ABSTRACT

In the health sector, the Internet of Things (IoT) offers many opportunities. In smart health care systems, IoT technology is inevitable. The emerging technology Internet of Things helps to improve the healthcare industry by making it more accessible and affordable through easy-to-use applications for visual and remote interaction with patients.

The basic concept of these connected health apps, known as Personal Health Devices, has been developed. Monitoring the health of the elderly and building a rehabilitation program is a daunting task. The model uses two health sensors: a heartbeat sensor and a body temperature sensor. Thanks to the integration of the Arduino Uno and Raspberry Pi, all these sensors are integrated into a single system. Raspberry Pi is used to transfer data collected from cloud storage. The system should be designed in such a way that it collects all the patient's information and diagnoses the disease as soon as possible. As a result, the patient's medical expenses also drop dramatically. Old people can use the IoT-based home-based care monitoring system to assess their health status and access services at community health facilities without leaving home. It will also enable governments and communities to cope with the effects of aging. Additionally, an application that monitors a patient's health over time allows physicians to fill out appropriate instructions. To understand how the sensor works, detailed signal studies related to changes in physical activity and natural function have been performed.

I.INTRODUCTION

China has just entered the elderly community. The problem of old age is getting worse. The physical condition of the elderly is deteriorating, which includes heart failure and the ability to maintain gait balance. The health and safety of the elderly has become an urgent matter. Thanks to Internet of Things (IoT) in healthcare based on digital medical devices, it is now possible to monitor the health of the elderly at home. By implementing an IoT-based home-based care program, seniors can check their health status with the comfort of their home and access services at public health facilities. It will also enable governments and communities to cope with the effects of aging. The smart home gate receives signals from the sensory network (BSN) and sends them to the health server of the home care monitoring system. There were three phases in the development of a home-based home care monitoring system. The phone modem acts as a home gateway in the first step and data is transmitted over the phone. In patients with persistent respiratory failure, Maiolo et al. and Vitacca et al. We have introduced a modem-based monitoring system. This type of medical system can only transmit a limited amount of data at a limited amount, which limits the system rating. On the other hand, when transferring data, there seems to be no problem for the user because the patient must change the data. Still consumes a lot of power, no doubt the PC has enough computing power. Embedded devices and smart gadgets define three phases of the health care monitoring system. Bansal et al. proposed a health gateway-based monitoring system like a smartphone and Jung et al. Lin et al created a home-based care system based on the box above. They have suggested a television approach to home care Ramani, etc used embedded technology to build a smart home gateway and a monitoring system that could track multiple signals of adult physical activity. Each of these approaches has its advantages, but it also has its drawbacks. Mobile gates cannot provide long-term and reliable services. The ECG, which is a very important signal for the survival of patients with heart disease, has not been measured with a box device mounted on top. On the other hand, these technologies cannot provide continuous monitoring for the elderly and are too complex for them to use. Additionally, the health monitoring process produces a large amount of physiology data. This can lead to data overload and network congestion, which may complicate the home gateway. Lin et al. [8] has developed a storage system that combines local and cloud storage to reduce storage load on home gates but consumes too many system resources when data transfer. Previous studies proposed a data compression concept, which could effectively reduce the amount of data. A smart home-based monitoring system was proposed in this study to initiate long-term monitoring of the elderly, solving data overload problems and network congestion, and facilitating adult running.

A. The architecture of the Internet of Things

The Internet of Things (IoT) is a web-based application that combines sensors, processors, and a communication gear that works together to collect, transmit, and process data from location. This Internet of Things object uses wireless cloud technology to give operators remote access to networked devices. Gadgets should be able to communicate with other smart devices found remotely without the need for external intervention. The construction of the Internet of Things is divided into four categories (IoT). Every level does different things.

Step 1: determines how many features are linked to obtain key data that can be used for further analysis. It usually consists of a few sensors that can be connected or wired.

Step 2: collects relevant data to connect to the Internet. This level also includes the conversion of analogue to digital.

Step 3: involves pre-processing data by IT systems before moving on to

Step 4: (storage of filtered, analyzed, and processed data in a storage based on cloud system in the traditional backend data system).

