The bracelet is designed to carry a small board and straps have been installed on it, as it is similar to smartwatches.



(a) Front side (b) Back side

Figure 5.2: Electronic Bracelet

5.2.2 Electronic components

- Health Monitoring System device:
  The two basic components in the system were ESP32 and Arduino Mega. We used both of them because not all of the pieces fit to be connected only to the Arduino. Problems occurred with the MAX30100, so we separated the module. Only MAX30100 was connected to the Arduino Mega as it is suitable for it and contains the required pins. As for the ESP32, the rest of the components were connected to it because it contains the pins we need. All components are inside the box.

  ESP32 is interfaced with the following electronic components:

- **AD8232 ECG Heart Rate Monitor sensor:** Electrocardiography, or ECG/EKG, is a technique for detecting electrical changes brought on by heart activity. It is a tiny chip used to measure the heart's electrical activity. An electrocardiogram can be used to graph this electrical activity. To assist in the diagnosis of various cardiac diseases, electrocardiography is employed. The measurement is done using 3 electrodes, which can be placed in two different ways as figure 5.3 shown

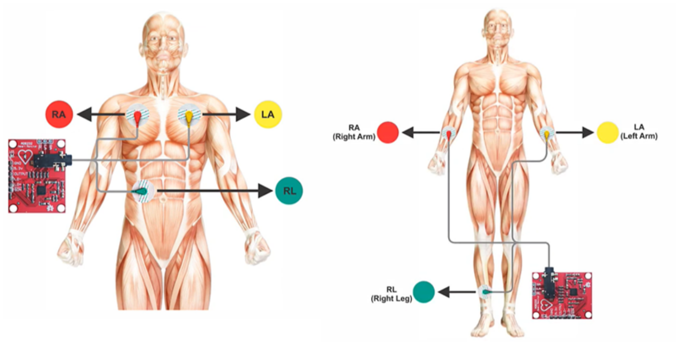


Figure 5.3: Electrodes placement.

RA: placed on the front of the right wrist or on the right side of the chest.
LA: placed on the front of the left wrist or on the left side of the chest.
RL: placed on the front of the right leg or on the lower right abdomen.

- **DS18B20 Temperature Sensor:** it is a 1-wire communication protocol with a waterproof option. It may be used practically anywhere because it is lightweight.
- **MAX30100 Pulse Oximeter:** the sensor can monitor heart rate and pulse oximetry (SpO2) signals and operates according to the I2C communication protocol.
- **RTC:** Real-Time Clock, it measures the passage of time.
- **Buzzer:** it is used to sound an alarm, as well as to hear the ECG pulses.
- **LEDs:** they light up when the alarm goes off.
- **Battery:** to supply the power.
- **Wires:** to connect the components.

• Electronic Bracelet:
The basic component in this system was NodeMCU ESP8266, it contains the pins we need in the connections. The components are shown on the board on the bracelet.

NodeMCU is interfaced with the following electronic components:

- **MPU6050:** it is six-axis motion tracking device.
- **Pulse sensor:** it is heart-rate sensor.
- **Battery:** to supply the power.
- **Wires:** to connect the components.

5.2.3 The process

The patient is seated in a comfortable way so that the medical examination can be done correctly. The electrodes in figure 5.4 are connected in an aforementioned way, paying attention to the part that needs to be connected to the right side and the part that needs to be connected to the left side. The ECG will appear clearly on the touch screen, which shows if there are problems that the patient suffers from or the presence of a certain heart disease that requires going to the hospital. The figure 5.5 explains the shape of the pulse in details.

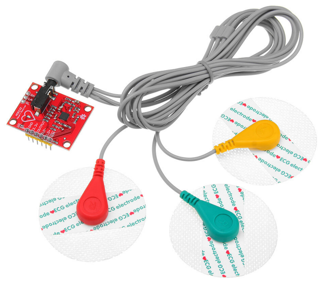


Figure 5.4: ECG sensor.

