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An Intelligent IoT Based Healthcare System Using Arduino (IIHS) Case Study: Cholera Observation System

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نظام الرعاية الصحية الذكي القائم على إنترنت الأشياء باستخدام الاردوينو دراسة حالة : نظام مراقبة الكوليرا

تم تقديم الأطروحة في استيفاء جزئي لمتطلبات للحصول على درجة الدكتوراه في نظم المعلومات الإدارية

الباحث:

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Dedication

To my mother, To my wife and my family.

Acknowledgment

I would like to thank my supervisor Associate Prof. Dr. Ammar Thabit Zahary, for his helpful advice. Also, my thanks to people who contribute to the survey work, I am pleased to thank everyone who has been a role directly or indirectly in the success of this work.

Abstract

The Internet of Things (IoT) and Intelligent equipment's are a rapidly evolving model that transforms traditional life into a high-tech style by integrating hardware, software, hardware, and computing for data exchange and communication. This includes health care for people with special needs or those with chronic diseases and their needs for remote care and monitoring. The rapid increase in development the lack of access to medical resources, and the desire for telemedicine in developing countries made the Internet of things an interesting topic in the field of healthcare systems. The Internet of things provides many health services that help improve the quality of life, on the one hand, others The Internet of Things still faces many challenges and issues that need to be addressed in order to achieve its full potential. In this study, we contributed to the establishment of Moodle in order to monitor infected patients with chlorosis to maintain their health condition and not to go out to the dangerous state by monitoring dangerous symptoms Cholera disease has many symptoms divide in two parts common symptoms (watery diarrhoea, nausea/vomiting, dehydration) and severe symptoms(low blood pressure and rapid heart rate), In this model we are dependent on the severe symptoms of cholera only (low blood pressure and rapid heart rate) that monitoring patient to that's infected by cholera This model is designed to monitor the health status of patients by monitoring blood pressure, and heartbeat, and since these symptoms are dangerous symptoms for people with cholera, this model works to monitor these symptoms in addition to monitoring and examining the environment surrounding patients by examining methane gas, liquefied petroleum gas or carbon dioxide and alerting that the surrounding environment is healthy and unpolluted. This model also works to display the results through various means of display such as screen, virtual terminal, oscilloscope, and this model can be developed in the future to send data through

the Android application to send critical results to the doctor or hospital or to the Ministry of Health.

Keyword:
Arduino UNO, Cholera, e-health , Healthcare, Internet of things, IoT, Intelligent

Abbreviations

AI	Artificial intelligent
API	Application programing Interface
BP	Blood pressures
Bpm	beats per minute
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HBP	Heartbeat Pulse
HIoT	Health Internet of Things
HRP	Heart Rate Pulse
I/O	Inputs/outputs
IBP	invasive blood pressure
ICU	Intensive care unit
IDE	Integrated Development Environment
IoT	Internet of Things
LCD	Liquid Crystal displays
LDR	Light Dependent Resistor
LED	Light Emitting Diode
MAP	Mean Arterial Pressure
Mhealth	Mobile health
NFC	Near Field Communication
NIH	National Institutes of Health
PPG	photo plethysmogram
PWV	Pulse Wave Velocity

R/W	Read/Write
RS	register select
SP	serum pressure
WSN	Wireless Sensor Network

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Chapter 1

Introduction

1.1Introduction

Cholera is a highly contagious disease and is endemic in many parts of Africa, Asia and conflicting countries. The war has led to an increase in environmental pollution due to long wars, and the past few years have witnessed an outbreak of cholera in Yemen.

The patient becomes infected with cholera by drinking contaminated water and beverages or eating contaminated food [1], The transmission of cholera is also associated with inadequate access to safe drinking water and a lack of healthy living conditions.

Areas with semi-urban camps are at risk of disease because people do not have clean water and proper sanitation facilities there. The consequences of any humanitarian crisis can increase the risk of cholera transmission due to exposure to cholera bacteria. Infected carcasses have not been reported as a source of the epidemic. According to the World Health Organization, cholera cases have been increasing continuously for several years. For example, in 2017, approximately 1,227,391 cases were reported in 34 countries, including 5,654 deaths [2].

The disease continues to spread in Yemen today in what has become the largest documented cholera epidemic in modern times. According to the report of the Yemeni health authorities, it is estimated that from September 28, 2016, to March 12, 2018, 113,683 suspected cholera cases (attack rate 3-69%) and 2,385 deaths (risk of death 0 22) were reported. %). reported across the country. The epidemic consisted of two distinct waves with an increase in transmission in May 2017, consistent with an average Rt of more than 2 in 13 of 23 governorates. Microbiological analyzes suggested that the same strain of Vibrio cholerae O1 Ogawa spread in both waves. We found a positive, nonlinear association between weekly precipitation and suspected cholera in the following 10 days; The relative risk of contracting cholera after a week of 25 mm 1424 rainfall (95% CI 1 31-1 55) compared to a week without rain [3].

Cholera is a disease that continues to pose a threat to public health globally and is an indicator of inequality and a lack of social development in countries. For this reason, control strategies must be investigated. In this work, the optimal control problem related to cholera is formulated by creating and designing a model based on IoT and Arduino board to monitor patient health. The effectiveness and efficiency of the proposed controls were determined through a cost-effectiveness analysis. The results showed that patient monitoring is the most adequate, cheapest, and most effective form of disease control [4].

The Internet of Things (IoT) is a new paradigm that has transformed the traditional way of life into a high-tech way of life. Smart cities, smart homes, pollution control, energy savings, smart transportation, and smart industries are among these transformations due to the Internet of Things. Many important Research studies and surveys have been conducted to advance technology through the Internet of Things. However, the Internet of Things still faces many challenges and issues that need to be addressed to realize its full potential. Therefore, these challenges and issues must be viewed from various aspects of IoT such as applications, challenges, enabling technologies, social and environmental impacts, etc.

The Internet of Things is a network in which many devices are connected, and these devices can communicate over the network. Through this global network, we can get information through sensors related to it. Using the network, we can access this information anywhere in this world. The Internet of Things can connect physical objects to the Internet and can provide an opportunity to build systems based on different technologies such as Near Field Communication (NFC) and Wireless Sensor Network (WSN). Sensors in the wireless sensor network sense the environment and send information to the base station[5].

There are many different methodologies in IoT such as healthcare systems, monitoring environments, IoT-based irrigation systems, smart healthcare systems, and traffic control. In the healthcare system, the Internet of Things provides a tool for health monitoring. Health data can be accessed with the help of the Internet of Things using sensors. Health care is a system used to improve health and help treat diseases Health-related problems or complications are increasing day by day, among them problems related to chronic diseases or widespread and growing epidemics[6].

Wireless technology has helped in health monitoring through the use of various technologies such as wearable sensors, portable telehealth, wireless communication, and expert systems [7].

Because of the lack of sanitation, awareness of diseases, and adequate access to healthcare systems, people are losing their lives. In any case, the Internet of Things (IoT) helps detect diseases and treat patients [8].

Conflicting countries need to develop health models that contribute to reducing the spread of diseases such as cholera and limiting its spread through the Internet of things technology and telemedicine. Telemedicine refers to the practice of remote patient care when the provider and patient are not physically present with each other [9].

Telemedicine is simply defined as "the delivery of health care services from a distance". Although telemedicine brings with it many benefits, it has some downsides as well [10].

1.2 Problem Statement

Healthcare problems are exacerbated in conflict countries, which are at risk of developing chronic, rapidly spreading and contagious diseases and are the leading cause of death among children, the elderly and adults.

In countries experiencing conflict, cholera can lead to limitations in life activities, reduced health-related quality of life for people and increased use of emergency health care and hospitalization [11].

Cholera can cause disabilities that lead to falls and injuries, and contribute to debilitating pain and depression. There are many health care models that have been developed but a model for detecting diseases and epidemics is lacking in such countries.

Since conflicts cause epidemics and diseases, the problem lies in the lack of means to assist in the detection of these diseases in these countries as well as the lack of devices to help maintain the health status of patients.

There are many studies that have contributed to surveillance in the field of health care, they have focused on the analysis of environmental families to analyses cholera epidemics[12], and others have focused on surveillance health care through monitoring systems for the elderly, people with special needs or those with chronic diseases[13], but they are limited to the possibility of monitoring cholera patients and the healthy environment at the same time. In this model, various means have been provided to maintain patients who have been infected with cholera using Arduino devices and equipment. Which combined monitoring the patient's health status with monitoring the environment surrounding patients and verifying that it is healthy and does not contain toxic gases such as carbon dioxide or methane, which may cause the deterioration of the health condition of patients.

1.3 Research Objectives

The focus of this Research is to examine the following Objectives:

1. To develop IIHS model to enhance the healthcare monitoring of cholera and chronic disease in healthcare system using Arduino with other applications to design a model for healthcare monitoring to enhance the monitoring system for cholera-infected patient.
2. To examine gases in the room around patients such as methane and carbon dioxide.
3. To investigate the last Researches about healthcare systems and IoT techniques to choose the best technique to increase healthcare monitoring.

1.4 Research Significance

The importance of the Research lies in monitoring the health care of people with cholera or chronic disease or the elderly who have symptoms similar to cholera that may cause death. In the conflict country and due to epidemics and pollution in their many daily lives are affected because patients are not seen promptly ,also for real-time parameter values are not measured efficiently in the clinic as well as in hospitals .Sometimes it becomes difficult for hospitals to check the patient's conditions frequently Continuous monitoring of ICU patients is also very difficult .To deal with these types of situations ,our system is useful .Our system is designed to be used in hospitals and homes also to measure and monitor body parameters such as checking the patient's surrounding environment and measuring blood pressure and heart rate .Results can be recorded using Arduino . And saved using cloud computing, the doctors can also see these results on the Android app .Our system is useful for monitoring each person's health system by easily attaching the device and recording it .We can analyze the patient's condition through their previous data.

1.5 Research Contribution

The Internet of Things contributed to solving many of the problems in the world and has contributed to health care through, therefore will be built IIHS model to facilitate healthcare in conflict countries such as Yemen and to deal with common diseases including cholera, The studies we reviewed on the Internet of Things and cholera detection have made many contributions to the discovery of the environment and dirty water, some of which have focused on regulating parenteral nutrition, our model collect collects sensors that monitor the serious symptoms that lead to death for cholera patients, the Moodle examines the surrounding environment of patients, whether healthy or unhealthy and can send information through transmitters and display a report on the status of symptoms As referred to in the chapter 3.

1.6 Research Organization

IoT-based Health Monitoring System using Arduino Uno & ESP8266 WIFI module final Research is a combination of 6 chapters including this chapter that contains the objectives of the project will be elaborated. It is followed by an explanation in the scope of the project and also the problem statements, and elaborates specific topics such as the Introduction, Literature survey, system hardware and design, system software design and methodology and Conclusion.

Chapter 2: Background and Literature review for the development of smart home system. This chapter describes the literature review of the project elaborately. Explanation will be focused on IoT based Health Monitoring System related Research ed and based on theory and conceptual ideas. Some literature reviews of current existing projects based on IoT based Health Monitoring System are also be discussed.

Chapter 3: System hardware and design. This chapter discusses the full methodology of the overall project. Hardware architecture and software implementation of the project. This chapter discusses about the architecture of the project focused on the hardware design

Chapter 4: System software design and methodology. This chapter discusses the software implementation.

Chapter 5: Results and Discussion. This chapter shows the result of the proposed model and compares the result.

Chapter 6: Conclusion and further development or future work that can be applied in this project are being discussed.

Chapter 2

Background and Literature Review

2.1 Introduction

One of the most dynamic and exciting developments in information and communications technology is the advent of the Internet of Things (IoT). Although networking technologies have become increasingly ubiquitous over the past two decades, until recently they have largely been restricted to connecting traditional end-user devices, such as mainframes, desktop and laptop computers, and, more recently, smartphones and tablets.

Recent years have witnessed the attachment of a much broader range of devices to the network. These have included vehicles, household appliances, medical devices, electric meters and controls, street lights, traffic controls, smart TVs, and digital assistants such as Amazon Alexa and Google Home. Industry analysts estimate that there are currently more than eight billion such devices connected to the network and project that this number will expand to more than 25 billion by 2020. The increasing deployment of these devices has enabled new use cases for network technologies. Some experts project that the IoT may generate as much as US$13 trillion in revenue by 2025.

2.2 Background

In this section, a brief definition of IoT and healthcare is presented. At first, an outline of IoT and healthcare is explained. Then, the layered architecture of Healthcare IoT is described. Finally, the important metrics that are used in this subject are defined.

2.2.1 Internet of things overview

IoT solutions are developing very rapidly in the healthcare sector from a simple design to more complex and smarter systems, as artificial intelligence and the Internet of Things have played a key role in healthcare and building a lot of models around mHealth and a lot of tools that have affected the availability of healthcare [14].

Sharing data is one of the biggest challenges in the Internet of Things (IoT), as billions of heterogeneous devices are already connected and more are to come. Improving data transmission efficiency, scalability, and survivability in a fragile network environment and limited resources in IoT systems are always key issues [15]. a good algorithm for message routing improves data transmission in the Internet of Things in a resource-limited and fragile network in the subscription model. Messages in an MQTT queue to take over thread-based session flows with the controller when the broker is disabled [16]. a spread rapid spread of infectious diseases and epidemics such as COVID-19, a need has emerged for technologies that enable countries and their healthcare sectors to confront the pandemic, reduce its spread and infection rate, and find a way to detect it as soon as possible. Due to the spread of the Corona pandemic, the adoption of IoT technology in the Saudi healthcare sector contributed to confronting the COVID-19 pandemic by collecting field information and taking a clear initiative to adopt IoT technology, It also showed privacy and security major obstacles facing the adoption of the Internet of things and its implementation in closed systems and not to share it online or outside the cloud [17]. The Internet of Healthcare Things (IoHT) consists of a variety of medical equipment connected via the Internet that has transformed traditional healthcare into smart and connected through wireless wearable sensors network (W-WSN), through various applications of patient-centered (IoHT) architectures to map realistic topological maps Limited resources for IoHT to estimate crowding out and not lose important medical information [18].