The 4 Stage IoT Solutions Architecture

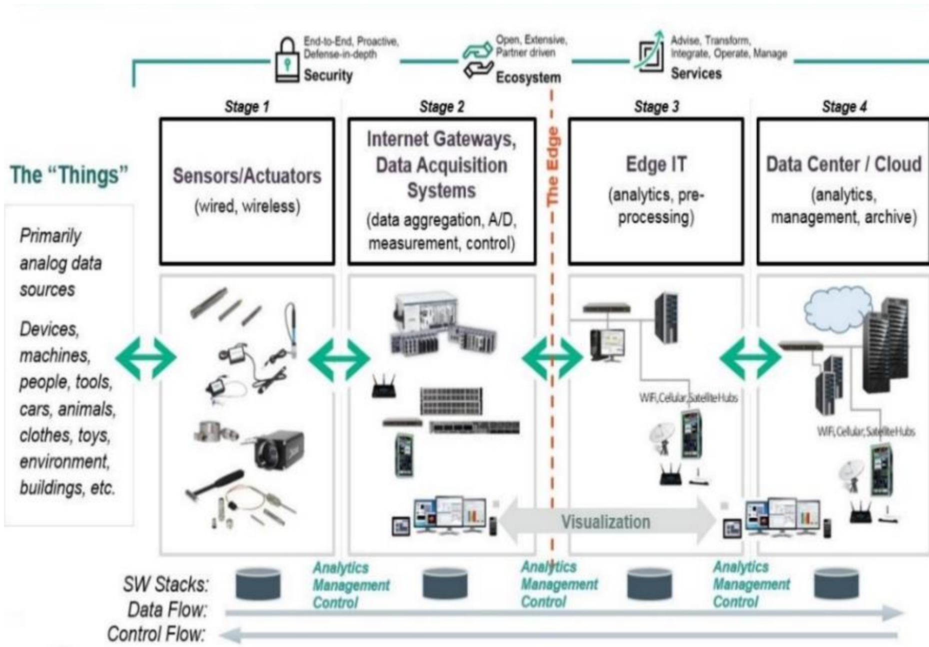

Figure 1: Stages of IoT Architecture

B. Principle of Photoplethysmography

Photoplethysmography is an unconventional technique for measuring heart rate that has become quite popular in recent years. Its objective is to emit infrared light and see how it absorbs the appearance of light and the absorption of biological tissues, keeping an eye on the heartbeat. Cardiovascular cycle is a series of events that occur during a single heartbeat. The two stages of the heart cycle are the systolic and diastolic stages. The systolic phase is when the heart contracts to pump blood throughout the body, and the relaxation of the heart is known as diastolic phase (contraction). During this phase change, blood flow to the arteries changes dramatically. Photoplethysmography sensor on the skin surface is used to detect this volume change. The sensor generates light and detects it after a series of absorptions causing a difference in the intensity of the received light. A waveform (photoplethysmography) showing the current alternating and direct components shown in Figure 2.

The DC component is similar to the optical transmitter or signal of a tissue, determined by the shape of the tissue and the amount of blood in between your arteries and veins. The AC component shows a variation in blood volume as it changes from systolic to diastolic and vice versa; heart rate determines the normal frequency of the AC segment, then covered the DC segment.

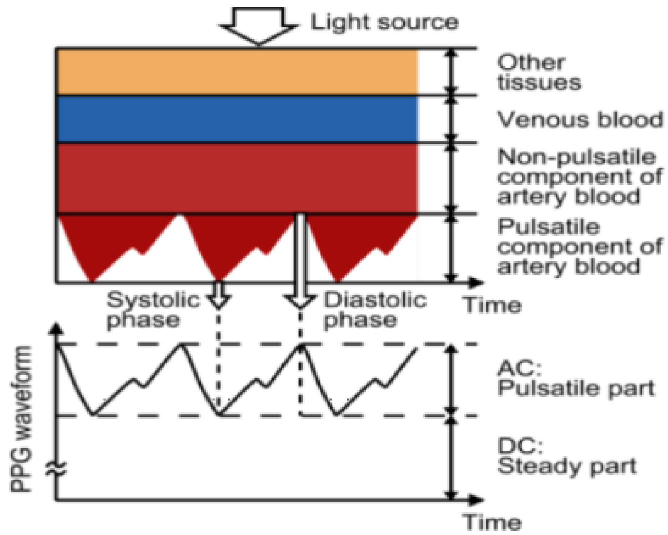

Figure 2: Variation of light attenuation by tissue

C. GALVANIC SKIN RESPONSE

One of the most subtle signs of nerve stimulation is galvanic skin response (GSR), also known to be as skin conductance (SC) or electrodermal activity (EDA) . The EDA regulates the amount of sweat produced by the sweat glands. The removal of sweat is important for thermoregulation and vision, and emotional arousal causes a significant increase in the behavior of the skin in the areas of the hands and feet, and has a stimulating effect, the height of the skin. When stimulated by stimuli, sweat glands produce moisture through the pores facing the skin. As a result, the electrical energy produced by the balance of charged ions, Skin Conductance, High Skin Conductance, Reduced Resistance are all indicators of this. This syndrome is referred to as Galvanic Skin Response.

II. HARDWARE ARCHITECTURE AND SOFTWARE ARCHITECTURE

A. Hardware Architecture

An Arduino Uno is used in this project's hardware architecture to track body health indicators. This information is collected on the Raspberry Pi's server and sent to a cloud server, which the Android app can then access. The architecture of the project's hardware implementation is depicted in the diagram below.