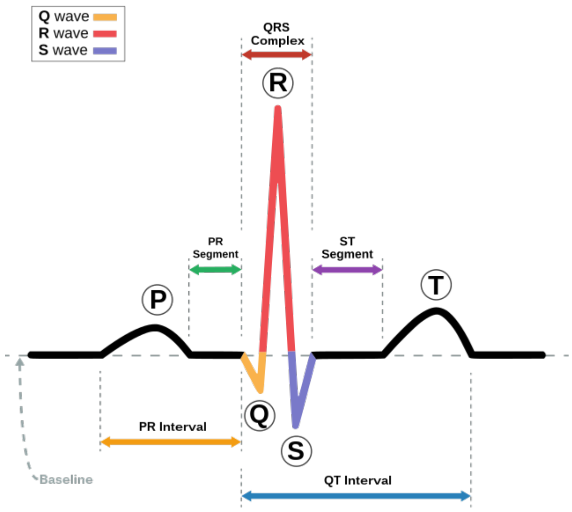


Figure 5.5: Electrocardiogram of a pulse.

Table 5.1

Symbol	Representation
P-waves	Atrial depolarization.
PR interval	The time taken for the electrical activity to move between the atria and ventricles.
QRS complex	Depolarization of the ventricles.
ST segment	The time between depolarization and repolarization of the ventricles.
T-wave	Ventricular repolarization.
QT interval	The time taken for the ventricles to depolarize and then repolarise.

Then the patient places a finger on the MAX30100 sensor as shown in figure 5.12 in order to measure heart rate, and blood oximetry (SpO2). A normal resting heart rate for adults ranges from 60 to 100 beats per minute a rapid heart rate outside 60 to 100 beats per minute should be monitored closely may be a heart attack. The sensor operates by shining both lights onto the finger or another area with thin skin so that both lights may readily penetrate the tissue. A photodetector is then used to measure the amount of light that is reflected.

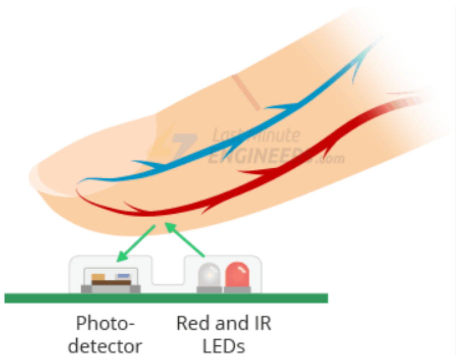
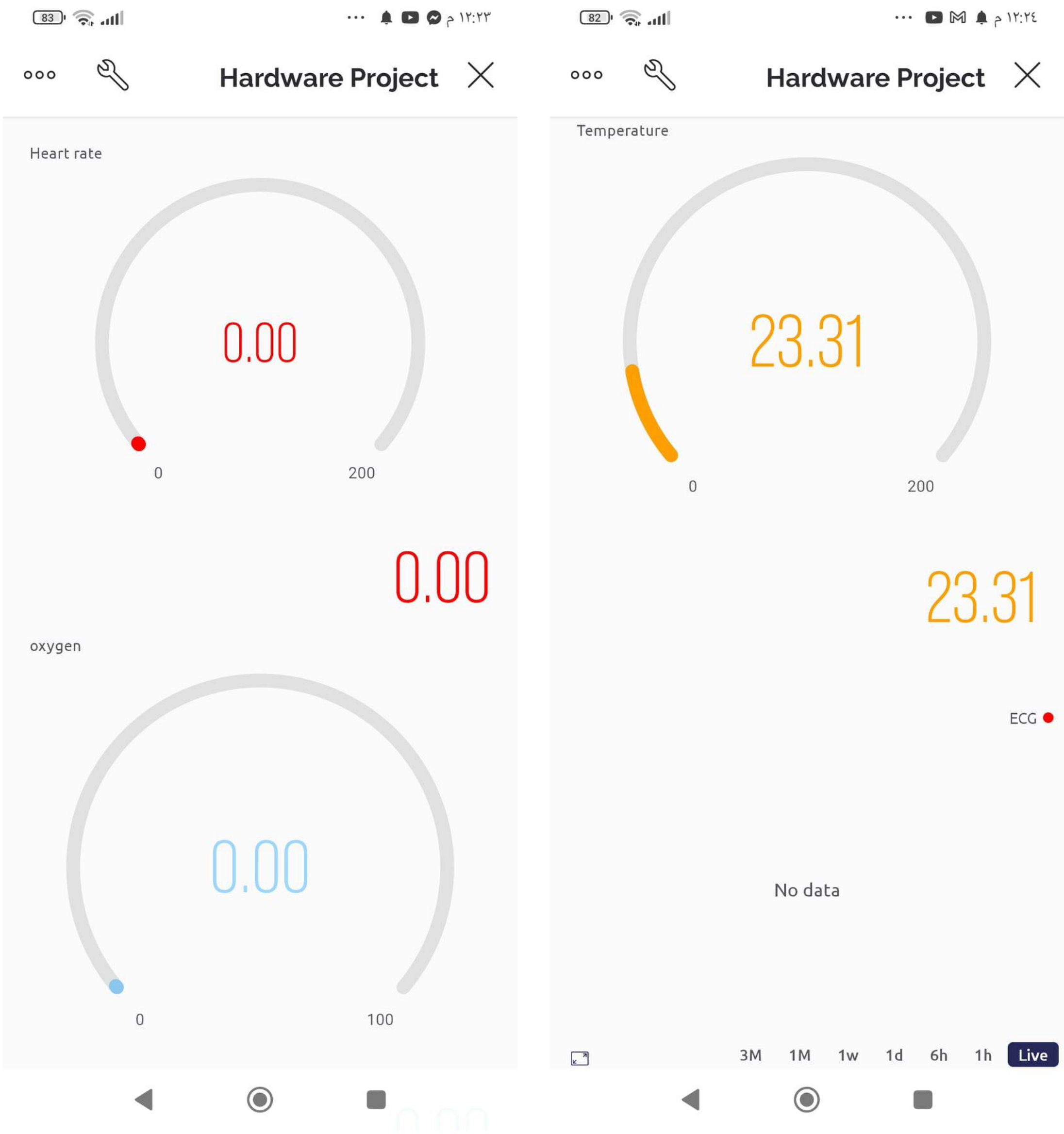


