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Department of Electrical-Electronic Engineering

DESIGNING AND IMPLEMENTATION OF ELECTRONIC DEVICE CONTROLLED IoT FOR COVID 19 PATIENTS MONITORING THROUGH SECURED COMMUNICATION SYSTEM

Master Thesis

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Supervisor

Assist. Prof. Dr. A. F. M. Shahen SHAH

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TURKISH ABSTRACT

:Koronavirüs (SARS-CoV-2) salgını, 2019'un sonunda ölüme neden olan ve dünyanın çoğunu tehlikeye atan ve dünya ülkelerini ciddi şekilde tehdit eden tehlikeli bir pandemi olarak dünyayı kasıp kavurmaktadır. Ön saflarda yer alan doktorlar tarafından virüsü keşfetmek ve gerekli aşıları geliştirip tedaviyi icat etmek ve yayılmasını durdurmak ve yayılmasını sınırlamak için büyük çaba sarf ediliyor. Bu tezin amacı, Koronavirüs bulaşmış hastaları izlemek ve doktorların yaptığı çabayı ucuz bir maliyetle azaltmak için bir elektronik sağlık sistemi oluşturmaktır.

Bu tez, özellikle sağlık durumlarını izlemek için karantinaya tabi tutulan hastalara yerleştirilecek bir dizi sensörün geliştirilmesine imkan sağlayacaktır.

Şu anda, Nesnelerin İnterneti (IoT), büyük bir bilgi devrimi ve hayatımızı kolaylaştıran yeni bir çağın başlangıcı için çalışıyor. IoT, hastanede veya karantina yerlerinde uzaktan sağlık izleme için gelişmiş bir model sağlar. Sensörler hastanın tıbbi bilgilerini alır ve IoT bunu bir web tarayıcısı veya uzaktan bakım sağlayan özel programlar aracılığıyla depolar ve görüntüler. Önerilen program, insan hatasını azaltır ve özellikle birçok ülkede virüs bulaştıktan sonra ciddi doktor sıkıntısı nedeniyle sağlık sisteminin çökmesinden sonra doktor sayısını azaltır ve ayrıca hastaları izlemek için gereken tıbbi cihazların boyutunu azaltarak maliyetlerinin çoğunu azaltır.

Sistem, hastaya zamanında ilaç verilmesi için gerçek zamanlı müdahale sağlar, ayrıca hasta için herhangi bir tehlike olması durumunda e-posta ve SMS ile bildirim uyarıları gönderir. Bu bildirim, doktorları her hastanın durumu hakkında bilgilendirecektir.

Bu tez EKG, vücut ısısı, vücut hareketi ve kandaki oksijenasyonu, kalp atış hızı, solunum hızı, Glikoz, kan basıncı, GSR ve Hava akışını tartışmaktadır.

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DECLARATION

I hereby declare that in the preparation of this thesis, scientific ethical rules have been followed, the works of other persons have been referenced in accordance with the scientific norms if used, there is no falsification in the used data, any part of the thesis has not been submitted to this university or any other university as another thesis.

Alaa Hussein ABDULAAL

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THE DIRECTORATE OF GRADUATE EDUCATION INSTITUTE

The thesis study of Alaa Hussein ABDULAAL titled as Designing and implementation of electronic device controlled IoT for COVID 19 patients monitoring through secured communication system has been accepted as MASTER THESIS in the department of ELECTRICAL and ELECTRONIC ENGINEERING by our jury.

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Director of the Institute

SUMMARY

The Coronavirus (SARS-CoV-2) epidemic swept the world at the end of 2019 as a dangerous pandemic that causes death and exposes much of the world to danger and seriously threatens the countries of the world, while great efforts are being made by doctors in the front ranks to discover the virus and invent treatment and develop vaccines necessary to stop its spread and limit its spread. The objective of this thesis creates an electronic health system to monitor patients infected with Coronavirus and reduce the effort made by doctors at a cheap cost.

This thesis will specifically present the development of a set of sensors to be placed on patients who are subject to quarantine to monitor their health status. At this time, the Internet of Things (IoT) is working to bring about a great knowledge revolution and the beginning of a new era, which makes our lives simpler. The IoT provides an advanced model for remote health monitoring in the hospital or in quarantine places. The sensors obtain the patient's medical information and the IoT stores and displays it through a web browser or through special programs, which provides remote care. The proposed program reduces human error and reduces the number of doctors, especially after the collapse of the health system in many countries due to the severe shortage of doctors after being infected with the virus, and also reduces the size of medical devices required to monitor patients while saving much of their cost.

The system provides real-time intervention to administer medications to the patient in a timely manner, as well as send notification alerts by email and SMS if there is any danger to the patient. This notice will keep doctors informed of each patient's condition.

This thesis discusses ECG, body temperature, body movement, and oxygenation in the blood, heart rate, respiratory rate, Glucose, blood pressure, GSR and Airflow.

Keywords: sensors, mobile health pad for Covid 19 patients, microcontroller, GSM, and remote monitoring platform.

ÖZET

Koronavirüs (SARS-CoV-2) salgını, 2019'un sonunda ölüme neden olan ve dünyanın çoğunu tehlikeye atan ve dünya ülkelerini ciddi şekilde tehdit eden tehlikeli bir pandemi olarak dünyayı kasıp kavurmaktadır. Ön saflarda yer alan doktorlar tarafından virüsü keşfetmek ve gerekli aşıları geliştirip tedaviyi icat etmek ve yayılmasını durdurmak ve yayılmasını sınırlamak için büyük çaba sarf ediliyor. Bu tezin amacı, Koronavirüs bulaşmış hastaları izlemek ve doktorların yaptığı çabayı ucuz bir maliyetle azaltmak için bir elektronik sağlık sistemi oluşturmaktır.

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Anahtar Kelimeler: Dizi sensör, Covid 19 hastaları için mobil sağlık pedi, mikrodenetleyici, GSM ve uzaktan izleme platformu

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ABBREVIATIONS

IoT	Internet of thing
ECG	Electrocardiogram
WHO	World organize health
LPWAN	Low power wide area network
BLU	Bluetooth
CT	Computed tomography
WBAN	wireless body area network
GSR	Galvanic skin response
SPO2	Stood for senior police officer 2
HBO2	Hyperbaric oxygen
RR	Respiratory rate
RSA	Respiratory signals arrhythmia
EMG	Electromyography sensor
MRI	Magnetic resonance imaging
AI	Artificial Intelligence
HA	Hash code
ANN	Artificial Neural Network

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PREFACE

During the process of preparing this thesis, I would like to express my gratitude and thanks to Assist. Prof. Dr. A. F. M. Shahen SHAH who supported and guided me throughout the period.

I do not forget my family, my wife and my children who supported me until this moment. Also, I would like to thank my uncle Mr. Abbas al-Sudani for all that he has provided to me.

Thanks to all of my friends who have always encouraged me.

INTRODUCTION

Coronavirus (COVID-19) swept the world and became a very dangerous epidemic, affecting more than 213 countries around the world. According to the world health organization (WHO), the number of registered cases is more than 23 million, while about 800,000 patients have died, which is a global health problem. The outbreak of the Coronavirus has become a threat to global health, the global economy and many other aspects of life. Often, COVID 19 causes lung problems that begin with respiratory symptoms that may develop into pneumonia, which cause the patient's clinical deterioration very quickly.

The severity of a patient's infection with COVID 19 is divided into three categories: infection without clinical symptoms, mild infection and high-risk (fatal) infection.

The Corona virus epidemic has raised a threat to health care systems in all countries of the world, which weakens them in providing health solutions to patients, not only for those suffering from the virus epidemic, but for patients who have health problems outside the borders of the epidemic.

The injured are isolated on the basis of the severity of their infection with the Coronavirus, where patients are entered in critical condition to the hospital, while being sent patients with mild symptoms to home to receive medical treatment to reduce the pressure on hospitals, and these cases do not require medical intervention unless there is a rapid deterioration. Improving health methods for providing health care services and developing medical platforms has become necessary to monitor patients remotely and also to maintain the health of the medical staff and care service providers, as one of the most important things to think about to combat the virus, also reducing the process of direct contact with patients contributes to stopping the spread of the epidemic.

The modern technology that has produced the new generation of health sensing and monitoring technologies requires transferring health care from hospitals to home or quarantine places, and thus providing medical devices to patients who are most in need of them. Technological advances in medical care, along with sensors and remote monitoring enable patient control and also a promising solution to help doctors deal with the Coronavirus (COVID -19) epidemic.

Internet-connected devices provide tremendous potentials towards switching to remote medical care, especially with low prices for their components, which leads to more new innovations. The Internet of Things is a collection of systems and sensors. Given that medical innovation is very important issues in the new era, the IoT has become one of the issues that must be provided to monitor medical care, which is available to all.

Health care is considered very important issues in this era, and the Internet of things can enter the health monitoring system, especially for COVID 19 patients who need constant monitoring for fear of exposure to clinical collapse. When the patient is admitted to the hospital or quarantine places, they are monitored remotely using the Internet of things, and also the relatives of the patient who are concerned about their health condition are informed of the patient's condition moment by moment.

With Raspberry Pi and the Internet of Things monitoring is done through a set of sensors at a low cost. In this proposed system, blood oxygenation, heart rate, temperature, blood pressure, respiratory rate, and body movement are measured.

The instantaneous transfer of information enables the doctor to monitor more than one patient at the same time, which reduces the burden on the medical staff and also preserves the lives of doctors, especially when they are in the advanced ranks, they are more vulnerable to injury, which avoids the collapse of the medical system and also the transfer of this information to the patient's relatives makes the health system More responsible.

The devices used in hospitals are large and bulky to measure the patient's health data in addition to its very high price, which is expensive. On the other hand, we can do this using the sensor platform with the Internet of Things.

A health monitoring system has been developed by us to monitor patients and share information with the responsible medical staff through remote monitoring, and to do this, health data is collected from the sensors by a microcontroller and sent to the cloud and then displayed on computers and smartphone application using a secure security protocol to protect Patient information.

The body area system has unique improved communication for the low-energy sensors and its scope of work is to provide complete information about the patient and is controlled by Raspberry Pi.

CHAPTER ONE

MOTIVATION AND CONTRIBUTIONS

1.1 Motivation

Given the critical condition that the health system suffers from due to the emerging corona virus epidemic around the world, the process of going to the hospital takes time, as the patient visits the specialist doctor to obtain vital information. This problem was solved by our proposed system, which depends on the wireless body area network (WBAN), which is a group of wearable computing devices where communication is made by GSM and WIFI to secure the communication between the patient and the medical care unit.

Our thesis proposal is a device that can be achieved with a low cost with an electronic device driver through smartphone application based on the web. This work will be an appropriate model for monitoring COVID-19 patients and informing the health system when any changes occur.

The work also provides real preparation for epidemic patients and informs the relevant authorities of updates in real time.

1.2 Overview

Our proposed system monitors new Coronavirus (COVID-19) patients, and it is cost-effective and avoids collapse in the medical reality, as the device measures the oxygen level in the blood, the number of heart beats, temperature and blood pressure and are sent via GSM and Wi-Fi, the cloud has a special database through which the doctor and the patient’s relatives can access it and monitor them moment by moment.

The cost of the project is taken into consideration, which is important for any proposed system, in our project the cost will be very low and available to all, and mobile applications will be free for any user.

1.3 The main objective of the thesis is:

- The process of managing and monitoring more than one patient with the new Corona epidemic (COVID-19) .

Doctors can monitor patients continuously and get notifications for any change that may occur in the patients' readings, as the doctor does not need to be present with the patient, and this provides high flexibility in the health system in addition to maintaining the safety of doctors from contracting the disease.

- Reducing the burden of going to the hospital

The main objective of our proposed system is to monitor patients by using the Internet of Things to save time and reduce expected risks.

- The application is easy to use by the doctor and relatives

The application is designed with an easy-to-use interface with a high-level security layer to provide remote healthcare service

- Obtaining the real numbers of patients with the Corona epidemic and the information of the competent authorities and the WHO immediately.
- Reducing the risk of the patient going to the hospital

As the patient may come into contact with someone else and be a cause of the spread of the virus.

- Avoid a crash in the health system

As happened in many developed countries such as Italy, France and the United Kingdom, where the number of patients exceeded the capacity of hospitals, causing a collapse in the health system.

- Providing care service for patients who do not complain of Coronavirus

The high turnout of COVID-19 disease has prevented the rest of the patients who suffer from other problems that need to be looked after by doctors and are unable to reach the hospital due to its overcrowding with Corona epidemic patients

Providing remote medical care service for epidemic patients will reduce the pressure on hospitals, allowing the rest of the patients to enjoy the care service.

1.4 Thesis Organization

This thesis is composed of seven chapters.

- **Chapter One** presents simple introduction for the proposed system, includes general information, motivation, and the objective of the thesis.
- **Chapter Two** presents the literature review, phycological measurements, and wireless communication technologies.
- **Chapter Three** presents design and working methodology
- **Chapter Four** presents the telemedicine technology and medical imaging
- **Chapter Five** presents cloud commuting, data encryption and suggested methodology
- **Chapter six** presents the analysis of the results for each sensor
- **Chapter seven** presents the conclusions and future work.

CHAPTER TWO

STATE OF THE ART

2.1 Introduction

A number of health monitoring systems have been developed, specifically mobile health applications, using technology in the provision of health care.
This chapter aims to review the latest technologies used in telehealth systems and take advantage of its features in the context of creating a smart health monitoring system for COVID-19 patients with the outbreak of the Corona epidemic.
A smart computing system is being followed, including smart phone applications, short message service and e-mail service, to administer health care systems.

2.2 literature review

Ding, X. R et al. 2020) present wearable sensing and telehealth technology with potential applications in the coronavirus pandemic. A summary of sensors and remote mobile health systems and their applications in facing the Coronavirus epidemic. The task of these devices is to reduce the burden on the health system and prevent it from collapsing by transferring medical services from the hospital to the home, where the intervention is immediate to prevent any possible deterioration in the patient's health and also to reduce contact between the patient and the medical staff to prevent the spread of disease and to maintain the safety of doctors, so health systems are portable and telemedicine are very promising in the fight against COVID 19.

There is a clear interest by researchers and developers in the field of mobile health and the use of mobile health applications in the face of COVID 19. Care providers and physicians are beginning to adapt to its impressive and promising results for widespread use.

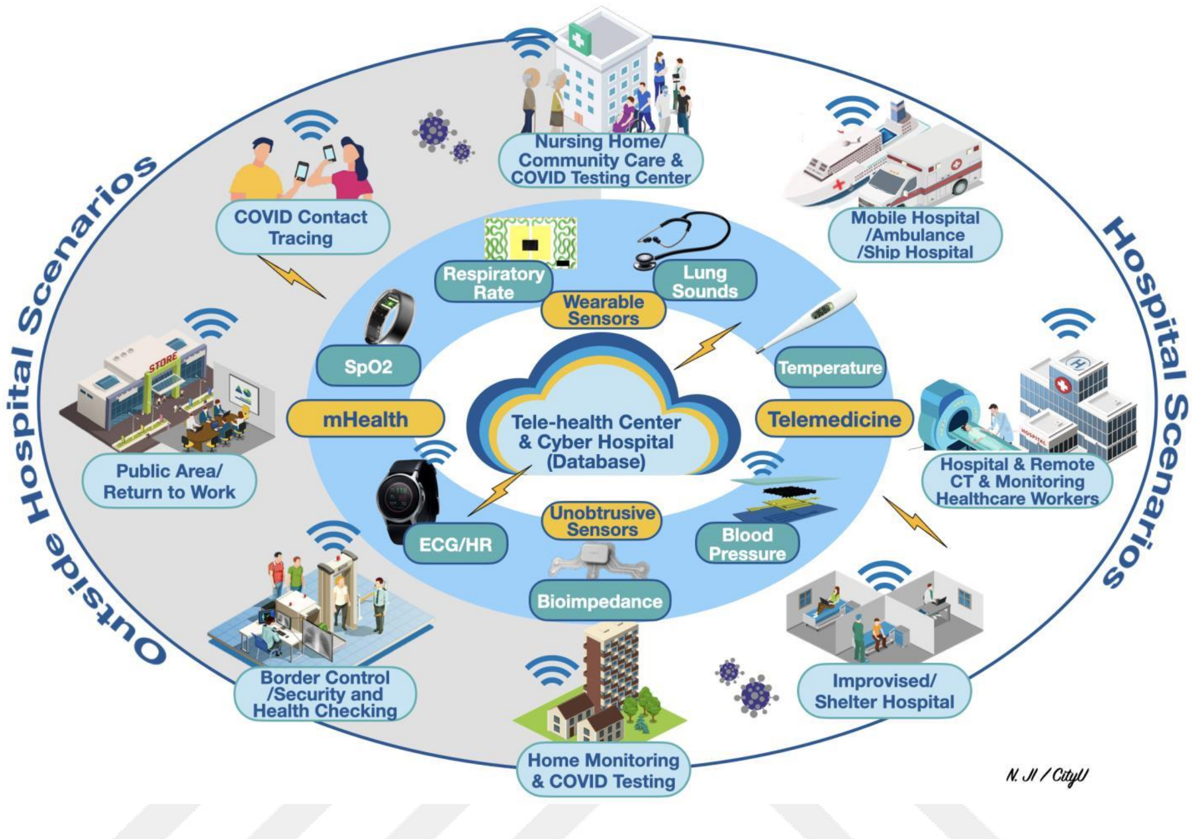

Figure. 1. App scenarios of sensors devices. Ding, X. R et al. (2020).

Figure. 2. Wearable pulse oximeters

Kumar, S. S. (2020, August) propose an emerging technologies and sensors that can be used during the COVID-19 Pandemic. Sensor technologies that can monitor patients with the emerging coronavirus are reviewed, and ways of developing and adopting them are discussed.

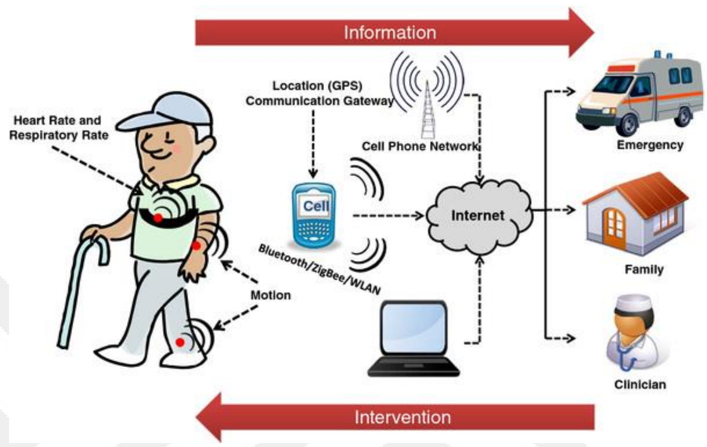

Figure. 3 E-health monitoring system with wearable sensors.

Rahman et al. (2019, January). IoT Based Patient Monitoring System Using ECG Sensor. Their research discusses a remote patient monitoring system using the ECG sensor. A mobile health system has been suggested that is controlled remotely to follow the patient through the ECG sensor and send data to the cloud where caregivers and the responsible staff can access it and follow up on the health status and alert them of any possible deterioration that may occur.

Yeri, V., & Shubhangi, D. C. (2020, July). IoT based real time health monitoring. The proposed research is based on mobile and web applications with a set of sensors to monitor the patient’s condition, where data are collected and a database is created so that care service providers and medical staff can view it and provide instructions and avoid any side effects.

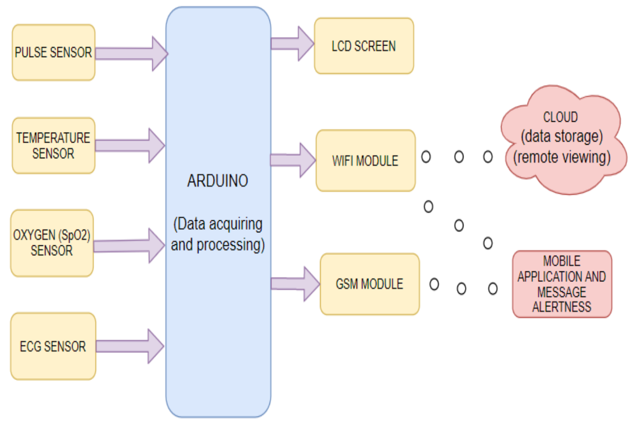

Figure. 4: Block diagram of the proposed system

Ruman et al. (2020, February) IoT Based Emergency Health Monitoring System has been suggested. The paper proposes a health system through which the patient can be monitored every few seconds and collect temperature data, the number of heart rate and pulse, and create an integrated database through which the doctor can inform and monitor the patient’s health status.

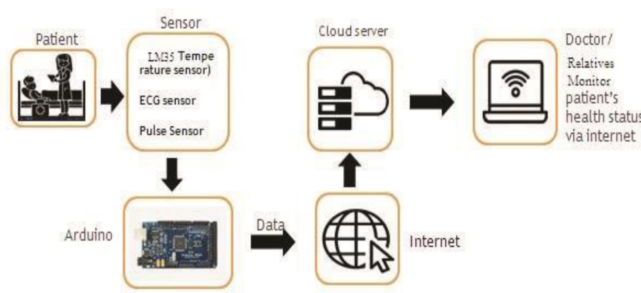

Figure. 5. Block diagram of proposed model.

Tamilselvi et al. (2020, March) IoT Based Health Monitoring System has been suggested. In this paper, the cost optimized device used for continuous monitoring of health for detecting variation in human body was achieved. Where pulse rate, humidity and temperature were detected with help of sensors by comparing the sensor values with preset value and stores those data in cloud, then triggers the alert message to the user or doctor with help of cloud and Node MCU to user android application about health variations when sensor value exceeds the preset value. From experimental result it can be concluded that health monitoring device is easier and highly reliable device to detect the variations in human body within short period.

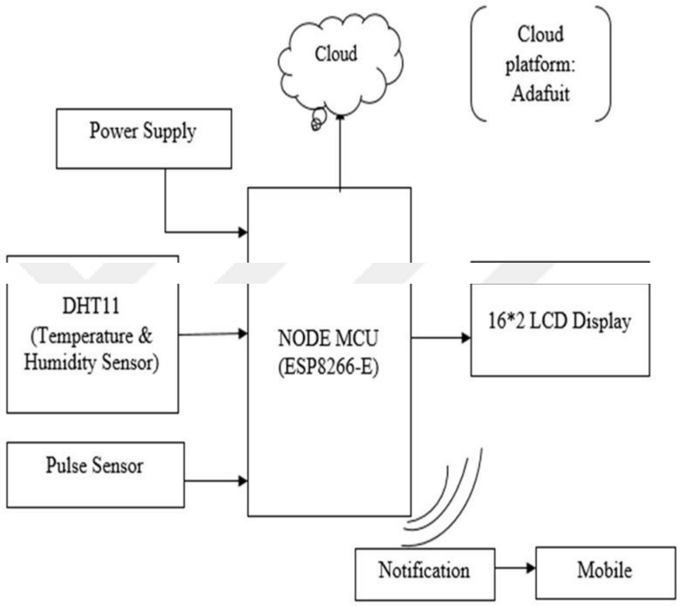

Figure 6: Block Diagram of Health Monitoring System

Mishra, S. S., & Rasool, A. (2019, April) IoT Health care Monitoring and Tracking has been suggested. An IoT is nothing but an integration of sensors attached to various objects with the internet in order to provide data to the internet along with using the already available data from the internet. The relationship can extensively be used for the betterment of human health. The various devices explained above (which are available) are helping every individual in maintaining his/her physical well-being. Early detection of any issues in the human body has been made quite easy. The main aim of this work was to give a comprehensive view of IoT usage in medical health and to report the extensive range of gadgets and tools available as well as proposed. In this survey paper, we have given priority to both research works and commercial devices to study and investigate the currently available and future tech- neologies.

Warsi, G. G., Hans, K., & Khatri, S. K. (2019, February) IoT Based Remote Patient Health Monitoring System has been suggested. In this paper, they proposed an IoT based model for remote patient health monitoring. With the help of sensors, the proposed system is able to track the basic vitals like temperature, blood pressure, heartbeat rate and Electro-cardiogram readings of patients at home or remote site. The user can remotely monitor the live status of the patient from anyplace with the only constraint that there should be internet connectivity as to receive the live updates about the patient. The proposed model is extremely useful for the society and would supplement the existing solutions for health monitoring.

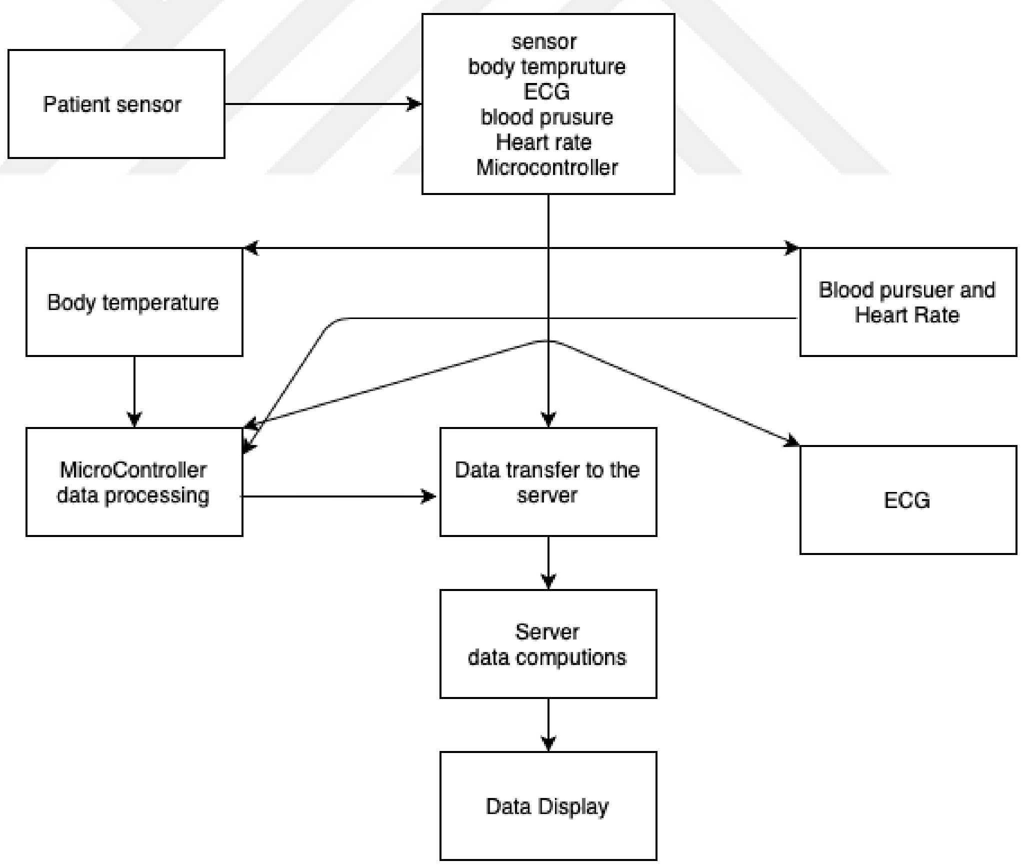

Figure. 7 Block Diagram for the proposed system

Fei, H., & Ur-Rehman, M. (2020, August) A Wearable Health Monitoring System has been suggested. This work proposed a wearable health monitoring system especially for people who have Parkinson's disease. Different from existing solutions on the market, this system includes a complete method for monitoring heart rate, real-time displaying, history data recording and transmitting important data to the mobile phone for further analysis. In addition to the heart rate monitoring, other features such as step counting, abnormal gesture detection and falling detection are also included, and users can self-define the abnormal gesture and trained off-line.

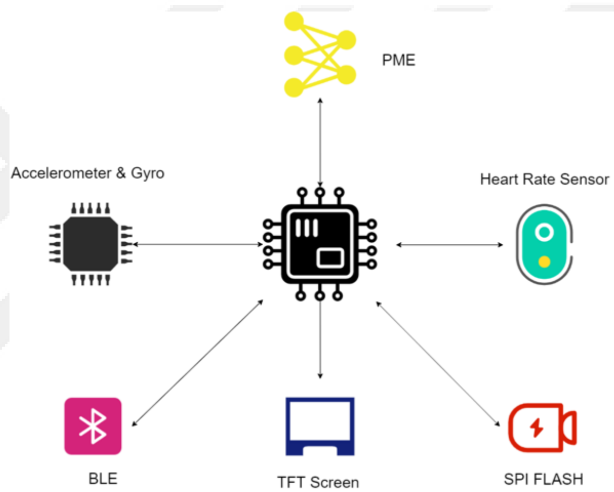

Figure. 8. Overall hardware configuration.

2.3 Physiological measurements

In this part, patients are monitored using wearable sensors to provide continuous monitoring of the patients' condition in order to ensure progress in the quarantine period and all data is relevant to adequate monitoring.

Vital signs used to assess the health status of COVID 19 patients include:

i. Oxygen Saturations
ii. Respiratory rate
iii. Blood pressure
iv. Heart Rate

v. Temperature

vi. ECG

vii. Glucose

viii. GSR

ix. Body position

2.3.1 Oxygen Saturations (SPO2)

Oxygen is one of the most essential components for sustaining life. Lack of oxygen is one of the most important symptoms of the emerging coronavirus disease. It is the amount of saturated hemoglobin in the blood. COVID 19 causes inflammation of the air sacs in the lungs, which impedes the transport of oxygen into the blood and leads to damage to the lungs (Shi, Y et al 2020). The percentage of Spo2 for a healthy person ranges between 95% to 99%, and this percentage decreases for patients who suffer from respiratory problems. Oxygen Saturations is an important predictor for diagnosing Coronaviruses patients.