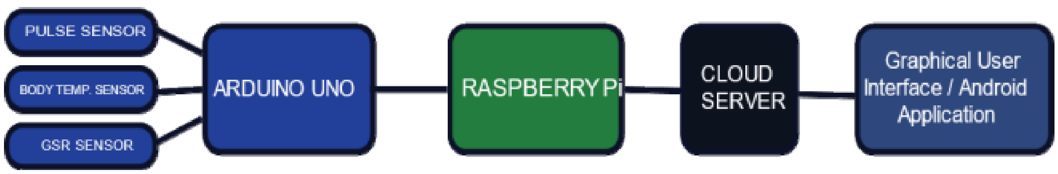

Figure 3: A block schematic of a remote health monitoring system's hardware architecture.

Each component was pre-calibrated separately to guarantee that the design was completed without systematic flaws. Individual parameters were later combined such that the entire system functioned together to meet the project's major objectives. The next section explains how the complete project is implemented in stages before being integrated to create the final product.

A. Software Architecture

The Software Integration Architecture is a critical component of the Remote Condition Monitoring System. It is the brain that learns to work in accordance with the flexibility of the user. The remote health monitoring system's software architecture ranges from an IDE microcontroller to the Android developer toolkit. The Arduino IDE, an open-source software that allows you to easily upload code to your development board, is used to extract data. The Raspberry Pi is then used to send the data to cloud storage. Google Firebase is a platform for developing mobile and web applications. Firebase provided the cloud storage. The Android Studio project app has remote access to the Google Firebase database, which is encrypted between users. Unauthorized individuals will be unable to access the patient's personal database because of this. The graphic below depicts the steps involved in developing the software architecture for this remote condition monitoring system.

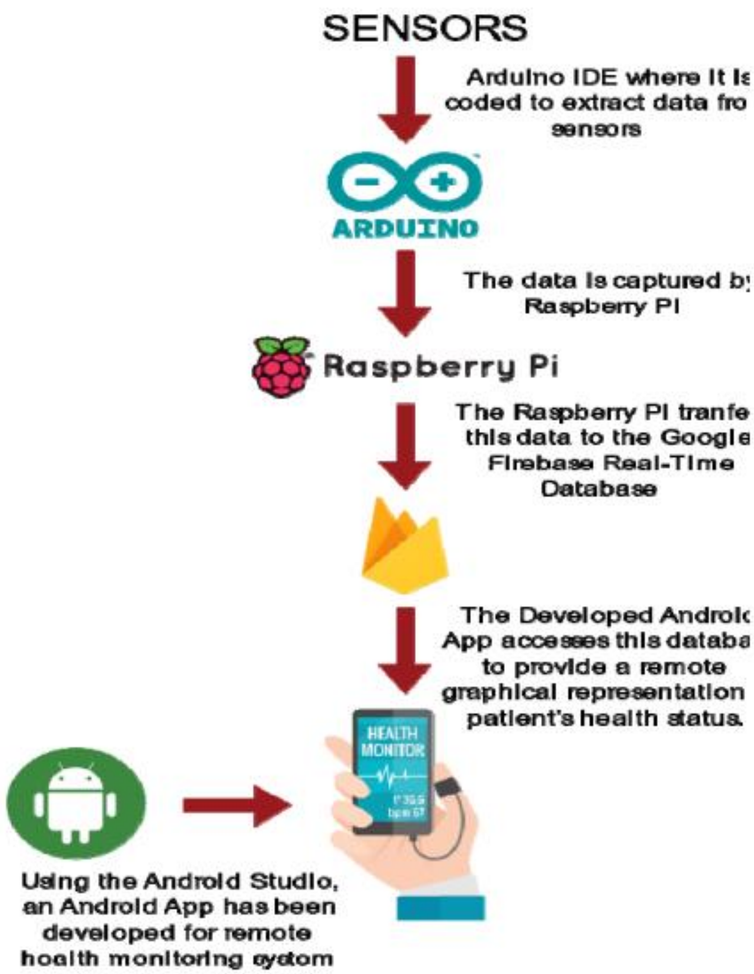

Figure 4: Architecture of remote health monitoring system as in software

III. IMPLEMENTATION OF THE PROJECT

A. Implementation of the heart rate monitoring system

The heart is one of the most crucial indicators of a patient's health. The heart rate and its accompanying waveform were measured for this investigation utilizing the photoplethysmography method. An Arduino board, a Pulse Sensor, and a few LEDs comprise the heart pulse monitoring hardware.