Technological advances in recent years have enabled researchers to develop smart devices to deal with health resources through Internet-based technologies [19]. The fifth-generation wireless networks have made the Internet of Things allow a large number of applications and features to connect with each other in one environment on a wide range of sensors and data communications with high speed and zero errors in addition to smart calculations [20]. Because of the technology of the fifth industrial revolution, which contributed to the growing interest in health through smart diagnosis, the importance of diagnostic medical information emerges, and such personal information causes problems related to security and reliability in information sharing and data transmission [19].

hybrid IoT architecture consists of the things involved, followed by the insight data processes which end with the action that needs to be done, it is that it can comprise several subsystem architectures the component in conventional IoT architecture as shown in Figure 2, the IoT Edge Devices form the smart IoT actuator since they are able to conduct some processing themselves and IoT Sensors are connected to the cloud, where they can transmit and receive the data, the Device Provision helps to connect a large number of devices to be registered.

The IoT Gateway/Framework proves a cloud hub to the IoT devices and provides command, management, and control of the devices and analyzes complex execution using time windowing ductions, stream aggregation, and external source combing the Machine Learning allows the algorithms to be predicted and executed using extreme data. It also analyzes and enables predictive maintenance, according to different scenarios, hold and store the data, while providing the necessary tools for batch processing, and the User Management can restrict and permit which users or groups are authorized to perform an action on the device. The process is done by using the capacities of the application of each user, Listed below are the functions of each component in a conventional IoT architecture, as shown in Figure 1.

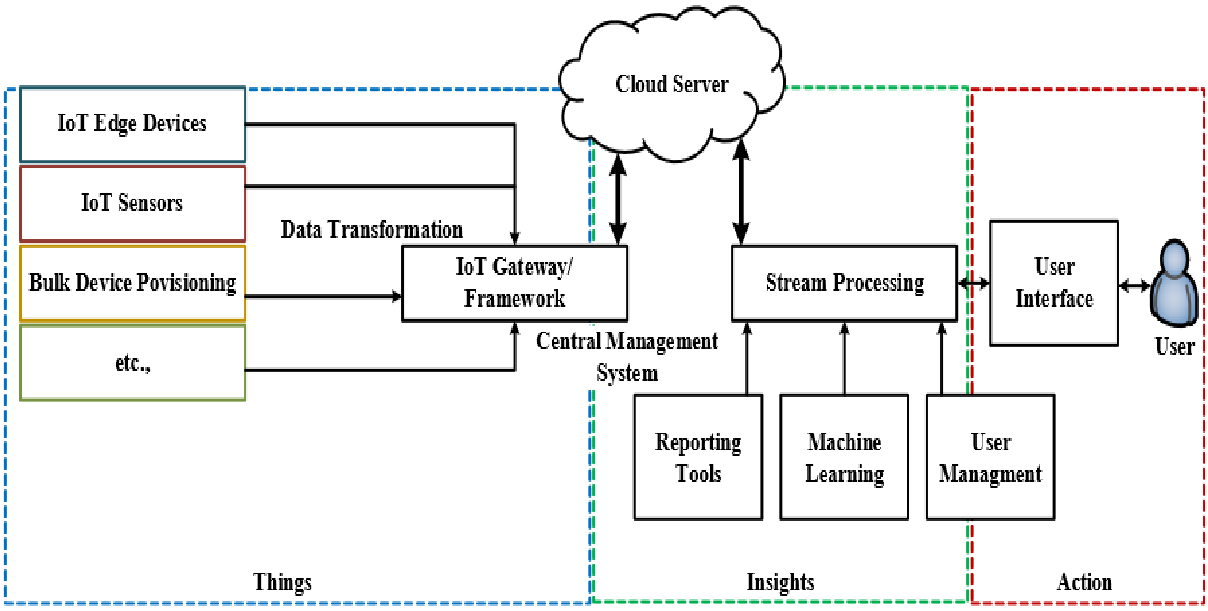


Figure1 : Internet of Things (IoT) architecture **[19]**

2.2.2 Healthcare overview

The recent outbreak of epidemics and infectious diseases such as COVID-19, the need for quarantine, high costs and long distances in the current period of time, and the difficulty of going to health centers, especially for the elderly and those with special needs who suffer from chronic diseases [21].The Internet of Things provides monitoring for patients who need health care without the need for communication between patients and doctors to prevent the spread of the Covid-19 virus, and introduces the idea of regular monitoring of the heartbeat of patients to COVID-19 patients through a heart rate sensor and BOLT Wi-Fi module to establish a connection to send online data [22] and [23]. The Internet of Things also monitors the movement, behavior and movement of Alzheimer's and Parkinson's patients by collecting data from multiple sensors installed inside the homes of the targets at home or outside their homes and smart watches to check the level of blood pressure and temperature, and different types of communication protocols have been used such as Remote Message Queuing Transfer (MQTT) and WebSocket (with authentication and automatic connection shutdown) for sensors and smartwatch A secure backend admin panel is used to track the location of doctors, patients and ambulances These protocols are also implemented securely to protect patient privacy [15]. LoRaWAN Communications Infrastructure is an integrated COVID-19 patient management system that monitors health symptoms from a distance that can be applied to isolated people without direct interaction with patients, IoT wearable devices monitor patient health parameters such as body temperature, pulse or oxygen saturation This helps to reduce the spread of the Corona virus[24]. The LogNNet algorithm is also effective in solving problems related to classification of medical data to calculate risk factors for the presence of disease in a patient based on a set of medical health indicators. Demonstrates a medical COVID-19 diagnostic algorithm after training LogNNet on a publicly available database that has been tested for SARS-CoV-2 using nasopharyngeal smear analysis by polymerase chain reaction (PCR). Additionally, the LogNNet algorithm assesses perinatal risk based on electrocardiogram data of 2,126 pregnant women obtained from a machine learning repository at the University of California, Irvine [25]. It obtains the user's vital signals from the wearable sensors and then sends the data to the smartphone via a connection such as infrared, the mobile device forwards this information to the database server over the network such as the 5G network, the database collects from the sensors by pressing button immediately, as other data is collected from health centers, doctors' decisions and medical analyzes and stored in the database, the system analyzes the stored data and discovers the condition of patients if they are abnormal, a warning is sent to the patient or doctor, and then the patient is transferred to the hospital, with Increasing demand focused on recent advances in health systems and digital communications, patients can now connect to telehealth services anywhere, considering the highest degree of choice and personalization of health care services, the figure illustrates the architecture of health care systems [26].

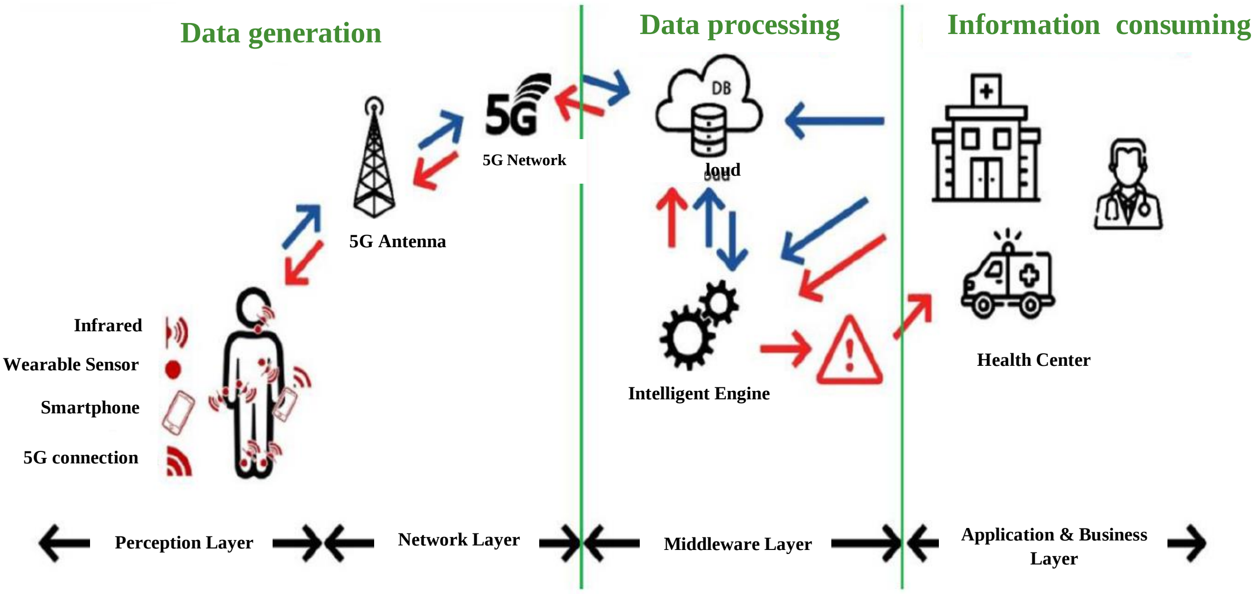


Figure2 : The architecture of IoT in healthcare systems**[26]**.

2.2.3 E-health overview

The author [9] Innovated solutions and implementation in telemedicine have led to a major transformation of healthcare in the wake of the impact of COVID-19 karma, providing the response to the pandemic and a unique opportunity to learn the cycle that telemedicine plays in e-health care, e-health is defined as the mechanism of using information and communication technology For health, which in turn has helped in the field of personal care to increase patient comfort, accessibility, and participation, and telemedicine serves as an important means of providing care even after the epidemic [27]. E-Health appears to be safe, and its results are clear and positive on disease control studied, quality of life, medication adherence, and there have been no negative outcomes. Physicians may consider the use of e-health in patients' daily practice as a standalone intervention or mixed care [28]. Patients view telephone consultations from health professionals, complementary interactive voice responses, and text message reminders as acceptable and beneficial, that the timing of messages is adjusted to suit the population at hand, and optimization of patient adherence to ICS to improve eventual outcomes or patients who Suffering from persistent diseases such as persistent asthma. [29]. AI has played a critical role in all disciplines and in medicine. By increasing medicine’s intelligence in diagnosis and treatment decision-making, kidney disease causes a significant economic burden worldwide, acute and chronic kidney injury brings global morbidity and mortality, AI and data can be leveraged Great for addressing distinct challenges in kidney disease [30].

2.2.4 HIoT overview.

The Corona Covid 19 pandemic has caused many problems for everyone, especially patients who need to monitor their condition without the need for contact between patients and doctors to prevent the spread of the Covid-19 virus. Patients who need remote monitoring or healthcare through IoT applications in healthcare, introducing the idea of regularly monitoring the heartbeat of COVID-19 patients through reliable components such as Arduino uno, heart rate sensor and BOLT Wi-Fi module to establish a connection To send data over the Internet[22],[23]. The Internet of Things also monitors the movement of targeted patients at home or outside their homes. Depending on their behavior and movement, Alzheimer's patients will be given treatment. This is by collecting data from multiple sensors installed in patients’ homes and smart watches to check the level of blood pressure and temperature, which is very important in the current Corona Virus (COVID-19) pandemic for these types of patients. As the movement of people around the world diminishes, the increasing environmental pollution and stress caused by modern robotic life and many brain and neurodegenerative diseases including Alzheimer's, Parkinson's disease, etc. are prevalent among people all over the world. Various types of communication protocols such as Remote Message Queuing Transfer (MQTT) and WebSocket (with authentication and automatic connection closing) have been used for sensors and the smartwatch. The secure backend admin panel is used to track the location of doctors, patients, and ambulance. These protocols are implemented safely to protect patients' privacy as well [15]. Design, development, and implementation of an integrated COVID-19 patient management system, using LoRaWAN communication infrastructure. Remote health symptom monitoring can be applied to isolated people without direct interaction with patients. Wearable IoT devices monitor patient health parameters such as temperature of The body, pulse, or oxygen saturation, and this helps prevent the spread of the virus[24]. The LogNNet algorithm has been shown to be effective in solving problems related to the classification of medical data to calculate risk factors for the presence of disease in a patient based on a set of medical health indicators. The algorithm demonstrates a diagnosis of COVID-19 after training LogNNet using a publicly available database from the Israeli Ministry of Health. This database publishes data on patients tested for SARS-CoV-2 using nasopharyngeal smear analysis by polymerase chain reaction (PCR). In addition, LogNNet assesses perinatal risk based on electrocardiogram data of 2,126 pregnant women obtained from a machine learning repository at the University of California, Irvine [25]. The healthcare industry and potential healthcare applications of Internet of Things (HIoT) technologies are growing. The Internet of Things has enabled many medical devices, sensors, and healthcare professionals to deliver high-quality medical services remotely, resulting in patient safety, reduced healthcare costs, and improved accessibility. For healthcare services and to increase operational efficiency, many modern technologies must be adopted to integrate different healthcare applications with the Internet of Things system through three classifications: identification technology, communication technology, and location technology[31].