The WHO suggests that people who have more than 94% spo2 can have access to home health care (World Health Organization, 2020). While indicating that patients whose percentage is less than 93% with a critical health condition and a serious indicator of having COVID- 19 should be hospitalized (Liu, Y et al. 2020). Patients with a percentage of less than 90% are more likelihood of death (Hui, H., Zhang et al. 2020). Continuous monitoring of Oxygen Saturations hemoglobin is very important to maintain the health of patients and avoid any possible health deterioration and can save many lives, especially as it is wearable and can be provided in any home, especially in poor countries. (Nacoti, et al. 2020), (MacLaren, G., Fisher, D., & Brodie, D. 2020).

The principle of work of pulse oximetry devices is based on optical imaging, which is the amount of change in light absorption due to the volume of arterial blood. The oxygen device contains an LED and an infrared ray that is usually attached to the finger. The wavelengths are discovered and then the ratio is calculated based on the amount of absorption of the two wavelengths of light by oxygenated and non-oxygenated hemoglobin. There are two types of hemoglobin in red blood cells, de-oxy and oxyhemoglobin (HBO2) (Ding et al. 2020).

2.3.2 Respiratory rate

Respiratory rate (RR) is an important necessary sign for controlling COVID-19 patients, its being an effective and early predictor of Situations like hypoxia (low amount of oxygen) as well as increased carbon dioxide inside the blood. Respiratory rate is the primary factors to determine the respiratory disease.

In addition, respiratory rate is one of the clinical features of a predictor of COVID-19. Experiments showed that Patients infected with sars-cov-2 in Wuhan, China, 63% of patients who died due to the virus had a higher respiration rate (54) per minute (Zhou et al. 2020). So, measuring the respiratory rate using the Internet of things is one of the important factors to monitor the progression of COVID 19 and identify any possible deterioration to intervene in a timely manner to administer clinical treatment.

Respiratory rate monitoring is performed using Internet of Things in three ways:

1- By measuring the amount of respiratory airflow by detecting parameters like temperature, and carbon dioxide.

2- By sensing mechanical stress related to breathing such as respiratory sound and chest or abdomen movements Associated with respiration.

3- By identifying other cardiovascular signals like the ECG and PPG based on the modulating effect of respiration on these respiratory arrhythmia (RSA) signals. Technologies include thermal, humidity, acoustic, pressure, resistance, inductance, acceleration, electromyography and resistance. A wearable device with these sensors can be attached to chest straps, attached to a chest strap (Zhang et al. 2019), (Liu, H., & Zheng), (Liu, G. Z., Guo, Y. W., Zhu, Q. S., Huang, B. Y., & Wang, L. 2011), (Yamamoto et al. 2019) or placed on skin (Chu et al. 2019), (Liu et al. 2020).

2.3.3 Airflow

The airflow method is based on Exhaled air is more heat with high humidity rates and more carbon dioxide than the Inspiratory air. according to that respiratory rate is measured by the amount of change in temperature rates and carbon dioxide. The principle of the air flow sensor is a sensor connected to the airways of the nose. The sensor is a thermostat in the mouth or nose. It calculates the humidity and the amount of carbon dioxide between inhalation and exhalation. A high sensitivity respiratory sensor has been reported as it can detect different breathing patterns (Liu et al. 2020). Also been reported to develop a multi-air flow sensor electrolyte can be placed with a face mask under the crisis of COVID -19 (Dai et al. 2019).

Respiratory rate is an early, extremely good indicator of physiological conditions such as hypoxia (low levels of oxygen in the cells), hypercapnia (high levels of carbon dioxide in the bloodstream), metabolic and respiratory acidosis.

The respiratory rate is measured by the number of breaths per minute, as it represents one breath for every movement of air inside and outside the lungs. An average healthy adult has a rate of 12-20 breaths per minute. This percentage changes depending on the patient's health condition, where a low or high respiratory rate indicates the body's need for a greater or lesser amount of oxygen. Also, a decrease in the respiratory rate to 9 breaths per minute or less indicates a significant deterioration in the patient's health.

Figure.9 A Airflow sensor

Of human respiration rate of the normal 15-30 breaths per minute

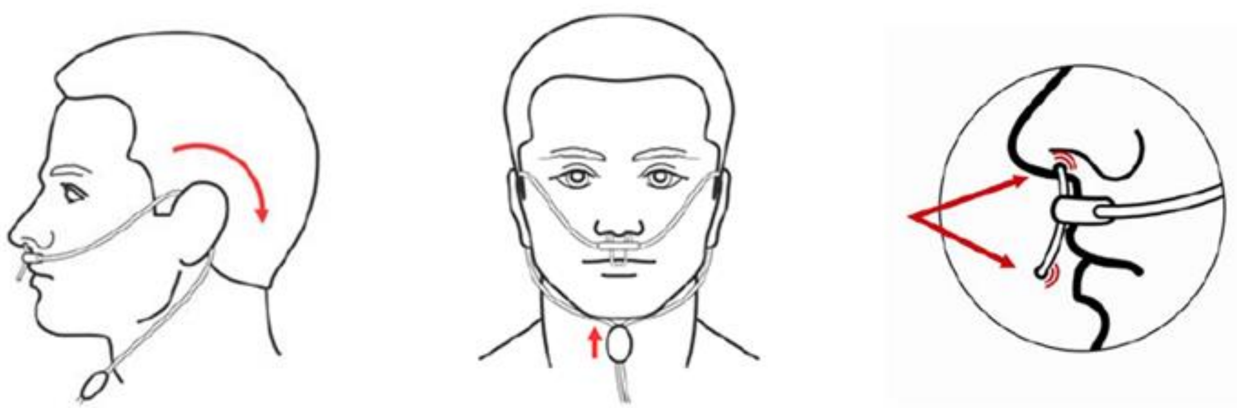

Figure.9 B Airflow sensor

2.3.4 Electrocardiogram for Monitoring COVID-19 Patients

The ECG machine is the process of evaluating the muscle and electrical function of the human heart by monitoring the heart's activities. It is one of the vital signs of the human being. With patients who have cardiovascular problems, it has become necessary to monitor cardiac activity, especially with COVID 19 patients. Significant change in ECG signals and accelerated heart rate have been reported in COVID 19 patients (He, J., Wu, B., Chen, Y., Tang, J., Liu, Q., Zhou, S., ... & Peng, D. 2020). In addition to the treatment protocols used for HIV patients and the medical treatments that have side effects that lead to serious heart problems (Kochi et al. 2020), so heart functions must be monitored continuously to avoid any deterioration of the patient's health. In addition, the IoT-based ECG sensor reduces direct contact between doctor and patient and prevents potential infection. The portable ECG device consists of 3 ends with a circular adhesive and connecting wires, which are connected to the patient's chest and monitor the monitor. The suggested sensor is extremely easy and comfortable to use.

There are a number of products authorized to monitor COVID 19 patients by the Food and Drug Administration, and one of them is the ECG (Gabriels, J., Saleh, M., Chang, D., & Epstein, L. M. 2020).

Figure. 10 ECG sensor

2.3.5 Body temperature

It is very important indicators of a healthy body. We can accurately diagnose whether a patient has a fever by monitoring the temperature. During the outbreak of the COV-SARS-2 virus (COVID 19), thermal scanning systems such as infrared scanning were used in densely populated public places such as airports and metro stations.

Therefore, the proposed temperature monitoring device can be able to monitor changes in body temperature, as it can detect the high temperature of patients suspected of being infected with the virus at an early date (Abbasi, J. 2017), especially patients who do not suffer from any symptoms where they can be taken care of remotely. Using advanced technology, sensors can be attached to the body to monitor a patient's temperature.

Figure.11 Temperature sensor

2.3.6 Blood Pressure Monitoring

High blood pressure, which is known as blood pressure, is a sign that reflect the health of the heart and blood vessels, as it is considered a dangerous indicator of heart patients and responsible for 10 million deaths worldwide (Patel et al. 2018).

Studies and research conducted on 5800 patients with Corona epidemic have shown that high blood pressure is one of the most common diseases that afflict the patient (3090 out of 5800, with a rate of more than 57%), (Richardson et al. 2020). Recent studies that included 44,900 patients revealed that the mortality rate for people with high blood (6.1%) and heart disease (11%) compared to patients without heart problems (1%) (Wu, Z., & McGoogan, J. M. 2020).

In the past century, blood pressure is measured in the usual way that requires the presence of medical staff face to face, but with the spread of the Corona virus epidemic, requests by patients to detect blood pressure indicators increased, which generated great pressure on medical workers and caused a severe risk of infection of the medical staff and because a virus COVID 19 is highly contagious.

Therefore, with the use of (Internet of things) technology with some wearable sensors, we can monitor the patient’s blood pressure in real time to anticipate the developments that may occur while providing the medical staff with the latest developments. This will lead to better control of blood pressure associated with Coronavirus.

Figure. 12 Blood pressure sensor

Table 1 Summary of blood pressure levels.

	Systolic (mm Hg)	Diastolic (mm Hg)
Optimal BP	<120	<80
Normal BP	<130	<85
Mild hypertension	140-159	90-99
Moderate hypertension	160-179	100-109
Severe hypertension	≥180	≥110

2.3.7 GSR

It is the galvanic skin response. The sympathetic nervous system is stimulated by strong emotion, which prompts the sweat gland to secrete sweat and through which the electrical conductivity of the skin is measured. Emotions are monitored by connecting the polarity on the fingers, as in the following figure.

Figure. 13 GSR sensor

2.3.8 glucose

It is a device for measuring and monitoring glucose levels. A sample is taken from the patient’s blood and placed on a single-use test strip, and the result is displayed after several moments, as in the following figure.

Figure. 14 glucose sensors

2.3.9 body position

The body position sensor is placed around the chest to determine the shape of the body for example (standing, lying down, lying down, left, right) and the patient is monitored continuously as in the following figure.

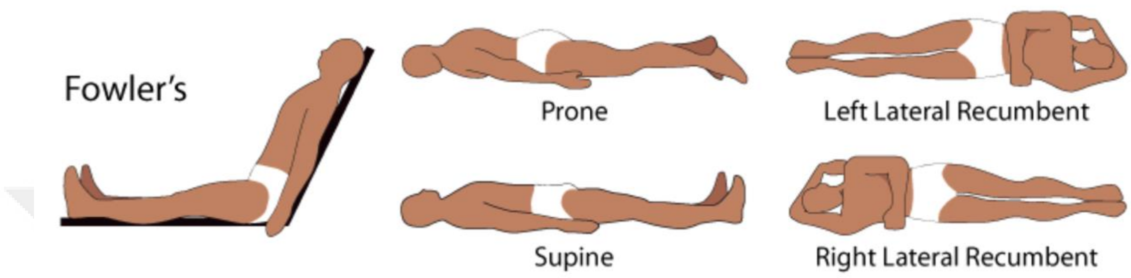

Figure. 15 body position

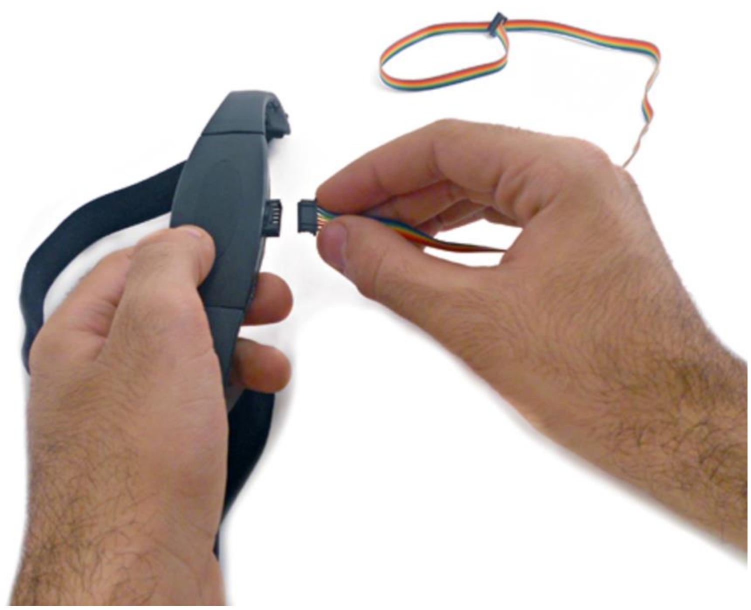

Figure. 16 body position sensor

2.4 Wireless Communication Technologies

2.4.1 IoT Communication Protocols

The IoT Includes several smart devices connected with each other, allowing communication and exchange of information, and the Internet of Things has become, at the present time, one of the important factors that go into medical care, as it allows the transfer and processing of data and delivery to the medical staff. The connection of smart devices can be wired or wireless. There are several types of Internet Protocol over low energy wireless personal area networks such as ZigBee and Bluetooth. The Sigfox and cellular are a low-power large-scale network (Al-Sarawi, S., Anbar, M., Alieyan, K., & Alzubaidi, M. 2017, May).

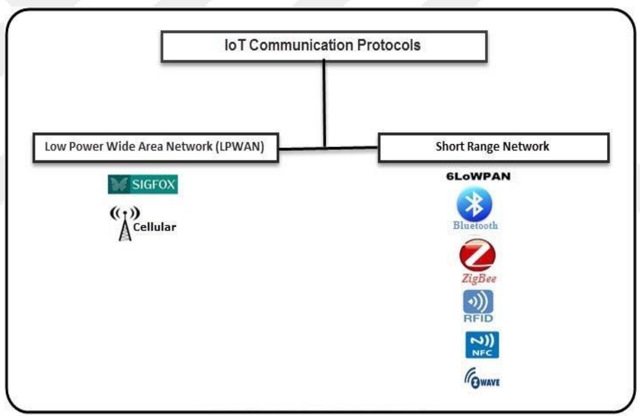

Figure. 17: IoT communication protocols

2.4.2 Low Power Wide Area Network (LPWAN)

2.4.2.1 Sigfox

It is a group of low-energy things such as M2M applications and sensors, as it allows the transfer of a small group of data, up to 45 kilometers, by means of narrow band (UNB) technology, this technology allows data transmission in small quantities (from 10 - 1000 bps) (Samie, F., Bauer, L., & Henkel, J. 2016, October).

2.4.2.2 Cellular

Cellular technology deals with high data, as it drains more energy and needs a power source with IoT applications that deal with large distances, as it uses GSM / 3G / 4G / 5G and provides high-speed Internet connection so it consumes large energy and is not suitable for M2M applications or network communications Local (Samie, F., Bauer, L., & Henkel, J. 2016, October).

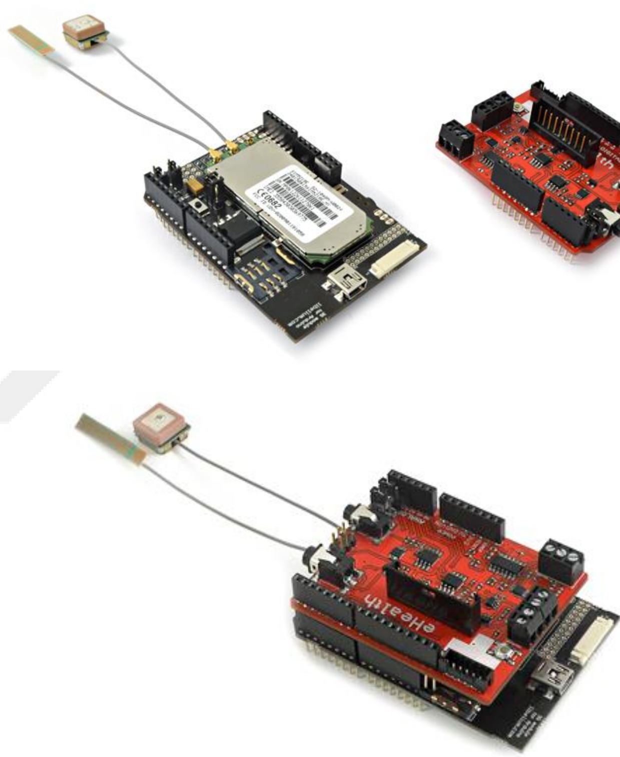

Figure.18: GSM shield

2.4.3 Short Range Network

2.4.3.1 6LoWPAN

6loWPAN is the most widely used area of the Internet of Things, as it is a standard protocol based on IP addresses. It can be connected without intermediate devices and directly with another IP network. It was created by ITEF that supports low energy consumption.

The star and mesh topology are one of the most important types of structures supported by 6loWPAN. In order to deal with the interoperability between IEEE 802.15.4 and IPv6, 6loWPAN proposes a middle layer between the network layer (IPv6) and the MAC layer. (Hossen, M., Kabir, A. F. M., Khan, R. H., & Azfar, A. 2010), (Lu, C. W., Li, S. C., & Wu, Q. 2011, December).

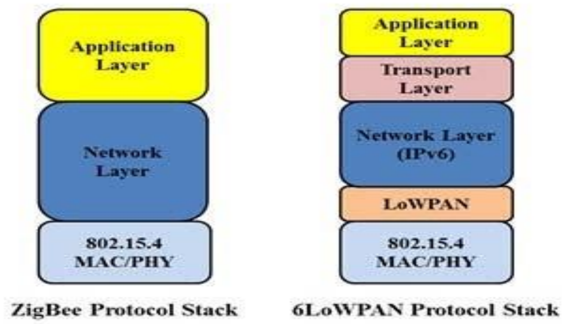

Figure 19: ZigBee and 6LowPAN protocol (Lu, C. W., Li, S. C., & Wu, Q. 2011, December)

2.4.3.2 ZigBee

ZigBee is used in communications that require little data and low power consumption, as it features long battery life and a secure data network. It was created by the ZigBee Alliance based on IEEE802.15.4 networks standard. ZigBee is suitable for low-cost, high-level communications protocols that transmit data over long distances. ZigBee supports several topologies such as Tree, Star and Mesh Network Topology (Samie, F., Bauer, L., & Henkel, J. 2016, October), (Salman, T. 2015).

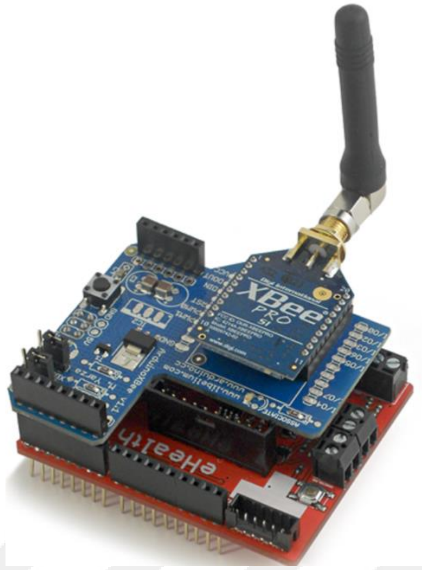

Figure. 20 ZigBee shield

2.4.3.3 BLE

BLE, also called Bluetooth smart, is one of the important protocols for IoT applications. Uses short and low bandwidth and is characterized by being less energy-consuming and typical of IoT applications and supporting the star network topology with a large number of nodes (Samie, F., Bauer, L., & Henkel, J. 2016, October), (Salman, T. 2015).

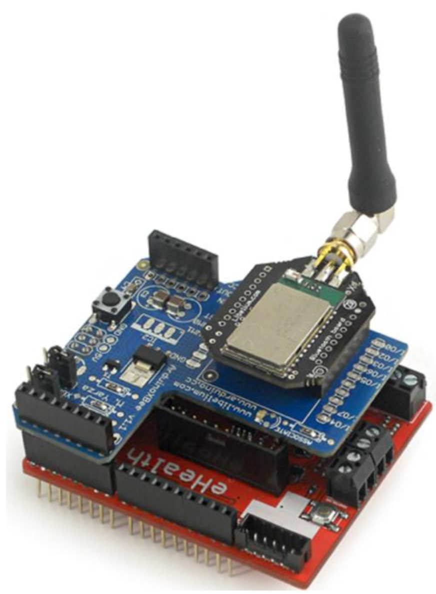

Figure. 21 Bluetooth shield

Table 2 ZigBee and Bluetooth.

	ZigBee	Bluetooth
Range	10 – 90 m	12m
Data Rate	250 Kbps	1 – 4 Mbps
Power	35 mW	95 mW
Security	128-bit AES	128-bit AES

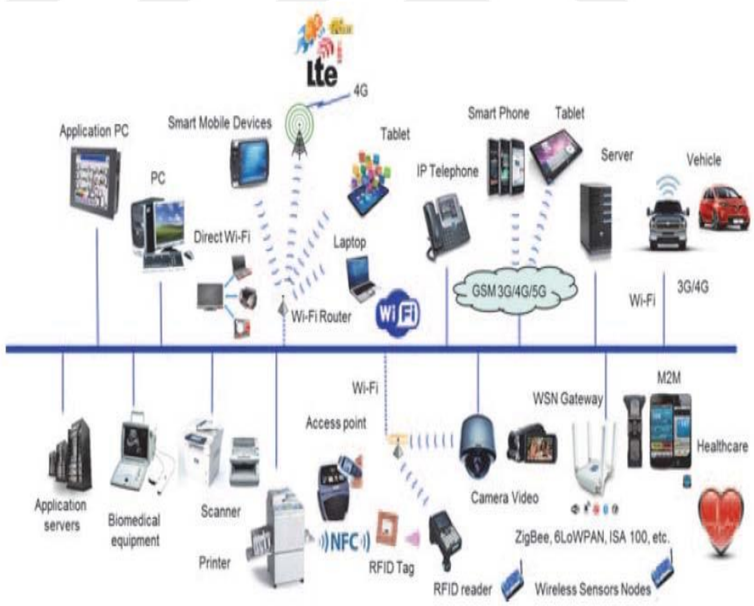

Figure. 22 COMMUNICATION PROTOCOLS IN IoT

2.4.3.4 WIFI

The Wi-Fi network has the unique feature of processing files for you, which is considered one of the pillars of the Internet of things and is used in various applications such as vehicle services, security cameras, and e-health applications. The Wi-Fi network works uniquely to support IoT applications, as the new version (Fifth Generation) provides a latency of less than 3ms and very high compatibility.

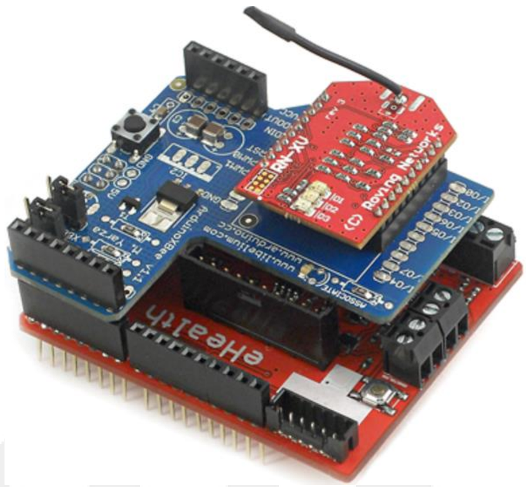

Figure. 23 Wi-Fi shield

Characteristics	6LoWPAN	ZigBee	BlueTooth LE	RFID	NFC	SigFox	Cellular	Z-Wave
Standard	IEEE 802.15.4 [18]	IEEE802.15.4 [18]	IEEE 802.15.1 [18]	RFID [18]	ISO/IEC 14443 A&B,JIS X-6319-4 [30]	SigFox [20]	3GPP and GSMA, GSM/GPRS/EDGE (2G), UMTS/HSPA (3G), LTE (4G) [7]	Z-Wave [18]
Frequency Bands	868Mhz(EU) 915Mhz(USA) 2.4Ghz(Global) [12]	2.4 GHz [19]	2.4 Ghz [15]	125 kHz, 13.56 MHz, 902-928 MHz [31]	125Khz 13.56Mhz 860Mhz [15]	868MHz (EU) 902MHz(USA) [20]	Common Cellular bands [31]	868 MHz - 908 MHz [12]
Network	WPAN [23]	WPAN [23]	WPAN [23]	Proximity [10]	P2P Network [23]	LPWAN [10]	WNAN [20]	WPAN [23]
Topology	Star Mesh Network [16]	Star ,Mesh Cluster Network [19]	Star –Bus Network [16]	P2P Network [04]	P2P Network [14]	Start Network [20]	NA [05]	Mesh Network [19]
Power	(1-2 years lifetime on batteries) Low power consumption [14]	30 mA Low power [26]	30 mA Low Power [26]	Ultra-low power [05]	50 mA low power Very Low [30]	10 mW - 100 mW [20]	High power consumption [05]	2.5 mA Low power consumption [14]
Data Rate	250 kbps [15]	250 kbps [16]	1Mbps [15]	4 Mbps [18]	106 212 or 424 kbps [15]	100 bps(UL), 600 bps(DL) [20]	NA [05]	40kbps [17]

Table 3: IoT protocols (Ding et al. (2020))

Range	Short Range 10-100 m [12]	Short Range 10-100 m [12]	Short Range ~15-30 m [15]	Short Range Up to 200 m [18]	Short Range 0-10cm 0-1m 10cm-1m [15]	Long Range 10km(URBAN) 50km (RURAL) [20]	Several km [31]	30m (indoors) 100(outdoors) [12]
Security	AES [13]	AES [13]	E0 Stream AES-128 [13]	RC4 [32]	RSA AES [25]	Partially addressed [29]	RC4 [27]	AES-128 [13]
Spreading	DSSS [17]	DSSS [17]	FHSS [17]	DSSS [33]	GSMA [23]	DSSS [11]	DSSS [27]	No [17]
Modulation Type	BPSK O-QPSK [12]	BPSK/BPSK O-QPSK [12]	TDMA [17]	FSK PSK [32]	ASK [23]	UNB DBPSK (UL), GFSK(DL) [20]	BPSK OFDM [27]	BFSK [28]
Features	Commonly Used Internal Access [31]	Mesh Network [31]	Low power version available [31]	Low Cost [31]	Security [31]	Long Battery life (up to 20 years) Low Cost [10]	Longer Range [31]	Simple Protocol [31]
Common Applications	Monitor and Control via internet [31]	Home industry monitoring and controlling [31]	Wireless headsets, Audio Applications [31]	Tracking, Inventory, Access [31]	Payment, Access [31]	Street Lighting Energy meters [24]	M2M [31]	Home Monitoring and Control [31]

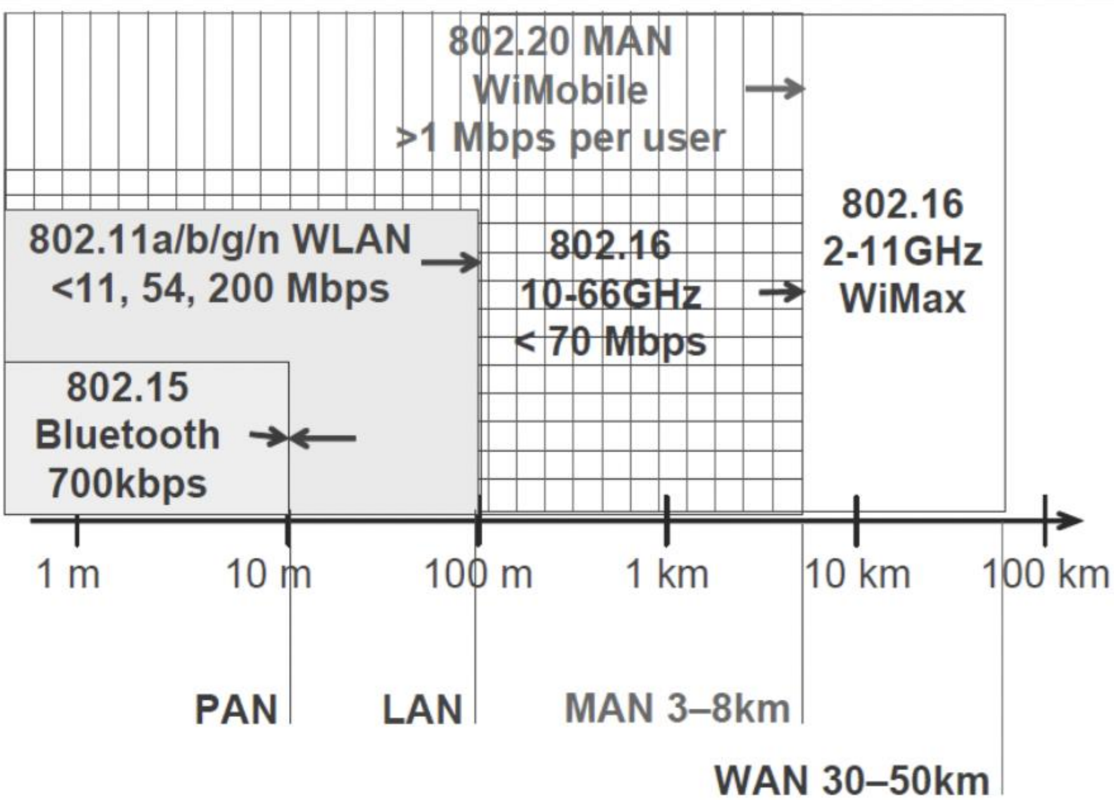

Figure. 24: Comparison of different wireless communications.