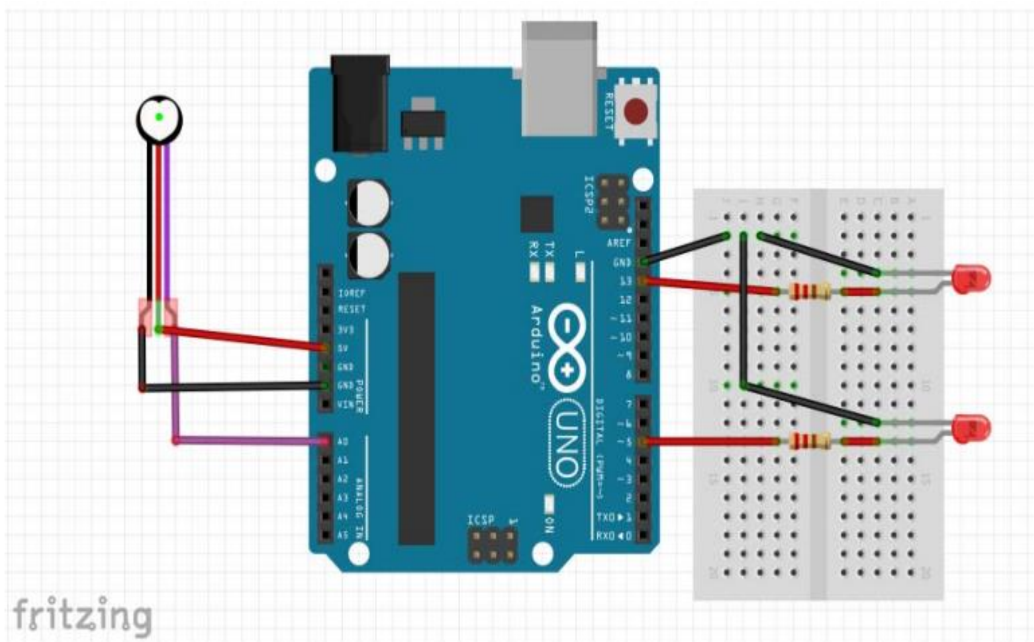

Figure 5: Circuit implementation of a heart rate monitoring system

B. Implementation of galvanic skin response

The Galvanic Skin Response (GSR) is a continuous change in the electrical characteristics of the skin, such as conductance, caused by changes in perspiration. According to the GSR study, skin resistance varies based on the state of sweat glands in the skin. Sweating is controlled by the Autonomic Nervous System in the human body (ANS). When the sympathetic branch (SNS) of the autonomic nervous system is stimulated, sweat gland activity increases, which improves skin conductance and vice versa. As a result, skin conductance can be considered a measure of the reactions of the human Sympathetic Nervous System.

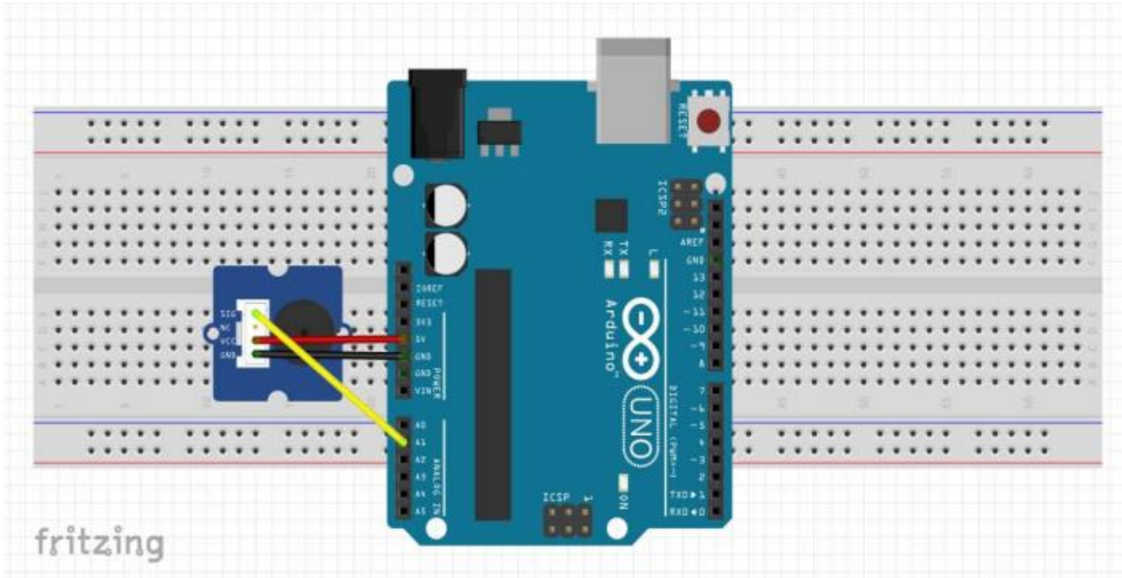

Figure 6: Circuit implementation of measuring galvanic skin response

C. Implementation of body temperature measurement

The skin is necessary for maintaining a healthy body temperature and ensuring that body enzymes are functioning properly. It prevents our body temperature from reaching dangerously high or low levels, which would be fatal if the enzymes were unable to function properly.

