AccuVital Monitor

Faculty of Engineering & Information Technology
Computer Engineering Department

Hardware Project

Group members:
Aya Ghazal
Mennat Allah Khayat

Supervised By: Dr. Sufyan Samara

June 2023

Acknowledgment

We would love to extend our sincere appreciation to all individuals who helped with this project. Without their support and help, it would not have been possible. A great thanks to Dr. Sufyan Samara for his guidance and relentless supervision along with his support in completing the project. Gratitude and huge thanks go to our families for supporting us during this difficult and stressful experience, our colleagues who gave Moral and technical support, and the individuals who helped out willingly.

Disclaimer

This report has been written by Aya Ghazal, and Mennat Allah Khayat at the Computer Engineering department, Faculty of Engineering, An-Najah National University. There have been no changes made to the document to improve its content or language, other than editorial corrections. Neither Aya Ghazal nor Mennat Allah Khayat endorse the opinions expressed or any recommendations made in it. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

Contents

List of Figures

Abstract

A multi-parameter patient monitoring system is a compact and portable device designed to facilitate easy movement and use in various healthcare settings. This system incorporates sensors to measure essential vital signs, including blood pressure, heart rate, temperature, electrocardiogram (ECG), and blood glucose levels. Its small size and lightweight design make it highly maneuverable, allowing healthcare professionals to conveniently transport and position the device as needed. The system's portability enables flexible monitoring capabilities, enabling healthcare providers to assess patients' health status in different areas of a hospital or even during patient transfers. With its user-friendly interface and comprehensive data collection, analysis, and display functionalities, the multi-parameter patient monitoring system empowers healthcare professionals to make informed decisions and provide timely interventions. The combination of its compact size, ease of movement, and advanced monitoring capabilities makes it an indispensable tool for efficient and effective patient care.

1

Introduction

1.1 Problem

Doctors and nurses have to take patients' vital values frequently throughout the day, record these values on paper, and then transfer them to the hospital system database, which requires effort, a tedious routine, lack of real-time monitoring, and the possibility of messing up the entered data, which is a very big problem. This is inconsistent with the technological development and proliferation of mobile devices.
In addition, traditional measuring methods are almost too heavy, and nurses have difficulty moving them around.

1.2 Objectives

The objectives of the project are to save time and effort for workers in the medical sector and ensure their comfort at work. Also, to ensure that there is no chance of the validity of the data entered into the system, provide real-time monitoring, avoid any problems in the future.

1.3 Significance of The Work

The importance of the work stems from the need to ensure that vital measurements are taken and stored quickly without any doubt about the process of messing up the data, and also from the necessity of having support for the workers, ensuring their comfort, and saving their time to help the largest number of patients.

1.4 Organization of The Report

The body of the report will start with **The First Chapter**, Introduction, providing a background for the research. **The Second Chapter**, Constraints and Earlier Coursework, that shows project constraints, and who they were overcame and solved. Previously taken courses that were helpful in building this application in any step of its development. Followed by **The Third Chapter**, Literature Review, which establishes familiarity and understanding of the current research and includes any similar project. Then **The Fourth Chapter**, Methodology, that includes a systematic plan to resolve the problem, the process of building this robot, software tools, hardware equipment. After comes **The Fifth Chapter,** Results and Discussion, to summarize the data collected, their statistical treatment and compare the results. And finally **The Sixth Chapter**, Conclusion and Recommendation, will show the final project summary, with everything learnt in the journey of building it. Also, it'll introduce some of the features/subsystems that can be added in order to improve and enrich it.

2

Constraints and Earlier course work

2.1Constraints

- Finding a sensor or creating one to monitor diabetes without needing a blood sample is one of the most challenging aspects of this project, and this presents a problem for us in terms of developing up with a way.
- Because of the country's political climate, it can be challenging to get to the university at times, so we must find alternative means to collaborate.

2.2 Earlier Course Work

- **Micro-Controllers:** Helped with micro-controller part, and how to control the hardware parts through it.
- **Micro-Processor:** Gave a background on how to deal with ICs and modules in terms of current and voltage.
- **CPU Lap:** Helped with wiring and welding the hardware parts and debugging them.

- **Critical Thinking and Scientific Research:** Makes searching and writing papers much easier and more professional.
- **Micro controllers Lab:** Brought theoretical knowledge into practice in dealing with I/O, serial communication.

3

Literature Review

Multi-parameter patient monitoring systems have attracted a lot of attention recently in the healthcare industry. These technologies enable healthcare providers to analyze and manage patients' health status more effectively by providing real-time monitoring of numerous vital signs.