CHAPTER THREE

DESIGN AND WORKING METHODOLOGY

3.1 Introduction

A number of sensors will be used, such as the blood pressure sensor, temperature sensor, pulse sensor, oxygen sensor, heart rate sensor, sugar sensor and motion sensor, so we will need a Health sensor shield in order to connect all the sensors together and then we can connect them with the microcontroller device (Raspberry Pi or Arduino). After data is taken from the patient by sensors, it is sent via Wi-Fi or GSM to the database where it is stored. The doctor can read the data remotely using a smartphone or computer devices, as the department must be connected to the Internet.

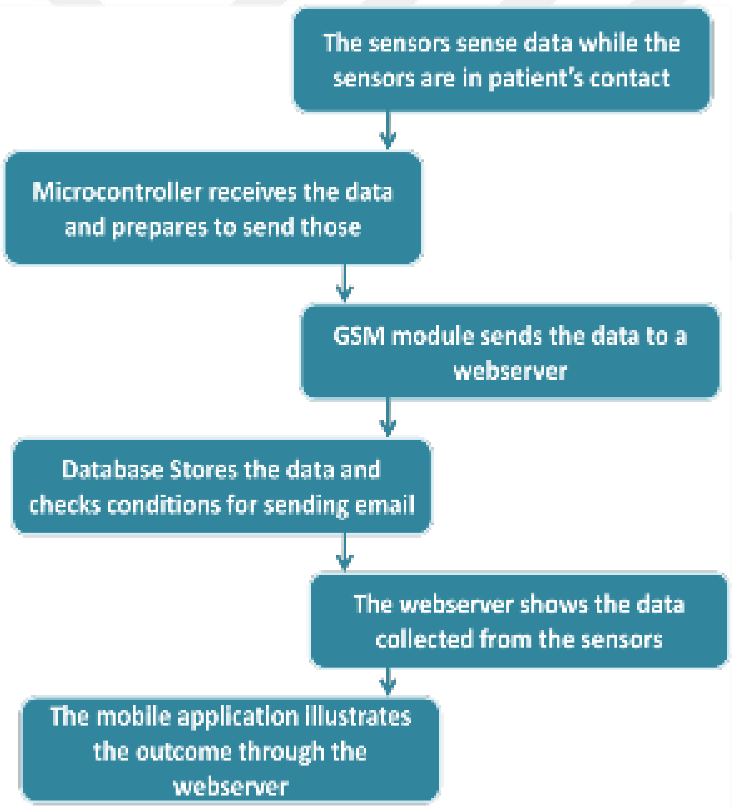

Figure.25: Work Flow of the System

3.2 System Model

The project proposes a system in which data are collected from sensors and sent to the microcontroller, where the latter sends vital signs via Wi-Fi or GSM to the cloud, where a database is created and stored. To be displayed and used by smartphone and computer devices.

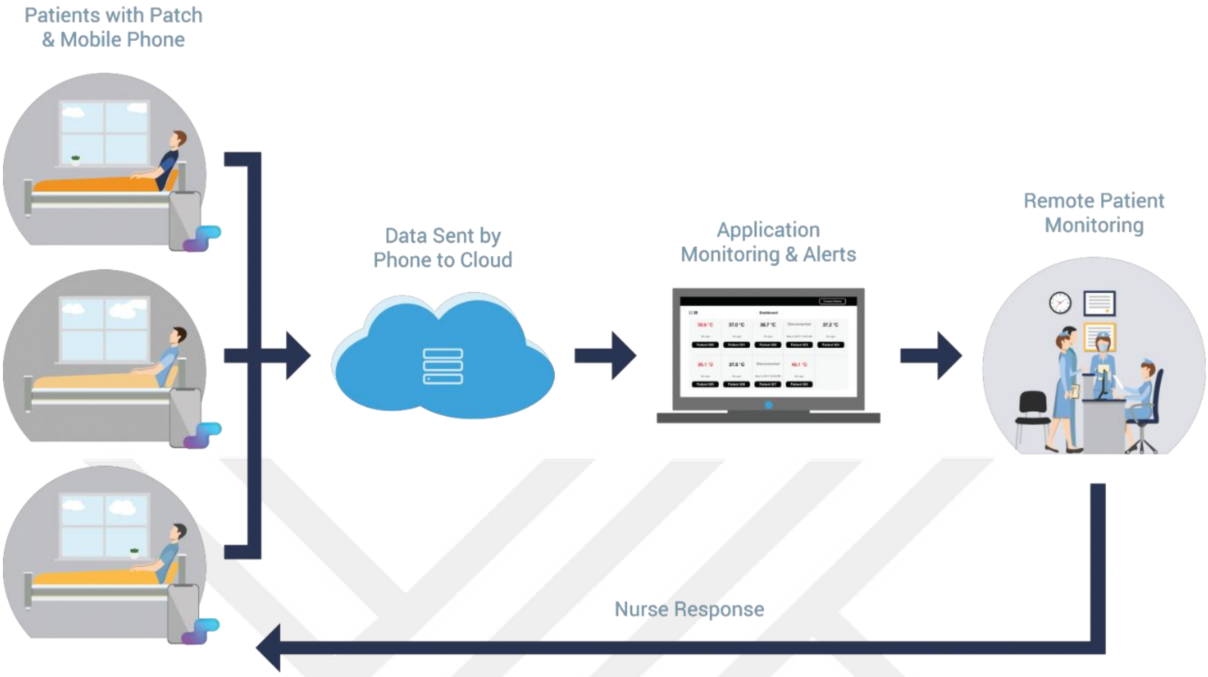

Figure.26 system model

3.3 Hardware Implementation

Hardware Overview of the System:

The hardware components used will be explained below:

3.3.1 Microcontroller

The microcontroller works like a small computer and can operate embedded systems as it consists of the processor, its memory, inputs and outputs. In our proposed system we use Raspberry Pi and Arduino.

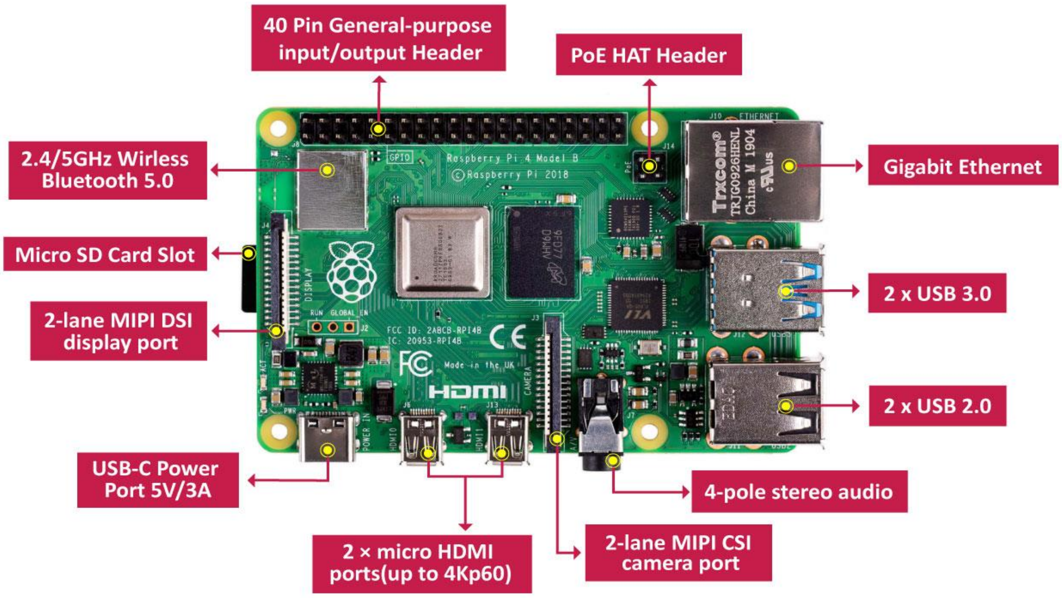

Figure. 27 Raspberry pi microcontroller.

Figure.28 Arduino microcontroller

3.3.2 COVID-19 e-health sensor platform shield

It is an electronic circuit designed so that we can use a number of sensors simultaneously such as: pulse, oxygen in blood (SPO2), body temperature, airflow (breathing), electrocardiogram (ECG), galvanic skin response (GSR - sweating), glucometer, blood pressure (sphygmomanometer), muscle / electromyography sensor (EMG) and patient position (accelerometer).

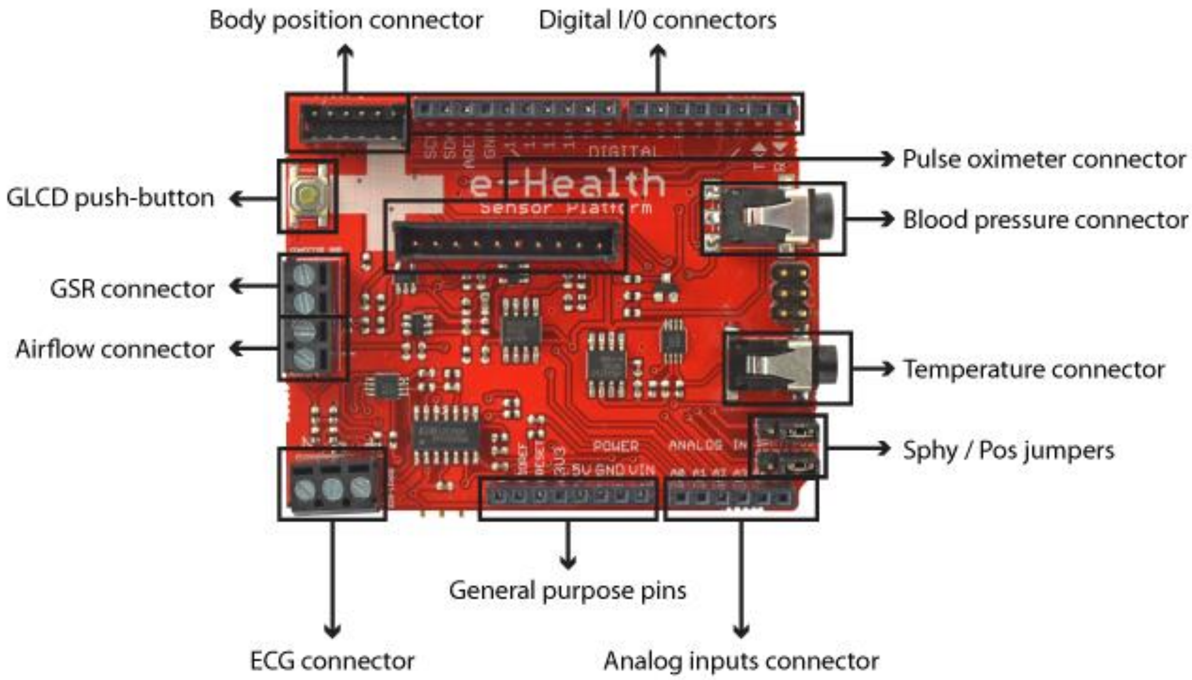

Figure.29 COVID 19 e-health sensors

3.4 Connection Set-Up

3.4.1 Pulse and Oxygen in Blood (SPO2)

The sensor is connected to the COVID-19 e-health sensor platform, as shown in the figure below:

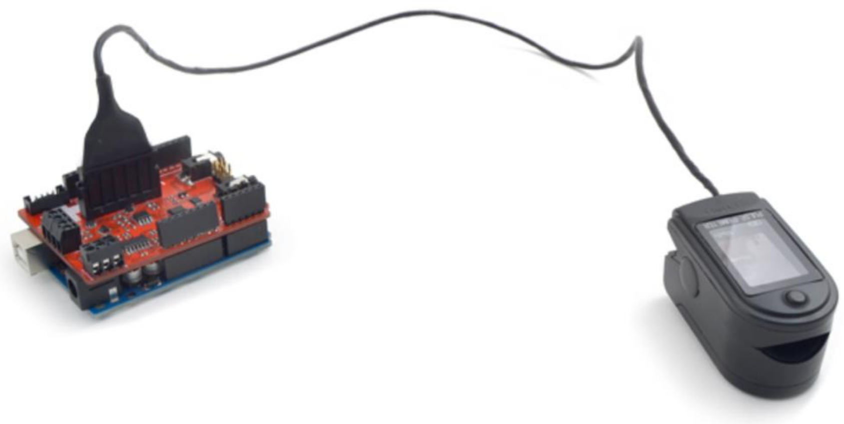

Figure.30 A SPO2 sensor

A finger is inserted and we press the Start button.

Figure.30 B SPO2 sensor

The result is obtained after several seconds.

Figure.30 c SPO2 sensor

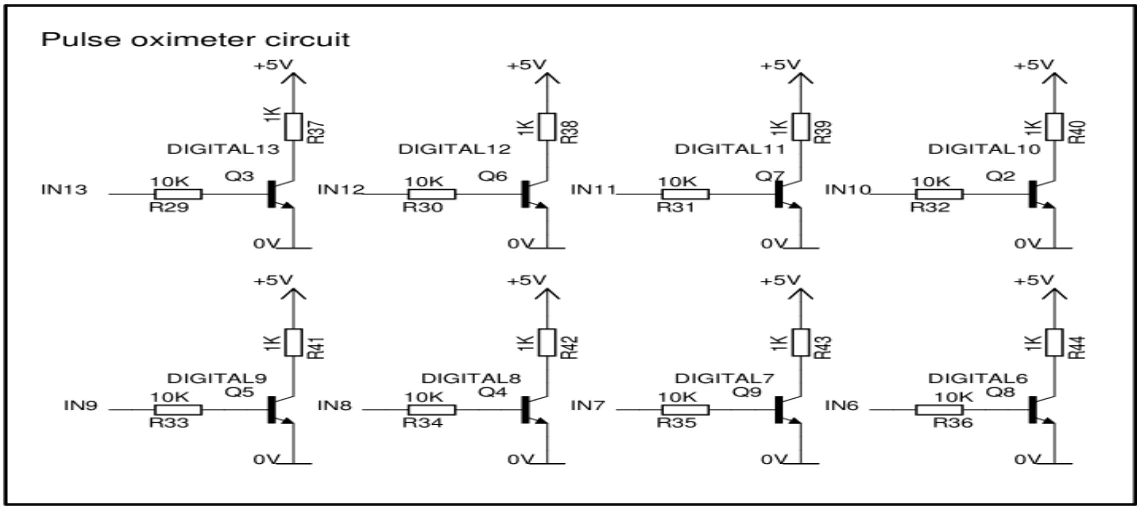

Figure. 31 SPO2 circuit design

3.4.2 Electrocardiogram (ECG)

The three poles (negative, positive, and neutral) are connected to the COVID-19 e-health sensor platform.

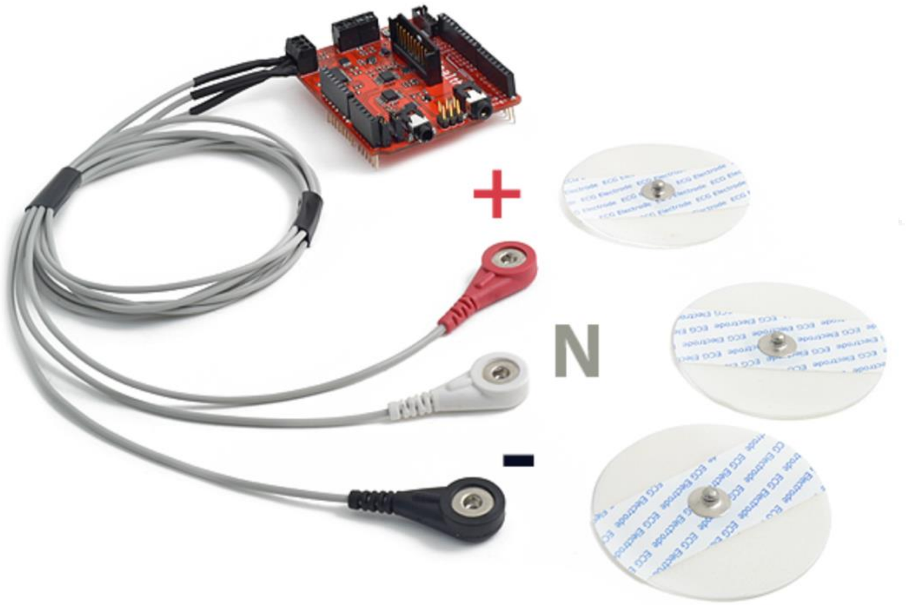

Figure. 32 A ECG sensor

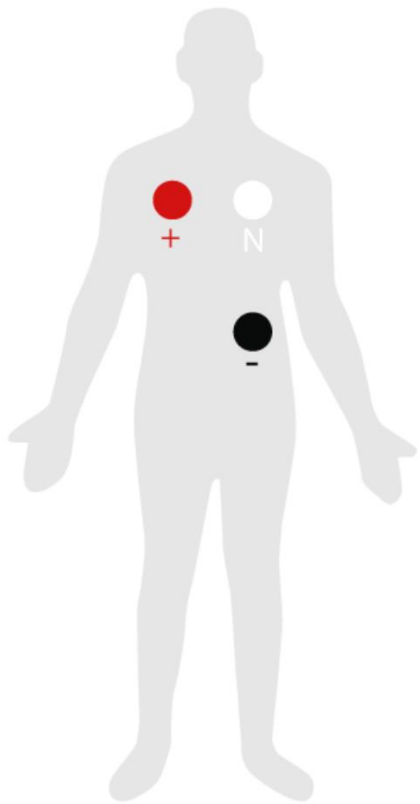

Figure. 32 B ECG sensor

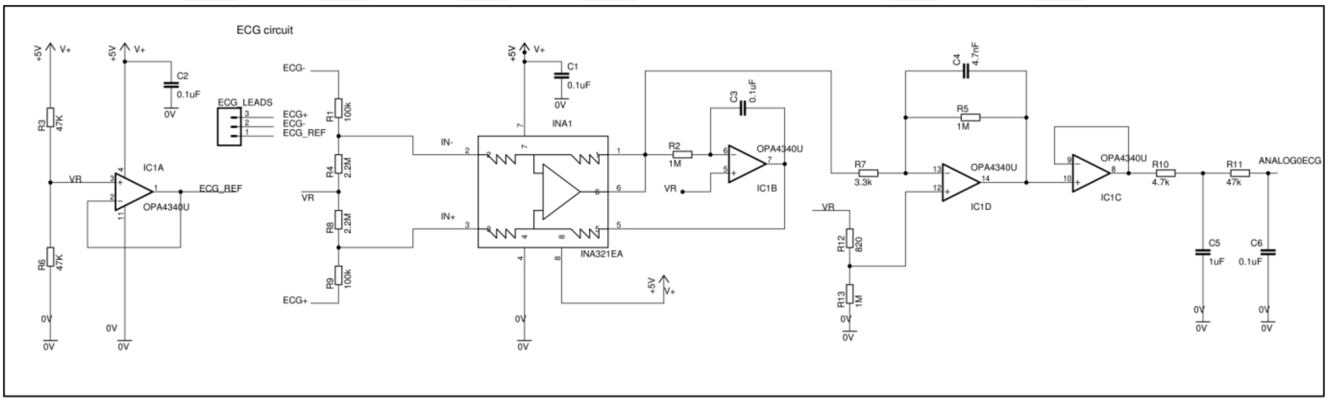

Figure.33 ECG sensor circuit design

3.4.3 Airflow: breathing

The air flow sensor has two positive and negative poles. The black wire connected to the negative pole and wire red positive pole as in the figure below:

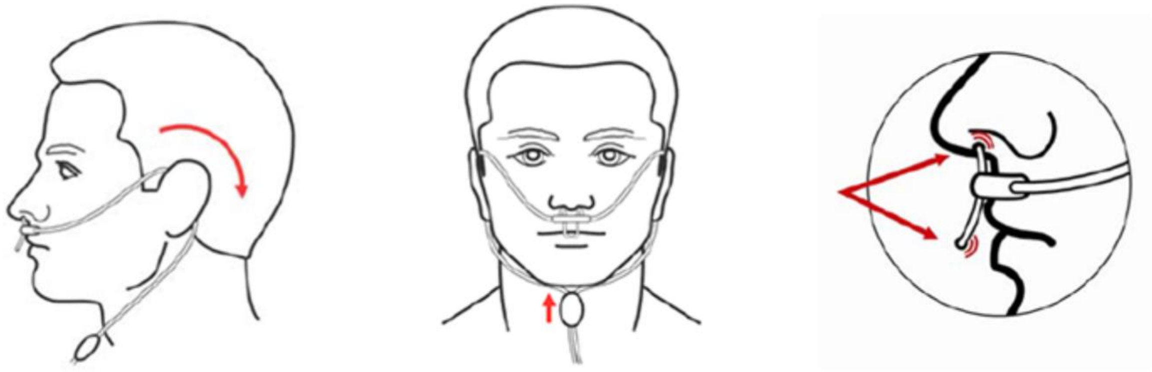

Figure. 34 A Airflow sensor

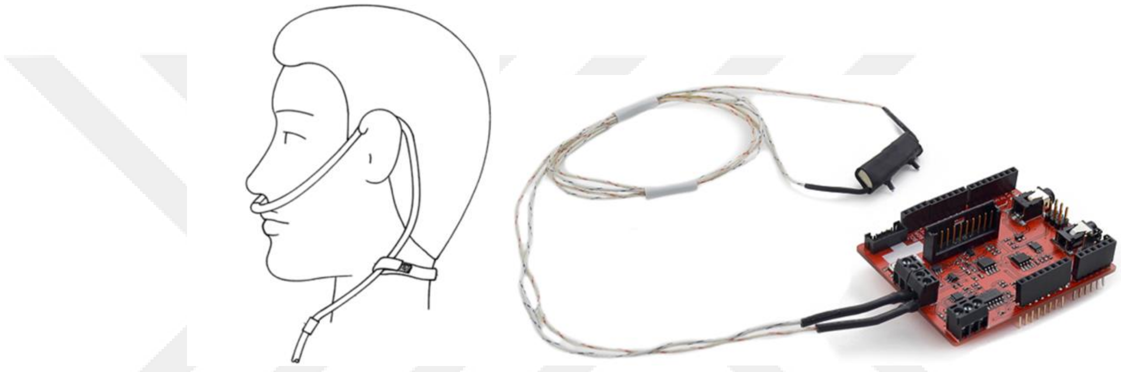

Figure. 34 B Airflow sensor connection

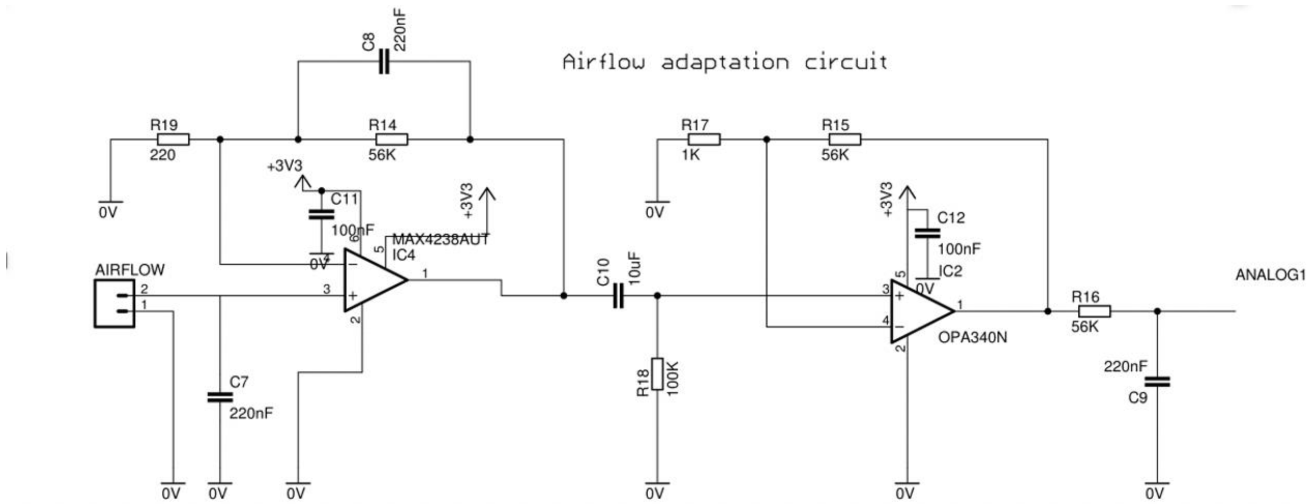

Figure. 35 Airflow sensor circuit design

3.4.4 Body temperature

To obtain the temperature value, the sensor is connected as shown in the figure below:

Figure. 36 A Temperature sensor

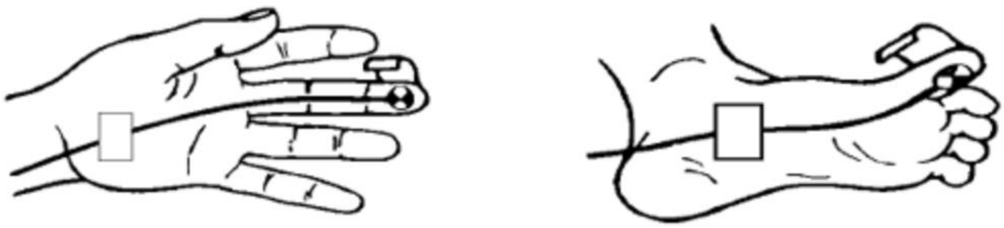

Figure. 36 B Temperature sensor

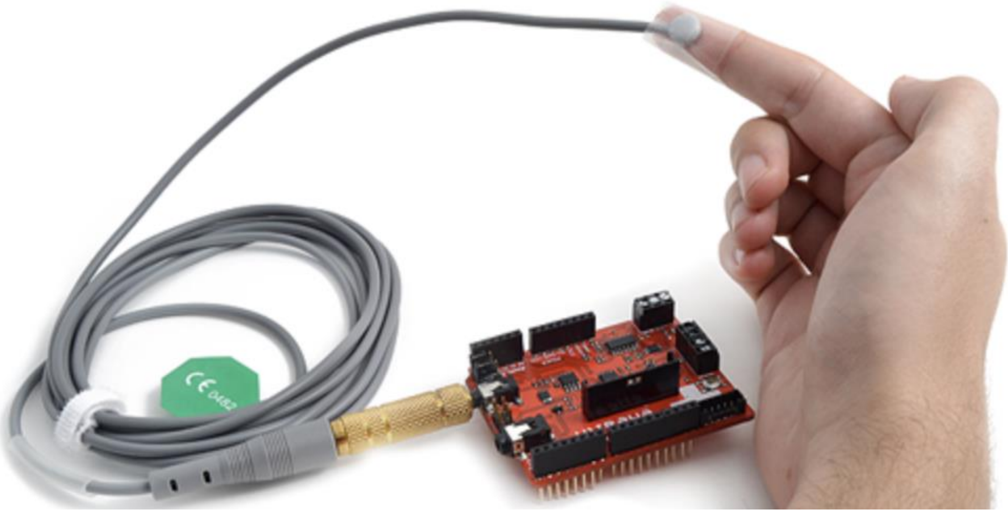

Figure. 36 C Temperature sensor connection

3.4.5 Blood pressure

The blood pressure sensor is connected to the COVID-19 e-health sensor platform unit and the connectors are connected with the SPHY gate.

It is important to maintain a horizontal position to obtain the best result. After pressing the start button and waiting some time, the result is obtained. You should not make any sudden movements.