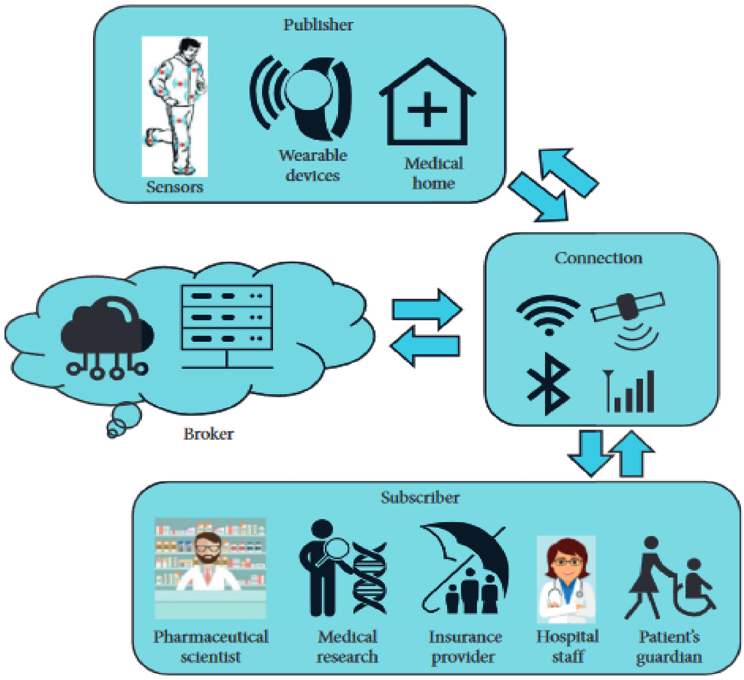


Figure 3: Architecture of an HIoT framework **[31]**

The Internet of Things (IoT) has also contributed to the provision of health care for the elderly and their associated health problems by monitoring their health standards from a remote location. As well as dealing with various issues such as chronic diseases, mental illness, cognitive diseases, adherence to medication and the impact on different areas of health care (AAL). Telemedicine, robotic technology, wearable sensors, etc.) in the elderly [18]. Mobile Health Care (mHealth) uses advances in wearable sensors, telecommunications, and the Internet of Things to propose patient-centered healthcare. The mobile health system performs continuous telehealth monitoring, remote diagnosis and remote patient treatment in real time. Wearable Connect to a smart device (smartphone or smart tablet) to store health-related data, record diagnoses and treatments, and send alerts to patients and medical professionals. Using blockchain technology for transparency, privacy and security of health data for its features such as decentralization (no central authority needed), persistence, traceability, and transparency. medical professionals[21]. An estimated model to handle congestion by calculating the expected number of packets lost due to buffer overrun in a resource-limited 6LoWPAN-based IoHT. The average number of packets that successfully reached the local pelvic node was also estimated in this work. After reviewing the existing congestion control schemes for 6LoWPAN networks, IoHT architectures for remote health monitoring were identified for various application purposes. Topological diagrams of these architectures are distinguished along with their networking aspects and also used for buffer loss modelling. To estimate packet loss due to node buffer insufficiency [17]. The synergistic personal area networks SPANs contributes to the provision and synergy of information from multiple sensors instead of individual sensors such as blood pressure assessment, and provides long-term continuous monitoring of user activity and vital signs. SPAN also provides home monitoring and integration of many sensors into the car seat, wheel, etc. Therefore, the automatic integration of all records in the medical record can also provide more powerful monitoring[32]. AI contributes to healthcare IoT The patient’s vitals are collected using AI-enabled IoT devices that are connected to the patient, This system is primarily intended for real-time scheduling of patients and provides resources such as doctors, medicines, ambulance services, blood, intensive care units, medical equipment such as oxygen masks on a priority basis, and reserves resources based on a person's condition or class. This system consists of network edge, control edge, and data edge linked Together with each other to provide resources and store the data in the edge data server for later access, the architecture is illustrated in the figure, the data is analyzed, the symptoms of the disease are inferred, and the appropriate treatment is proposed jointly with an expert specialist through the machine learning algorithm in the deep network[33].

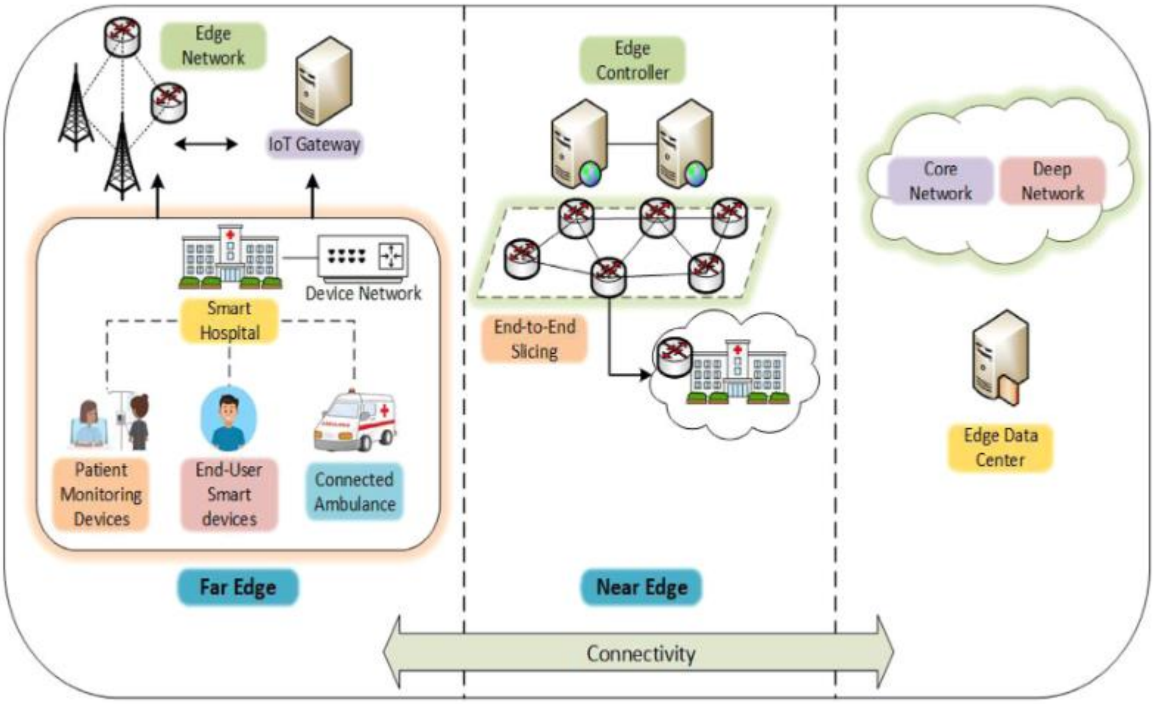


Figure 4: Architecture of edge AI enabled IoT healthcare monitoring system**[33]**

Foggy neural networks are a new and improved method for diagnosis and improve system effectiveness for patient care and monitoring in terms of time, cost and manpower use. The patient is monitored with sensors by sensors for body temperature, pulse rate and blood pressure to assess the patient's condition, to identify possible cases and treatments, and use a cognitive hall A ة , logical system for making intelligent patient care, monitoring, and management decisions[34]. Digital Twin (DT) is a method that has contributed to the improvement of healthcare operations by bringing together patients and healthcare professionals in a comprehensive, scalable, intelligent health system, the ECG model using machine learning to diagnose heart diseases and detect heart problems [35]. The author [36] Introduced an effective system for efficiently monitoring patient sleep using Commercial off the Shelf (COS) sensors as well as predicting outcomes using the smart power of the random forest model. The vital status of the patient, including the physical movement of the body, heart rate, the level of SpO2 (oxygen saturation in the blood for the proper functioning of the body), and snoring patterns can be measured through this system.This system strengthens patient care by analyzing data behavior using the smart technology of the random forest model and decision rules in a real-time environment, then processing the data in batches, allowing detailed data analysis using statistical methods to determine and produce the general condition of the patient in a specific time period.

Technically analyzed the articles and categorized them into five categories including sensor-based, resource-based, communication-based, application-based, and security-based approaches. Including the benefits and limitations of the chosen methods made a comprehensive comparison in terms of assessment techniques, assessment tools and assessment measures. the authors [26] reviewed previous studies, which contain energy management, trust, privacy, fog computing, and resource management as leading open issues, tactile internet, social networks, Analyzing Big Data, SDN/NFV, Nano Internet of Things, and Blockchain as Important Future Trends; Interoperability, real-world test implementation, scalability, and mobility as challenges deserve further study and research in HIoT systems. By reviewing 146 articles between 2015 and 2020. the authors [37] reviewed the available approaches in the field of fog-based healthcare systems; Explore, classify and discuss applied updates in healthcare. First, classify fog computing approaches in healthcare into three main categories: communication, application, and resource/service. They were discussed and compared based on assessment tools, methods and assessment criteria, and some open issues and challenges were also highlighted. The authors selected 34 articles published between 2015 and March 2020, based on the authors' rating, the resource/service category was on top of other articles with a frequency of 52%, application-based at 26%, and communication-based at 24%. The most used tool and systems was iFogSim with 17%. In addition, a comparison of evaluation methods showed that 52% of the studies were applied to a simulated environment. Additionally, most of the papers reviewed attempted to improve latency by 17% and then power and security by 16% and 13%, respectively the authors [38] reviewed studies published between 2000 and 2018 in major online scientific databases including IEEE Xplore, Web of Science, Scopus, and PubMed. A total of 3,679 papers were found, of which 89 papers were ultimately selected based on specific inclusion/exclusion criteria. The use of technology in a range of healthcare fields, including nursing, rehabilitation sciences, assisted living (AAL), medicine, etc. Medical objects were experimental and prototypes in nature. They reported that in general, the home was the most popular place for IoT applications, as well as neuroscience, cardiology, and psychiatry (psychology) and the sub-fields of medicine that received the most interest in IoT were shown. Bibliometrics that the IEEE Internet of Things published the most influential articles on the Internet of Things. India, China and the United States were found to be the countries most involved in research The Internet of Medical Things. The researchers [39] reviewed the literature and delved into the drivers for the convergence of IoT and big data analytics in the healthcare industry, and the disruptive technologies popularizing these two technologies. The healthy IoT trend started from mid 2014; While the validity of Big Data has been gaining in popularity since mid-2012. As we write this paper, the convergence of Big Data to the Internet of Things began in 2015. Researchers conducted a qualitative and quantitative review of the scientific literature to understand how the Internet of Things and big data analytics are converging in the healthcare industry. The researchers conducted a qualitative and quantitative review of 46 papers on IoTBDA, and a quantitative review of 84 papers on fog computing in the healthcare industry.

The Table shown the systematic review between 2000 up to 2021 and their contributions in healthcare / IoT health / e-health with deferent applications.

2.2.5 Existing Health Monitoring System

The researcher [34] proposed a method consisting of sensors of body temperature, pulse rate, and blood pressure to assess the patient's condition under observation. To identify possible conditions and treatment, the system used a knowledge base and a vague logical system to make smart decisions to care, monitor and manage patients. In order to improve the effectiveness of the patient care and monitoring system in terms of time, cost and use of manpower. The proposed approach addresses patient monitoring using sensors and shows reasonable accuracy and cost savings in relation to the systems used. The researcher used a small sample of the population for testing and found it to be effective, accurate and efficient for this purpose. Three contributions were also made:

1) The A new idea for the use of sensors with traditional telemedicine

2) The A new and improved method of diagnosis using a fuzzy neural network-based approach

3) The Use of a decision support system to reduce the time constraints of the traditional method of telemedicine in rural areas.

These activities are performed on different levels of purification called the application layer, the management layer, the network layer, and the device layer.

The use of sensors and decision support system in telemedicine is a new idea that improves the performance of work in the field of telemedicine in rural areas.

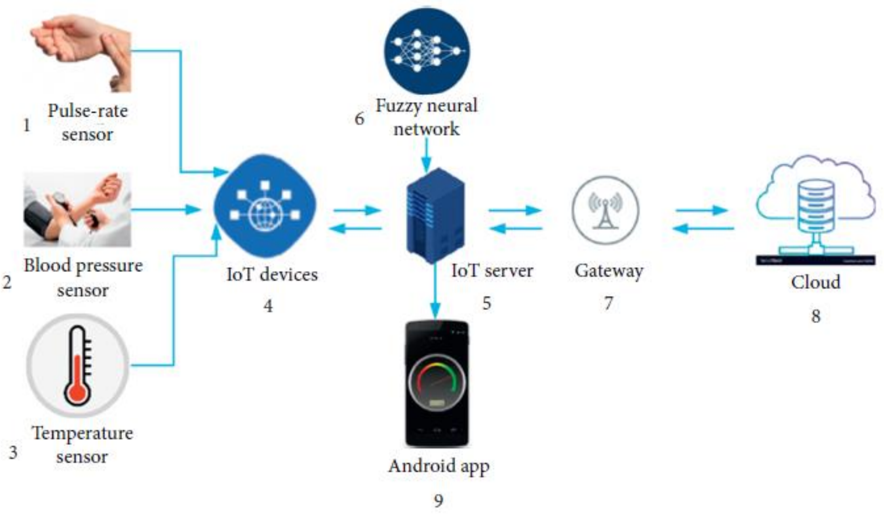


Figure5 : Smart healthcare system architecture **[34]**.