Figure 5.6: How to put the finger on the sensor.

A DS18B20 temperature sensor will be fitted to the patient and placed under their armpit. The sensor will then take the patient's temperature, and the information will be transferred to the microcontroller.

Figure 5.7: DS18B20 temperature sensor.

All the results will be processed by the microcontroller, then they will be displayed on Nextion display. The results that have entered the microcontroller will also be sent to the Blynk web page and application.



(a) Heart rate blood oximetry

(b) Body temperature ECG

Figure 5.8: Blynk mobile application

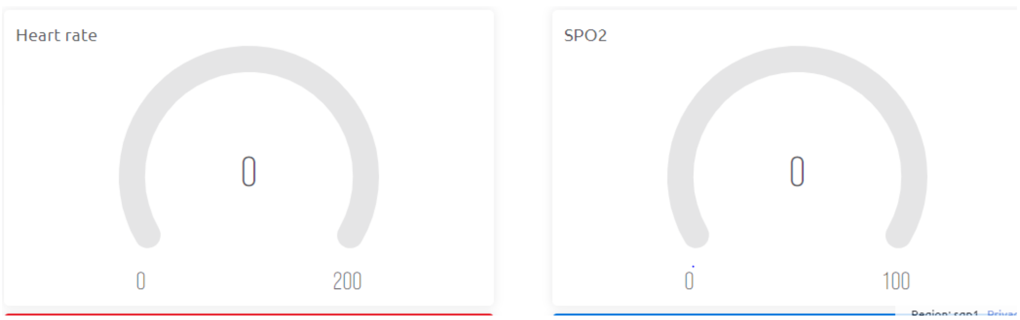


Figure 5.9: Hear rate SpO2 in Blynk web dashboard.

Figure 5.10: ECG using Blynk web dashboard.