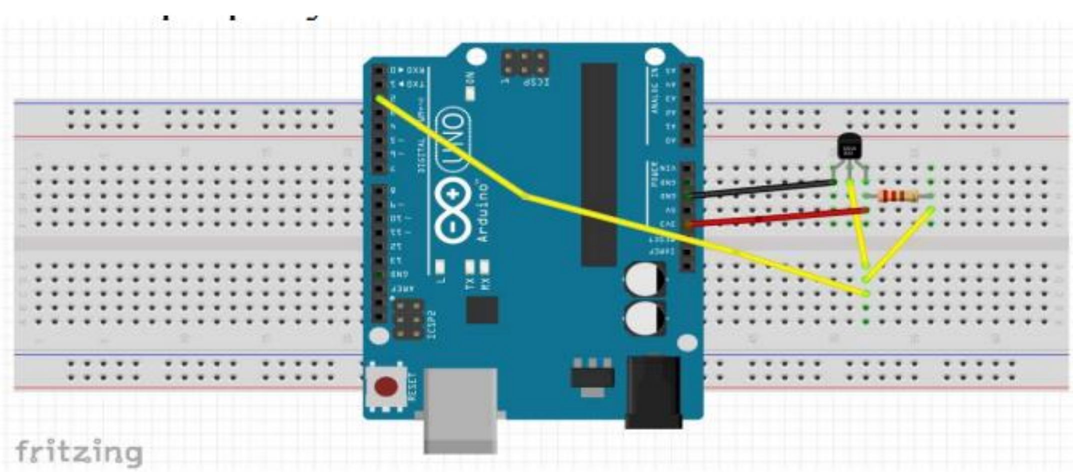

Figure 7: Circuit implementation of body temperature measurement

D.Merging of Sensors to form a Single System

When all the individual circuits and calibrations were completed, it was time to connect all of the sensors into the Arduino Uno so that it could function as a single system. Sensing and transmission are the two stages of the architecture. The Arduino Uno collects and analyses sensor readings, whereas the Raspberry Pi 3B connected to Arduino receives data from Arduino and delivers it to cloud storage after extensive processing and analysis.

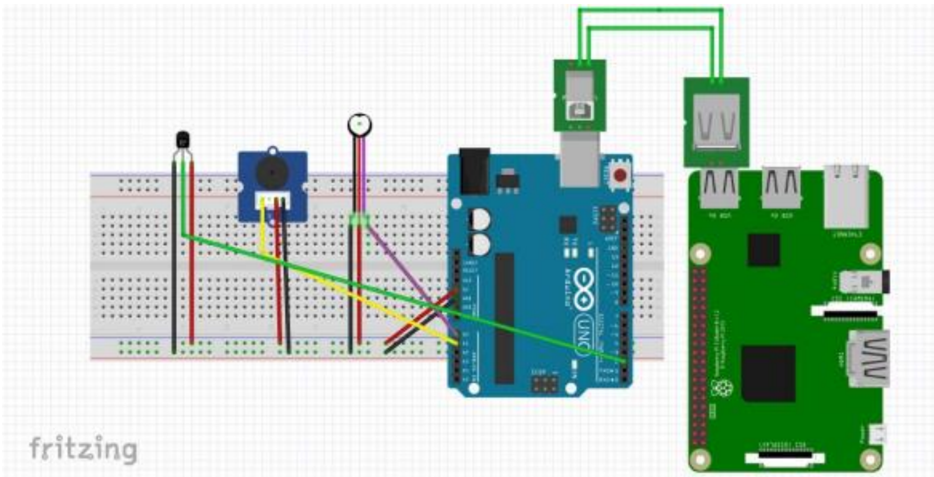

Figure 7: Circuit connection of the merged system

The Raspberry Pi was programmed using the algorithms shown in the diagram below. Raw data from each sensor was captured when the sensor pins were initialized. Using library functions and mathematical methods, the standard values of Heart Rate, Body Temperature, and Galvanic Skin Response were retrieved. The sensor results were then saved in the cloud, where they could be viewed remotely using the built Android app.

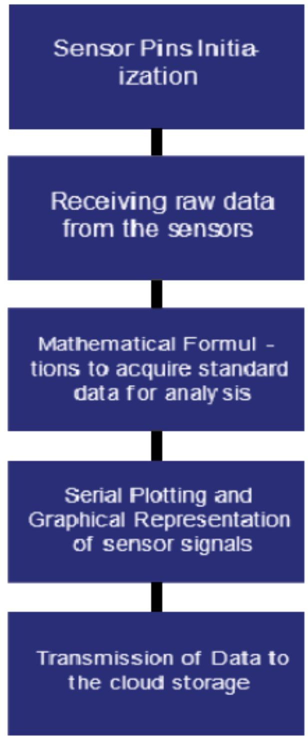

Figure 8: programming flowchart for Raspberry Pi and Arduino Uno

IV. RESULT AND ANALYSIS

This device was designed to assess heart rate, body temperature, and skin electrical reaction independently. To further understand how the sensor responds to certain changes, the results obtained for each physical health measure were investigated by changing behavioral or environmental variables. The next section discusses the signal analysis and the integrated mechanism for transmitting data to cloud storage for graphical representation in Android applications.

A. Analysis of PPG Signal from Heart Pulse Sensor

The patient being monitored had a heart rate of 121 beats per minute and an IBI of 1826 milliseconds. The patient's heart rate dropped to around 8090 BPM after a few minutes of rest. When people were stimulated or under physical stress, their heart rates increased to more than 120 beats per minute (BPM). These results in terms of behavioral changes and physical stress corroborated the hypothesis.