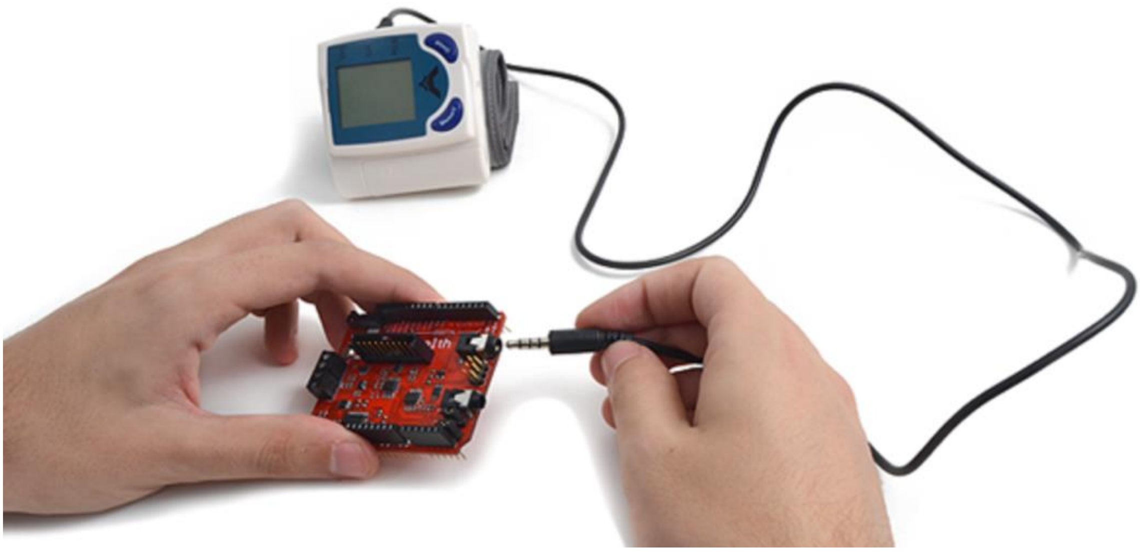

Figure. 37 A Blood pressure sensor

Figure.37 B Blood pressure sensor

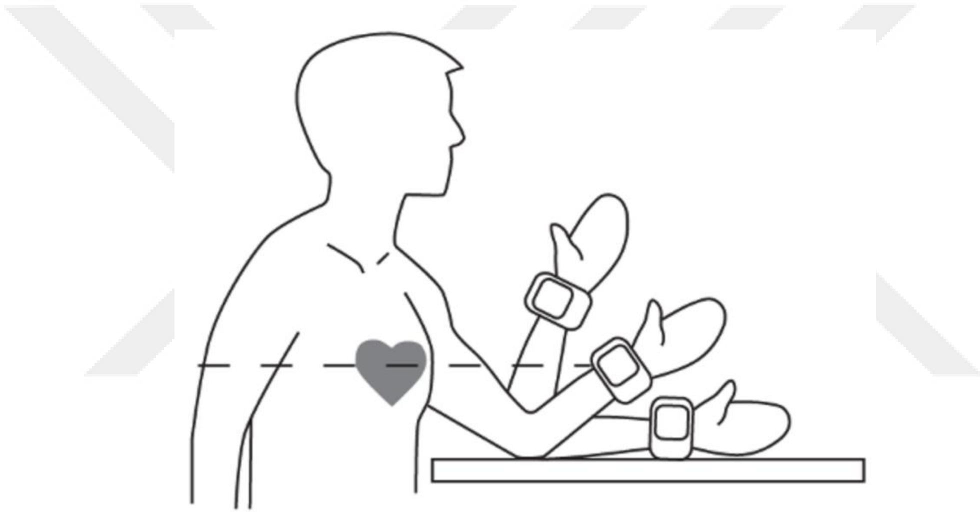

Figure. 37 C Blood pressure sensor

Figure. 37 D Blood pressure sensor connection

3.4.6 Patient position and falls

The body position sensor is connected to the COVID-19 e-health sensor platform and The sensor is wrapped around the chest with the sensor connector facing down as shown in the figure below:

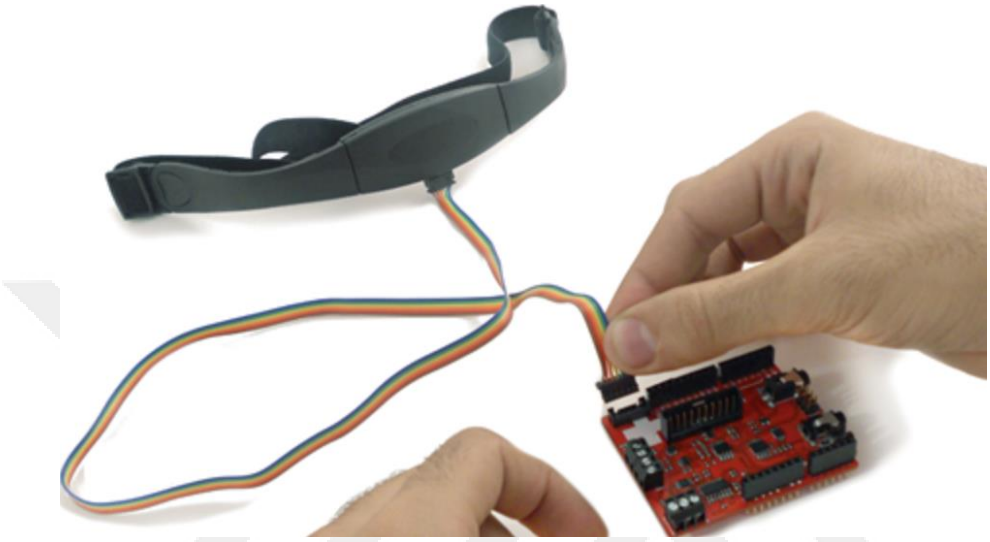

Figure. 38 Patient position sensor

3.4.7 Galvanic Skin Response (GSR)

Two GSR wires are connected to the COVID-19 e-health sensor platform as shown in the figure below.

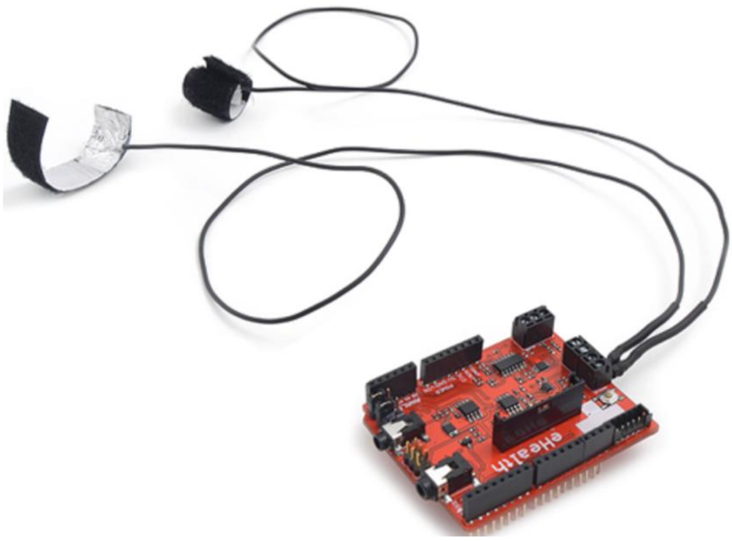

Figure. 39 A GSR sensor

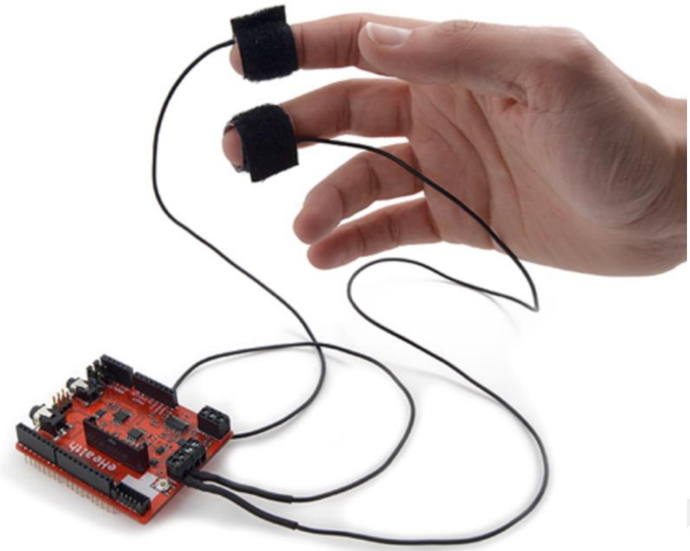

Figure. 39 B GSR sensor connection

Figure .39 C GSR sensor

3.4.8 Glucometer

The glucose meter is turned on and we put the test strip inside. It is important to clean the finger with alcohol before it is squeezed, put a drop of blood on the test strip and observe the sensor device, after a few seconds the result will be displayed. It is necessary to verify the correct connection of the sensor, and if P-C appears on the sensor screen, this means that the connection is correct.

Figure. 40 A Glucometer sensor

Figure. 40 B Glucometer sensor connection

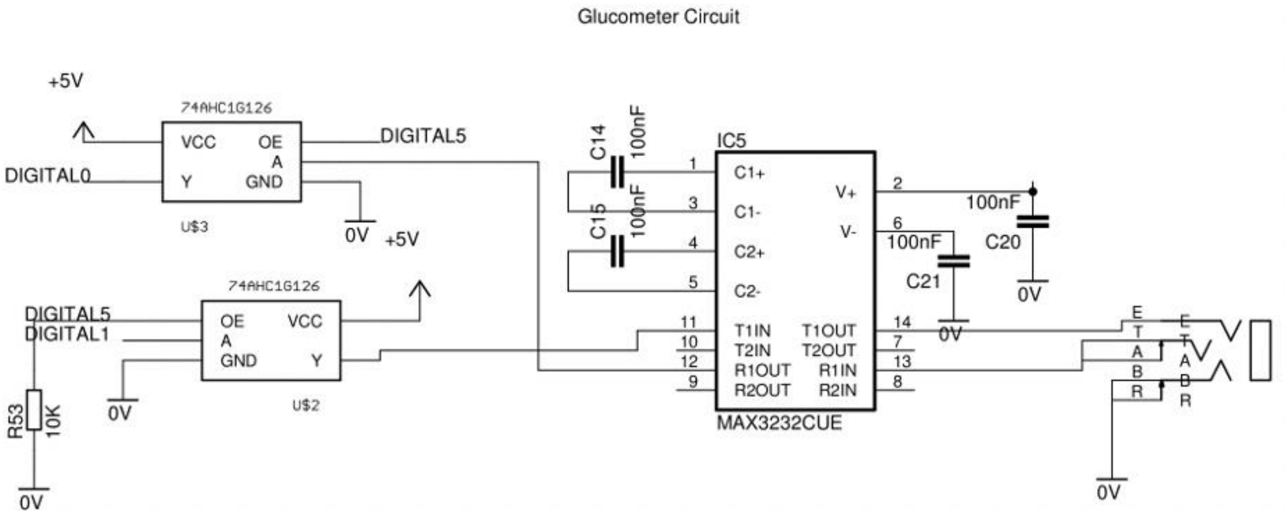

Figure. 41 Glucometer sensor circuit design

3.4.9 GLCD

The COVID-19 E-Health Library contains screen management commands for displaying data and graphics. We connect the screen and make sure of the correct connection.

The results are distributed on three different interfaces that we control by pressing the button as shown in the figure below:

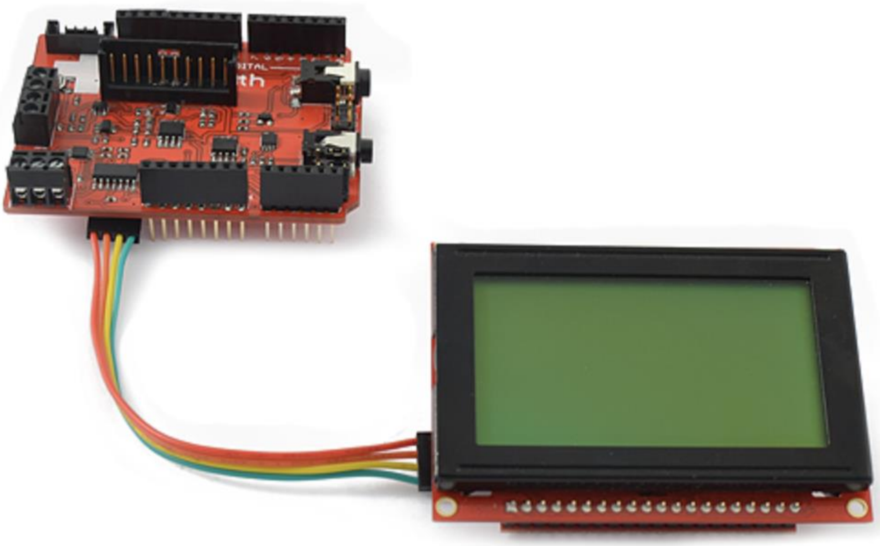

Figure. 42 A GLCD connection

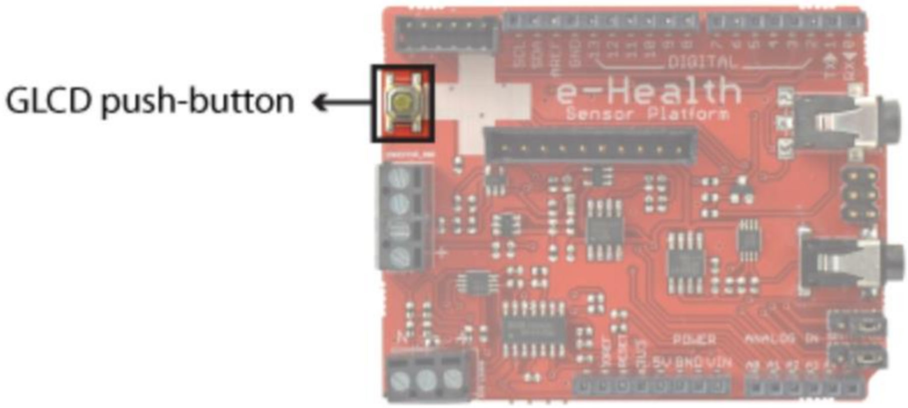

Figure. 42 B GLCD push button

In the first screen, the results of pulse, temperature and oxygen are displayed

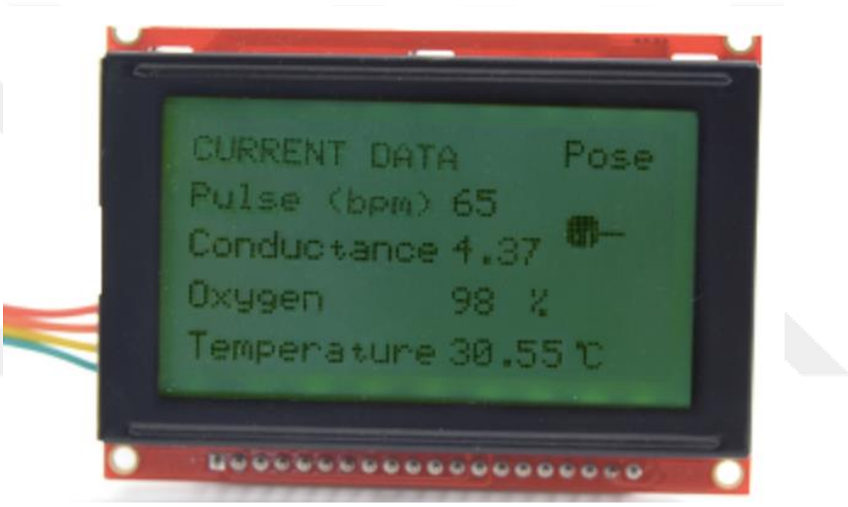

Figure. 42 C GLCD Result

On the second screen the airflow wave results are displayed

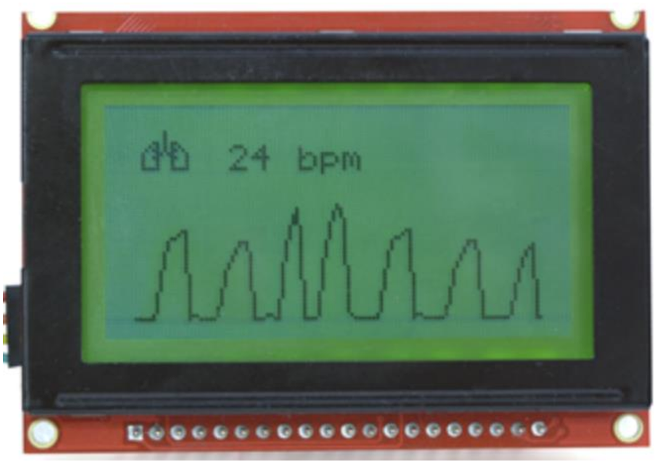

Figure. 42 D GLCD airflow wave

When there are no respiratory results, the screen informs of disturbed breathing

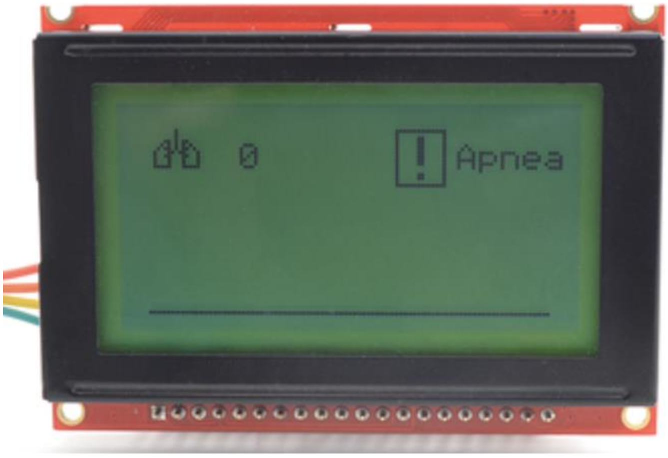

Figure. 42 E GLCD Results

In the third screen the ECG wave is displayed.

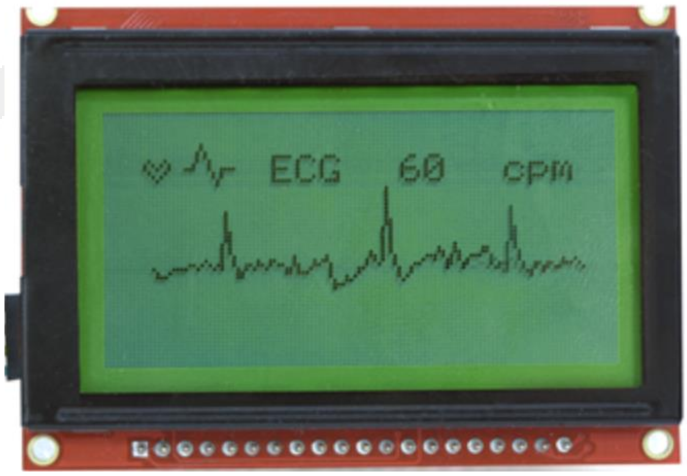

Figure. 42 F GLCD ECG wave

Figure. 43 COVID 19 e-health with sensors

3.5 Connection set up with microcontroller

3.5.1 Raspberry pi

Figure. 44 A Electronic project parts (raspberry pi)

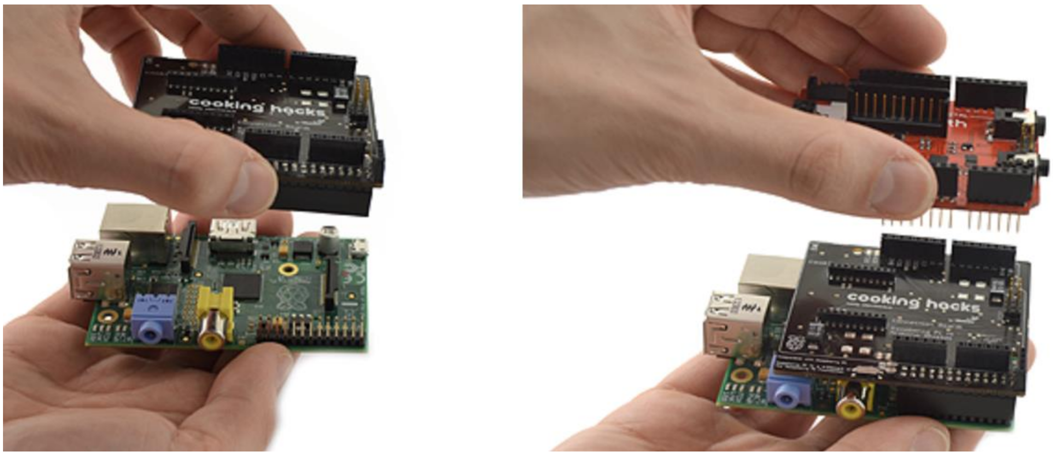

Figure. 44 B Electronic project parts connection

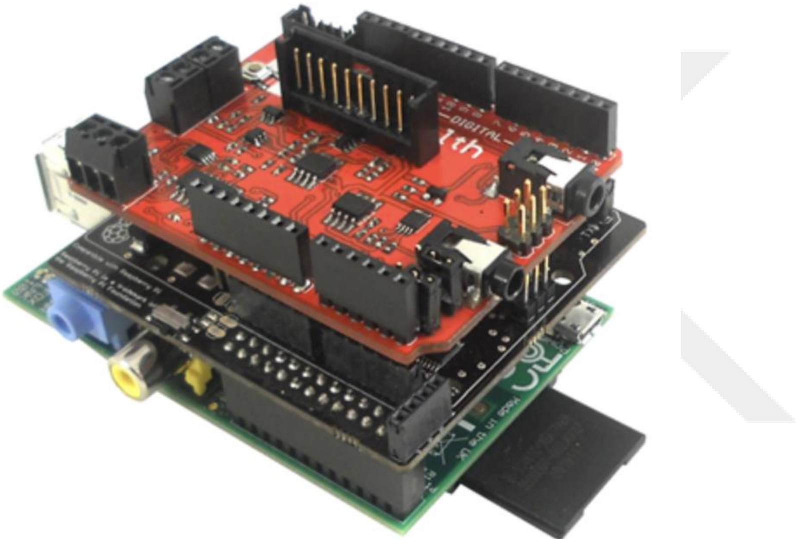

Figure.44 C final form

3.5.2 Arduino

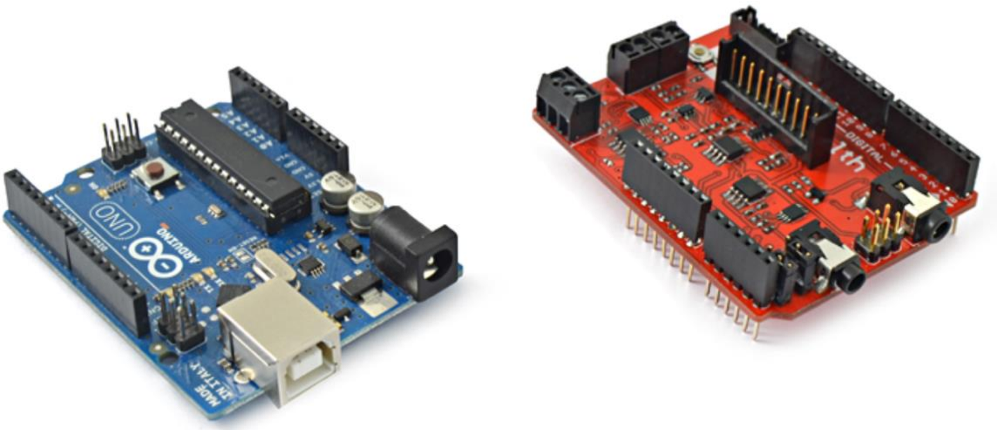

Figure. 45 A Electronic project parts (Arduino)

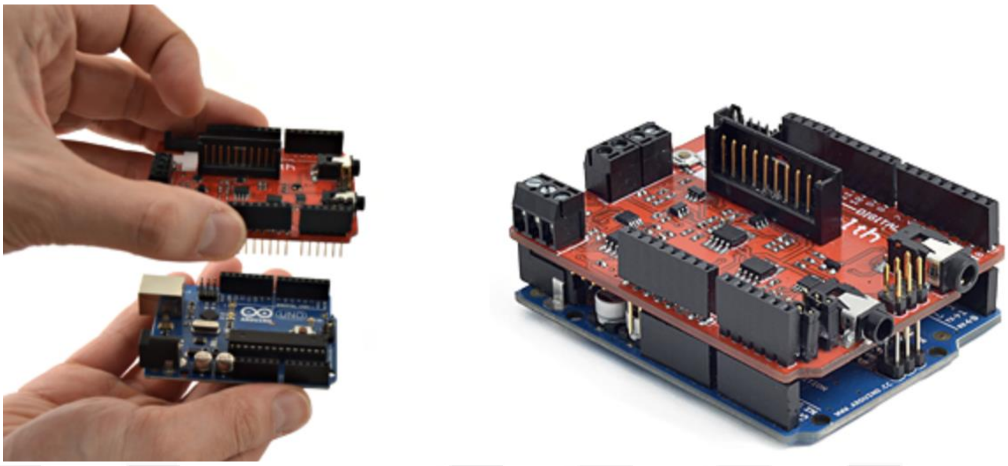

Figure. 45 B Electronic project parts connection

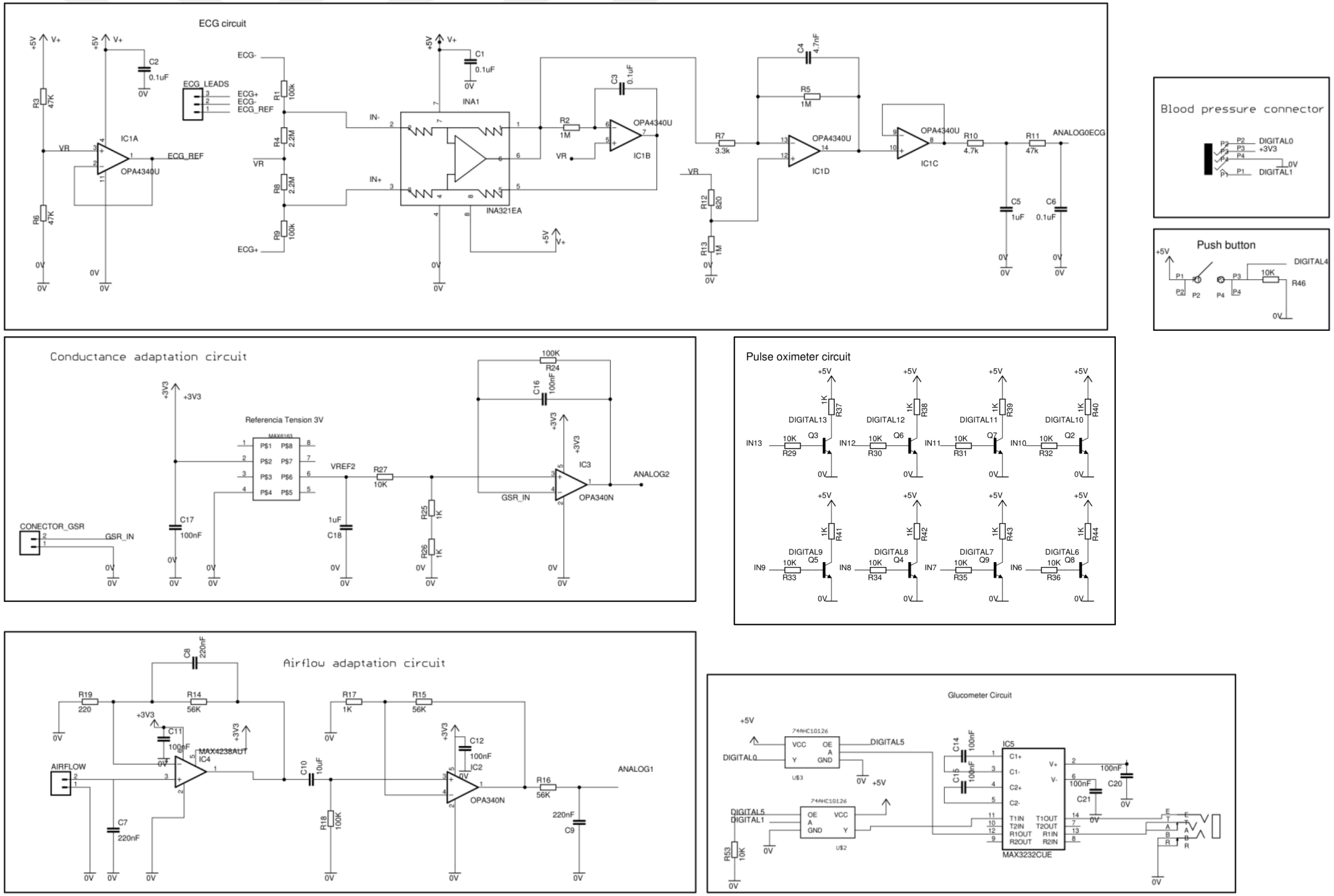

Figure. 46 COVID-19 E-Health sensor platform circuit

CHAPTER FOUR

TELEMEDICINE TECHNOLOGY

4.1 Introduction

E-health and telemedicine are not nascent today but it is a very important project in the fight against SARS-CoV-2. The rapid spread of Corona virus 19 has led to the deterioration of many medical systems around the world, including countries with an advanced medical character such as the United States (Smith et al. 2019).

In light of this crisis, it has become important to develop and create a new digital health system, adopt telemedicine technology, expand health care systems, and carry out the digital revolution in the field of mobile health (Keesara et al. 2020).

Mobile health and telemedicine as well as wearable medical sensors equipped with Internet of Things and Neural Networks (ANI) technologies and big data analysis can make a quantum leap in the field of health and telemedicine through video medical care (videoconferencing service) (Barsom et al. 2020). And also, by following-up, monitoring the health status of patients and providing appropriate treatment remotely. One of the most important benefits of mobile health and telemedicine is to reduce the risk of direct contact with patients, reduce the rapid spread of the virus, and protect the medical staff and the medical system from the risk of collapse with the high incidence of infection.

One of the countries that converted its medical dealings to telemedicine is the United States of America (Keesara et al. 2020). It recommended conducting remote medical examinations and reducing any direct contact and contact with patients in addition to reducing the time required and reducing the number of doctors.

In this part, modern mobile health and telemedicine technologies that have the potential to treat the emerging corona virus will be discussed. Emphasis will be placed on providing medical care to patients suspected of having Corona Virus, telehealth technologies like the intensive care unit and imaging (tele-imaging) and providing care.

In the end, we will provide a model medical sensor platform that can manage and address a range of data.

4.2 E-Health Monitoring of SARS-CoV-2

Mobile Health is a health platform that supports smart devices and wearable sensors (Istepanian et al. 2004).

The proposed system consists of 3 main parts:

1- Wearable sensors whose function is to collect the required data

2- A network whose function is to transfer the collected data to the main station monitoring like a central computer.

3- A cloud whose function is to analyze the data produced from the sensors and exploit the useful information.

The great development in technology and communication technology that should be used in the mobile health platform with wearable sensors and medical telemetry devices and supported by the clinical decision tool has enabled the COVID-19 E-Health sensor platform to track the patient’s health and physiological status and to optimally diagnose and manage the disease.

The platform can track the contacts of infected patients and provide needed healthcare.

4.2.1 Contact tracking technology

To control the spread of the virus, the most important strategy is contact tracing (Hellewell et al. (2020). Without effective treatment and vaccine, quarantine, isolation of those in contact and social distancing will remain the most important factors in controlling the outbreak of the epidemic (Keesara et al. (2020).
Given the outbreak of the SARS epidemic more than 21 years ago, the new Corona Covid 19 epidemic is taking place in a different technological situation in a more modern and stronger world in terms of capabilities. Remote monitoring and tracking of infection in a specific area is useful to limit the spread of the disease (Ienca, M., & Vayena, E. (2020).