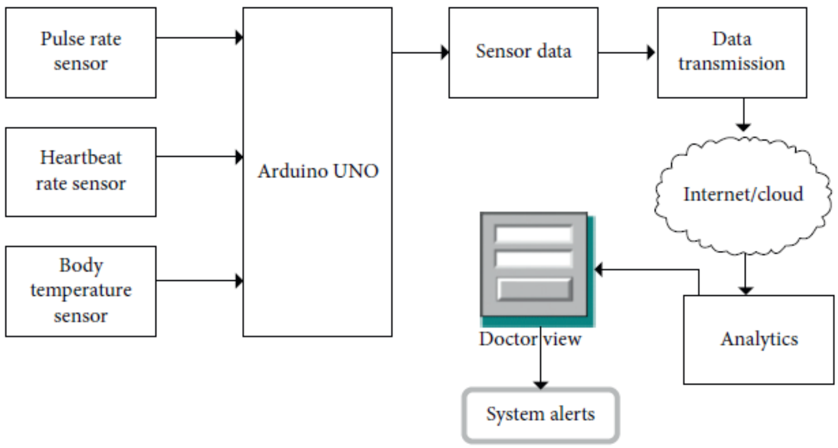


Figure 6: Diagram of monitoring patients in remote area clinics **[34]**.

The author [40] proposed It integrates the idea of an active electronic healthcare system. The system essentially reduces human effort by contacting people from far away to reduce the difficulties faced by the rural population. Sensors play a major role in this non-human healthcare facility here is designed, the Temperature sensors (LM-35) are used to measure the patient's body temperature. The sensors are interconnected with the Arduino using coding. Similarly, the heart rate sensor is used to measure the pulse of the human body. Also, an ECG sensor module (AD-8232) is connected, which is used to measure the heart's rhythm and blood flow through it. These sensors are connected together with the Arduino. Then, a portion of the server and web page is presented in relation to the IOT which acts as a link between the patient and the doctor.

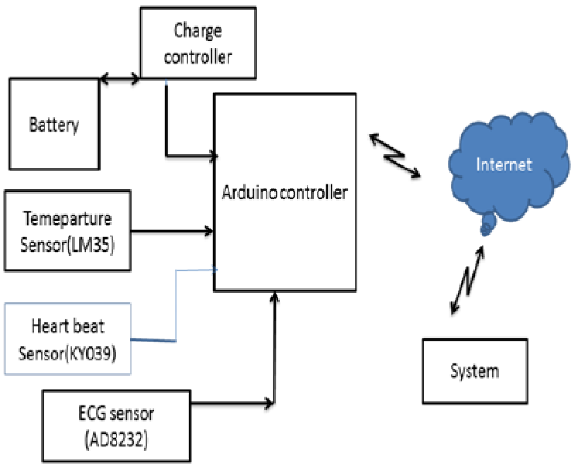


Figure 7: Block Diagram of Proposed System **[40]**

As shown in the figure, a power supply is provided by either a USB cable or a battery. In order to control the power supply, a charge controller can be used to reduce the effect. These supplies are connected to the Arduino controller. Next, the sensors are connected from the temperature sensor (LM35). Pin 5V, A0, and GND are connected to the Arduino and its interface. The heart rate sensor (KY039) is also connected in the same procedure to measure the heart rate. Then the ECG sensor module (AD8232) is used. This sensor has a five-link contact. They are connected with respect to the Arduino. PQRST measures the difference in heart wave shapes. These things are related to the Arduino. Next, the ESP8266 Wi-Fi module is connected to the Arduino. It acts as a source for establishing a connection of a specific hotspot through a connection between the device and the system that is created together. The system gets a specific set of URL from which to display the results of the interaction

2.2.5.1 Arduino/Genuino Uno:

An Arduino Uno board was used. Arduino / Genuino Uno in the proposed system, is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital I/O ports (6 of which can be used as PWM outputs), 6 analog inputs, a 16MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. Contains everything needed to support a microcontroller; Simply connect it to a computer with a USB cable or power it with an AC to DC adapter or battery to get started.

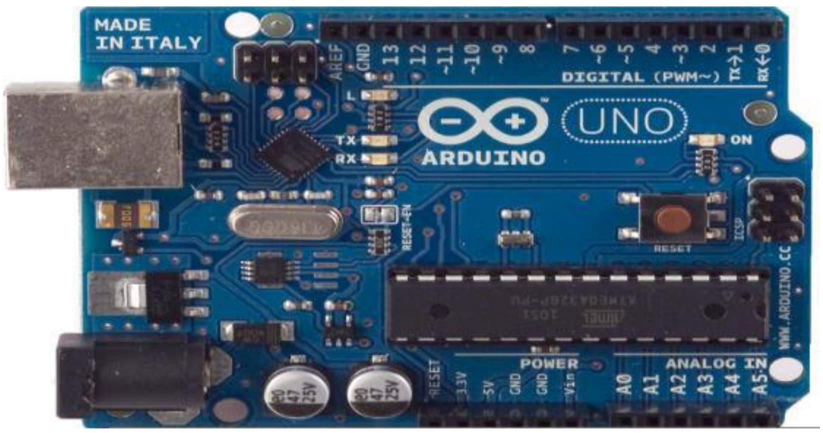


Figure8 : Arduino Uno Board**[40]**

2.2.5.2 Temperature Sensor (Lm-35):

The LM35 series are precision integrated-circuit temperature sensors. The output voltage of LM35 is linearly proportional to the Celsius or centigrade temperature. It provides more accuracy of ±¼°C at room temperature and ±¾°C over a full -55C to +150C temperature range than other temperature sensors without the need of any external calibration. This temperature sensor has linear output, low output impedance and provides accurate inbuilt calibration so that the control circuit is becomes easy. Only single power supply is needed to operate this temperature sensor.

Figure9 : Temperature Sensor (Lm-35) **[40]**

2.2.5.3 Heartbeat Sensor (KY039):

Blood pressure is the pressure of the blood in the arteries as the heart pumps it around the body. When your heart beats, it contracts and pushes blood through your arteries to the rest of your body. This unit consists of an optical sensor and an infrared (IR LED) heart rate monitor in beats per minute (BPM). The heart rate sensor is based on the principle of photo-throscopic imaging. It measures the change in blood volume through any organ in the body causing a change in light intensity through that organ (vascular area).

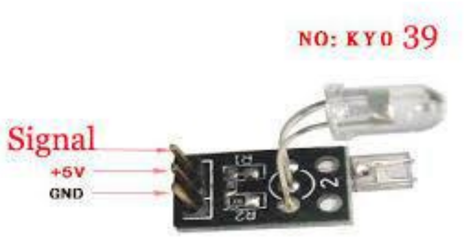


Figure 10 : Heart bit sensor (KY039) **[40]**

2.2.5.4 ECG Sensor Module (Ad-8232):

This sensor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analogy reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily. The AD8232 is an integrated signal conditioning block for ECG and other bio potential measurement applications.

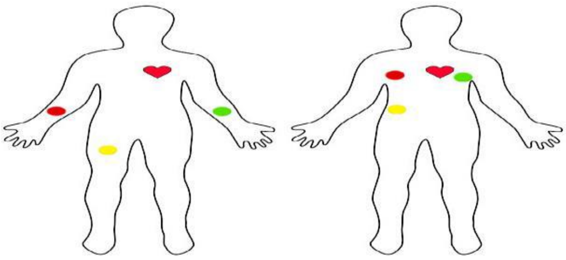


Figure 11: ECG Sensor Module (Ad-8232) **[40]** Figure12 : Sensor Pad location on Body**[40]**

2.2.5.5 WIFI Module: Esp8266

The ESP8266 Wi-Fi Module is a standalone SOC module with a built-in TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 can either host an application or offload all Wi-Fi network functionality from another application processor. Each ESP8266 unit comes pre-programmed with AT command set firmware.

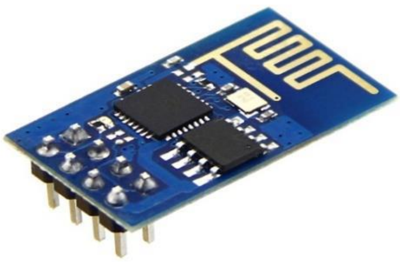


Figure 13: Wi-Fi Module (ESP8266) **[40]**

It has been concluded that through the Internet of Things, information can be put away and accessed anywhere.

Specialists and parental figures can immediately interact with the patient and take a real step in crisis situations, moreover, administering medicines conditional on the standards of well-being. Specialists and caregivers can cooperate with the patient without their physical proximity, so the framework can create a diagram of the body, if the patient has a body temperature, it will be easy for the specialist to realize the problem, moreover, our recording season provides a particularly reasonable framework For medicine in the city center services and county areas where the absence of correctional offices can be reached. This framework maintains ongoing safety at home as well as in the recovery facility. This wellbeing screening framework has been shown to be very beneficial for the patient's social security. The network of objects and tools collect and transmit data to each other, which makes it possible to more accurately visualize the collection, examination processing and storage of information. Then, the IOT can also be used to examine the patient and give administrations to patients. An IOT-based human services framework will provide benefits in an appropriate manner and may save millions of lives [40].

The author [41] presented The use of wearable body sensors for health monitoring has become a rapidly growing field with the potential to offer reliable means for clinical and remote health management, including real-time monitoring and monitoring of health trends to predict health deterioration or act as a preventative tool. The author [42] presented The use of wearable electronic devices in different scenarios of screening, tracking, communication, remote management, automated assessment of COVID-19 and an assessment by analysing these wearables and their needs in the health care system taking into account the reliability and acceptance of these modern technologies implemented. The author [24] presented wearable devices can monitor parameters of health conditions such as pulse, temperature, blood oxygen saturation and remotely monitor symptoms of COVID-19 patients through the use of communication technology and the LoRaWAN protocol. The author [43] Connected and wearable sensor technology and devices in the Internet of Things have provided extensive solutions for monitoring, evaluation, and reliable and remote support for the elderly and active and healthy aging of those who have aging-related diseases, especially dementia, Alzheimer’s disease, weakness, Parkinson’s disease and cardiovascular diseases, which increases the financial and human burden on individuals and providers Care for them, monitor their movements, detect falls, determine locations and places and focus on health from specific diseases to general elderly care. The author [44] presented a microservices architecture-based system, which collects sensory data while elderly perform automated ADLs (IADLs) in combination with BADLs. IADLs include the physical dimension, but also cognitive and social dimensions. Using sensory data, this model performs machine learning for assessment A weak case that outperforms previous works using only BADLs. This model is an accurate and environmental non-intrusive and flexible model has been built. It can help health professionals detect weakness automatically.[45] proposed an AI-enabled IoT-CPS that doctors can utilize to detect diseases in patients based on AI with security. daily medical and physical data of patients is collected through wearable sensors Doctors can use Medical healthcare IoT-CPS(Cyber-Physical Systems) IoT-CPS to detect diseases in patients based on artificial intelligence by finding a small number of disorders of diseases according to different symptoms of patients or the elderly Such as diabetes, heart disease and gait disorders, effectively and more efficiently in terms of accuracy, recall and F-measurement. The author [21] proposed an Mobile health (mHealth) is used in wearable sensors, telecommunications and the Internet of Things for remote continuous health monitoring, remote diagnosis and remote treatment of patients in real time. With the main limitations including security, privacy and transparency of health data, blockchain technologies have multiple advantages such as decentralization, immutability, traceability and transparency to resolve health data restrictions. The author [46] proposed an wearable sensors help recognize gestures in children with autism spectrum disorder (ASD). Using various classification techniques, by observing the gestures of individuals, the data is transmitted using the Bluetooth interface to the data acquisition and classification server, the time and frequency domain features are extracted from the sensor data, The transformation of traditional healthcare into smart healthcare is caused by modern technologies. The author [47] presented a personal devices from mobile phones, computers, and wearables have helped facilitate the healthcare environment and the extraction, examination, and monitoring of data from sensors and actuators in health fields. With cloud technology, the healthcare system must be intelligent, interoperable, and trusted in healthcare platforms. Cost-effective artificial intelligence (AI) aims to enable e-health care based on advanced 6G computing and promote cost-effective healthcare application. The author [32] proposed wearable devices interacting with the Internet of Things that have transformed industries and homes by interacting with objects with embedded activity and bio-signal sensors (Smart STU) with wearable sensors and ambient sensors. Dynamic Personal Area Network can SPAN and customized to extend over multiple areas and facilitate the process of processing and providing information from multiple sensors.

The author [48] presented an wearable Internet of Things devices contributed to the human body to monitor the symptoms of COVID-19,Through IoT sensor, cloud and web layers, patient health information is collected and then transferred to data storage in the cloud, then health data is checked and patients are alerted through the network and help users to take immediate action. The author [20] Proposed an intelligent health monitoring system that detects abnormal movements such as falls with sensor values received from accelerometer sensors and analyzes basic vital signs of an individual's blood pressure, heart rate and body temperature after abnormal movements are detected. So that users, guardians and experts can check the user's measured vital information anytime and anywhere using a smartphone, and performance assessment with biometrics has been conducted, fever is the most common symptom, making temperature sensors a critical component of a wearable sensing system For COVID-19.[49, p. 19] To limit the spread of the Corona virus, wearable devices are working with Internet of Things (IoT) integration for real-time monitoring of body temperature and internal condition via an alert system for the person in quarantine. The alarm is transmitted when the body temperature exceeds the permissible temperature. The successfully designed system monitored the body temperature, exercise activity and internal condition of the quarantined person which has been useful during the Covid-19 pandemic [50] . The wearables enable monitoring of several health parameters such as body temperature, pulse and blood oxygen saturation and allow remote symptom and health monitoring that can be applied to isolated COVID-19 patients using LoRaWAN communications infrastructure[24]. The Internet of Things plays a key role in reducing heat-related illnesses at outdoor construction sites by building physiological data monitoring models to reduce heat-related risks. By integrating real-time environmental data with individual physiological data, these platforms allow for individual monitoring and management more effective [51].