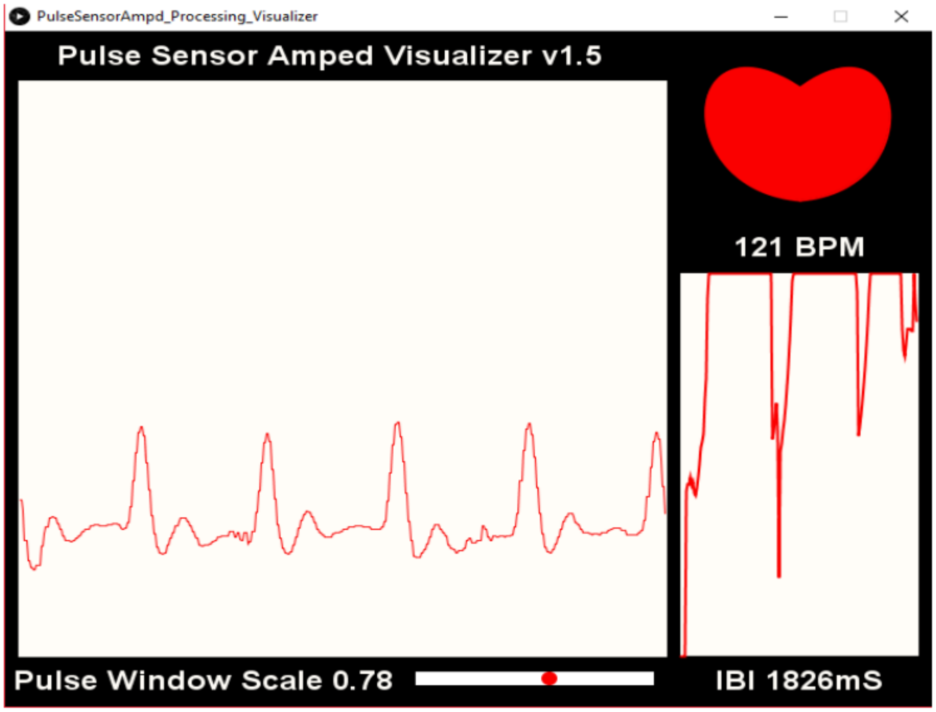

Figure 9: PPG Signal, Heart Rate, and IBI

B. Analysis Of Galvanic Skin Response Signal

A patient's skin resistance is used to determine the Galvanic Skin Response, which is a measure of skin conductivity. The human impedance and skin conductance were calculated using the following formulas.

Equation (1): Human Resistance = ((1024+2*Serial_Port_Reading) *10000)/(512-Serial_Port_Reading) [10]

Due to random oscillations in the data, interpreting the electrical skin activity signal was difficult. on the other hand, were determined by finger movement. When the skin is stressed, the produced graph exhibits a spike in conductivity, which is easily detected by the peak in the graph. The longer the voltage length, the longer the conduction duration, as shown in the graph. The pattern, on the other hand, changed when the patient inhaled and exhaled. The skin's electrical conductivity rises with inhaling and falls with exhalation. Even though the variances in these signals made understanding electrical skin activity challenging, we were able to clearly detect patterns by analyzing changes in body behavior. Different environmental and physical factors can be used to identify multiple patterns.