Medical treatments delivered in the intensive care unit make it necessary for constant monitoring of patients. For constant observation of the patient, patient monitoring systems provide continuous visibility of the subject's physiological condition and provide immediate treatment whenever required.[3]

Multi-parameter patient monitors (MPMs) are widely used in intensive care units (ICUs) and general wards to continuously monitor patients' health based on the following human vital parameters: heart rate; blood pressure; respiration rate; and oxygen saturation (SPO2) [2].

Multiphysiological parameter medical devices must leverage ever-improving technology to meet demands for improvements in accuracy, functionality, and size, as well provide advances in data capture, transmission, storage, and compatibility—ultimately empowering improved healthcare and enhanced patient outcomes.[1]

During treatment, it is highly imperative to continuously monitor the vital physiological signs of the patient. Patient monitoring systems hold an important position in patient care. The consistent developments in technology not only help us in transmitting the crucial physiological signs to healthcare workers and also simplifies the measurement and therefore

results in raising the monitoring efficiency of patients. Multi-parameter Patient Monitoring Systems are used to transmit vital data like electro cardiographs, respiration rate, blood pressure etc.[3]

Results show that the use of the correlation features, to capture the intrinsic relationship between the vital parameters, helped improve sensitivity by 10.55%, specificity by 0.32% and the overall classification accuracy by 1.03% [2].

While multi-parameter patient monitoring systems offer numerous benefits, several challenges and considerations need to be addressed. Standardization of data formats and interoperability between different devices and systems remain a significant challenge [4].

4

Methodology

In this chapter, we are going to talk about the design of the system, the components that were used to accomplish it, and discuss the development process and the outcome at the end of that process afterward.

4.1 Overview of The System

In this study, a health care device that is differentiated by its compact size and integrates many medical devices was created in order to guarantee the precision of the entered medical data, the precision of the time recorded in it, and the simplicity of viewing it on a mobile device. employed the ESP32 microcontroller as a control unit and combined hardware and software to finish this project.

4.2 Hardware Components

- ✓ **ESP-WROOM-32**

  The ESP32 is a popular microcontroller and Wi-Fi/Bluetooth module developed by Espressif Systems. It is widely used in various Internet of Things (IoT) applications and projects .

Use this microcontroller to connect the project with the mobile using Wi-Fi, connect sensors using GPIO pins, and use UART to control the display screen.

Figure 4.1: ESP-WROOM-32

✓ DS18B20 Temperature Sensor

Popular digital temperature sensors like the DS18B20 communicate with each other using the One-Wire interface .ability to precisely measure temperatures between -55°C and +125°C. Internal digitalization of the temperature value makes it simple to interact with microcontrollers. In addition to being waterproof.

Figure 4.2: Temperature Sensor

✓ AD8232 heart monitor

For heart rate monitoring applications, the AD8232 is an integrated signal conditioning block. It is frequently employed to determine heart rate and evaluate the electrical activity of the heart.
Three electrodes must be fastened to the body in order for it to work. To find the electrical signals produced by the heart, these electrodes are typically positioned on the chest.
To obtain heart rate data, it boosts and filters the signal. analyzes the ECG waveform to produce digital output that represents heart rate.

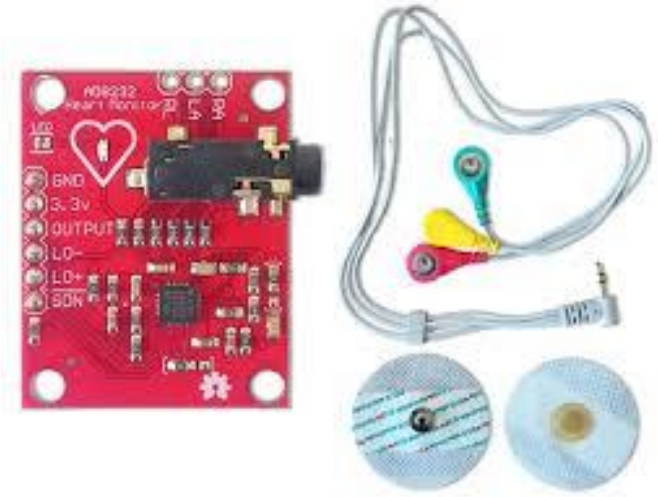

Figure 4.3: AD8232 heart monitor

✓ MH-ET Live MAX30102 Heart Rate Sensor Module Pulse Detection Blood Oxygen

For non-invasive heart rate and blood oxygen saturation (SpO2) monitoring, the MH-ET Live MAX30102 Pulse Oximeter is intended.