Smart methods in sports that use Internet of Things devices to collect data play a key role in improving the athlete’s training and performance through modern wearable devices and wireless communication strategy with developments in smart algorithms that have the ability to identify patterns online and classify them with smooth results. An intelligent data analysis system for swimmers' performance powered by wearable inertial oximetry (AHRS) and biosensors (heart rate and pulse oximetry) placed on the swimmer's body[52]. One of the most important processes in the human body is the transport of oxygen through hemoglobin through the circulatory system,The lack of oxygen may lead to brain damage, heart failure or sudden death when the oxygen drops below 95%. The pulse oximeter sensors play a very important role as they determine the level of oxygen saturation in the blood based on the light absorption properties of oxygenated and deoxygenated hemoglobin and are most of the sensors On fingers, toes, or earlobes[42]

Changes or abnormalities in a patient's respiratory rate help determine disease progression along with other symptoms such as body temperature, SpO2, HR and RR along with which are features that determine the severity of respiratory illness for those with chest disease or patients with COVID-19. RR acts as a vital predictive factor and wearable stress sensors, electrostatic friction sensors, and accelerometers widely aid in detecting respiratory motion in the chest or abdomen caused by volumetric changes in the respiratory tract [42],[53].

A dry cough is a symptom of COVID-19. People infected with COVID-19 may spread disease when they cough. Monitoring a dry cough helps diagnose and prevent coughing. Wearable devices in the Internet of Things obtain cough signals through an audio or mechanical sensor that can detect coughing sound or vibration caused by This cough, these sensors contain a microphone or a piezoelectric transducer and a highly sensitive accelerometer and can be installed in the throat or chest area [42]. One of the remote diagnostic tools used to assess cardiac activity and provide risk assessment and treatment of COVID-19 Help reduce infection through wearable-based remote ECG monitoring Instead of the traditional monitoring systems used by practitioners via staff-patient contact, ECG patches are one of the most popular wearable ECG monitoring methods. An ECG correction device typically consists of a sensor system, a microelectronic circuit with a recorder and memory storage, and a built-in internal battery. These patches are small in size, wireless, with miniature electronics, easy to wear, convenient to use and can record an EKG for several days[50], [42]. The development of a wearable electrocardiogram (ECG) by adopting the analog front-end (AFE) chip model ADS1292R to collect electrocardiogram

(ECG) data to examine the health status of elderly patients and emergency patients. In addition, healthcare is monitored through IoT-based CPS[47].

One of the most important vital signs that reveal the functions of the heart and blood vessels and blood vessels is high blood pressure (BP). High blood pressure is one of the most dangerous factors for patients with heart and blood vessels.

Continuous, remote monitoring of BP in real time may help prevent sudden events and reduce the possibility of cross-contamination. There are many wearable blood pressure monitoring devices such as BP watches, BP glasses, flexible BP patches, BP shirts, and skin-like BP patches, due to The dynamic nature of blood pressure and its variability in different individuals makes it difficult to obtain accurate estimates of BP for a long time without calibration[54], [42].

The author [55] presented One of the most important factors for wearable sensors is the importance of their placement on the body and the number of wearable devices that contribute to data collection and improve public health responses, cumulative data can be used to identify geographical COVID-19 hotspots. It is clearly seen that sensors such as accelerometers, electrocardiograms, electrocardiograms, altimeters, pressure sensors, and thermometers can be integrated into clothing and can record many physiological parameters such as motor activities, small electrical signals generated by muscles, electrical impulses from During the myocardium, the location/distance of the person, the force of the vertical reflex while walking, the fever. Likewise, the smart watch can contain various sensors and measure various parameters such as EEG signals, location of the person, number of steps, body temperature, SpO2, EMG and ECG as shown in the Figure 14.

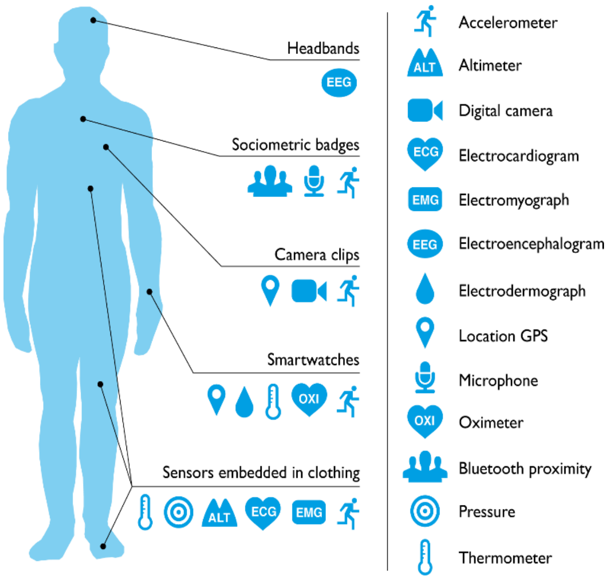


Figure 14: Wearables based on-body location **[55]**,**[56]**

The authors [48], [42], [24] are introduced COVID-19 monitoring system and their IoT applications and wearable electronic devices in different scenarios of screening, tracking, communication, remote management. Introduce possible new applications for SPANs and results of feasibility studies Collect vital signs by testing and interaction of users with a smart stu Monitor daily users logins on a smart water bottle Smartwatch and related objects have helped users' daily use and assess new parameters that sensors cannot They are generated as pulse wave velocity (PWV) and blood pressure. The authors [43],[45].[32] are Introduced an AI-enabled IoT-CPS which doctors can utilise to discover diseases in patients based on AI. And find a few disorders such as Diabetes, Heart disease and Gait disturbances.

2.2.6 Internet of Things Enabled Healthcare Kit

The researcher [57] present smart IoT-based health monitoring system which have non-invasive sensors to read various health parameters and displays them on an LCD module in real time. The user can also transfer the data to the cloud to be safely stored and can share this data with doctor for treatment. Data can be live viewed from any location on the planet. Since the battery capacity of each system used in this project is minimal, it would reduce the power usage in order to prolong the life of the healthcare kit. The IoT-based hospital healthcare kit developed using an Arduino Uno, ESP8266, pulse rate sensors, blood oxygen sensor, ECG sensor, blood pressure sensor, and temperature sensor is described in this paper. As a result, IoT-enabled systems improve treatment delivery while also lowering costs by continuously collecting and analyzing data.

2.2.6.1 Internet of Things Enabled Healthcare Kit Model

The system monitors the patient's vital signs in real time and detects any anomalies. Medical personnel are given the tracked info. When irregular parameters are detected, the device notifies the medical personnel. As a result, there is less of a requirement for medical personnel to conduct physical supervision. The framework makes use of an Arduino and an esp8266 to transmit data from sensors to a cloud network Thingspeak [57]. The esp8266 module on the Arduino has been programmed with the API key received from the Thingspeak website. Using the thing talk access key, any number of users will view the medical records stored on the device.

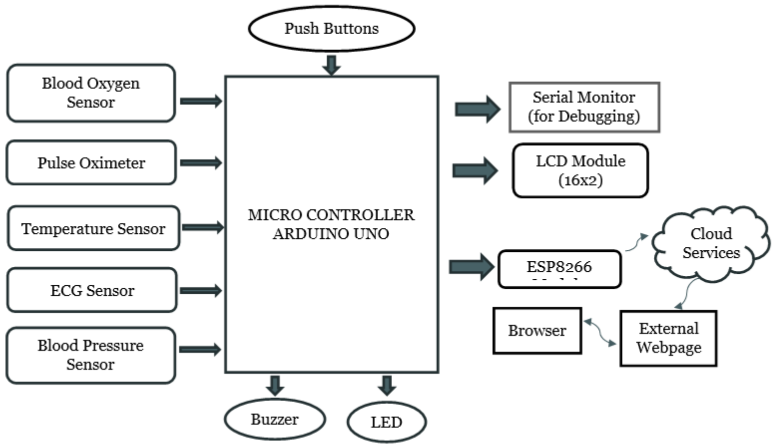


Figure 15: Block Diagram of Healthcare Kit **[57]**

2.2.6.2 Internet of Things Enabled Healthcare Kit Platform

Transfer data to the cloud from every Internet-connected computer using the Think speak platform. After that, we can set up activities and warnings depending on the information gathered. Unlock the importance of your real-time results using visual methods to evaluate data. Take advantage of ThinkSpeak's which allows to collect sensor data quickly and easily transform it into useful information. “Thing Speak is available as a free service for noncommercial small projects (<3 million messages/year or ~8,200 messages/day). Thing Speak is bought in units, where one unit allows 33 million messages to be processed and stored in a one-year period (~90,000 messages/day)” [57].

Figure16 :Wearable Healthcare Kit **[57]**

2.2.3 Summary of previous studies

Ref	Title	Year	Contributions	Limitations	Software components	Hardware components
[22]	Heart pulse monitoring and notification system using Arduino	2021	Establish a communication bridge between the patients and the concerned caretakers/doctors.	• As our system is automated, it requires continuous internet connection for transmitting the data. • Failure in any hardware component might lead to inaccurate results(outputs). • as the results are sent through SMS, the client/ recipient should be in network coverage area only.	• Arduino ide software	• Arduino uno microcontrol ler. • Heart pulse sensor • Bolt wi-fi module.
[58]	IoT based garbage monitoring using Arduino	2019	We built an efficient garbage monitoring system which can be used to monitor the level of garbage in the dump. This data can be further used to plan garbage collection trips more efficiently, ultimately reducing overflowing bins and helping have better public sanitation.	• Cannot detect liquid waste. • only detects the top of the garbage level. It wouldn't realize if there is space left. • Gsm module needs a 12v source.	• Arduino ide software	• Hc-sr04 ultrasonic sensor. • Arduino uno. • Gsm module • connecting wires.
[59]	A novel method for predicting bradycardia and atrial fibrillation using fuzzy logic	2021	Our study shows how simply we can create an Arduino based intelligent system and shows the user real time information on their heart health.		• Arduino ide software • google spreadsheet	• Arduino. • Pulse sensor. • the lcd

	and Arduino supported IoT sensors		Our model is tuned to predict bradycardia and atrial fibrillation.		• Arduino studio • Tera term	
[60]	Design, simulation, and implementation of a digital pulse oxygen saturation measurement system using the Arduino microcontroller	2021	• Design a low-cost spo2 measurement system. • Use the microcontroller for faster signal processing and several other computation tasks • Simulate the system in the proteus environment. • analyses the oxygen saturation data	• High cost and high electricity consumption	• Arduino IDE software	• Arduino. • Pulse sensor. • the lcd • Mx10300 sensor
[61]	Arduino uno and GSM based wireless health monitoring system for patients	2017	• Develop a device which is interfaced with an android application so that the heart rate, temperature of body and saline level are monitored efficiently.	• The disadvantage of this developed approach is that it requires a computer for sending the data to the web server through the internet.	• Arduino IDE software	• Arduino uno. • Heart beat sensor. • Gsm modem. • Temperature sensor(lm35). • Ultrasonic level sensor
[62]	Patient health monitoring using Arduino through IoT	2020	This project aims at developing a system which gives body temperature, blood pressure and heart rate using lm35, pressure sensor and pulse sensor respectively. These sensors are interfaced with micro controller Arduino atmega328.	• Not mentioned	• Arduino IDE software • Thinkspeak platform	• Ardiuno board • Temperature sensor • Wifi module

						• Blood pressure sensor • Heartbeat sensor • Laptop. • Lcd
[63]	IoT based distribution transformer health monitoring system using Arduino, NodeMCU and thingspeak	2019	The proposed project is about acquiring real time status of transformer health parameters.	• Overcurrent is the flow of error current that occurs in the power system through the transformer.	• Arduino IDE software • Thinkspeak platform	• Temperature sensor- lm 35. • Current sensor acs 712. • Arduino nano. • Voltage sensor circuit. • Node mcu v3.
[64]	Development of Smart Healthcare Monitoring System in IoT Environment	2020	This paper proposes a smart healthcare system in IoT environment that can monitor a patient's basic health signs as well as the room condition where the patients are now in real-time.	• the error percentage of the developed scheme is within a certain limit (< 5%) for each case.	• Arduino IDE software • Thinkspeak platform	• heart beat sensor • body temperature sensor. • room temperature sensor. • CO sensor.

						• CO2 sensor.
[65]	Internet of Things (IoT) Based Healthcare Monitoring System using NodeMCU and Arduino UNO	2019	proposed system can monitor, diagnose, and advice the patients all the time.	The NodeMCU microcontroller only accepts systolic transmission to Ubidots, and the Ubidots cloud must be downloaded to the controller or doctor.	• Arduino IDE. • Ubidots cloud	• Temperature Sensor (DS18B20) • NodeMCU. • Arduino UNO • Blood Pressure sensor (ASDXAD015PGAA5)
[66]	A working prototype using ds18b20 temperature sensor and Arduino for health monitoring	2021	Building a working prototype of a WBAN in which using a temperature sensords18b20, connected with the computing device, collects and transmits signals using wired and wireless communication.		• Arduino program • Visual basic 6. • Wamp server	• Zigbee communication module • Ds18b20 temperature sensor • Arduino nano with pin configuration
[67]	Heart pulse monitoring and notification system using Arduino	2021	The main aim of our project is to establish a communication bridge between the patients and the concerned caretakers/doctors.	• As our system is automated, it requires continuous internet connection for transmitting the data.	Arduino IDE software	• Arduino uno board. • pulse sensor. • bolt IoT wi-fi module.