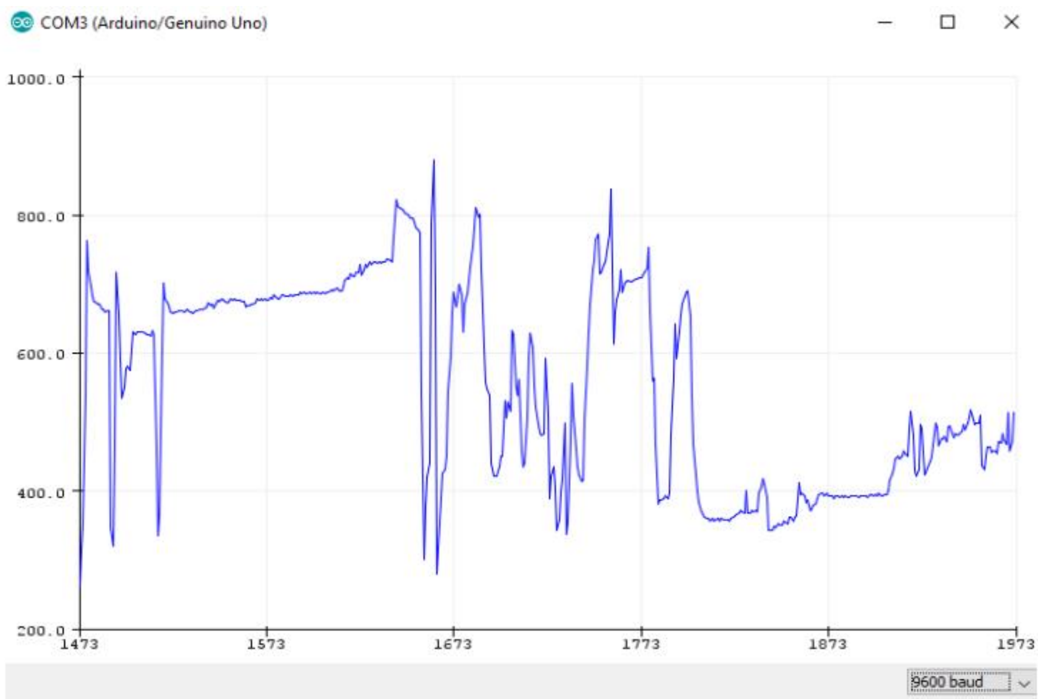

Figure 10: A GSR Signal acquired from a patient showing random variations while putting stress on the skin of the fingers

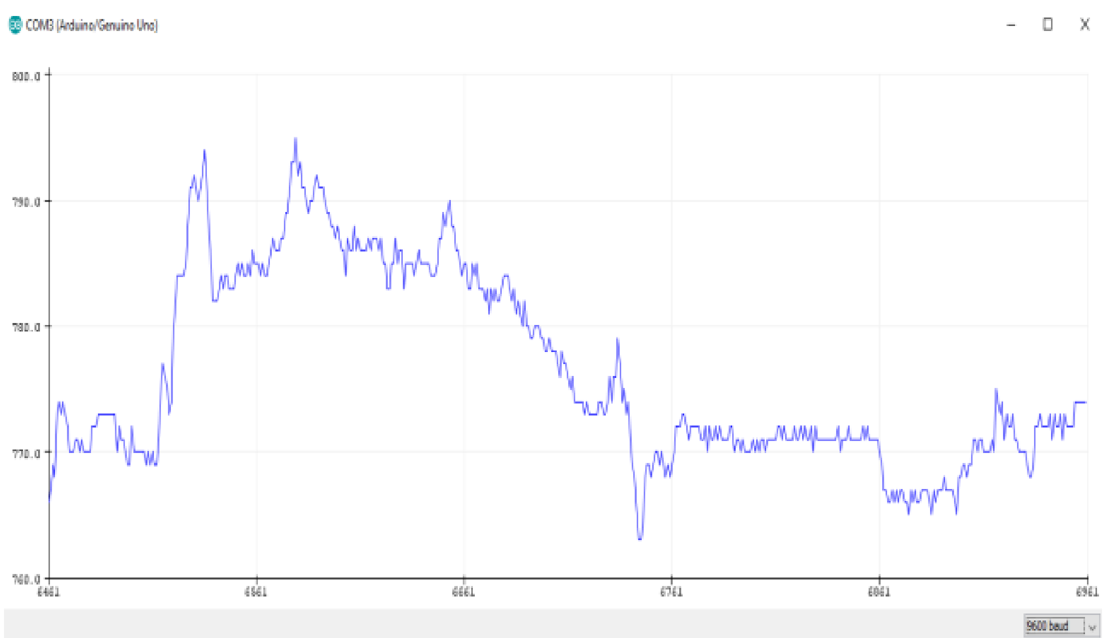

Figure 11: The GSR Signal showing variation while breathing in and out deeply

C. Android Application of the project

All sensor implementations have been combined into a single a. The system will be operational after all the separate implementations are completed. The data is saved in the Google Firebase Realtime Database, which can be accessed via the Android app. The tool we designed was called "Third Nurse," and it had a very simple user interface to make it easy to grasp.

Figure 12: Android Application titled, The 3rd Nurse

Android Studio the Android app was used to create the Android app. It provides the ability to monitor patient health indicators and allows supervisors to monitor from a distance. However, anything stored in the cloud is at risk of data breach. For security reasons, the application is encrypted with login credentials to prevent this.

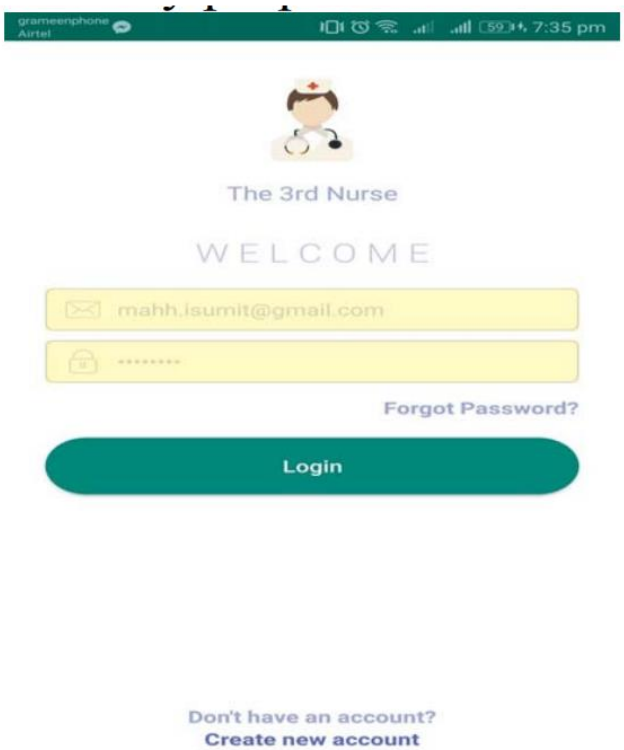

Figure 13: Application requesting for login credentials of the user

Doctor, Personal, and Relatives are the three monitoring modes available to the user. Each of these modes has its own unique ID that only the patient has access to. The figure below depicts the display of such a feature.