To gauge how well blood arteries absorb light, it combines red and infrared LEDs with a photo detector. The heart rate and the SpO2 levels are then determined using this data.

It offers measures of the blood oxygen saturation level and heart rate in real time. These numbers can be used to track and evaluate a person's health and wellbeing.

It is intended for non-invasive monitoring, thus no invasive procedures or blood samples are necessary. To capture the requisite optical signals, it is often mounted on a finger, earlobe, or other suitable body part.

Figure 4.4: MH-ET Live MAX30102 Pulse Oximeter

✓ MQ-138 Gas Sensor

In several investigations and research, the use of the MQ-138 semiconductor gas sensor for breath acetone detection has been investigated. Acetone is a volatile organic molecule that can be found in the breath and may be used as a biomarker for diabetes and ketosis, among other disorders.

Figure 4.5:Gas Sensor

Figure 4.6: Blood Glucose Measurement

- ✓ **Humidity Sensor**

  is a tool for measuring and monitoring the level of humidity or moisture in the air. It frequently finds use in a variety of settings, including weather monitoring, HVAC systems and indoor air quality control.

  The level of humidity in the air can affect respiratory function and blood oxygen levels. ASHRAE recommends maintaining indoor humidity levels between 30% and 60% for comfort and health. Blood oxygen saturation is determined by the amount of oxygen-saturated hemoglobin in the blood, which ranges between 95% and 100% [7] .

And that's why we had to use Humidity Sensor.

Figure 4.7:Humadity Sensor

- ✓ **Nextion Display NX4832F035**

  A series of intelligent touch display modules called Nextion screens was created by ITEAD Studio. In addition to supporting images and animations, these screens are made to be user-friendly. Use the serial communication protocol UART to communicate with microcontrollers.

  It was used to show the ECG waves, display the data for the measured vital statistics, and add a new user or patient.

Figure 4.8: Nextion Display NX4832F03

✓ Breadboard

To connect All the pieces together and form a unified system.

Figure 4.9:Breadboard

✓ Resistors

We used two resistors, one 10k and the other 4.7k

Figure 4.10 : 4.7 K resistor

Figure 4.11: 10 K resistor

- ✓ **LEDs**

  When vital numbers are aberrant or unusual, we employed led to signal this.

Figure 4.12 : Led

- ✓ **Buzzer**

  When vital numbers are aberrant or unusual, we employed buzzer to signal this.

Figure 4.13. :Buzzer

4.3 Software

We have created a straightforward Android mobile application with the ability to present all of a patient's medical history as well as the data that was read from the ESP32 in an approachable and straightforward manner.

Naturally, this program has pages for signing up, logging in, and a home page that lists the cards of every patient enrolled with the registrar's doctor.