A contact tracking app that creates a list of contacts can send an alert to contacts of infected cases and limit the spread of the epidemic. The process of collecting data from mobile devices at a large scale from people raises security concerns related to user privacy. To solve this problem, a peer-to-peer contact tracing normalization has been developed, using encryption of user identity by Ysak to preserve user privacy as it can be used with the outbreak of the pandemic (Yasaka, T. M., Lehrich, B. M., & Sahyouni, R. (2020).

Recently, Google and Apple developed a contact tracing program using Bluetooth technology by exchanging signals without revealing the identity of the user or sharing data. The system enables notifications of users who were in contact with a suspected and diagnosed case (Greenberg, A. (2020).

4.2.2 Remote monitoring physiological

By using the mobile health platform for COVID 19, it is possible to transport care from the hospital to the home, especially with patients who have been diagnosed with mild injuries and patients suffering from other diseases who are at risk of infection from contact with other patients. The medical devices such as tethered with a temperature sensor platform and blood pressure sensor and the proportion of oxygen is necessary to monitor the patient's health, in addition to the very important portable ECG device with COVID 19 disease to monitor the patient's tachycardia problems.

The mobile medical platform that relies on a set of remote-acquired sensors cannot replace the specialized medical staff, however it can be a supportive part of medical decisions that allow the medical unit to intervene in a timely manner.

4.3 Telemedicine for COVID-19 Patients

Telemedicine is the utilize of modern communication technology to identify and treat disease (Wilson, L. S., & Maeder, A. J. 2015). Currently, telemedicine services are provided by smartphones and computers using encrypted communications. Telemedicine services are provided to patients who suffer from chronic diseases and patients who have mild disease while patients with COVID 19 disease can help telemedicine in monitoring patients and monitoring their health status. In this part, 3 main parts of remote patient management will be discussed, which are the central care unit, the rehabilitation unit, and the remote imaging unit.

Table 4. Medical imaging techniques (Ding et al. 2020).

Medical imaging techniques	Functions	Weight/size	Communication Networks (Transmission Rate)	Advantages	Maturity	Exemplary Products	COVID-19 Application Scenarios
Tele-ultrasound	Imaging scan for different body parts including lung	System: 4-8kg; scanner: 0.2-0.5kg/mobile size (handheld)	Mobile phone or tablet, 4G/5G (150Mbps ~10Gbps), or LAN (10Mbps-1Gbps)	Real-time, fast diagnosis	High	Butterfly/Lumify (Philips)/Vscan (GE) portable ultrasound system [176, 180, 181]	Home, community care, improvised hospital, hospital
Tele-X-ray	Lung imaging, body imaging	400-750kg/4-6.5m^3	Short distance wireless communication - UWB (480Mbps up to 1.6 Gbps)	Fast, low dose, high imaging quality	High	Optima XR220amx, GE portable X-ray machine [177]	Mobile emergency units, community care, improvised hospital (including ICU and CCU), hospital
Tele-CT	3D imaging of the lung and other body parts	~1600kg/13-20m^3	Wireless communication - 5G (10Gbps), or LAN (10Mbps-1Gbps)	Automatic positioning, rapid and accurate scanning, lower does	Medium	BodyTom, Samsung portable CT scanner [178]	Mobile emergency units, community care, improvised hospital, hospital
Tele-bedside MRI	3D imaging of brain, neck, knee	640-930kg/1-5m^3	Controlled with a wireless tablet, view images on a mobile phone, 5G (10Gbps).	Without shielded room, fast diagnosis	Medium	Hyperfine, portable MRI [179]	Mobile emergency unit, community care, improvised hospital, hospital

4.3.1 Remote Imaging

Due to COVID 19 disease, it is possible to damage the organs and tissues of patients and one of the common clinical indications is acute pneumonia associated with SARS-CoV-2, where medical imaging plays an important role to monitor and diagnose the condition. The results of the MRI and CT scan are transferred for remote diagnosis to the medical unit.

Figure. 47. Portable medical imaging devices (a) ultrasound system (Arathy et al. 2019), (Liu et al. 2019), (b) portal X ray (Rajasekaran, A. R. 2020), (c) CT scanner [(Zhang et al. 2017), (Ponce, F. A. 2020), and (d) portable [(Steinhubl et al. 2015), (Rajasekaran, A. R. 2020).

A lot of medical imaging technology, including remote x-ray, remote ultrasound and tomography, through which images are processed using neural network techniques (artificial intelligence). By providing a mobile medical imaging center, people who suffer from the virus can obtain a CT image, provided that the diagnosis is made by remote doctors and the results and images are saved in a cloud where a mobile medical center is reported to provide CT images [(Matsumura et al. 2018), (Shi et al. 2020).

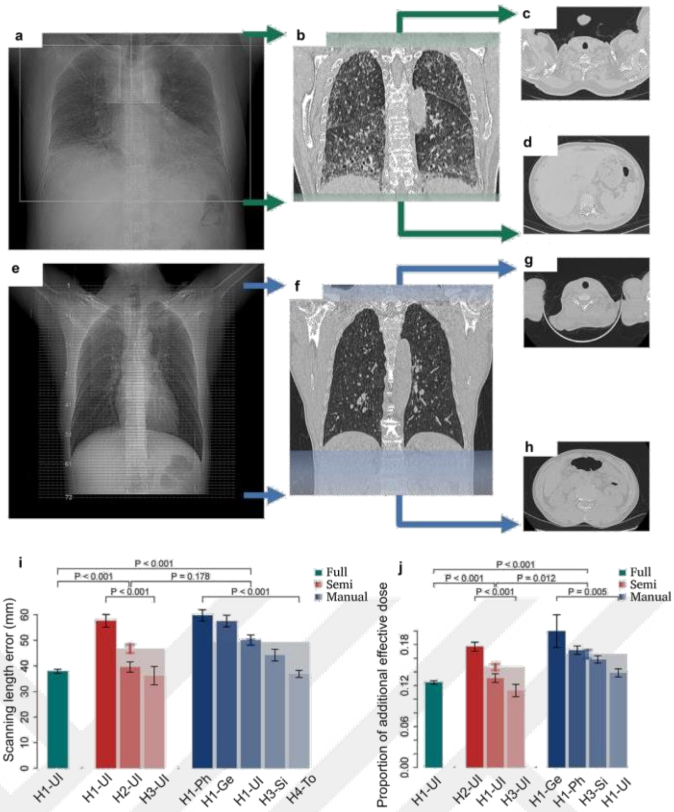

Figure. 48. Performance testing for CT scan.

Three scenarios were created to evaluate the performance of automatic localization: semi-automatic scanning, manual scanning and full scanning, and the results showed that the latter greatly outperformed others, Figure 12. This technology was used in the Chinese city of Wuhan (the source of the virus) and prevented the spread of the virus among the medical staff by the patients, i.e., to prevent any possible contact between them. Also, CT scan was provided to patients remotely, and the results were transferred to another hospital with the help of the fifth-generation communication technology (Ferretti et al. 2020).

4.3.1.1 Medical imaging using artificial intelligence techniques

Medical imaging engineers and technicians are always at risk of infection due to the large spread of the virus and their permanent presence with suspected patients, so they always have high priority to reduce the risk and save people.

4.3.1.1 (A) Applications in SARS-CoV-2 (COVID-19)

During the spread of Coronavirus, remote imaging techniques were used to reduce contact between the responsible person and the patient. It was suggested to use a computed tomography platform that supports artificial intelligence, as shown in Figure (49-A). A smartphone platform that supports artificial intelligence has been redesigned to separate the person responsible from the patient. To avoid any contact.

Through voice and video commands, the patient is asked to stand on the bed. Figure (49-B) so that the responsible person can monitor the patient through the window and through the artificial intelligence camera, directing orders to correct the patient's condition. After the patient lies on the bed, the positioning algorithms restore the 3D position and after obtaining the results they are processed.

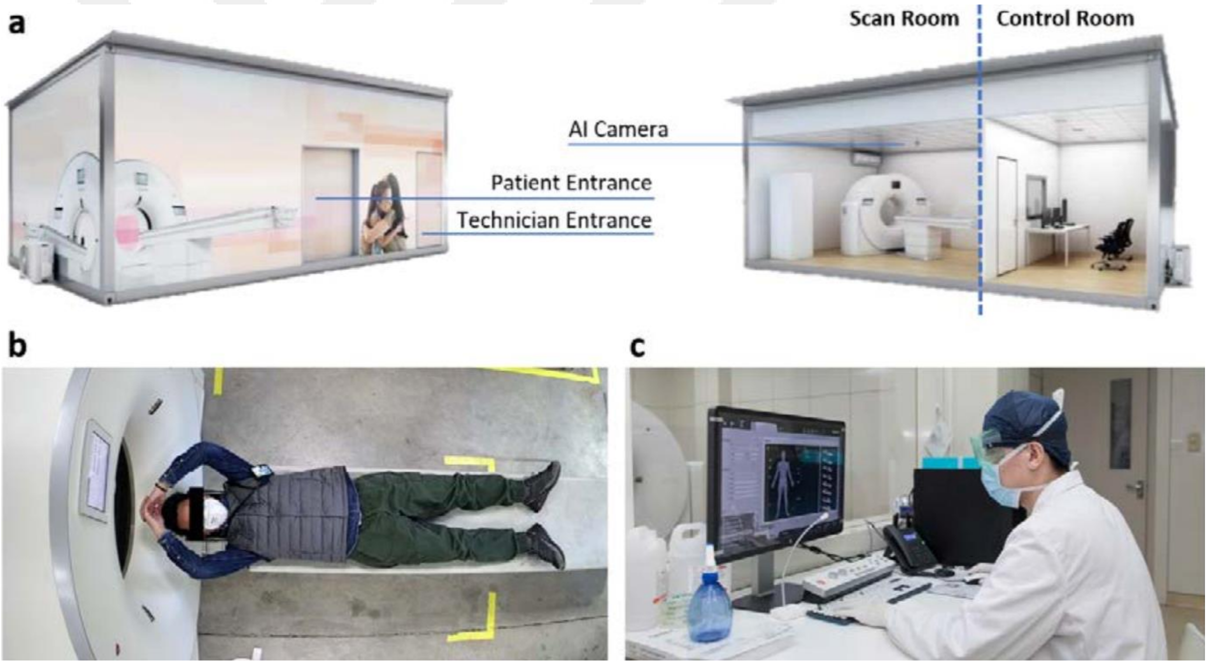

Figure. 49 Portable CT scan device with artificial intelligence techniques

4.3.1.1 (B) IMAGING DATASETS FOR SARS-CoV-2

The data collection process is only the first step to develop artificial intelligence methods for facing COVID-19. In recent times, many collected data related to the Corona epidemic have been reported. A group of images related to the disease was created by Cohen (Cohen et al. 2020). by extracting them from publications and websites and it currently contains more than 150 x-ray images.

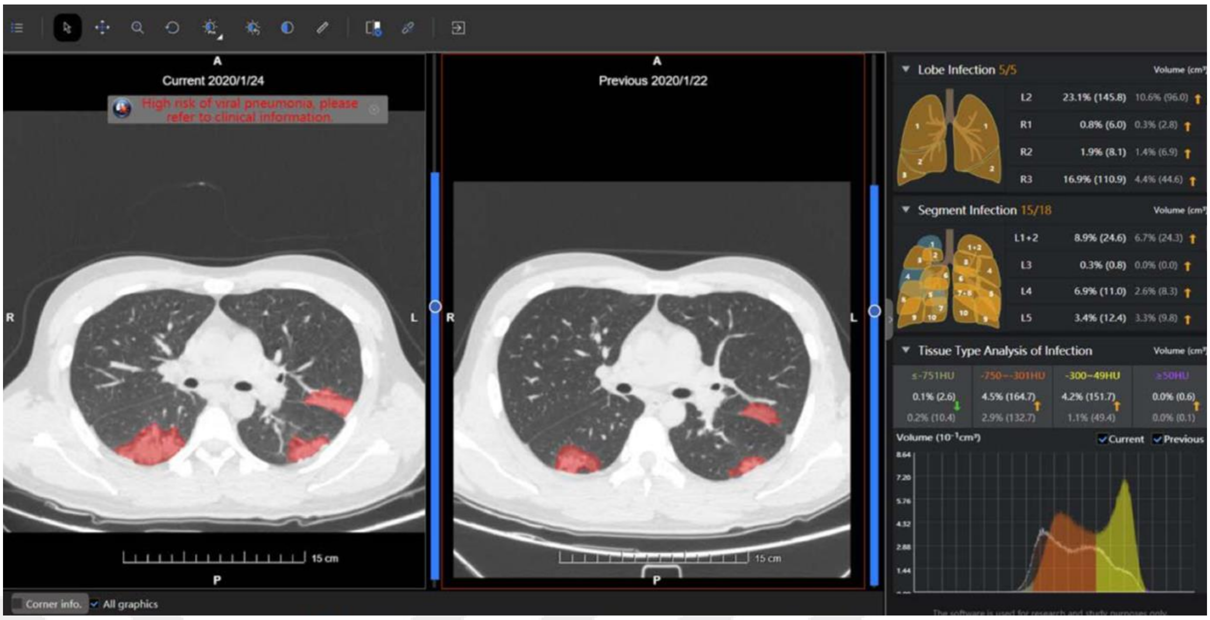

Figure 50. Measurement for a COVID-19 patient.

4.3.2 TELE- INTENSIVE CARE UNIT

A major deterioration can occur for elderly patients who suffer from heart diseases and have COVID 19 virus, and also the high turnout for the intensive care unit leads to a great challenge due to the current situation and the large number of injuries and the possibility of infection of the medical staff due to the large number of patients, therefore it is recommended to provide a remote care service and provide support Remote clinical decision.

By activating the intensive care unit, which includes a center for patient follow-up remotely and by means of satellites, the medical staff can supervise, diagnose and follow-up remotely through voice or video technology. The central remote care unit was used and had great clinical results, including reducing time inside the unit, reducing the number of deaths and preventing any contact between medical staff and patients (Lilly et al. 2011), (Lilly et al. 2014).

4.3.3 Rehabilitation remotely

The process of pulmonary rehabilitation strengthens the respiratory system, especially with patients with Coronavirus 19, as it must be done as a curative care, taking into account 4 basic principles that must be met to relieve symptoms of shortness of breath and anxiety: psychological intervention, exercise, posture management, and respiratory management [(Zhao et al. 2019), (Koh et al. 2020). Remote rehabilitation contributes to coping with disease by transferring care from hospital to home.

One of the aspects of telehealth intervention is the public relations that are supervised by it through a communication platform between patients and a team of care specialists, all of this is done remotely.

4.4 Conclusion

Telemedicine using mobile health supported by wearable sensors reduces pressure on the medical staff and prevents direct contact between patients and the doctor or technician by providing health care services remotely while addressing the problems of user security and privacy, as this technological revolution can help give Positive clinical results, even when this epidemic ends.

CHAPTER FIVE

CLOUD COMPUTING AND DATA ENCRYPTION

5.1 Cloud

Cloud computing: It is a new technology that has acquired a large space in the field of the IoT and mobile health technology and has become an integral part of it. This technology provides the possibility of accessing and accessing data from anywhere and at any time. This technology allows communication between the patient and the central medical unit and the exchange of information. The cloud service provides the ability to save and process data and store, protect and archive records, as it enables the patient to obtain the best health care services by building a database that contains all the patient's information (Al-Issa et al. 2019).

Like other applications of technology based on the technology of the Internet of things, the computerized cloud faces challenges based on data security and user privacy, and because it operates in an open environment and is vulnerable to many attacks, it is subject to data loss and unauthorized access. Therefore, a cryptographic algorithm has been proposed that secures the communication between the patient and the medical center, which will be explained in the second part of this chapter.

5.2 Cloud Computing C'Cs:

This technology has 5 main pillars, which are data collection, network access, flexibility, automatic service and measured service (Mell, P., & Grance, T. 2011).

5.3 Cloud models

The computerized cloud contains 5 types:

1- Private Cloud: is available within the work center, institution, company, hospital, etc., and is managed by the same institution to provide its services.
2- Public Cloud: It is managed from outside the building via Internet connections, as it is less protected than private.
3- Hybrid Cloud: A hybrid between a public and private cloud.

4- Community Cloud: Collects a group of entities with a single goal and shares a single cloud.

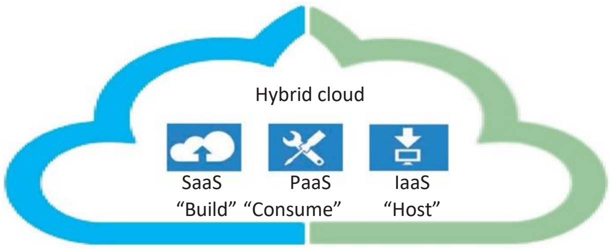

Figure 51: Cloud properties

Table 5 Private and public cloud

Private cloud		Public cloud
premises	On	Off
Intranet	On	On
security	High	Low
firewall	Behind	Outside

5.4 Data encryption

5.4.1 Introduction

In addition to the wearable sensors, the IoT is now occupying a large space in medical care and telemedicine applications. This led to a focus on the Internet of things, and opened a great opportunity for development and increased productivity, which led to an increase in quality. As it became the provision of medical care for patients with Corona virus.

Due to modern technology, especially after the launch of 5G communications services, remote medical care has become one of the most important aspects of life, not only for COVID 19 patients, but for all patients suffering from chronic diseases and the elderly, as it is possible to manage, diagnose and treat patients remotely, shortening the time and reducing the effort exerted and preserving the health of the staff Medical.

The increasing concerns of users about privacy and security is one of the main reasons hindering the Internet of Things and mobile health platforms for fear of any malicious attacks and breaches of privacy (Gupta, P. K., Maharaj, B. T., & Malekian, R. 2017). Therefore, there is an urgent need for more research in the field of information security and user protection

Patient data must be secured by encrypting data and securing apps. The process of manipulating sensitive cloud data, unauthorized access, and breaching patient privacy are among the most important security threats and considered one of the most important challenges facing mobile health applications and cloud services. We will review the most important safety standards for mobile health (Tarouco et al. 2012), (Abdel-Basset et al. 2019), (Zhang, R., & Liu, L. 2010, July).

1- Authentication: proving the identity of the user if he is sick or the medical staff and verifying his identity using one of the encryption algorithms

2- Authorization: This is the second step, after verifying the user’s identity. Access rights are distributed based on the privileges given to each side.

3- Non-repudiation: It is the process of making sure that the sender has actually sent this message as it may contain specific symbols or signature etc. using a special encryption platform.

4- Confidentiality and integrity: it ensures that the recipient is only the one who reads the message and that the transmission is confidential.

5.5 Suggested methodology

A 4-layer framework is proposed for a mobile health system with the cloud, where each layer is connected to each other (Figure 52).

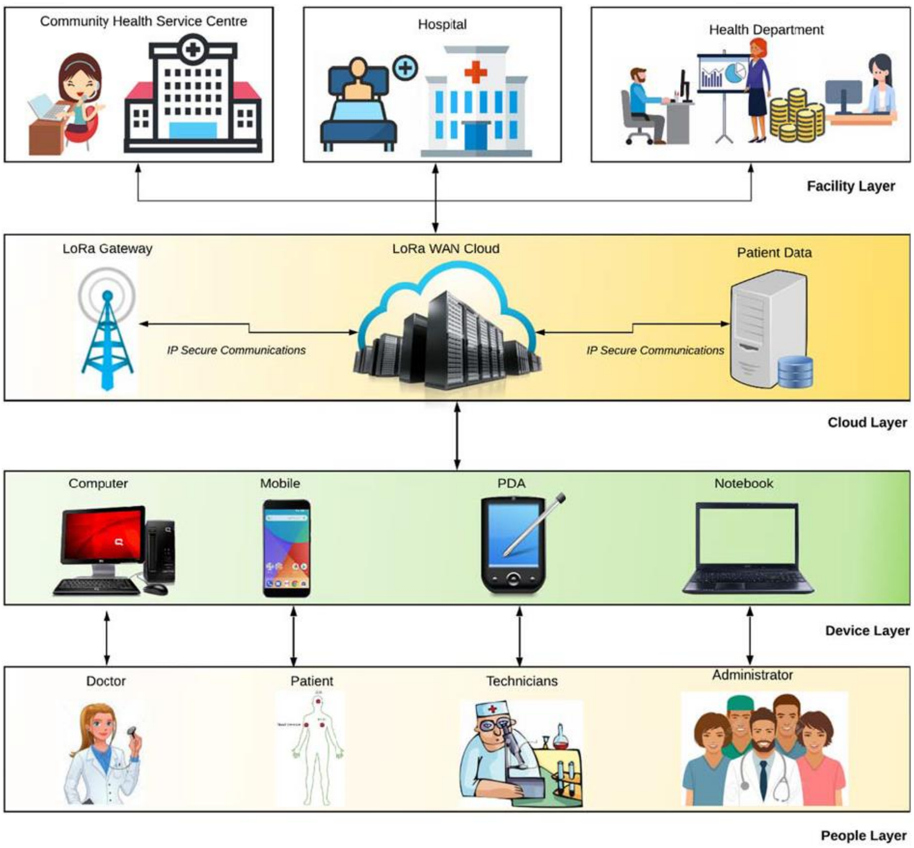

Figure 52. Proposed secure framework for IoT-based medical data.

First layer: This layer contains users in general, such as patients, doctors, technicians, and hospital administrators.

Second Layer: This layer contains smart devices, office devices, and computers that receive, send, and display data for the first layer.

Third layer: This layer is responsible for the communication process and the delivery of data between the first layer and fourth layer.

Fourth layer: This layer contains health centers, hospitals, and decision-making centers for monitoring patients, directing orders and giving instructions.

In order to protect data and provide a secure connection between the user layer (first layer) and the communication layer (third layer), an encryption algorithm has been proposed that goes through three stages: authentication, data encryption and finally decryption.

It goes through three stages, which are data recording, then logging in using the information that was entered, and finally verification. All user login data is saved inside the cloud, where a user name and password are given to the user. Using the SHA-512 encryption algorithm, hash codes are generated to verify the identity of the patient and upon authentication, the e-health platform is activated, the sensors start working, and the results and information are encrypted using Caesar encryption. The encryption technique is done by replacing the text with the encrypted text. The information is then encrypted using another encryption algorithm called elliptic. The cloud receives the encrypted data in succession and begins to open the encryption, compile it and send it to the hospital's private layer, Figure 53.

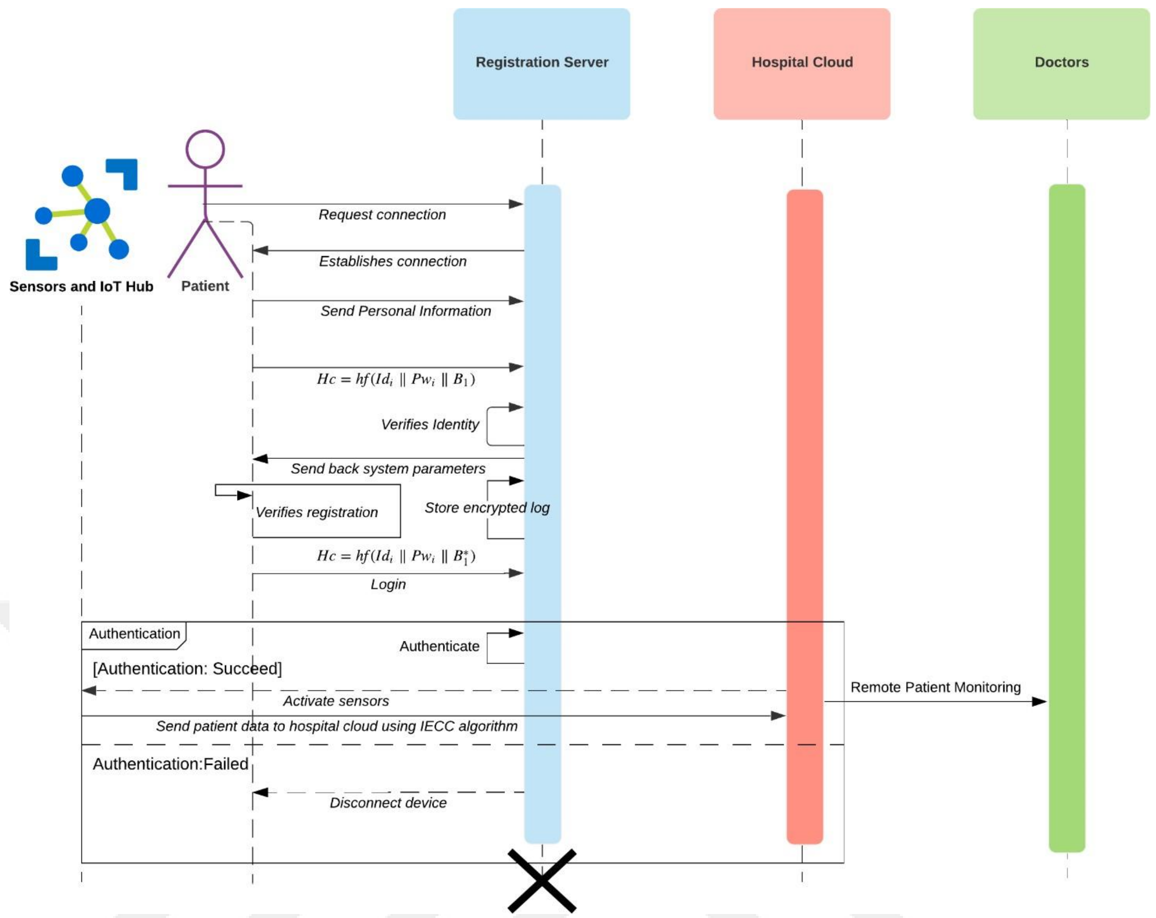

Figure 53 Encryption scheme (Khan et al. 2020).

5.5.1 Authentication

It is considered the first step in securing patient contact as it goes through the data recording, login and verification stages.

5.5.1.1 Recording data

The patient data, date of birth, date of infection with COVID 19, e-mail are recorded, after which a hash code is generated using the hash encryption algorithm.

Suppose a COVID 19 patient is a P_C, the ID is d_p, the password is P_a, and the confirmed patient is TP_c during entry. The TP_c create the private key P_K encrypted key using the hash algorithm for encryption as in Equation 1:

$$Hashcode = haf\,(d_p \,\|\, P_a \| Bi) \qquad (1)$$

Where *haf* is the hash function

5.5.1.2 log in

The log in process takes place after completing the first stage of registration and entering the data. Each patient has a username and password, where d_p, P_a1 and B^*1 are used to create hashcode1 as in Equation No. 2:

$$Hashcode1 = haf(d_p1 \parallel P_a1 \parallel B^*1) \quad (2)$$

By adding some bits by adding 0 in the beginning, the block size becomes doubled to 1024 bits. The hierarchy is standardized and the hash code is created in the SHA-512 algorithm, and then the block is combined with the previously created code. (B. Schneier et al. (1996).

Using the XOR operator between hash code and P_K we can get M as in equation 3:

$$Mc = Hashc \oplus P_k \quad (3)$$

5.5.1 C Verification

It is decryption process to obtain the value of N_c as in equation 4:

$$Nc = M \oplus P_k \quad (4)$$

The hash code is calculated again according to Equation 5

$$Hashcode2 = haf(d_p\,2 \parallel P_a\,2 \parallel B^{2}) \quad (5)$$

If the values of Hashcode1 and Hashcode2 are identical, then the patient is considered authorized, the health platform is turned on and the sensors start working, and if not, then the exit is logged (Khan et al. (2020).

CHAPTER SIX

RUSELT

In the previous chapters we discussed a definition of each sensor, the mobile health platform, how they are designed, and the communications and Internet of things technologies. The results we obtained will be discussed in this chapter.

6.1 Analysis of the results for Body temperature

The normal human body temperature is (37.0) degrees Celsius (98.6 Fahrenheit), where this value can change by half a degree Celsius (0.9 Fahrenheit) for 24 hours.

Table 6 Body temperature rates

Normal	36.5–37.5 °C (97.7–99.5 °F)
Hypothermia	<35.0 °C (95.0 °F)
Fever	>37.5–38.3 °C (99.5–100.9 °F
Hyperpyrexia	>40.0–41.5 °C (104–106.7 °F)

The results are show in the Serial monitor.

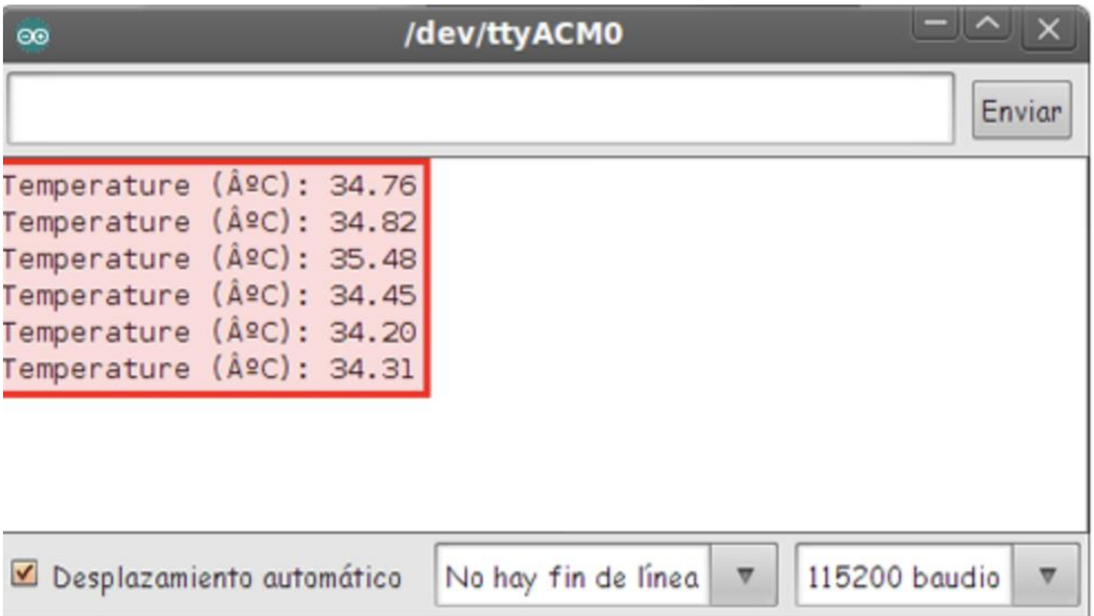

Figure. 54 Body temperature result in serial monitor

Mobile App

The smartphone app displays temperature information in real time. This can be seen through the following image.