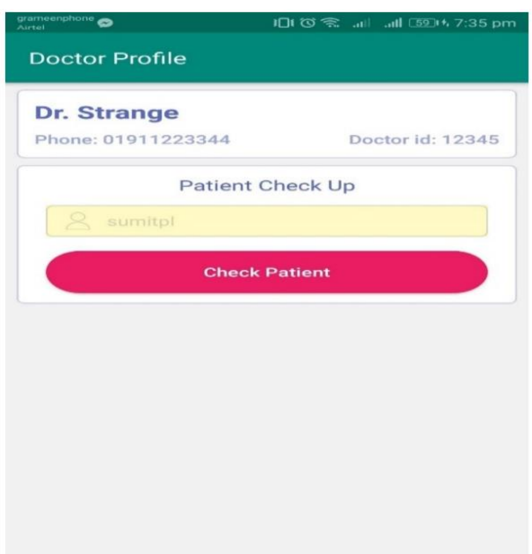

Figure 14: Application requesting for Patient's ID

After the person monitoring the patient can access the patient's ID, the monitor displays a page with real-time data of body temperature, heart rate, and GSR, as shown in the following figure. Doctors can also prescribe drugs to patients based on their health trends and historical and current medical records. This is the only way for patients and doctors to keep track of their medications.

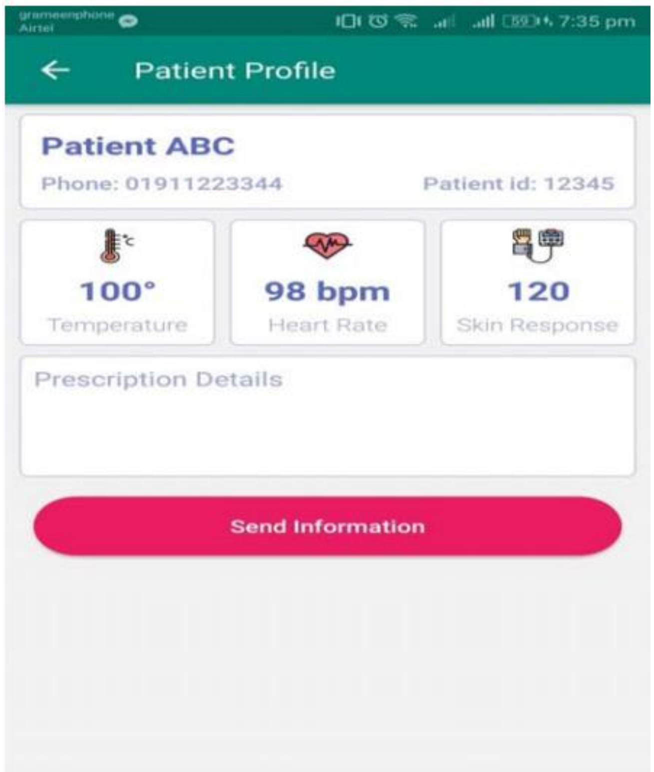

Figure 15: Display of the health parameter monitoring page

V. CONCLUSION AND FUTURE PLAN

The healthcare business is rapidly evolving to improve patient care. Wearable gadgets have been a key focus of scientists and engineers for many years as they try to better the healthcare sector using the latest technologies. This research looks at current requests for health-related wearable technologies that could be improved to function and satisfy the needs of patients.

A higher number of sensors could be included, such as a respiratory rate sensor, blood pressure sensor, and blood glucose sensor. The buyer of this device can acquire a complete health monitoring system that monitors all the body's critical data if these sensors are included. According to recent machine learning applications in wearables, machine learning or deep learning may also be a cutting-edge addition. It will not only alleviate the stress of hospital visits, medical bills, and varied diagnostics, but it will also predict the possibility of catastrophic diseases ahead of time, potentially saving lives. This will be a significant step forward in these efforts, with long-term implications for the healthcare business.

The project's purpose was to create a user-friendly remote health monitoring system. The patient monitor can examine parameters in graphical style using the Android application. Before the system design was executed, each sensor was calibrated separately. After then, the sensors were merged into a single set that measures health characteristics. The relationship between each signal obtained from a parameter and a change in physical activity was investigated. The signals and patterns discovered were found to be in accordance with the general concept of function. When the final result was sent to the cloud via the Raspberry Pi, the customer obtained the required result from the system. The critical evaluation, survey, and project review all demonstrated that the project's principal objectives were met.

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