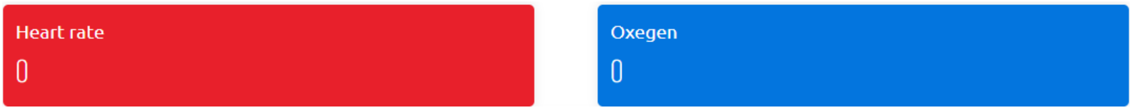


Figure 5.11: Hear rate SpO2 in Blynk web dashboard.

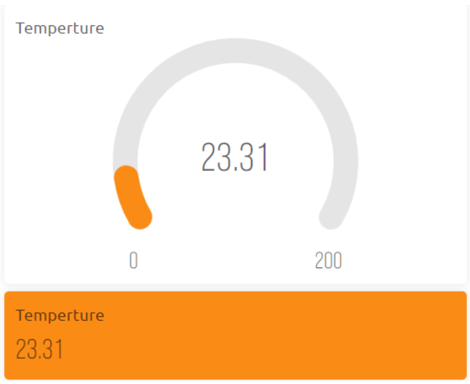


Figure 5.12: Body temperature in Blynk web dashboard.

As for the bracelet, the elderly wears the bracelet, especially when leaving the house. Wearing it is very simple, as it resembles a smartwatch, and doesn't require any effort. There is a sensor at the bottom to measure the heartbeat per minute, see figure 5.13, it is a plug-and-play heart-rate sensor. The sensor adds noise cancellations, and it is substantially quicker and simpler to obtain accurate pulse measurements.
The use of this sensor is quite simple. Place your finger, earlobe, or wrist on top of the sensor (where there is a thin layer of skin), and it will detect your heartbeat by detecting the change in light caused by the expansion of your capillary blood vessels. The sensor will continue measuring the pulses, and if the patient falls suddenly, it will immediately send an alert to one of the patient's family members with the value of the current pulse as shown in figure 5.14, so that the patient's family can know if there is a danger that the patient suffers from or an abnormal event, so they can then deal with the situation quickly.

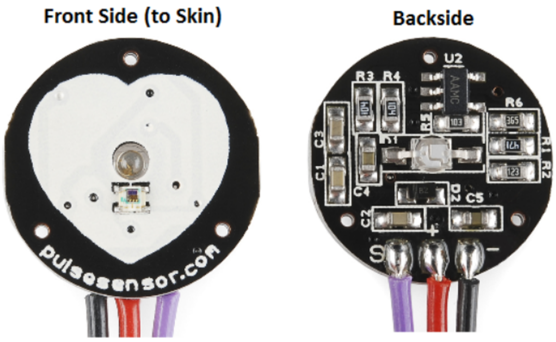


Figure 5.13: Pulse sensor.

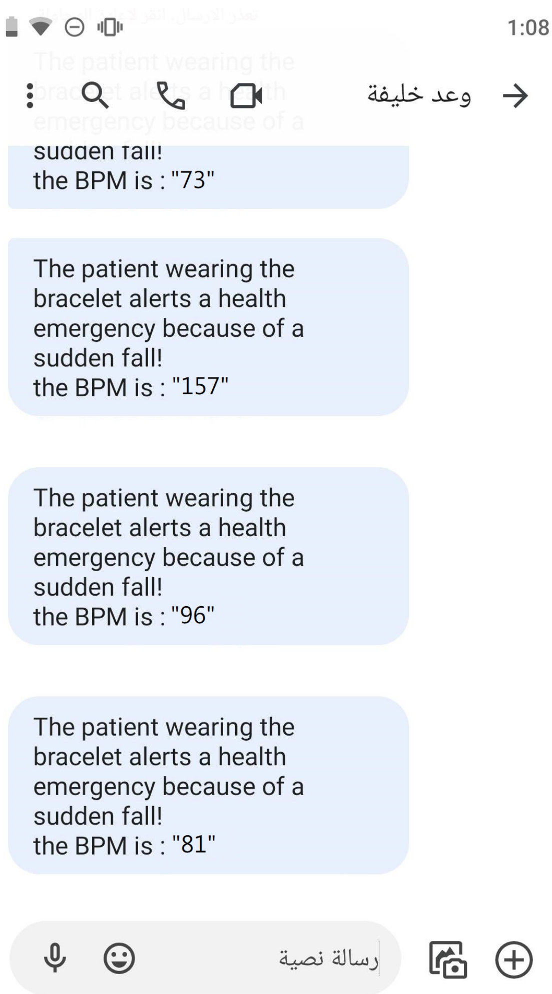


Figure 5.14: SMS by IFTTT.