				• Failure in any hardware component might lead to inaccurate results (outputs). • As the results are sent through SMS, the client/ recipient should be in network coverage area only.		• jumper wires (M-M,M-F)
[68]	Design and development of infant care system using Arduino technology	2021	Focuses on remotely supervising the child's health as well and necessary information will be sent to the parents using wireless link modules.	• Not mentioned	Arduino software (IDE)	• Arduino uno • Dht11 • Moisture sensor. • Sound senor • Vibrator module • Bluetooth detector hc05 • Channel 5v relay module
[69]	Hazardous gas detection using Arduino	2017	Design Arduino based hazardous gas detecting system using gas sensors. The toxic gases like butane (also known as lpg), methane and carbon monoxide are sensed and displayed on the lcd display	• Not mentioned	Arduino software (IDE)	• Arduino • gas sensors (mq-2,mq-4,mq-7) • lcd display
[70]	Smart health monitoring system utilizing internet of things (IoT) and Arduino	2022	Design a reliable health monitoring system utilizing the IoT, Arduino, and android applications.	• Lack of real devices and equipment on the Arduino instead of the devices available in the market for training and application.	• Arduino IDE software • Proteus design suite 8.9	• Arduino uno rev 3. • Lm35 temperature sensor.

						• Max30100 pulse oximeter. • Lcd 20x4 display. • Nodemcu v3 esp8266 (WiFi module)
[71]	Smart Urban Water Quality Prediction System Using Machine Learning	2021	Design model for water quality problems thereby preventing the spread of diseases such as dysentery, typhoid and cholera due to consumption of contaminated water.	• Drawback and problem were on Internet Connectivity and times may be a problem, since data won't be updated.	• thingSpeak server • Build an HTML page • Build a Python Code	• Arduino • Wi-Fi connectivity. • TDS • ph hydrogen sensor

Table 1: The Summary of previous studies

2.2.4 Summary

This chapter mentions previous studies and overviews of the Internet of Things, electronic health care, mobile health care, contributions and devices for health care, types of systems used such as Arduino and Raspberry-Pi, as well as Internet of Things platforms such as Think Speak and cloud computing.

Chapter 3

Proposed Model Design

3.1Introduction

This chapter aims to clarify the field study carried out and well also clarify the project work part, explaining the hardware components for the project.

3.2 Research Gap Analysis

Based on the comparison between previous studies and mentioned in Table 2.1 and our study of IIHTs, the researcher [9] touched on building a model based on observing patients through heart rate symptoms using Arduino. Establish a bridge of communication between patients and caregivers/physicians involved, but he uses only his system to monitor the heartbeat. The researcher [60] also presented the design and simulation of oxygen pulse examination and data analysis using the Arduino and Proteus simulation software and focused on the measurement of oxygen saturation. As [61] developed a new approach with Arduino for monitoring heart rate, blood pressure, and pressure, and used the Arduino IDE software with the Thinkspeak platform to monitor blood pressure and heart rate without determining the symptoms. The Author [64] presented a system to monitor the heart rate, body temperature, and room temperature, but did not mention the exact disease that the system monitored. The [71] Presented a model for water quality problems to prevent the spread of diseases, such as cholera and typhoid, but his model did not focus on cholera symptoms.

The IIHTs model focuses on monitoring the infected case with cholera according to the symptoms of cholera as low blood pressure and fast heart rate pulse, which is very dangerous for cholera patients and may cause death; the environment surrounding the patient affects the cholera patient, so the IIHTs check the gases of the environment and alarm the doctor if healthy or unhealthy. Across form

3.3 The Research contribution

Researchers have made many contributions to health care, the Internet of Things, and themonitoring of patients with special needs, the elderly, and those with chronic diseases [2], [72]. Analyzed and treated cholera and detected environmental pollution to reduce the spread of the disease by examining standing water or environmental pollution [73],[74]. Researchers[75],[76],[77] have also been provided in the field of healthcare system monitoring of COVID-19 patients to reduce the spread of the disease by monitoring patients remotely without approaching infected people using IoT technology. Through the results of previous studies, in this research, we found that there is a gap in the field of health care for those who are infected with cholera and need to monitor their health care, either in hospitals or homes, by providing a model that contains three layers: the patient's health status is monitored by tracking the dangerous symptoms of low blood pressure and increased heartbeat using sensors, monitoring the environment surrounding patients, and verifying the absence of gases. Toxic substances such as methane and carbon dioxide may further aggravate the patient's condition.

This study makes the following important contributions:

- Developing a monitoring model based on IoT using Arduino for medical healthcare services.
- We introduced a programmable service architecture as an integral component of healthcare systems. This feature allows the dynamic integration, configuration, and control of diverse clinical sensors in healthcare systems.
- We implemented a prototype of the model and evaluated it in an experimental wireless testbed consisting of wireless cellular networks.

3.4 Research Methodology

Our first task was to determine health complications associated with cholera monitoring. Once we did this, we looked for sensors to detect these problems and finally started working on the system. The system's orientation is centered on three stages, through which we seek to cover the health aspects of the patient and monitor the health status at the same time. The model examines the surrounding environment of patients by sensing gas tracking, which facilitates the maintenance of a clean environment through the MQ-2 gas sensor. The model also monitors the symptoms in patients, which may be very dangerous symptoms that need to be monitored continuously for patients and display the results and warnings through multiple screens or graphs and displays for each state of the environment, heart rate, blood pressure, or oxygen saturation in the blood, when the symptoms approach the expected risk of patients.

We integrated the following sensors: a heartbeat pulse (HBP sensor), Oxygen Oximeter (spo2(max30100edf) sensor), gas detection sensor (MQ-2), and ESP826an 6 sensor connected to an Arduino Uno. These sensors are used to measure the heartbeat pulse and Environment and MAX30100 for heart rate and SPO2 measurements.

The sensors ESP8266 used to sense data are collected and transmitted through Wi-Fi to the Internet and then to the cloud server, which can then be accessed by users through smartphones or laptops for further actions, and decisions can be made based on these by doctors. The LCD monitor was connected to an Arduino Uno and displayed the value of the environment.

This model works using the Proteus program and has been linked using the Arduino so that it works as a simulation of the physical reality hardware, all sensors and electrical circuits are defined and linked in the Proteus program and then the libraries of these sensors are called to the Arduino program with the definition of the virtual port of the linking process so that we can send the results to the output devices. All steps will be in Appendix A

3.5 Proposed model Architecture

To perform health analyses of people with cholera blink, we need to design a structure that is standard enough to process many types of data, such as blood pressure, heart rate, and environmental data surrounding the patient. This model contains the inputs, or what we call the sensor dome or input layer; then, the data are analyzed and processed through the Arduino, and the data are displayed through multiple projectors, the local display, and sending the data to the cloud.

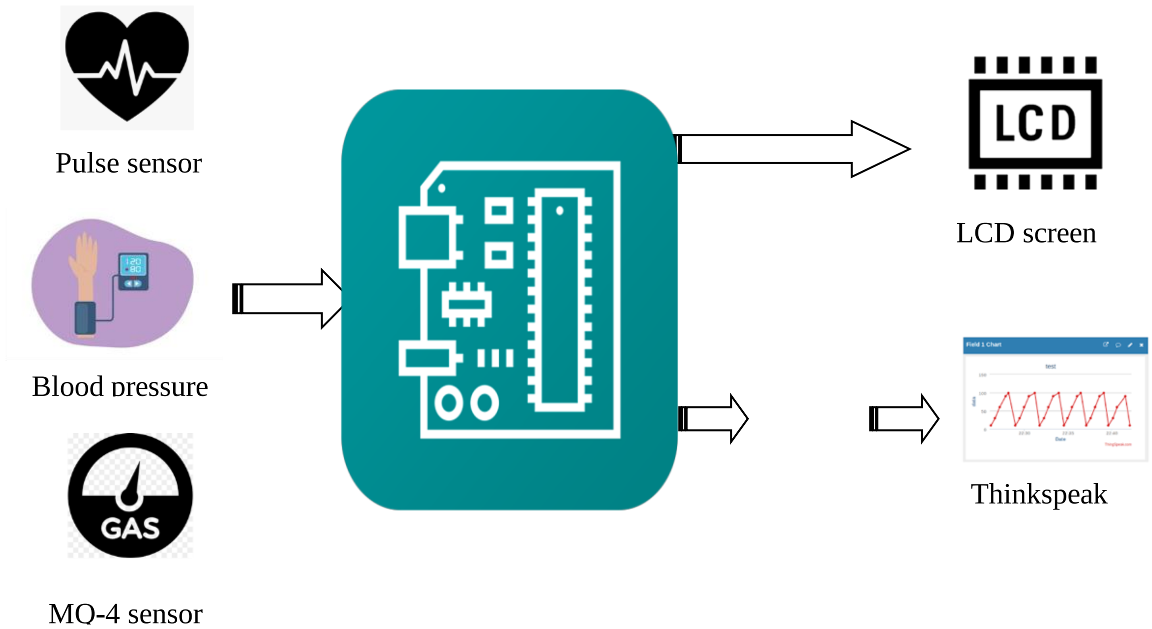


Figure 17: Proposed model diagram

3.6 Proposed model design

In this section, the hardware components will be explained the functionality of major components. Before that, the process flow of the concept design will be described where it is proposed based on background study, literature review, and certain experiments.

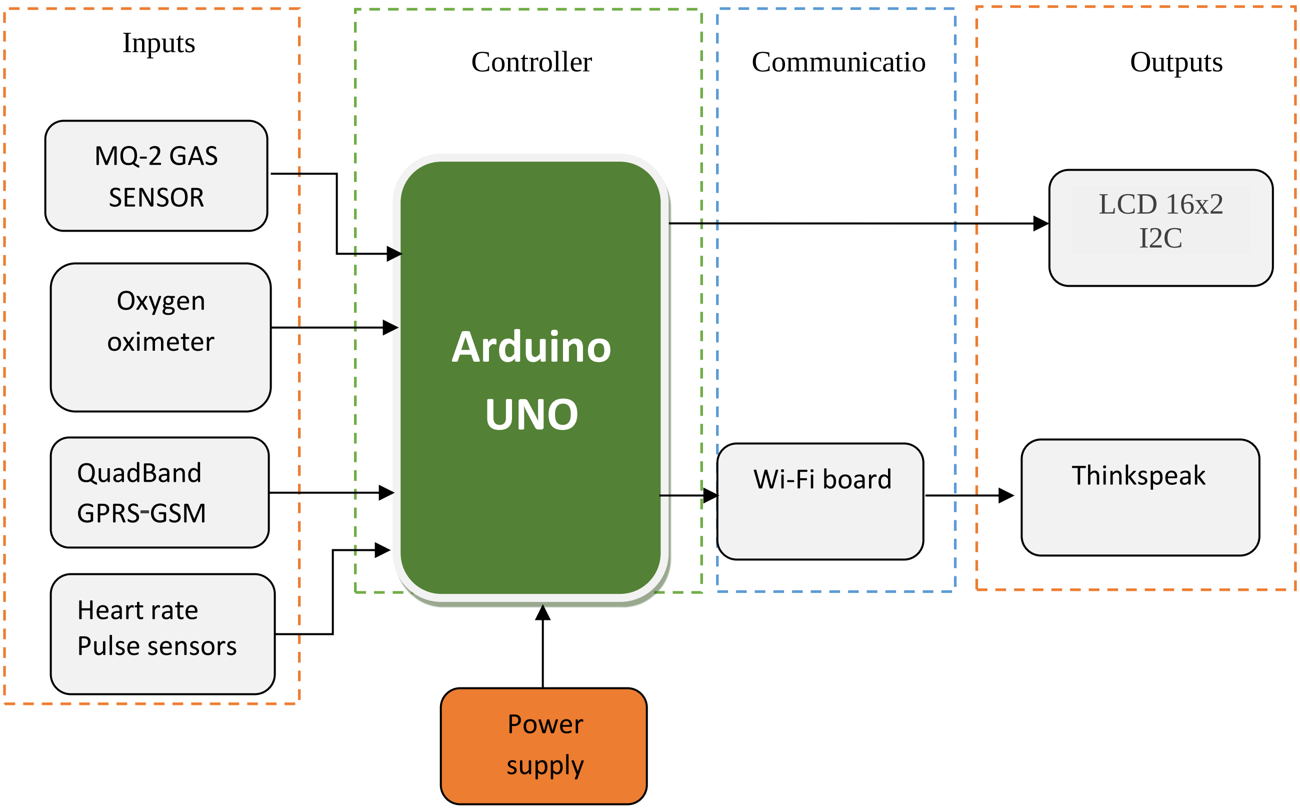


Figure 18: Proposed model diagram

3.6.1 The Proposed Model Components

This model consists of several components that can be divided into inputs, which are the devices through which data are received and collected; the Arduino control unit performs the processing process, in addition to linking the input devices (sensors) to the output devices and communication devices, as well as explaining and clarifying the components and devices.

3.6.1.1 Proposed model Inputs

The input devices are the main part of this model, through which we will enter blood pressure data by the blood pressure sensor (MAX10300), as well as the pulse rate by the pulse rate sensor, as well as examine the environment surrounding patients through the MQ-4 sensor, as explained in this section.