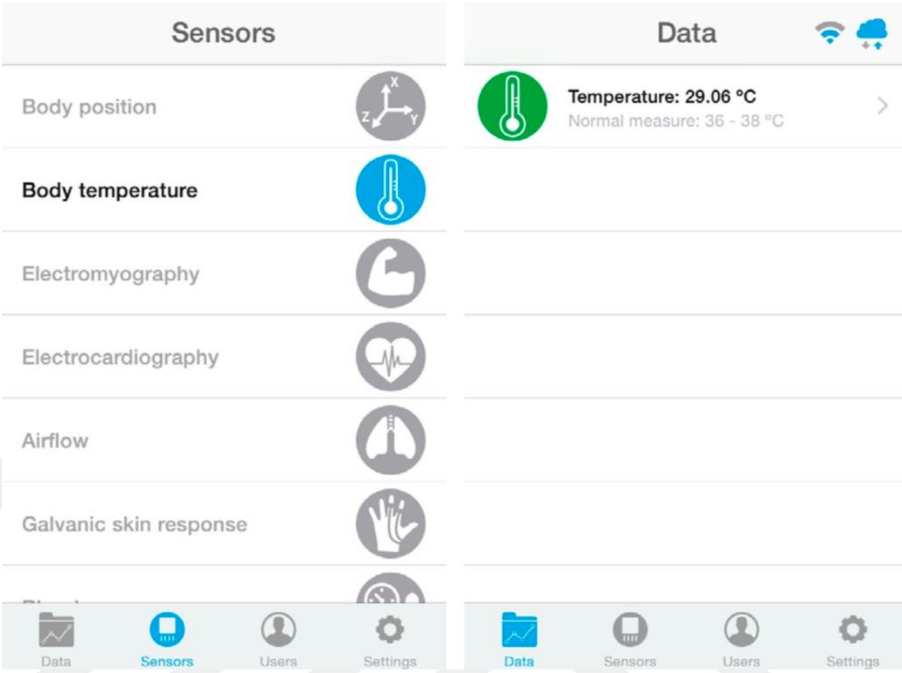

Figure. 55 Body temperature result in mobile application

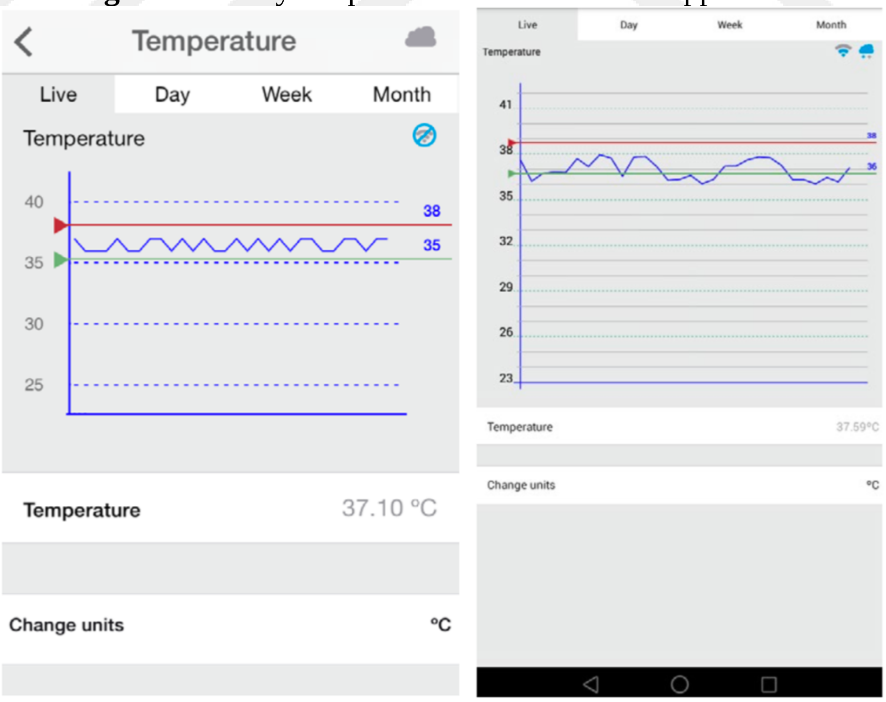

Figure. 56 Body temperature wave in serial monitor

The temperature can also be monitored through the web server.

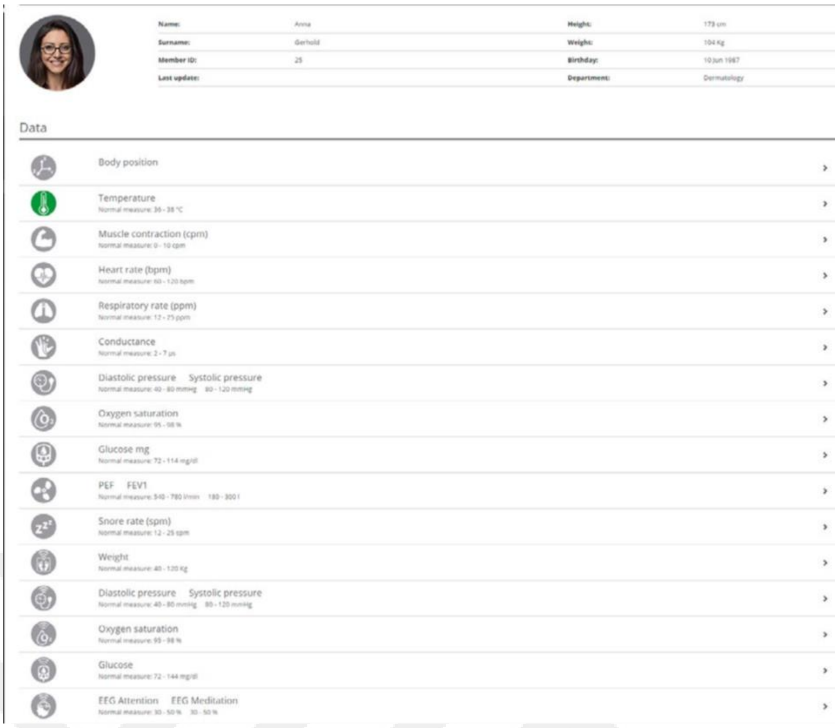

Figure. 57 Body temperature result in web server

Figure. 58 Body temperature waves in web sever

In addition to the smartphone application and the web server, temperature results can be displayed using the micro-controller screen.

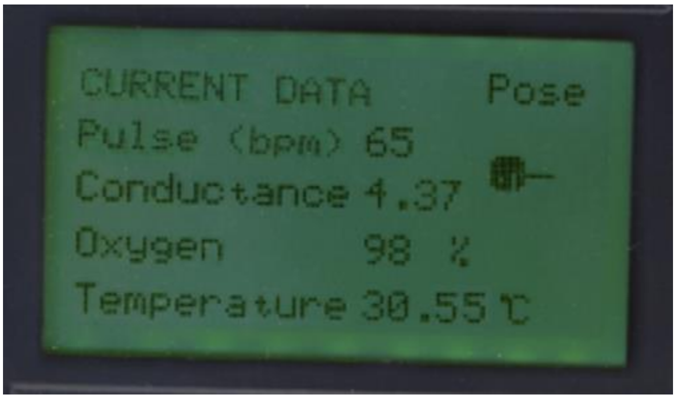

Figure. 59 Body temperature result in GLCD

6.2 Analysis of the results for Pulse and Oxygen in Blood (SPO2)

The normal rates range from 94% to 99% for healthy people, while this percentage drops to 85% and less for patients who suffer from lack of oxygen and patients with COVID 19, as the virus attacks the patient's respiratory system, which leads to a decrease in the oxygen level.

The results are show in the serial monitor.

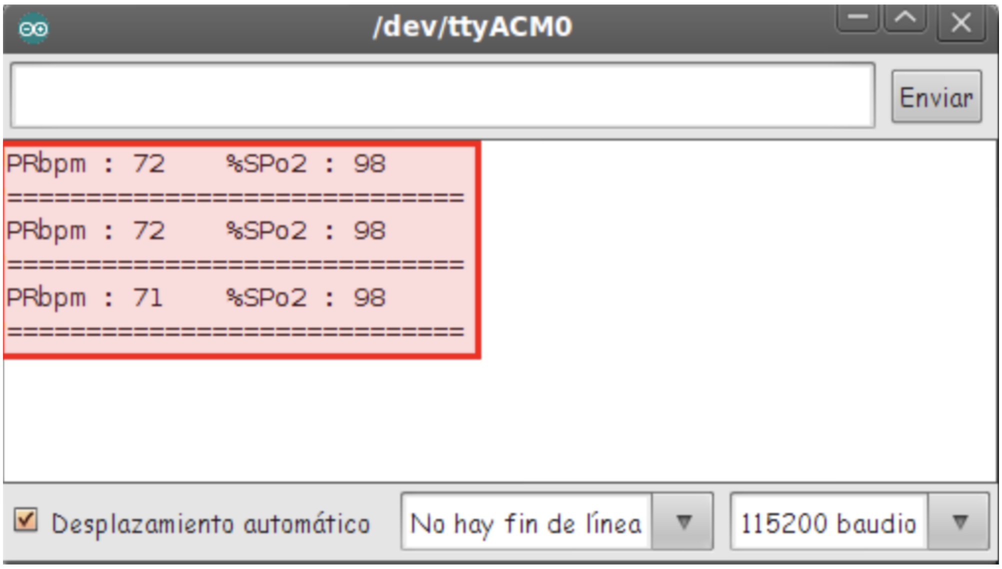

Figure.60 Spo2 result in serial monitor

Mobile App

The smartphone app displays SPO2 information in real time. This can be seen through the following image.

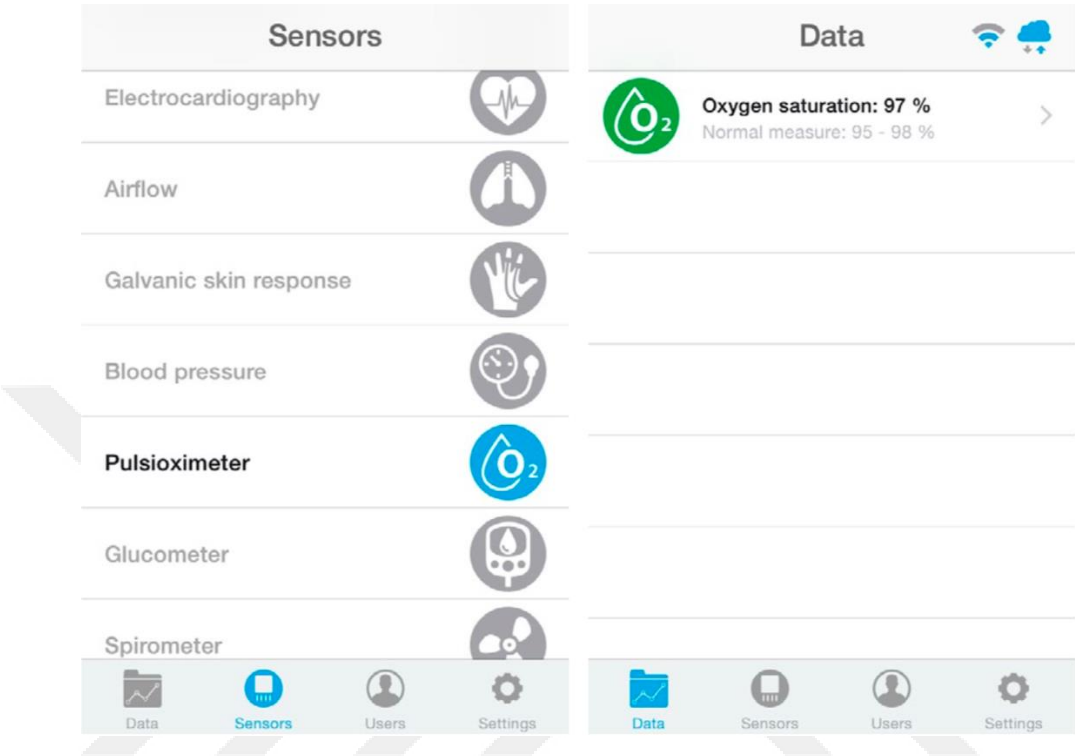

Figure. 61 Spo2 result in mobile application

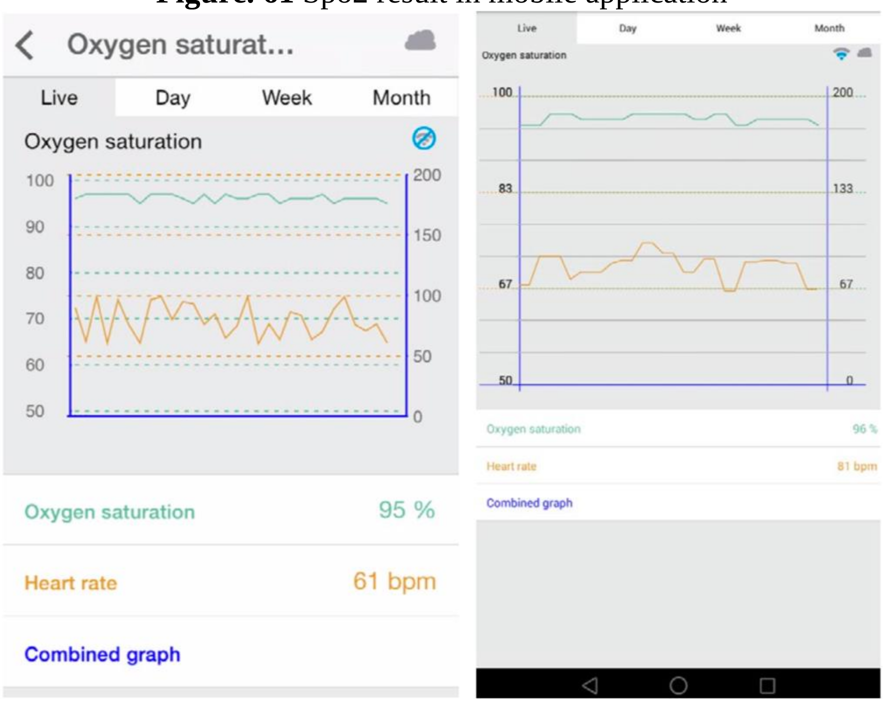

Figure. 62 Spo2 wave in mobile application

The SPO2 can also be monitored through the web server.

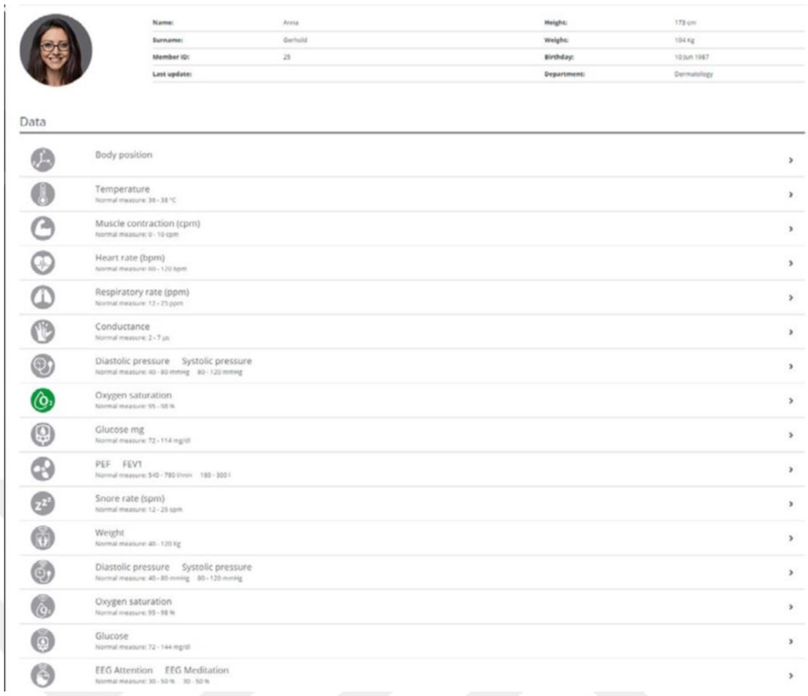

Figure. 63 Spo2 result in web server

Figure. 64 Spo2 wave in web server

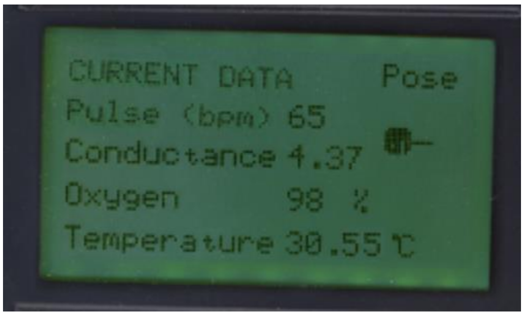

Figure. 65 Spo2 result in GLCD

6.3 Analysis of the results for Electrocardiogram (ECG)

The electrocardiogram machine is one of the most important medical solutions through which it is possible to diagnose and know the effectiveness of the heart.

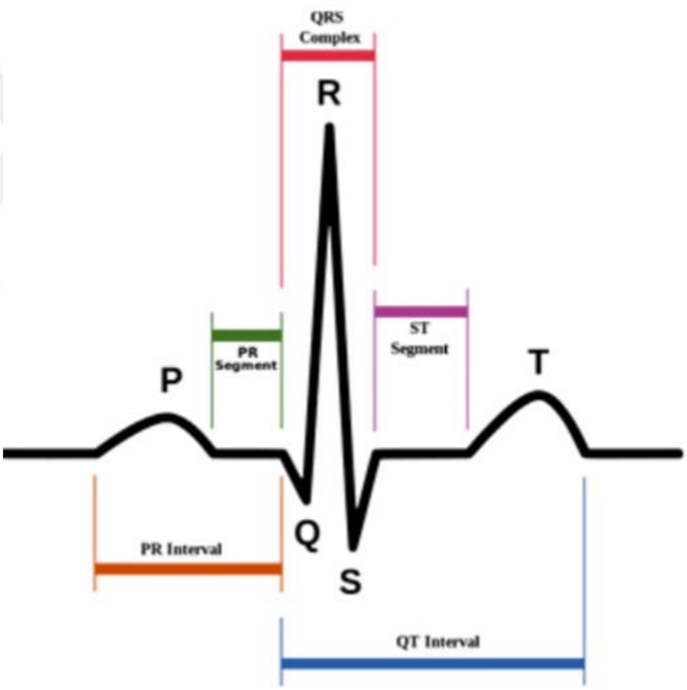

Figure. 66 ECG Schematic

The results are show in the Serial monitor.

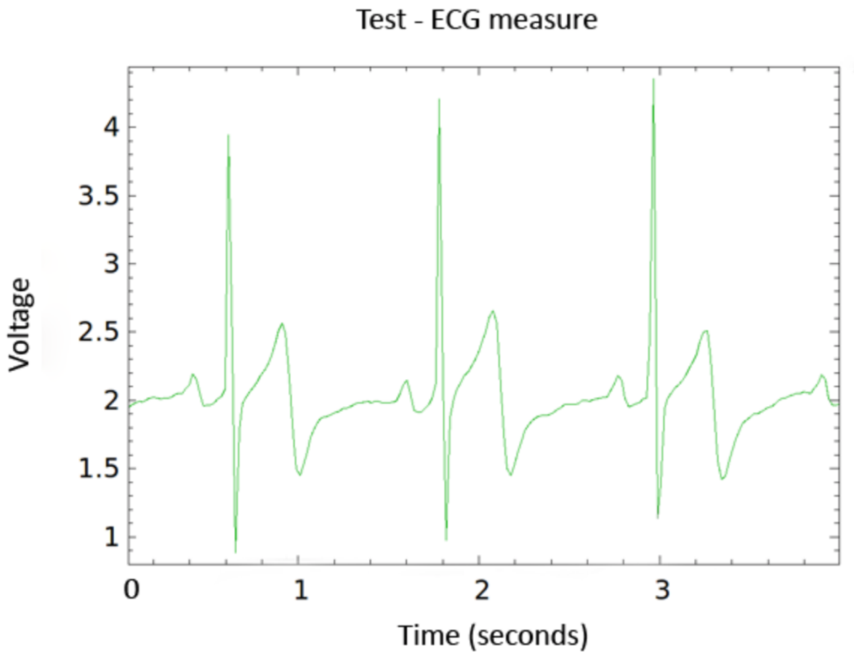

Figure. 67 ECG result in serial monitor

Mobile App

The smartphone app displays ECG information in real time. This can be seen through the following image.

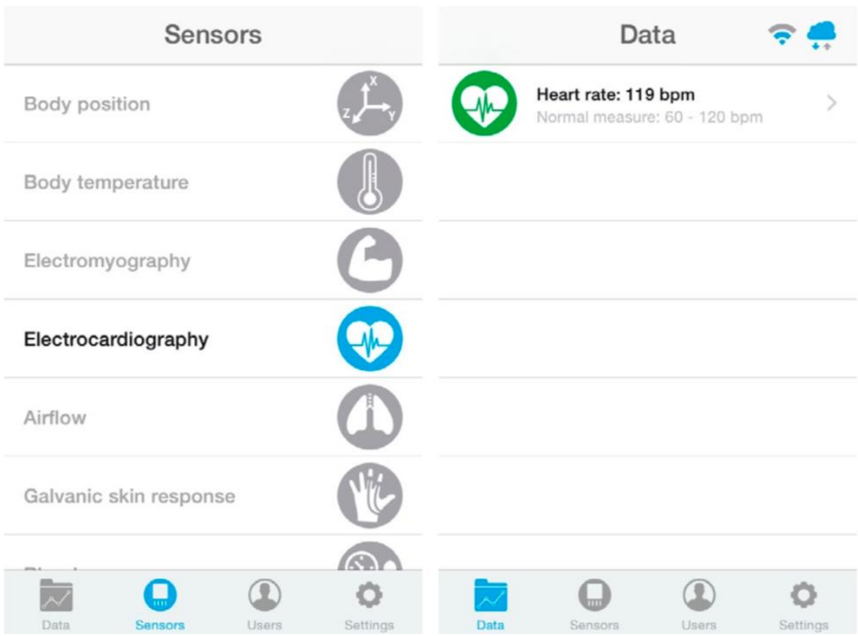

Figure. 68 ECG result in mobile application

Figure. 69 ECG wave in mobile application

The ECG can also be monitored through the web server.

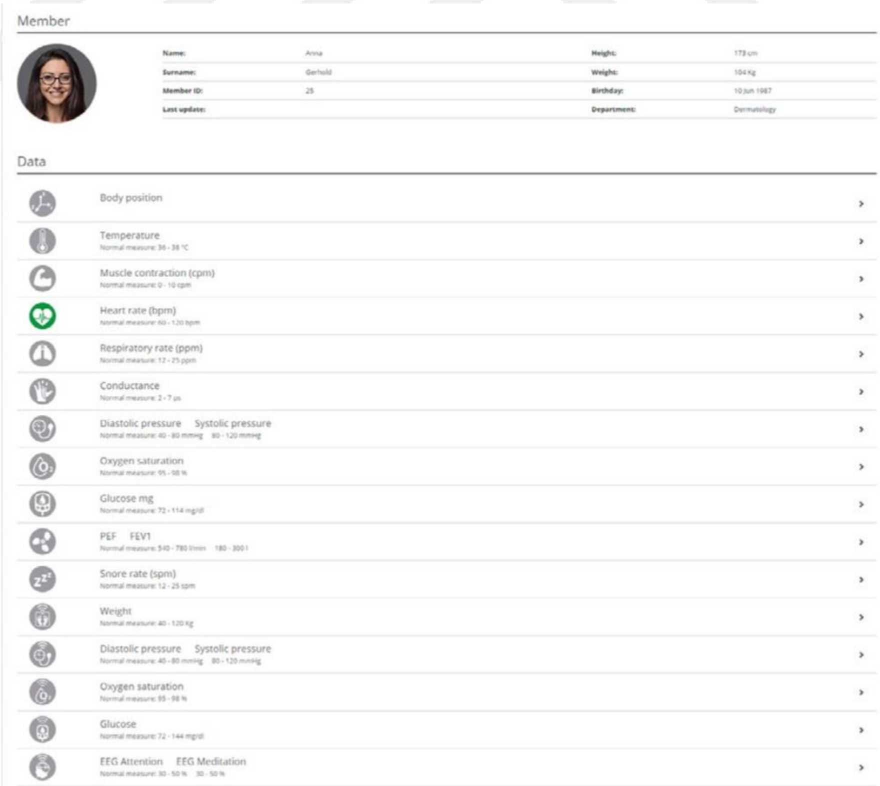

Figure. 70 ECG result in web server

Figure. 71 ECG wave in web server

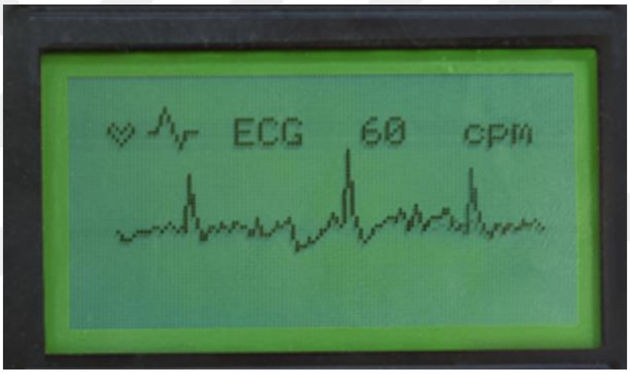

Figure. 72 ECG result in GLCD

6.4 Analysis of the results for Airflow: breathing sensor

The respiratory index is one of the vital signs about the health of the body, as the latest reports about COVID 19 disease indicate a change in respiratory rates from the damage that the virus causes to the human body.

The results are show in the Serial monitor.

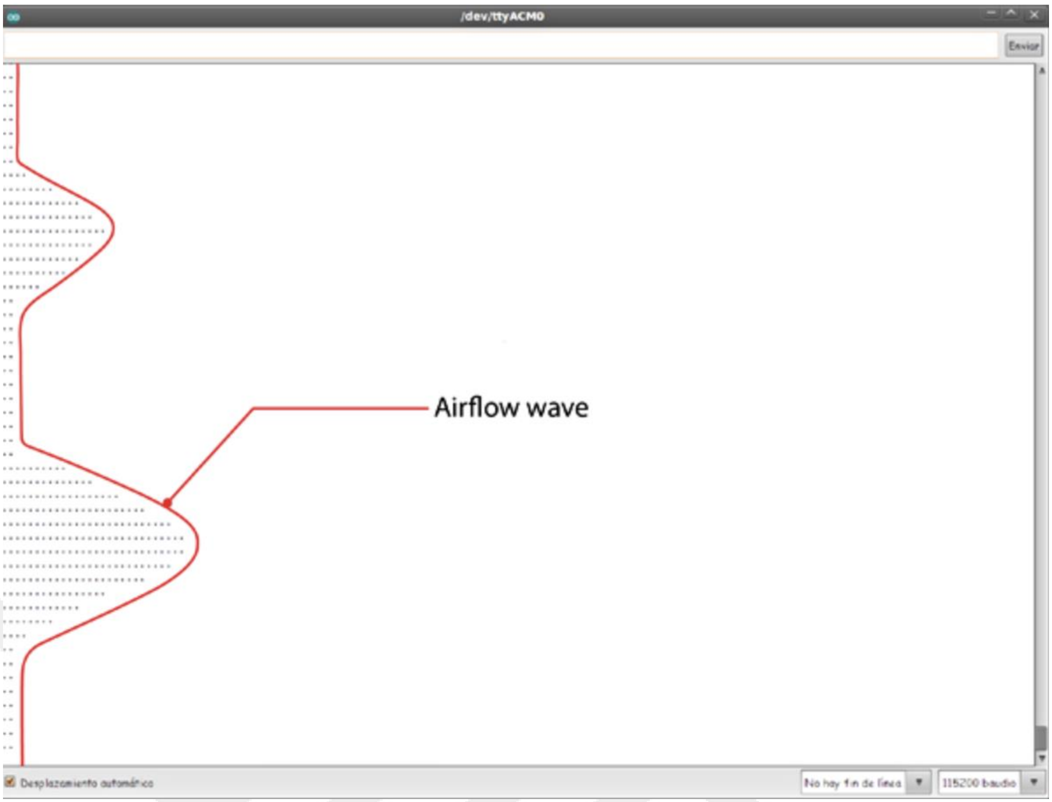

Figure. 73 Airflow wave in serial monitor

Mobile App

The smartphone app displays Airflow information in real time. This can be seen through the following image.