5.2.4 Circuits

After connecting the components together, we got the following circuits:

1. **Health Monitoring System device:**

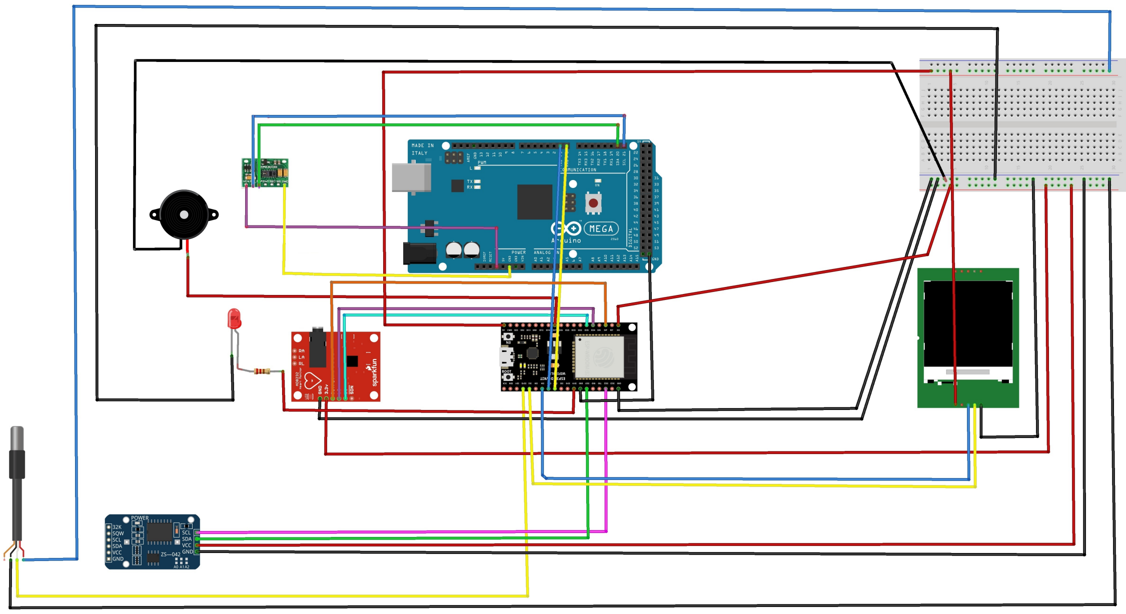


Figure 5.15: Health monitoring system device.

2. **Electronic bracelet:**

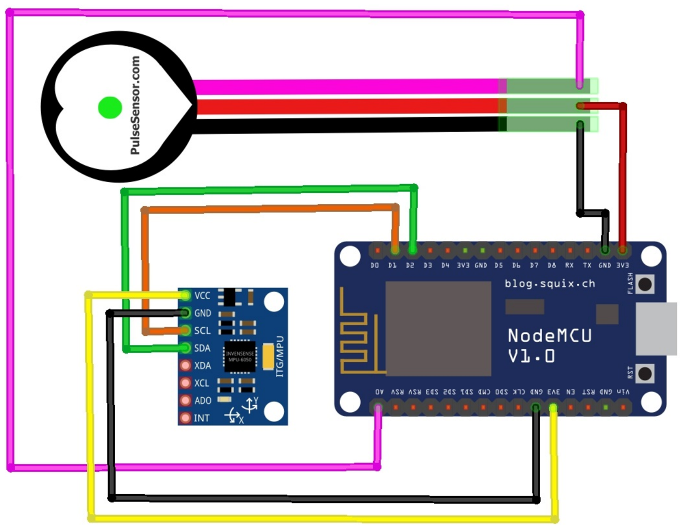


Figure 5.16: Electronic bracelet.