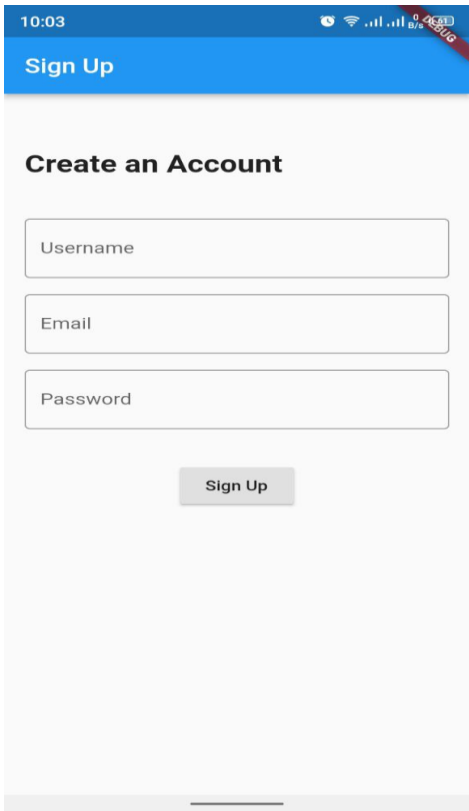

Figure 4.15 :Sign In Screen

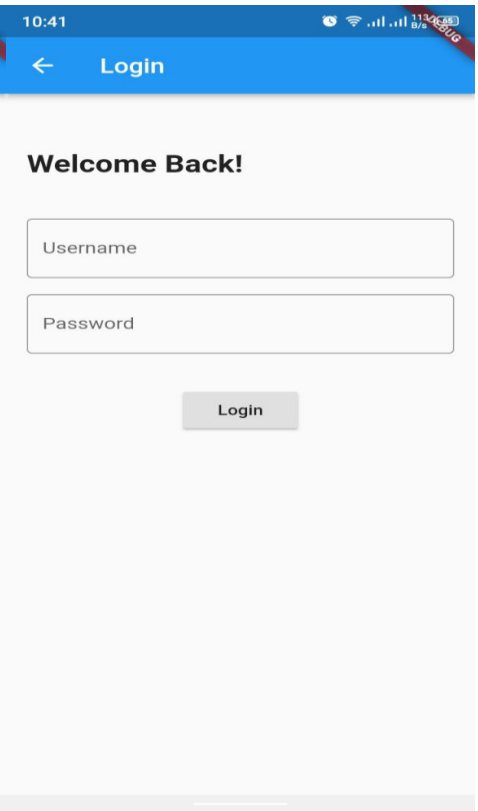

Figure 4.16. :Log In Screen

Figure 4.17 :Cards Screen

4.3. device Assembly

//later

4.5 Implementation

4.5.1 Esp32 :

i. **Standard medical checkups on frequently**

- **The measuring of temperature:**
  A sensor known as DS18B20 is used to measure the patient's body temperature; the steel component of the sensor is positioned beneath the patient's armpit. The accuracy of the sensor itself is within 0.5 °C [8] , and it takes several seconds to around a minute to take the final temperature reading.
- **Measurement of blood oxygen levels:**
  By placing the finger on the specific area on the sensor's surface, the MAX30102, which was built and programmed to detect the rate of oxygen in the blood, is used to carry out the procedure. Depending on the particular implementation and settings, the MAX30102 can take a different amount of time to test blood oxygen levels. A consistent reading typically takes a few seconds to get. The sensor measures the light absorption by oxygenated and deoxygenated blood using red and infrared light, which is then utilized to calculate the blood oxygen saturation level. The sensor module's accuracy is 2% or less [6].
  It's crucial to keep in mind, though, that this precision might not apply to all situations.
- **Measuring and monitoring the level of humidity:**
  Used Humidity Sensor to measuring and monitoring the level of humidity.
  The level of moisture or humidity in the air can influence respiratory function, which in turn can affect blood oxygen levels. Moisture in the air refers to the amount of water vapor present in the atmosphere. Respiratory function is responsible for taking in oxygen from the air and exchanging it for carbon dioxide. Impact on breathing: Extremely dry or low-humidity environments can cause the airways to become dry, potentially leading to irritation and discomfort.

Effects on oxygen exchange: Inhaled air that is too dry or humid may have an impact on the respiratory system's ability to effectively exchange oxygen and carbon dioxide in the lungs.

Monitoring and adjusting the humidity level in indoor environments can contribute to overall respiratory well-being, but it should be seen as part of a holistic approach to health rather than a direct determinant of blood oxygen levels.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends maintaining indoor humidity levels between 30% and 60% for comfort and health. Blood oxygen saturation, represented as a percentage, indicates the amount of oxygen-saturated hemoglobin in the blood. Normal levels typically range between 95% and 100%, and levels below 90% may indicate hypoxemia [7].

- **Measurement of Heart Rate :**

  We employed Based on the MAX30102 chip, the MH-ET Live MAX30102 is a heart rate sensor module intended for heart rate monitoring. The module measures changes in blood volume through the skin using an inbuilt optical sensor. Using red and infrared LEDs and light detectors to measure the reflected light from the user's skin, it can effectively detect and monitor the user's heart rate in real-time. As a result, the sensor is able to record the physiological information needed to measure heart rate.

  A study conducted by IJEECS suggests that the accuracy rate of the MAX30102 measurement is 97.11% and 98.84%, for heart rate [6].

ii. ECG

The AD8232 is an integrated signal conditioning block designed for electrocardiogram (ECG) applications includes a set of components and circuitry specifically designed to amplify and filter the weak electrical signals produced by the heart. This allows for reliable ECG signal acquisition and processing. The accuracy

of the ECG measurements obtained from the AD8232 module can be influenced by factors such as proper electrode placement, signal quality, and noise interference. It's important to note that while the AD8232 is a widely used and reliable component for ECG signal conditioning, it is not a medical-grade device.
Accuracy values reaching more than 90% indicate the reliability of the implementation results [5].

iii. Blood Glucose Measurement(blood sugar)

To this day, there is no device for checking diabetes without a blood sample, but there is a lot of research on finding blood sugar by knowing the percentage of glucose from the carbon dioxide that comes out in the exhalation process according to the equations:

$$CH3COCH3\ (gas) + O- \rightarrow CH3CO+CH2 + OH- + e-$$
$$CH3COCH3\ (gas) + O- \rightarrow CH3C+O + CH3O- + e-$$
$$CH3C+O \rightarrow C+H3 + CO$$
$$CO + O \rightarrow CO2 + e-$$

" In this work, MQ-138 semiconductor sensor was successfully integrated into a system which is portable, fast and easy to operate. This system was applied for breath acetone detection in both diabetes and nondiabetes patients. It was revealed that the sensor readsings to be linearly related to breath acetone indicated by the increasing of the sensor output voltage as the blood glucose values rising. Thus, the proposed system has a potential to be used for breath acetone detection as a new application of MQ-138 semiconductor sensor."[8].