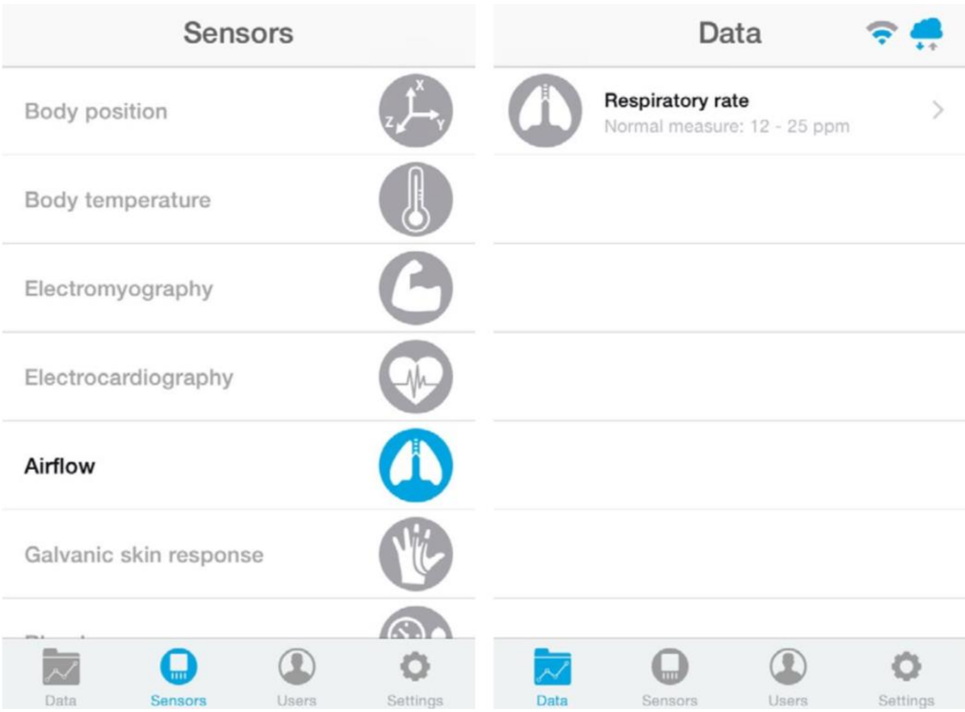

Figure. 74 Airflow result in mobile application

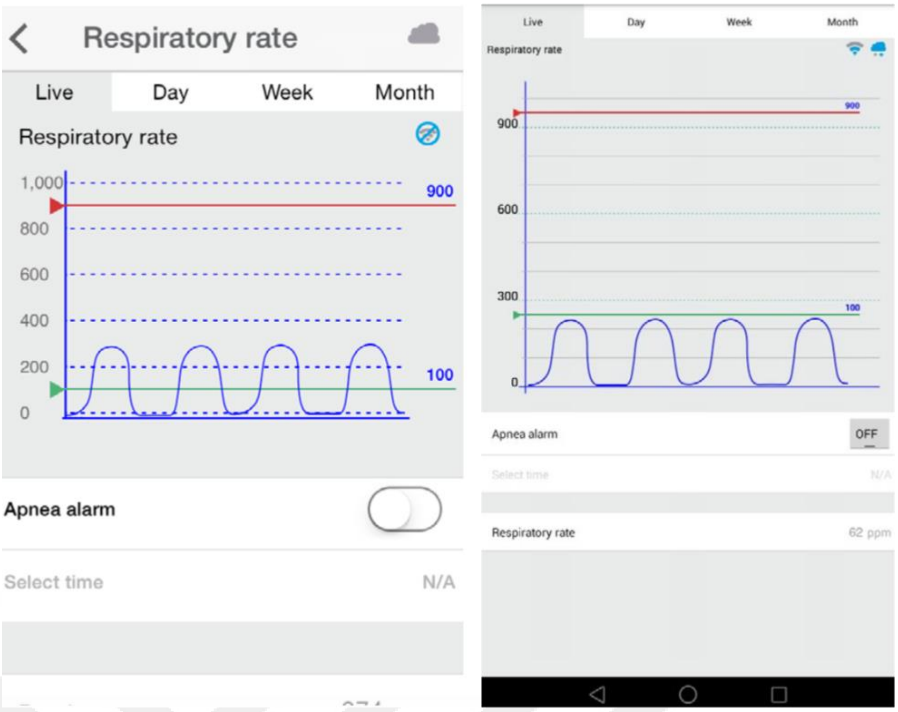

Figure. 75 Airflow wave in mobile application

The Airflow can also be monitored through the web server.

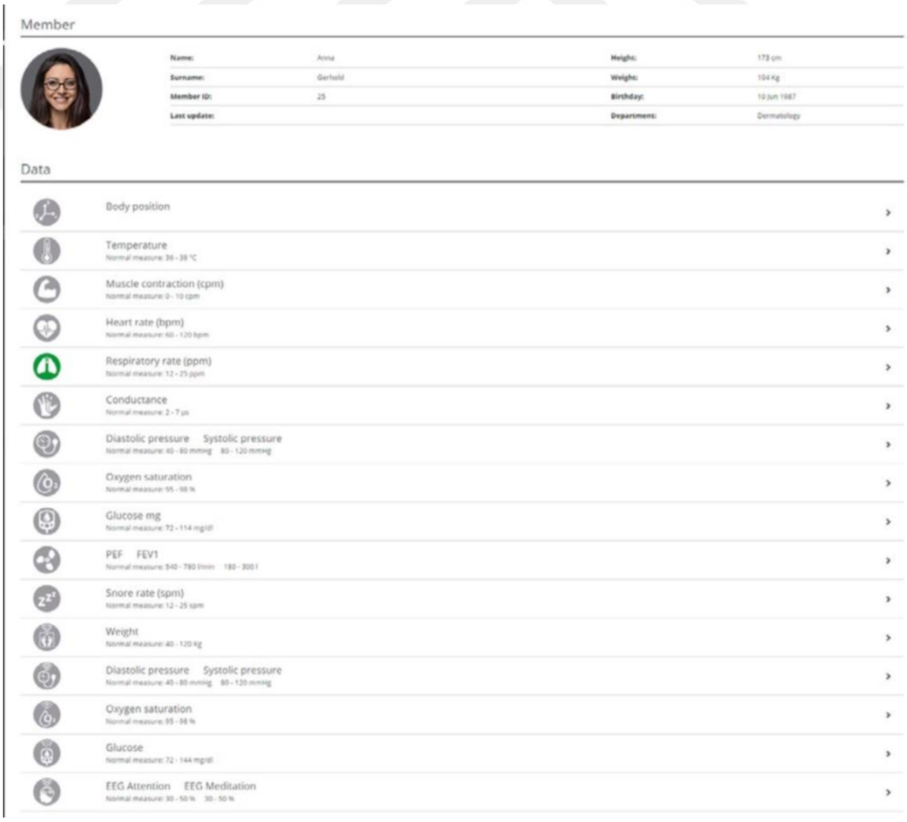

Figure. 76 Airflow result in web server

Figure. 77 Airflow wave in web server

Figure. 78 Airflow wave in GLCD

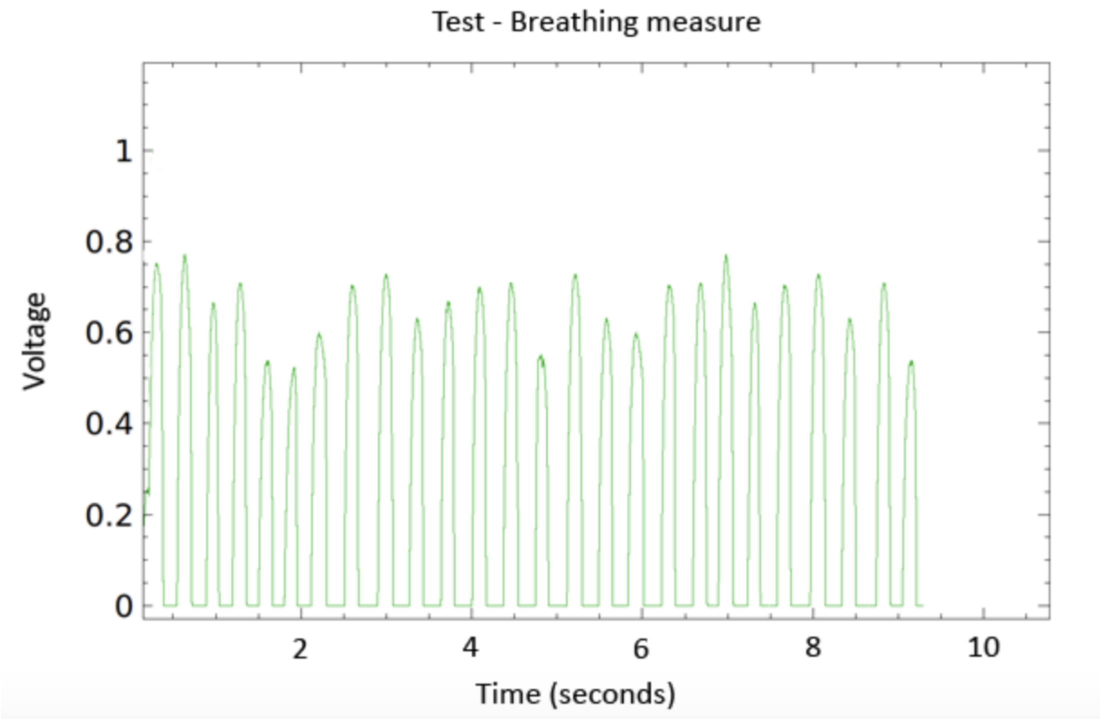

Figure. 79 Breathing measure wave

6.5 Analysis of the results for Blood pressure

Measuring blood pressure is one of the vital indicators of the patient's body, with the spread of the COVID 19 epidemic, especially with patients who complain of chronic diseases, blood pressure does not remain stable all the time, as it changes by changing the position of the body, stress and psychological state.

Table 7 Classification of blood pressure

BP	systolic	diastolic
ordinary	<120	and <80
High blood pressure	>119 – <140	81–90
Step 1 Hypertension	>141 – <160	91 –98
Step 2 Hypertension	>161	>100

The results are show in the Serial monitor.

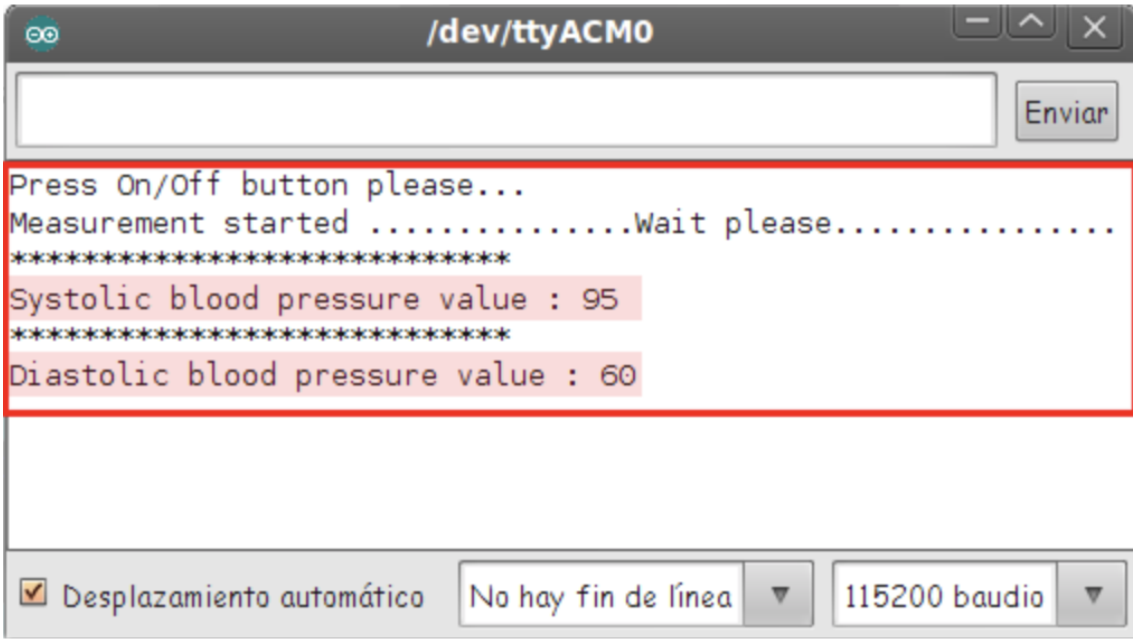

Figure. 80 Blood pressure result in serial monitor

Mobile App

The smartphone app displays blood pressure information in real time. This can be seen through the following image.

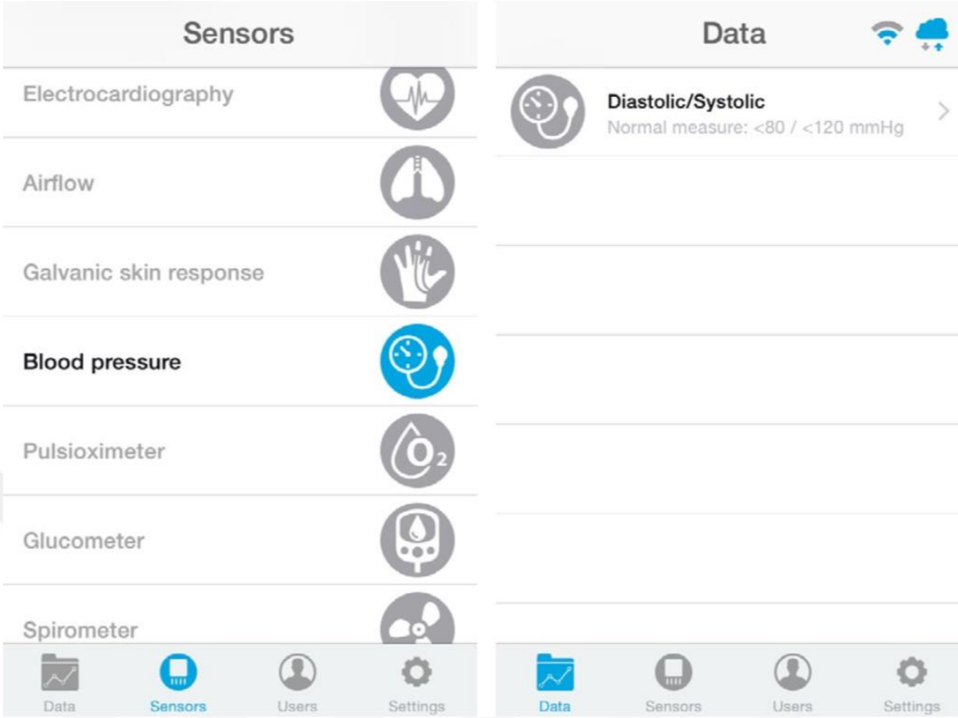

Figure. 81 Blood pressure result in mobile application

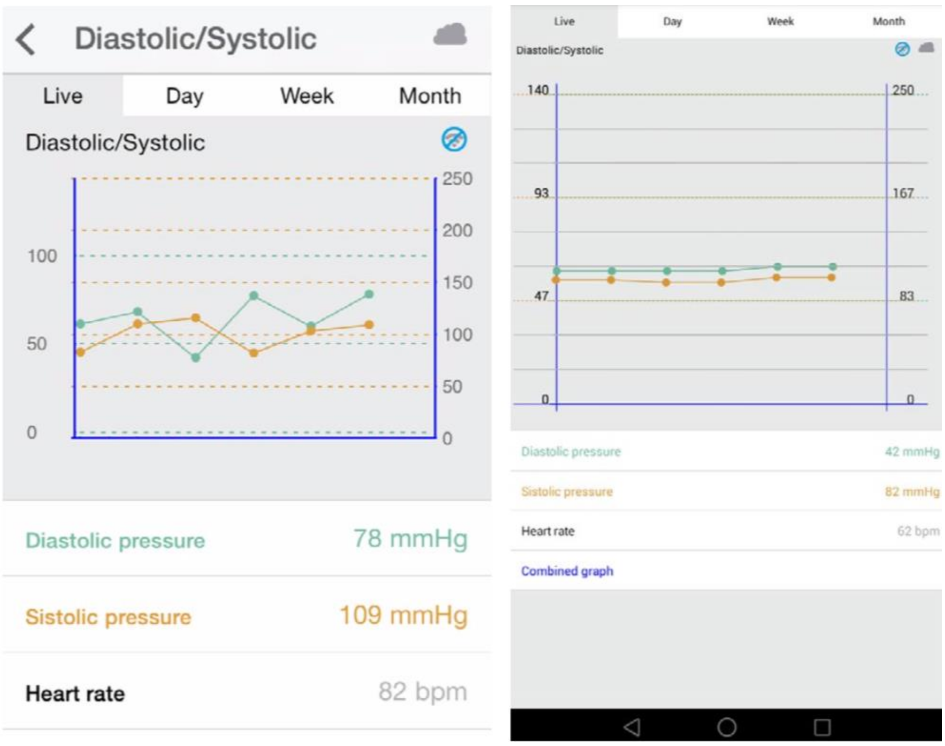

Figure. 82 Blood pressure wave in mobile application

The blood pressure can also be monitored through the web server.

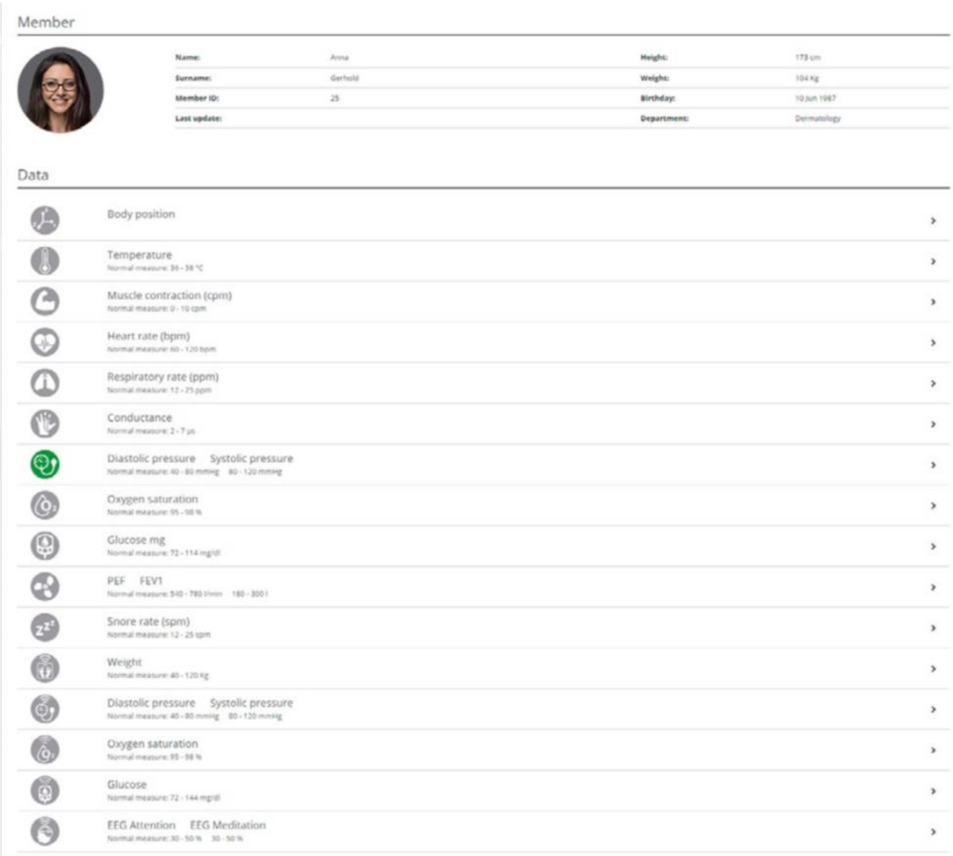

Figure. 83 Blood pressure result in web server

Figure. 84 Blood pressure wave in web server

6.6 Analysis of the results for Glucometer

It is the amount of glucose concentration in the blood. We put a drop of blood on the single-use test strip and put the strip into the machine.

The results are show in the Serial monitor

.

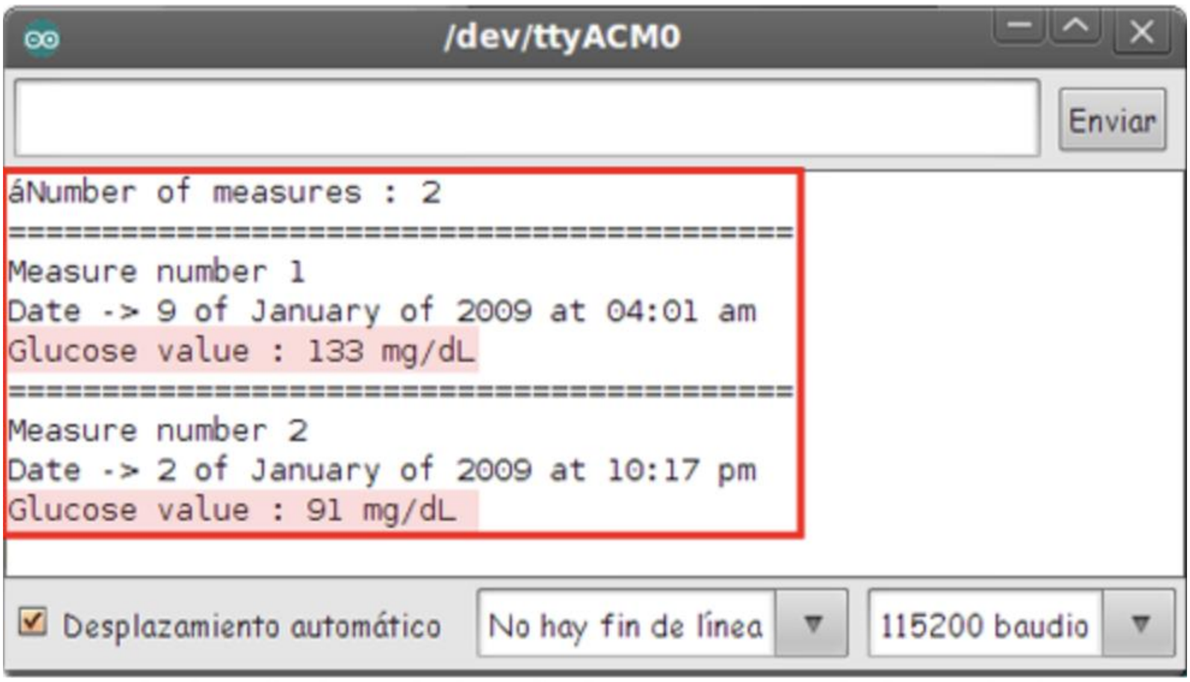

Figure. 85 Glucose result in serial monitor

Mobile App

The smartphone app displays glucose information in real time. This can be seen through the following image.

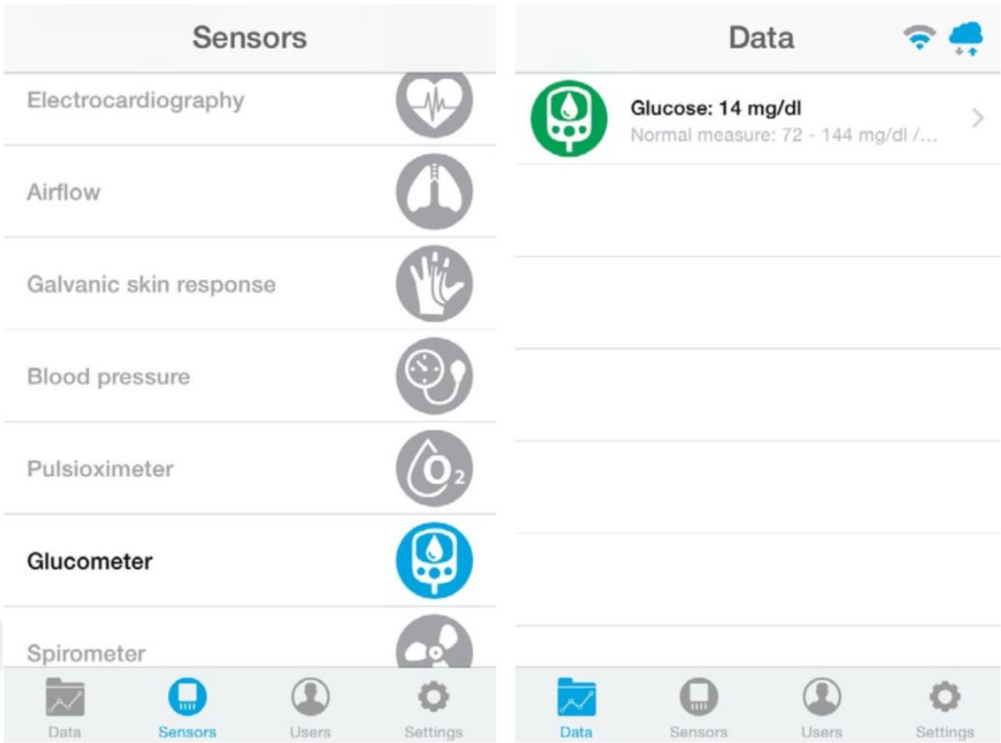

Figure. 86 Glucose result in mobile application

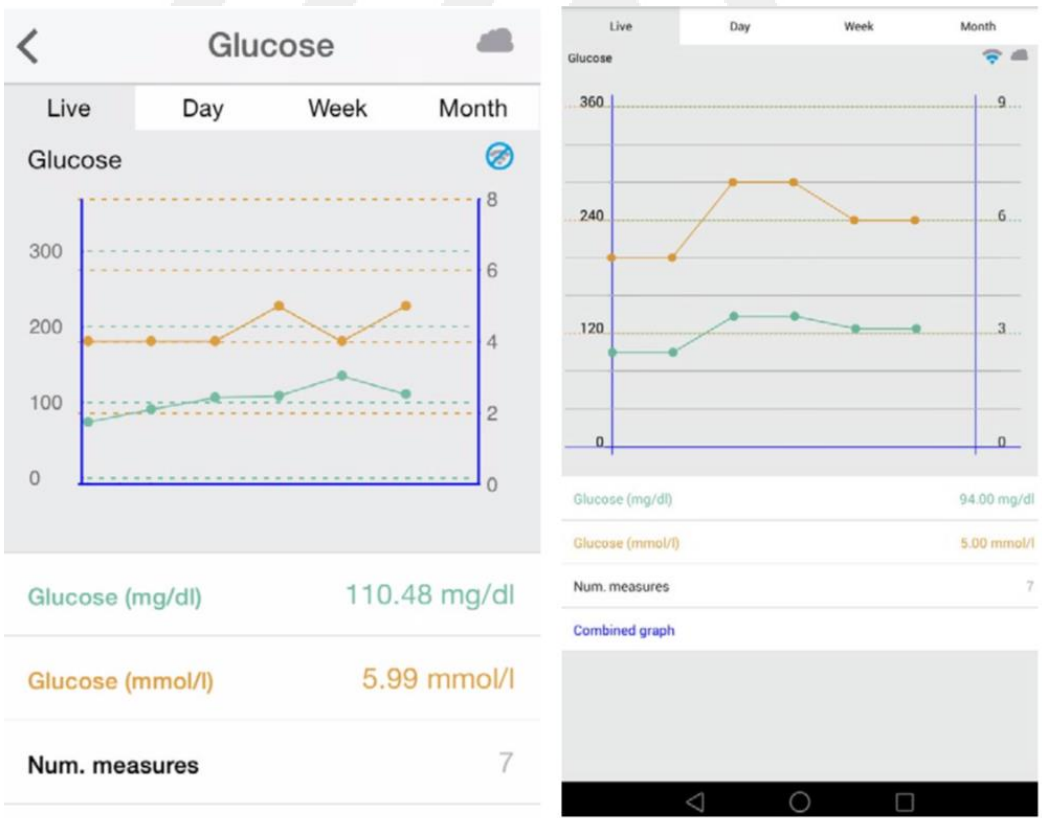

Figure. 87 Glucose wave in mobile application

The glucose can also be monitored through the web server.