Chapter 6

Results and Discussions

We present this work in the hope that it will be the beginning to facilitate patients, especially heart patients and the elderly, to be aware of their health, as heart diseases cannot be underestimated, so we developed a device to monitor the vital status of patients, the device monitors the electrocardiogram signal, finding out early can prevent serious consequences. The heart rate, blood oximetry, and body temperature are examined. The examination can be done easily at home. The device does not need a specialist, and anyone can perform the examination. If any unusual thing is noticed, the patient must immediately be taken to the nearest hospital. Also, the patient can store the times of taking the medicines, as the system contains an alarm that rings at the time of each medication. The device can be carried anywhere, whether at home or in the hospital, we made the size small for portability.
Moreover, we have developed an electronic bracelet that measures the patient's heart rate (BPM), and in the case that the patient suffers a seizure, sudden fainting, or fall, it detects the fall process and sends a message to the patient's family member with the current pulse rate measurement.

All of this offered us information and experience but accomplishing the objective undoubtedly required many obstacles, struggles, and opportunities to learn new things. This is what will be covered in this chapter.

6.1 Learning

Since we have used new components that we have never used before, learning new things clearly demands extensive investigation into these components and making sure they are used efficiently, both of which take time and effort. The internet provided us with a wealth of resources, which facilitated our learning.

6.2 Challenges

- There is no doubt that the MAX30100 is expensive despite its small size, but it is the thing we suffered the most from, it has serious problems. after connecting it to Arduino it worked well, and then we connected the rest of the components and sensors, but we noticed that it stopped working after that, we searched a lot for solutions and we tried several things, but all of them failed, and it took a lot of time to find a radical solution to the problem, and finally, we reached an effective solution, we separated the MAX30100 from the rest of the sensors. We connected the rest of the sensors to ESP32, and as for the MAX30100, we kept it alone connected to Arduino, after that it worked well.

- After we solved the first problem, we were surprised while we were testing the project in the laboratory that the MAX30100 started reading values without putting our fingers or anything on it, even though it worked perfectly at home. We noticed after several attempts that when we cover it in a box, for example, it works, and indeed we took into account the exterior design that the MAX30100 is inside the box.
- Despite the fact that the ECG technology is noninvasive—literally meaning it doesn't physically enter the skin—applying conductive electrodes to the skin can be harmful, so we must be careful in handling this sensor.

Chapter 7

Conclusion and Recommendations

7.1 Conclusion

The project's main goal is to preserve the lives of elderly and heart patients. We were able to create this system in roughly four months of nonstop labor and with a lot of guidance and advice from our supervisor.
By creating this application, we have improved our skills in a variety of areas:

- Dealing with Arduino as software(IDE) and hardware(microcontroller).
- Dealing with different sensors.
- Dealing with ESP32 and making a connection with the Blynk application.
- Dealing with Arduino libraries.
- Dealing with 2 heart rate sensors and learning how they measure pulses.
- Dealing with NodeMCU and learning how to send requests through IFTTT.

7.2 Recommendations

The ease of use of the Arduino hardware and software makes it possible to create these systems. More attention should be paid to the practical side of the courses and building projects using Arduino and its libraries, which will save the students time and effort.

7.3 Future work

This project is in the beginning stage, we can develop it and add many features and processes that will make it more effective. Medical standards can be developed into the project. The project can then be used by hospitals to keep an eye on their patients, who run the danger of developing unforeseen medical disorders like cardiac arrest, and heart attacks.

- Measuring blood pressure.
- Location: detecting the current location of the patient, and sending it with the information when a fall occurs.
- Developing the bracelet to measure vital signs: heart rate, body temperature, blood pressure, and blood oxygen.

- Creating personal accounts for patients, who will be logged in using their names and passwords, the measurements will be stored in the patient's account in the database.
- Transforming the system into a smart system so that if the values are abnormal, they are displayed in red, a sound is issued and alerts the doctor directly.
- The linked phone to the bracelet will immediately send an SMS if the bracelet detects life-threatening vital signs.
- Linking the system with the ambulance, in case there is any danger, they are notified.
- Use a larger and more advanced touch screen.

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