3.6.1.1.1 Blood pressure

Recently, considerable research has been conducted to develop a reliable system for measuring continuous blood pressure. The blood pressure measurement system can be constantly updated and alerted immediately if any critical blood pressure level is detected in patients. However, the developed continuous blood pressure measurement techniques are still not reliable enough to measure blood pressure using the oscillometric method and the gold standard technique, and the auscultation method using a mercury sphygmomanometer is chosen to measure blood pressure. One of these techniques is PTT. There have been findings that PTT techniques developed to measure blood pressure cannot be relied upon. Therefore, a clinical evaluation was performed by [78], and it was a clinical evaluation that was modified according to several PTT techniques. This clinical evaluation was performed on 22 samples (anesthesia patients), but only 14 samples were suitable for analysis. The data obtained were approximately 240 h of vital signs measured using different signal-type pairs. The types of signals or waves used in this research were electrocardiogram (ECG), optical imaging (PPG), gaseous blood pressure (IBP), biocarcardiogram, and biogeoprosis (IPG). This research found that PTT techniques are not ready to measure blood pressure where the smallest average error achieved is 4.91 mmHg (ECG and IBP pair).

Another study was conducted by [79],[80]. A portable continuous BP monitoring kit was developed. The researchers used only the BP monitoring group to continuously measure blood pressure continuously. A continuous blood pressure monitoring kit was also used to measure blood pressure with a mercury sphygmomanometer taken before the prototype was used as a reference to continuously measure blood pressure. The portable continuous blood pressure monitoring kit is based on a neural network model. Before the development of the portable continuous blood pressure monitoring kit, the ECG signal and blood pressure data were obtained from 20 people (aged 15–60 years) to train the neural network model. The results of this study prove that the portable continuous BP monitoring kit is suitable for BP measurement, but requires more studies to encounter an error average of -0.4712 mmHg with a standard deviation of 2.204 mmHg [81]. To improve continuous BP measurement, this research aims to develop an effective function based on the relationship between systolic BP and Pulse Wave Velocity (PWV). PWV is obtained from PTT, which is produced by the ECG and PPG. Several experiments were conducted on 63 volunteers, and data from 13 volunteers were used to determine the relationship between PWV and systolic pressure. The volunteers were required to ride on different loads on the bicycle ergometer. Finally, this study found a significant relationship between PWV and systolic pressure. However, the error recorded after comparison with the mercury sphygmomanometer (auscultator method) reached 20 mm Hg. Therefore, more studies are required to improve the relationship between PWV and SBP [78]. Another continuous BP measurement system was developed by [82]. who successfully developed a continuous BP monitoring system using the PPG technique. A high-intensity light-emitting diode (LED) and a light-dependent resistor (LDR), where both components are attached oppositely on a finger. Systolic pressure is determined when the least light intensity is received by the LDR, and diastolic BP is determined when the maximum light intensity is received. This is because the volume of blood in the artery is maximum when systolic pressure causes the 10 maximum light absorption and minimizes the light intensity received by the LDR. This occurs when the diastolic pressure is applied. Nevertheless, the system often requires calibration every time the BP of a person is measured. This is because every person has a different finger and artery size. Finally, the system has proven reliable, although the error is up to 4 mmHg when compared with a mercury sphygmomanometer.

3.6.1.1.2 Heartbeat rate

The heart rate is the number of times the heart beats in the space of one minute. It is important to identify whether the heart rate is within the normal range. If a disease or injury weakens the heart, the organs will not receive sufficient blood to function normally. The United States National Institutes of Health (NIH) have published a list of normal resting heart rates. [79] The heart rate progressively slows as a person moves from childhood to adolescence. The normal resting heart rate for adults over the age of 10 years, including older adults, is between 60 and 100 beats per minute (bpm). Highly trained athletes may have a resting heart rate below 60 bpm, sometimes reaching 40 bpm [56].

Age	Normal heart rate (bpm)
Up to 1 month	70 to 190
From 1 to 11 months	80 to 160
From 1 to 2 years	80 to 130
From 3 to 4 years	80 to 120
From 5 to 6 years	75 to 115
From 7 to 9 years	70 to 110
Over 10 years	60 to 100

Table1 : The normal resting heart rates at different ages according to the NIH

3.6.1.1.3 Pulse Rate Sensor

The pulse sensor had three pins, as described below. There is also an LED in the center of this sensor module, which helps detect the heartbeat. Below the LED, there is a noise elimination circuit that prevents noise from affecting the readings.

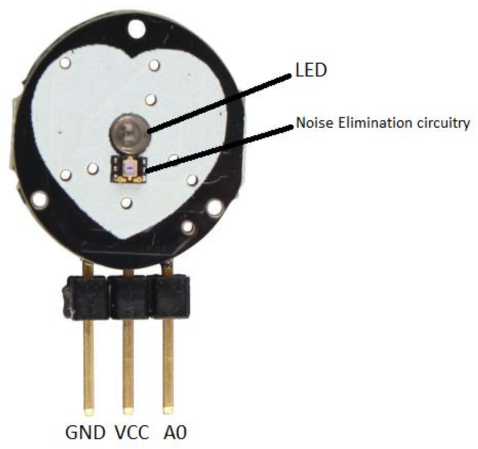


Figure 19: Pulse Rate Sensor pinout.

The operation of the pulse/heartbeat sensor is simple. The sensor has two sides: on one side, the LED is placed along with an ambient light sensor, and on the other side, we have circuitry. This circuitry is responsible for amplification and noise cancellation. An LED on the front side of the sensor was placed over a vein in the human body. This can either be your fingertip or your ear tip, but it should be placed directly on top of a vein. The LED emits light that falls directly on the vein. The veins have blood flow inside them only when the heart is pumping; therefore, if we monitor the flow of blood, we can monitor the heartbeats as well. If the flow of blood is detected then the ambient light sensor will pick up more light since it will be reflected ted by the blood, this minor change in received light is analyzed over time to determine heartbeats [22].

Features:

- Biometric Pulse Rate or Heart Rate detecting sensor
- Plug and Play type sensor
- Operating Voltage: +5V or +3.3V
- Current Consumption: 4mA
- Inbuilt Amplification and Noise cancellation circuit.
- Diameter: 0.625”
- Thickness: 0.125” Thick.

Pin Configuration:

Pin number	Pin name	Wire color	Description
Pin- 1	Ground	Black Color Wire	It is connected to the GND terminal of the system
Pin-2	(VCC)	Red Color Wire	It is connected to the supply voltage (+5V otherwise +3.3V) of the system
Pin-3	(Signal)	Purple Color Wire	It is connected to the pulsating o/p signal.

Table 2: Pulse Rate Sensor Pin Configuration

3.6.1.1.4 Gas Sensor

The input which is the gas is sensed through the particular gas sensors. In this system sensors for detecting Methane, LPG, and carbon monoxide are used. Then this sensed value is passed to the Programmable Interface Controller. The signals that are sensed are analog in nature and are converted into digital form by the analog-to-digital converter which is built inside the PIC. The names of the gases which have been sensed are then displayed on the LCD, and the concentration in percentage will be displayed on the LCD according to the conditions present in programming. Gas sensors (MQ – 4, MQ - 2, MQ -7) are used in systems with gas leakages detecting devices at smaller and bigger levels. It is also able to detect CH4, Natural gas. They have fast responses. They have a stable and long life. They consist of a simple drive circuit [69].

Model No.	MQ-4
Type of Sensor	Semiconductor
Standard used	Bakelite material (Black Bakelite material)
Capability to Detect Gases	Methane, Natural gas
Concentration limits	200-1000ppm (Methane, Natural gas)

Table 3: Specifications of MQ-4

3.6.1.2 Controller

The Arduino controller is an important part of the management and connection of input and output devices and communication devices, and this controller works to process data and display the output devices connected to it directly or through wireless means of communication the following is an explanation of the components of this Arduino chip and its components:

3.6.1.2.1 Arduino Board

The Arduino Uno R3 is an open-source hardware computing platform. It uses the ATmega328 microcontroller. The board also incorporates the ATmega16u2 to act as an onboard USB-to-serial converter.

The Arduino Uno R3 can be used to develop applications that operate in a standalone or connected environment. The device is programmed using the Arduino integrated development environment (IDE) [84].

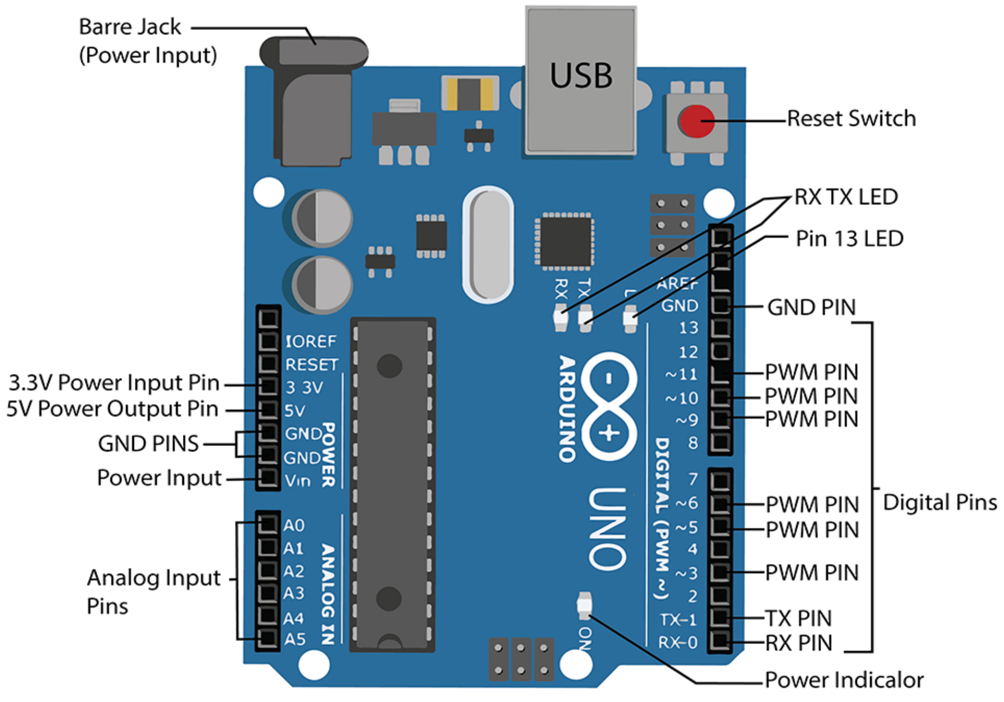


Figure 20: Arduino UNO board **[84]**

Technical Specifications:

- ATmega328 microcontroller
- Input Voltage between 7 - 12V
- 14 Digital Inputs of which 6 provide a PWM (Pulse Width Modulated) Output

- 6 Analog Pins
- 40mA DC current per I/O pin
- 50mA DC current for 3.3V Pin
- 32KB Flash Memory (0.5KB used by the bootloader
- 2KB SRAM
- 1KB EEPROM
- 16MHz Clock Speed.

Power

You can power the Arduino card via the USB connector or via the DC power socket. The power jack is 2.1mm, center powered.

You can use between 6V and 20V DC to power the board. It is recommended that you should not go below 7V to allow for the voltage drop across the power regulator. If you go too low then the regulator output might drop below 5V and this can cause issues with the board operation.

It is also recommended that you do not go above 12V. The power regulator may overheat and cause damage to the board.

3.6.1.2.2 Power and Aux I/O Port

The pins are used as follows:

- 5V: This is a regulated output from the onboard voltage regulator. This power willcome from either the USB or DC input jack. This is fed into the onboard 5V voltage regulator. The output from the regulator is connected to this pin. You use this pin to provide 5V power components connected to the Arduino board. The maximum current draw is approx 400mA on USB and higher if using the DC power jack.

- 3.3V: This is a regulated output from the onboard voltage regulator. The output from the 3.3V regulator is connected to this pin. You use this pin to provide 3.3V to power components connected to the Arduino board. The maximum current draw is 50mA

- You can power the board by connecting a regulated 5V source to the 5V pin or 3.3V to the 3.3V Pin. The power will go directly into the ATMega328 microcontroller. The onboard power regulators are bypassed. You could easily damage the ATMega328 chip if something goes wrong here. Arduino, advise against powering the board this way.

- GND: Board ground as fed from the ground pins on the DC input jack and the USB connector. Use this ground for components connected to the Arduino board.

- VIN: This pin is connected to the input side of the onboard voltage regulators. Whatever input DC is supplied to the board by the DC input jack will also appear On the VIN pin. You could connect power to the board using this pin instead of The USB or DC input jack. Because it is connected to the input side of the voltage

- Regulators, the regulated 5V and 3.3V Dc will be supplied to the board [85].

3.6.1.2.3 Android operating system

- Android is a Linux-based operating system designed primarily for touchscreen mobile devices such as smartphones and tablet computers. The operating system has developed a lot in the last 15 years, from black and white phones to smartphones or mini computers. One of the most widely used mobile OS These days is Android. Android is software founded in Palo Alto of, California, in 2003.
- Android is a powerful operating system, and it supports a large number of applications on Smartphones. These applications are more comfortable and advanced

for users. The hardware that supports android software is based on the ARM architecture platform. Android is an open-source operating system that is free, and anyone can use it. Android has millions of apps available that can help you manage your life one way or another, and it is available at a low cost in the market, which is why Android is very popular.

3.6.1.2.4 Arduino inputs/outputs

There are 16 digital pins on the Arduino board. They can be used as inputs or outputs. They operate at 5V and have a maximum current draw of 40mA. They have an internal pull-up resistor that is disabled by default. The pull-up resistors are between 2 - 50kOhms and can be enabled via software.