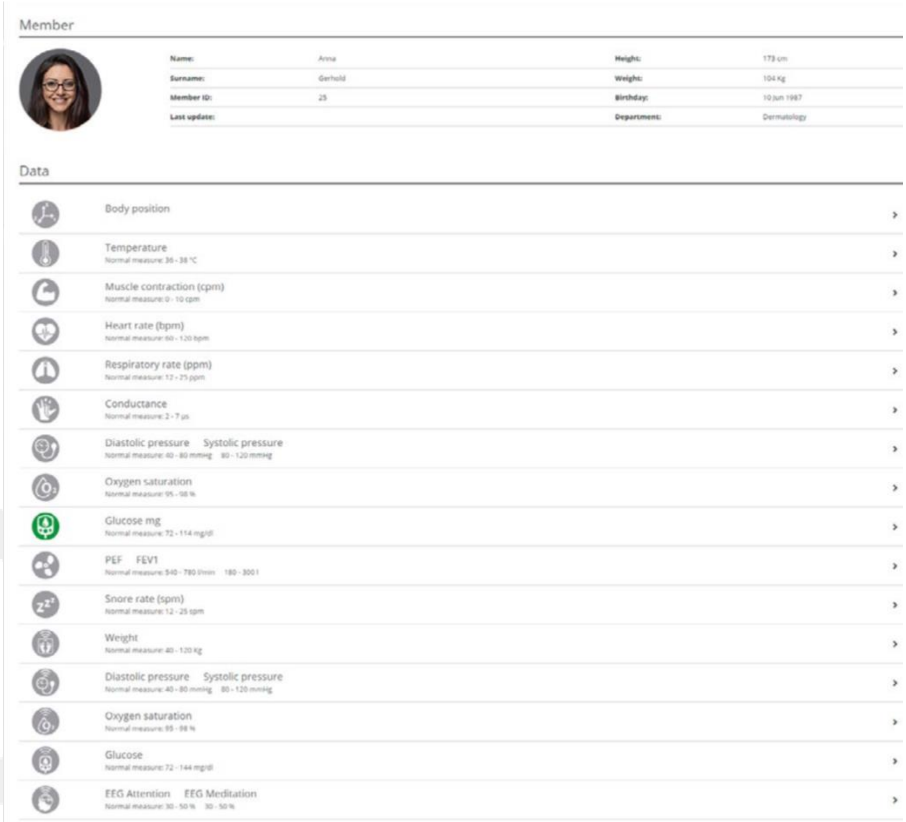

Figure. 88 Glucose result in web server

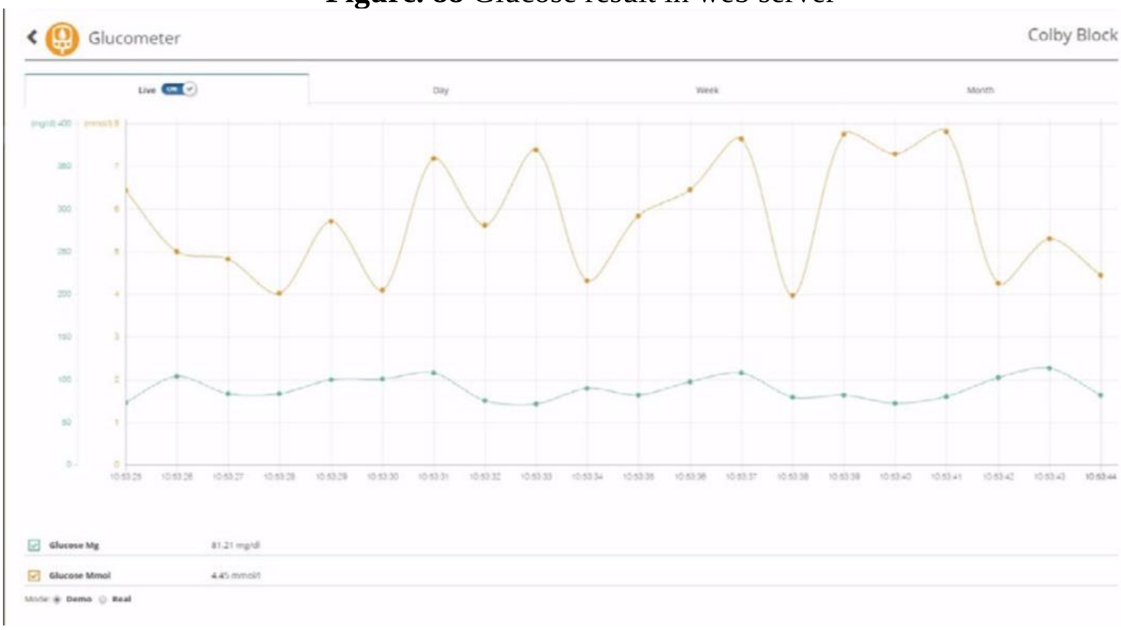

Figure. 89 Glucose wave in web server

6.7 Analysis of the results for Galvanic Skin Response (GSR)

The skin electrical conductivity sensor measurement depends on the level of moisture. The sympathetic nervous system is controlled by the sweat gland to monitor the strain when the skin's electrical resistance changes.

The results are show in the Serial monitor.

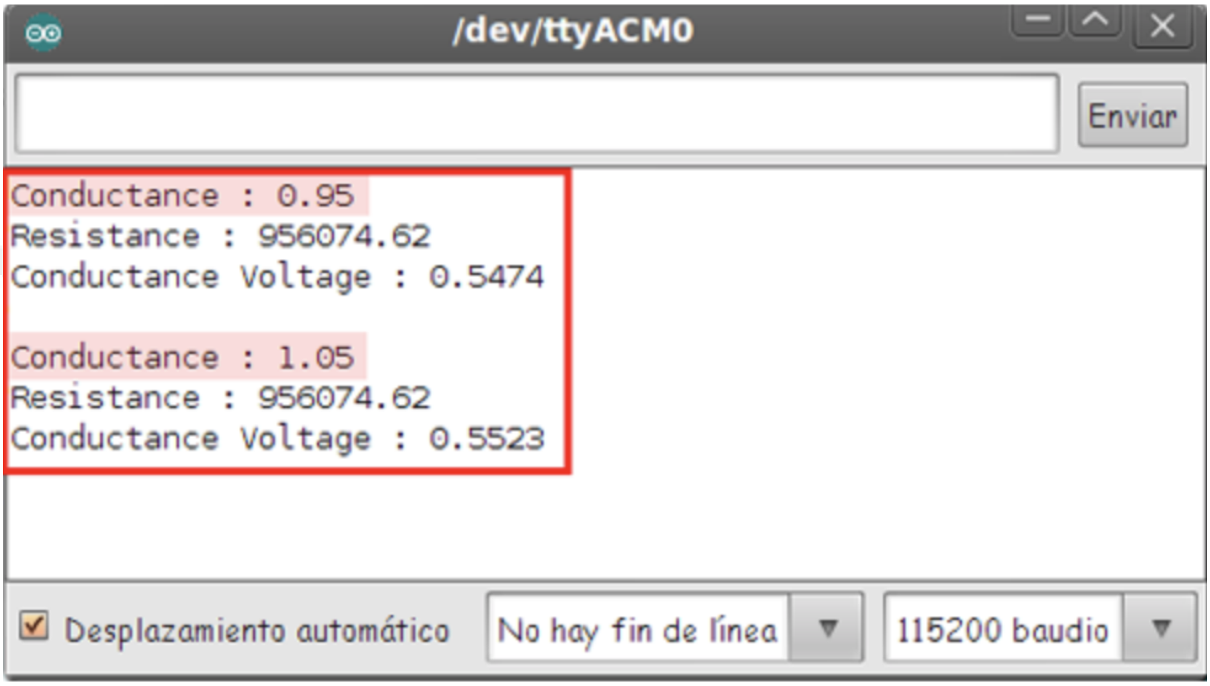

Figure. 90 GSR result in serial monitor

Mobile App

The smartphone app displays GSR information in real time. This can be seen through the following image.

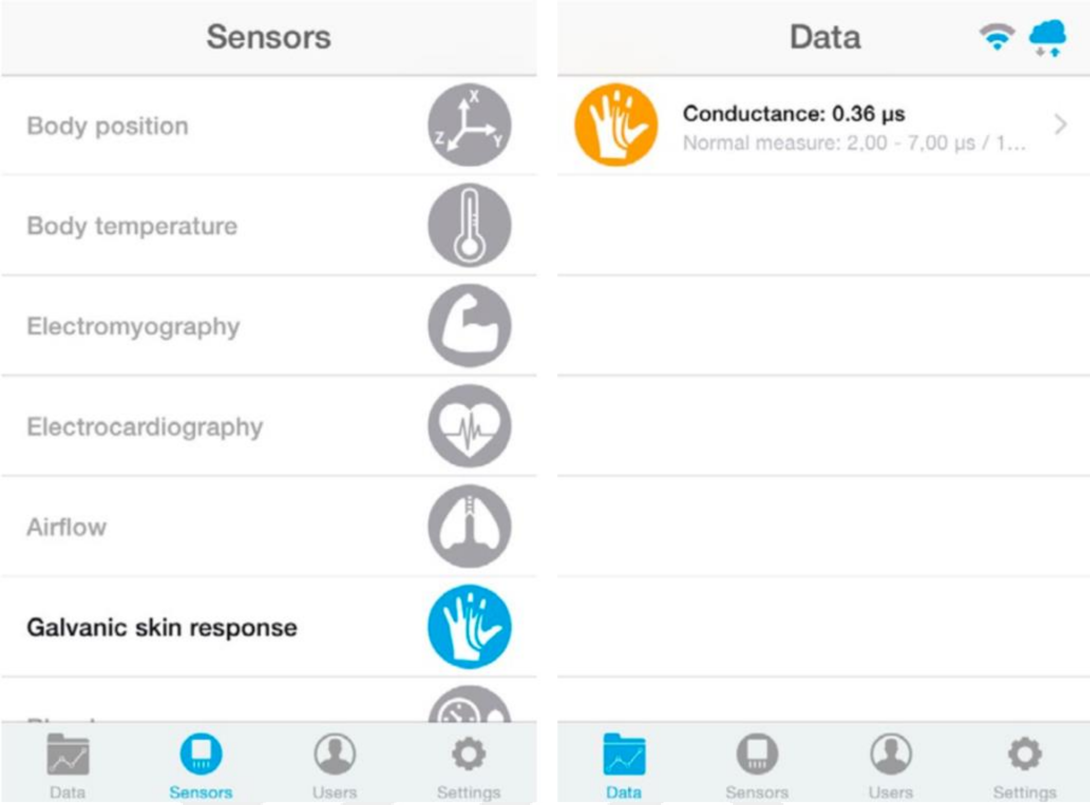

Figure. 91 GSR result in mobile application

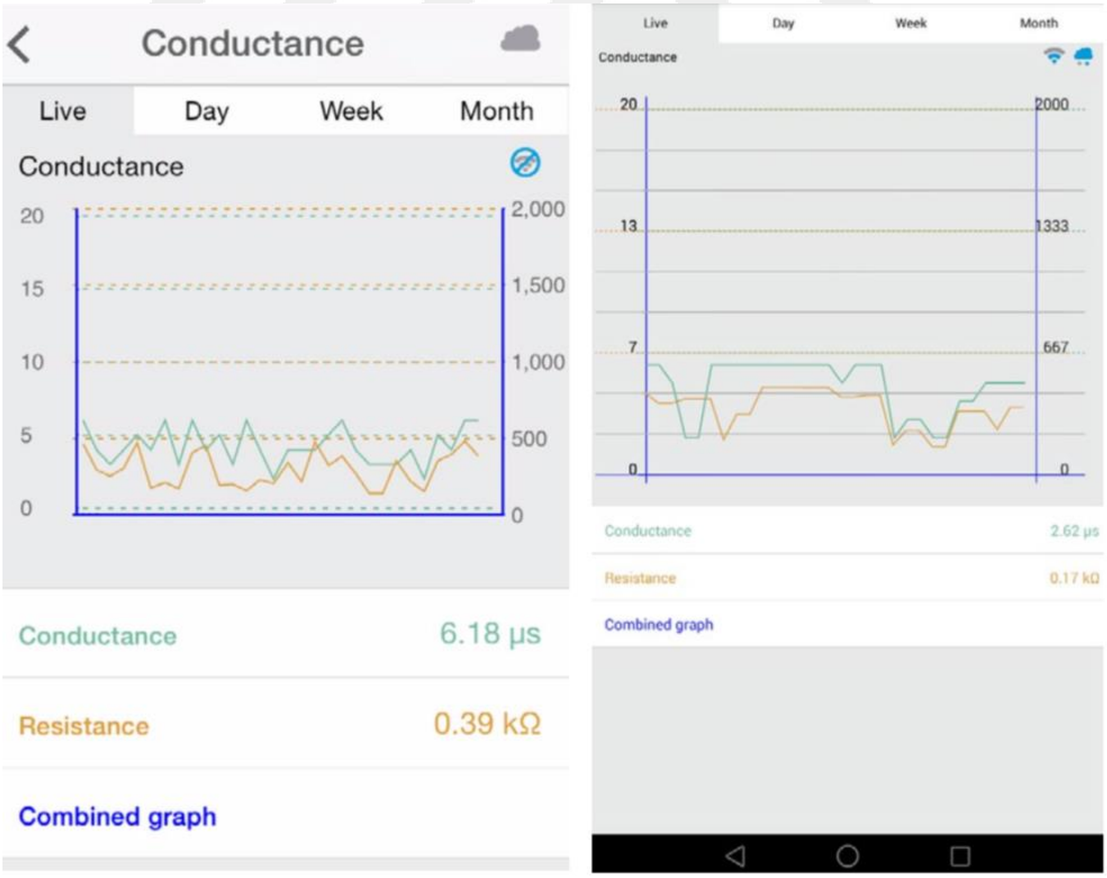

Figure.92 GSR wave in mobile application

The glucose can also be monitored through the web server

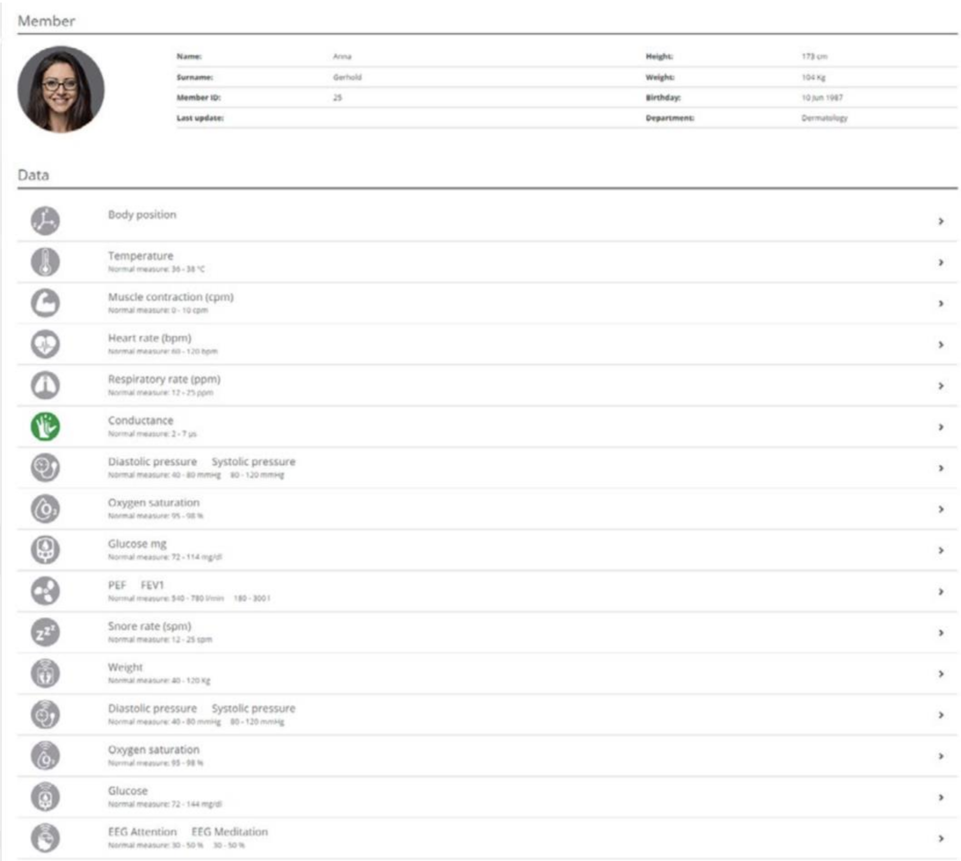

Figure. 93 GSR result in web server

Figure. 94 GSR wave in web server

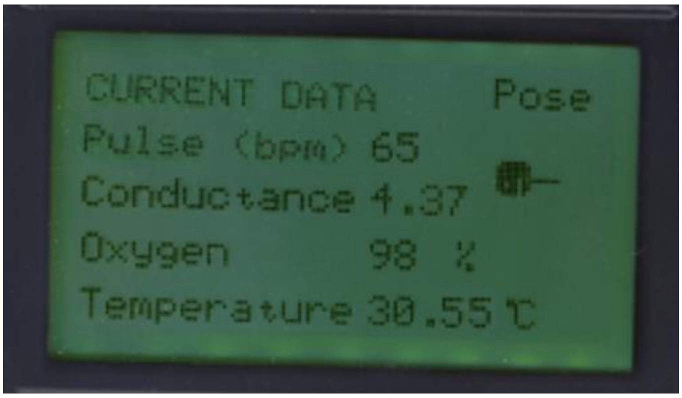

Figure. 95 GSR result in GLCD

6.8 Analysis of the results for Body Position

A 3-axis accelerometer is used to obtain the position of the object (sitting, standing, lying down, prone).

The results are show in the Serial monitor

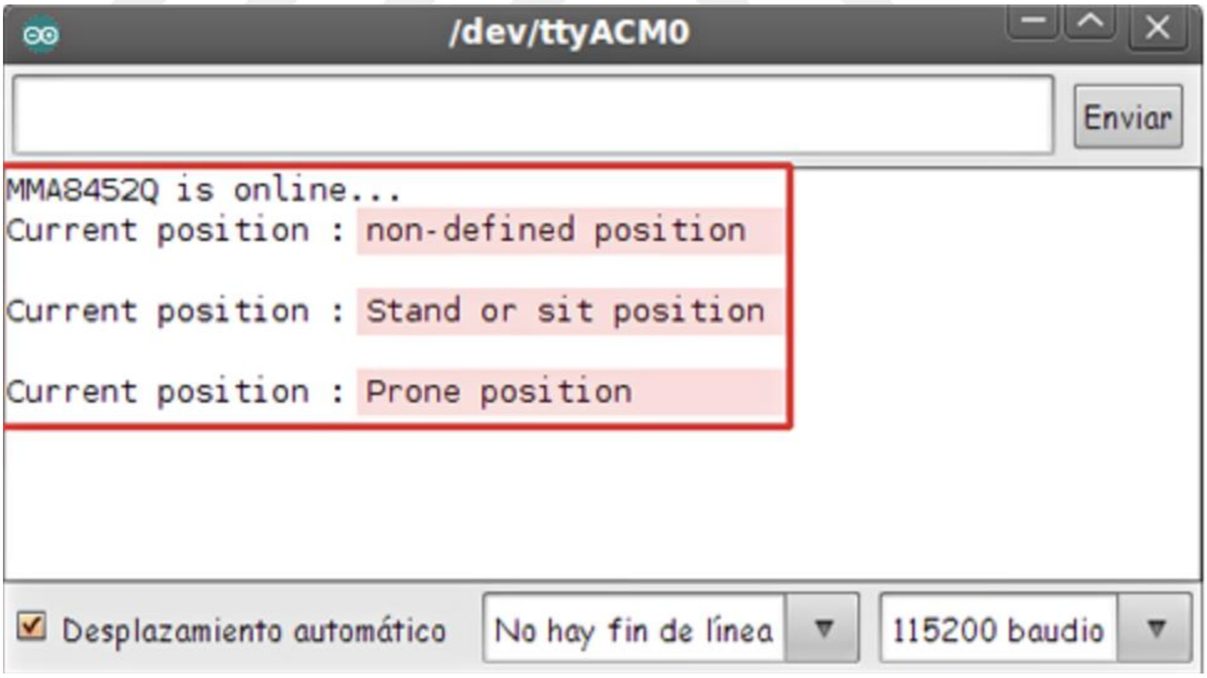

Figure. 96 Body position in serial monitor

Mobile App

The smartphone app displays information in real time. This can be seen through the following image.

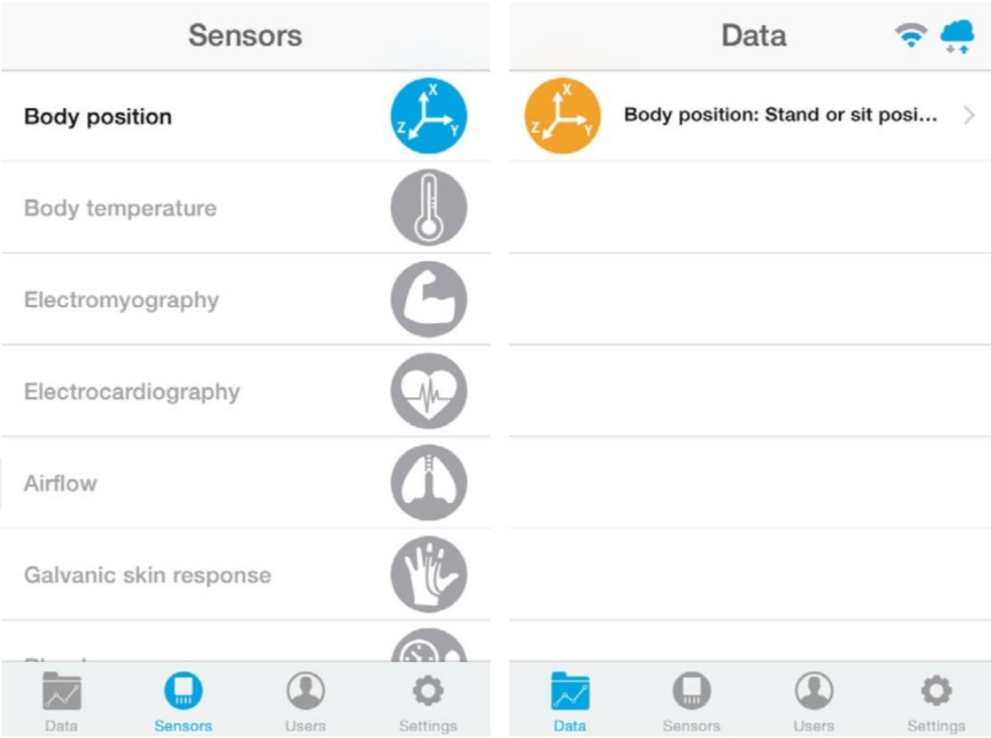

Figure. 97 Body position in mobile application

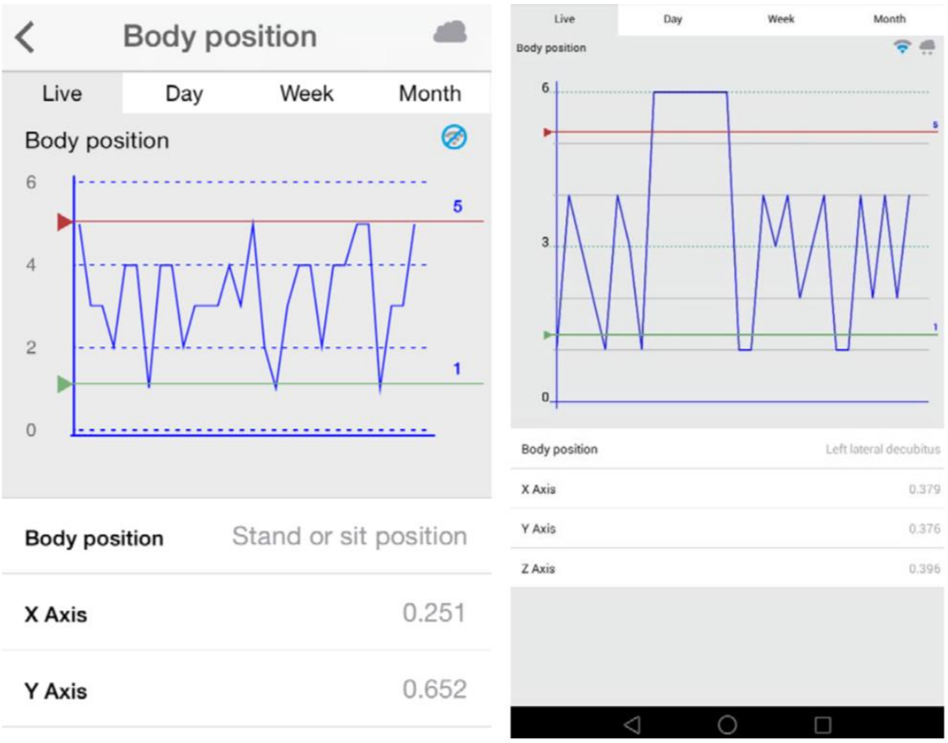

Figure. 98 Body position wave in mobile application

The body position can also be monitored through the web server

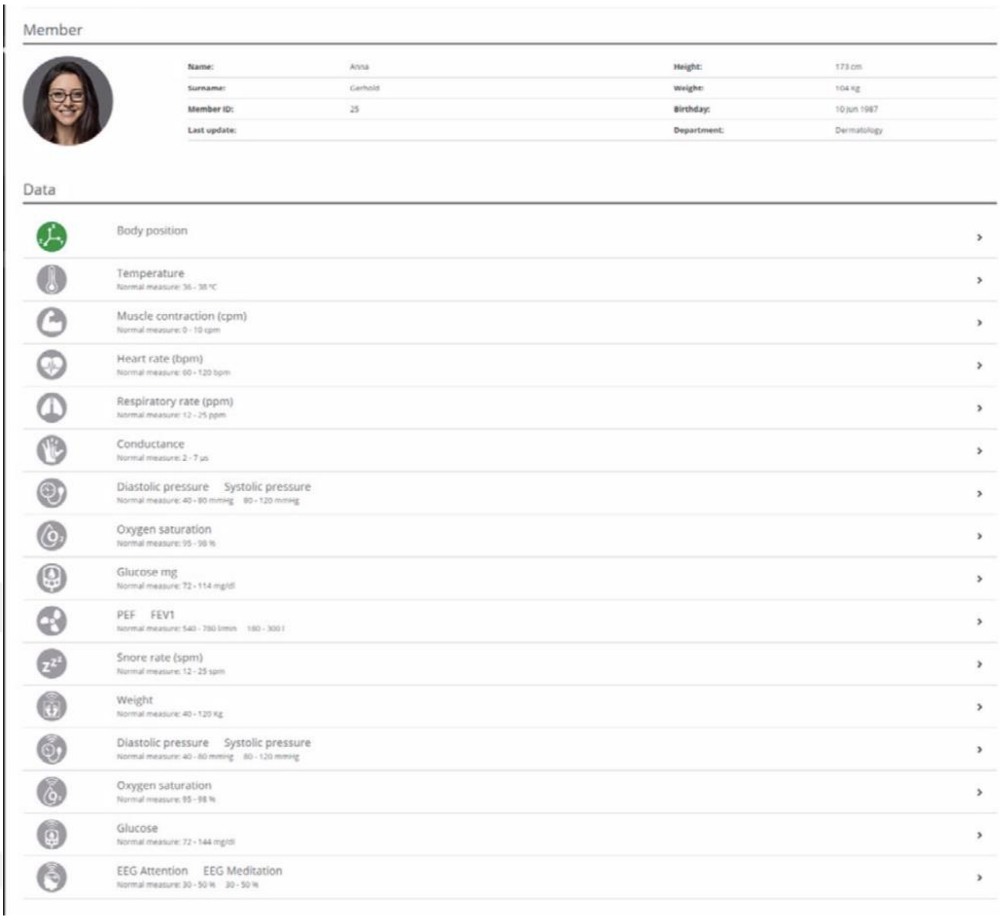

Figure. 99 Body position in web server

Figure. 100 Body position wave in web server

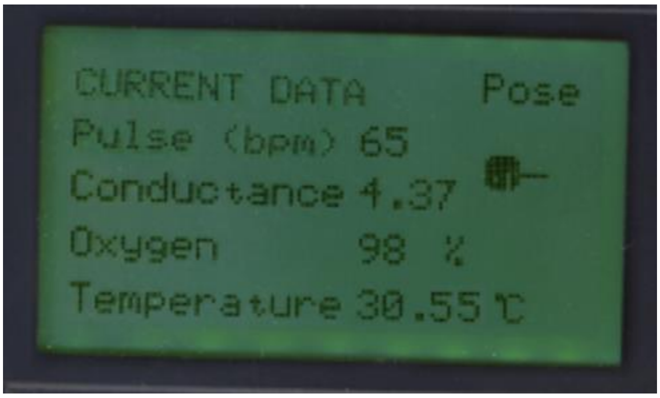

Figure.101 Body position in GLCD

CHAPTER SEVEN
CONCLUSIONS AND FUTURE WORK

7.1 Conclusion

In this thesis, we presented a complete real-world visualization of wearable sensors and remote medical care in the face of the emerging corona epidemic. Where it can reduce the pressure on health institutions by transferring direct treatment to remote (transferring care from the hospital to the home). By using the telehealth center, it is possible to monitor, diagnose and intervene in a timely manner to prevent any potential deterioration and reduce contact between medical staff and patients. Therefore, it is the future of treating epidemics, especially the COVID 19 epidemic.

In the past decades, there have been a number of attempts to develop remote health care systems and have already been used with COVID 19.

The technologies of IoT and artificial intelligence are required in the field of mobile health and the adaptation of care personnel and medical staff to use them in order to know the results that would reduce the effort exerted and the possibility of controlling the epidemic.

Despite all the tremendous capabilities provided by the mobile health platform in reducing the spread of COVID 19, there are many challenges that need to be addressed in order for the work to be widely adopted for research and development in the future, so we suggest the following:

7.2 Future works

1- Development of more flexible sensors, integrated with artificial intelligence applications, at a low cost, allowing them to be widely spread.
2- Development of artificial intelligence systems based on automated decision support that support real time to create electronically archived health records to assist medical staff with appropriate intervention and prevent any deterioration or aggravation.
3- Designing and managing tele-care platforms and ensuring their continuity and connectivity to patients.

4- Conducting more research to address ethical issues, privacy and information security, which increases the chances of spreading sensors.

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RESUME

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Education

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Work Experience

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Publications

1- *Motion control of Robots by using Smartphones*
2- *IM-LEACH: An Improved LEACH protocol for Wireless sensor Networks*
3- *Designing and Implementation of electronic Device controlled IOT for COVID 19 patients monitoring through secured communications system*