"A new application of MQ-138 semiconductor sensor for breath acetone detection is proposed in this work. MQ-138 semiconductor sensor was integrated to a system which consists of three blocks. This system offers benefits such as portable, fast and easy to operate. Experiments with breath acetone samples from both diabetes and nondiabetes patients validated the accuracy of this system. Based on the measurement results, it was found that as the sensor output voltage increased, the higher blood glucose values measured which means it has

been proven that sensor readings of MQ-138 sensor has linear relation to the breath acetone. Therefore, the proposed system has a potential to be used for breath acetone detection in diabetes patients as a new application of MQ-138 semiconductor sensor."[8]

4.5.2 Nextion Display NX4832F035 (Touch screen):

It was used to show the ECG waves, display the data for the measured vital statistics, and add a new user or patient.
And It was programmed and the front end was built using a program dedicated to it Nextion Editor .

4.5.3 Software :

- Mobile App:
  We have built the frontend using Flutter, backend php and data base MySQL, and of course adding the necessary libraries and identifiers to connect the application in ESP32 using Wi-Fi.

5

Results and Analysis

AccuVital Monitoring is the final product, which is lightweight and easy to carry. It is available in the hospital and contains several sensors to measure various vital values on a daily basis for each patient, such as the patient's temperature, heart rate, or oxygen level in his blood, while at the same time making sure that the room's normal and healthy humidity is compared to the results of the oxygen level in the patient's blood. In addition to periodic checks, there is a check of blood sugar by exhalation without the need for a blood sample. Finally, this product has an electrocardiogram measurement.
The data obtained from the tests may be simply viewed on the application, and we have thus automatically and without human interaction or paper record of the results stored the data in the database.

6

Discussion

6.1 Learning Curve

The learning process was helped by a wide variety of online courses and guidance as well as helpful community members, despite feeling initially like a severe obstacle. Developing such a project required recognizing different hardware elements with which We were unfamiliar and had to gain new knowledge. In addition, we are experiencing something fresh with the project's medical component.

7

Conclusions and Recommendation

7.1 Things we learned

- How to use ESP32 and how to connect with Wi-Fi using it.
- How to detect Glucose by MQ-138 (gas Sensor)
- How work and design front in touch screen
- How to deal with multi parameter patient monitoring

7.2 Future Work

Future work will involve adding more sensors to measure additional critical indicators, enhancing the effectiveness of the outcomes, and providing a precise and in-depth study of the outcomes.

References

[1] Bill Crone "Multiphysiological Parameter Patient Monitoring" Healthcare Systems Engineer, Analog Devices, January 2011 .

[2] V. Vaijeyanthi, K. Vishnuprasad, C. Santhosh Kumar, K.I. Ramachandran, R. Gopinath, A. Anand Kumar, Praveen Kumar Yadav " Towards enhancing the performance of multi-parameter patient monitors" March 2014.

[3] MEDIKABAZAAR "Patient Monitors: What are their components, uses and how are they providing quality patient care?" October 1, 2021.

[4] A L Goldberger 1, L A Amaral, L Glass, J M Hausdorff, P C Ivanov, R G Mark, J E Mietus, G B Moody, C K Peng, H E Stanley" PhysioBank, PhysioToolkit, and PhysioNet: components of a new research resource for complex physiologic signals" Jun 13 ,2000.

[5] Martin Clinton Tosima Manullang , Jonathan Simanjuntak, Ahmad Luky Ramdani "Implementation of AD8232 ECG Signal Classification Using Peak Detection Method For Determining RST Point" September 2019.

[6] Debashis Das "How MAX30102 Pulse Oximeter and Heart Rate Sensor Works and how to Interface it with Arduino? " May 4, 2022.

[7] " HUMIDIFIERS " Chapter 22.

[8] Programmable Resolution 1-Wire Digital Thermometer https://www.analog.com/en/index.html

[8] T I Nasution et al J. Phys "Application of MQ-138 Semiconductor Sensor for Breath Acetone Detection " 2018.