We can control the digital I/O pins using the pin mode (), digital Write(), and digital Read functions.

Some of the digital I/O pins have additional functions

- Serial: Pin 0 (RX) and 1 (TX). These pins transmit and receive serial TTL (5V) data. These pins are also connected to the Atmega16u2 USB to Serial TTL chip on the Arduino board.

- PWM: Pins 3,5,6,9,10 and 11. The pins can provide a PWM (Pulse Width Modulated) 8-bit output. We use the analog Write () function with a value between 0 and 255 to control the output's duty cycle.

- SPI: Pin 10 (SS), 11 (MOSI), and 13 (SCK) are used to provide SPI (Serial Peripheral Interface) communications using the SPI library

- External Interrupts: Pins 2 and 3 can be configured to trigger an interrupt on the signal going low or on a rising or falling edge. We use the attach Interrupt () function to enable interrupts.

- LED: There is a LED connected to Pin 13. When the output on pin 13 is high, the LED will be turned on. The LED will be turned off when the output is low.

The Arduino Uno has six analog inputs labeled A0 through to A5. Each of these Analog pins has 10 bits of resolution, which translates from 0 to 1024 different values. By default, they measure from ground to 5 volts. It is possible to extend the range using the AREF pin and the analogReference() function. Some of these pins have additional functionality.

- TWI: A4 or SDA pin and A5 or SCL pin. These pins are used to support TWI communications using the Wire library.

- AREF: Used to provide a reference voltage for the analog inputs and used with analogReference.()

- RESET: Bringing this line LOW will reset the ATMega328 microcontroller. It can be wired to shields to provide a reset button when the reset button on the Arduino Uno is blocked by security.

3.6.1.2.5 Using Analog Pins as Digital Pins

We can configure the Analog I/O pins to function the same as Digital pins. The Analog to Digital pin mappings are as follows:

A0 => Digital Pin 14

A1 => Digital Pin 15

A2 => Digital Pin 16

A3 => Digital Pin 17

A4 => Digital Pin 18

A5 => Digital Pin 19

We can now use the pin mode command to define the pin as an INPUT or OUTPUT. So for pin AO, we would use 14 as the pin value. To write to the pin we would use digital Write with the appropriate digital pin value as shown in the list above.

3.6.1.2.6 Communications

The Arduino has several modes of communication.

- USB: The Arduino Uno uses an onboard ATmega16U2 to connect the serial TX and RX pins on the AT mega 328. The 16u2 replaces the FTTI USB chip used on other boards. The USB chip sends out this serial data to appear as a virtual com port on the computer connected to the USB port. The Arduino IDE Serial monitor also uses the USB port to send serial data to and from the Arduino board. The TX and RX LEDs will flash when data is sent and received via the USB port.
- Serial TTL: The Arduino Uno board has a TTL level (5V) serial communication on the digital pins 0 (RX) and 1 (TX). This could also be connected to an RS232 or RS484 chip to provide serial communications to another device. Note: The onboard TX and RX LEDs will NOT flash when using serial commas on digital pins 0 and 1. These LEDs are USB commas only.
- I2C and SPI communications: The Arduino Uno supports these serial communication formats. Use the Wire library for the I2C bus. Use the SPI library for the SPI bus.

3.6.1.2.7 USB Overcurrent Protection

A resettable poly fuse protects the USB port from shorts and overcurrent on the Arduino board. If more than 500mA current is pulled from the USB port, it will poly fuse will trigger and break the connection to the USB power. Once the short overcurrent is removed, the poly fuse will reset [86].

3.4.1.3 Proposed model Outputs

This section shows the output tools used in the proposed model.

3.4.1.3.1 LCDs

The Liquid Crystal library allows you to control LCDs compatible with the Hitachi HD44780 driver. Many are out there, and you can usually tell them by the 16-pin interface [86].

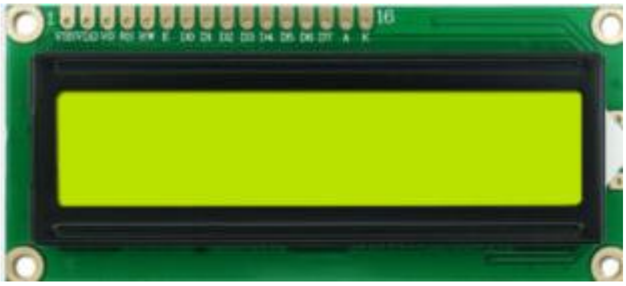


Figure21: LCD

The LCDs have a parallel interface, meaning that the microcontroller has to manipulate several interface pins to control the display manually. The interface consists of the following pins:

- A register select (RS) pin that controls where in the LCD's memory you're writing data to. You can choose either the data register, which holds what goes on the screen or an instruction register, where the LCD's controller looks for instructions on what to do next.
- A Read/Write (R/W) pin that selects reading mode or writing mode
- An Enable pin that enables writing to the registers
- 8 data pins (D0 -D7). The states of these pins (high or low) are the bits you're writing to a register when you write or the values you're reading when you read.

There's also a display contrast pin (Vo), power supply pins (+5V and GND), and LED Backlight (Bklt+ and BKlt-) pins that you can use to power the LCD, control the display contrast and turn on and off the LED backlight, respectively [87].

Controlling the display involves putting the data that form the image of what you want to display into the data registers, then putting instructions in the instruction register. The Liquid Crystal Library simplifies this for you, so you don't need to know the low-level instructions.

The Hitachi-compatible LCDs can be controlled in two modes: 4-bit or 8-bit. The 4-bit mode requires seven I/O pins from the Arduino, while the 8-bit mode requires 11 pins. For displaying text on the screen, you can do almost everything in 4-bit mode, so the example shows how to control a 16x2 LCD in 4-bit model [22].

3.4.1.3.2 Virtual Terminal

A virtual Terminal is a tool in Proteus used to display data coming from the serial port (DB9) and send data to the serial port. In Windows XP, there is a built-in tool called Hyper Terminal, and we use the virtual serial to connect the Proteus with the Arduino so that the outputs are displayed on the virtual terminals [88]

3.4.1.3.3 Oscilloscope

Proteus provides an oscilloscope, an essential instrument for analysis purposes. The Digital Storage Oscilloscope is featured as:

- 4-Channel input
- 2 MHz sampling frequency
- Invert option for each channel
- Relational output between channels
- Input coupling type selection
- Source selection between channels

- Adjustable Volts/Div through Knob or manual entry in the textbox
- Auto/One-shot selection for output update
- Cursor placements for detailed and accurate observations
- Finally, the analysis printing option, which made it Digital Storage Oscilloscope[89].

3.4.1.3.4 Thingspeak cloud

Things peak is an open-source platform made for the Internet of Things (IoT) device developers and learners where developers can send and log data to the server, analyze, retrieve and store results using graphs with Mat Lab support.

We can send up to 8 data simultaneously to the things peak account; the data uploaded will be converted to a graphical representation automatically, as illustrated in Figure 5.

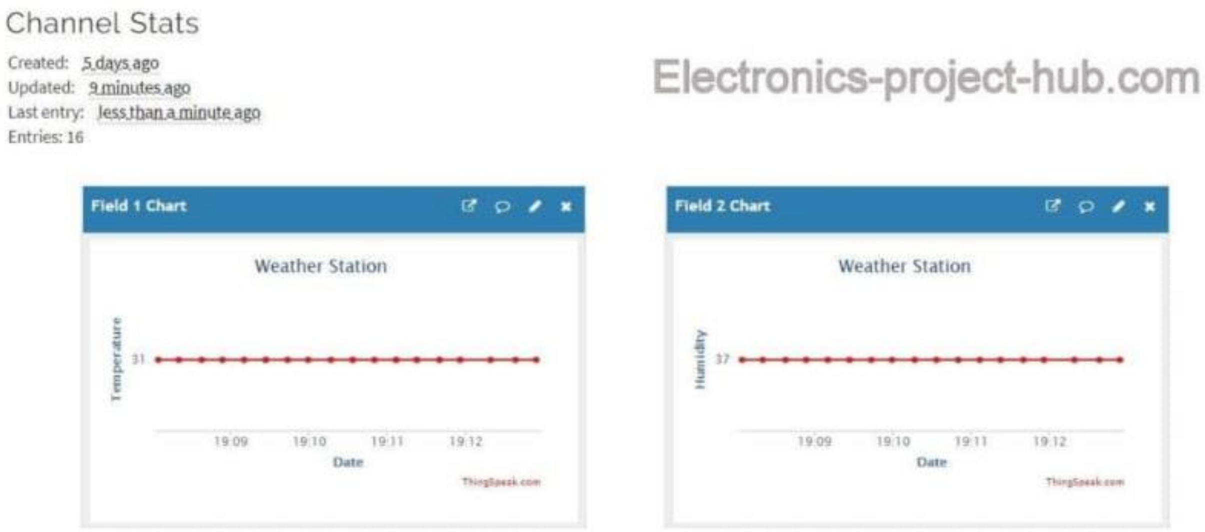


Figure 22: Sending data to Things peak

The straight line signifies no temperature or humidity change during data logging. You can hover the mouse cursor on these dots to see the numerical data recorded at a particular local time. Things peak updates the data/graph every 15 seconds.

To send your data to things peak, you need an API key from your account, which must be inserted in the given program code.

API stands for “Application programing Interface” From on things peak, it is a string of random character containing alphabets of lower and upper case, numbers, and even special symbols to identify your account and ensures that your sent data doesn’t end on someone else’s account and vice-versa.

Two API keys are generated while creating an account; one is called the read API key, and another is called the write API key. We will use only the write API key as we write data to the things peak [14].

3.4.1.4 Connectivity IOT

To display the results on remote peripherals or the cloud, the tools necessary for Arsenio’s communication with them are as follows:

3.4.1.4.1 ESP8266 Wi-Fi module

The ESP8266 module is a microcontroller board with Wi-Fi capability, designed to operate as a standalone application or as a secondary device connected to a microcontroller (master) to enable an internet connection wirelessly for the intended project.

Beginners might think that the ESP8266 module is a secondary device and always need a microcontroller to operate, but that is not true. The ESP8266 can act as a standalone device; it has its 32-bit microcontroller clocked at 80MHz and flash memory which can be programmed using Arduino IDE.

But this module has only two GPIO pins which will limit the number of sensors and peripherals we will connect. If you use only one sensor (connected to a single nail), you may not need any microcontroller; you can directly add the library (if necessary) and write code as you do for Arduino boards, and upload it to the ESP8266 module.

As we need more than two pins, we are using ESP8266 as an agent device; this is done by uploading a program code to ESP8266, which will accept serial data from Arduino [18].

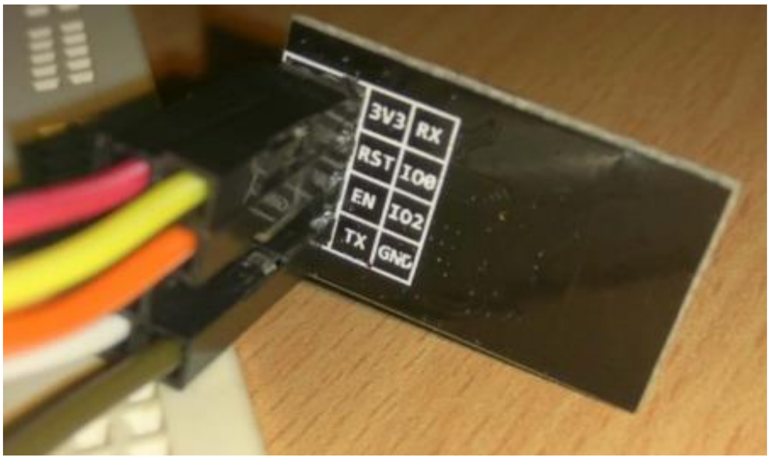


Figure 23: ESP8266 sensor

Specifications:

- ESP8266 module has its own SoC or system on chip, flash memory, etc. It utilizes a Ten silica L106 32-bit processor clocked at 80MHz.
- It has 32KB instruction RAM, 32KB instruction cache RAM, 80KB user data RAM, and 16 KBETS system data RAM.
- It can operate from 2.5V to 3.6V (nominal 3.3V), and 5V will kill the board. It has an average current consumption of about 80mA.
- It supports 802.11n (2.4 GHz) and can communicate up to 72.2 Mbps.
- It supports these network protocols: IPv4, TCP/UDP/HTTP.

Figure 24: ESP8266 Pin diagram

The pin diagram is also printed on the back of the ESP8266 module, which makes tasks much more accessible, as seen in Figure 7.

3.4.1.4.2 SIM900 GSM Module

The microcontroller accesses the location from the GPS modem and transmits the site to the GSM modem, which will send SMS messages to the saved number in the system. When the GSM modem receives a statement, the microcontroller will process it with the keyword saved. Then, it will get the location of the stick from the GPS modem and transmit the site to the GSM modem to respond to the sender. In an emergency, the bar user can press the emergency button.

Figure25 : SIM900 GSM Module

A GSM Module (like SIM 900) connected to a PCB with different types of output taken from the board – say TTL Output (for Arduino, 8051, and other microcontrollers) and RS232 Output to interface directly with a PC (personal computer). The board will also have pins or provisions to attach the mic and speaker to take out +5V or other power and ground connection values. These types of requirements vary with different modules.

We use SIM900 GSM Module – This means the module supports communication in the 900MHz band.

Check the power requirements of the GSM module – different companies manufacture GSM modules. They all have other input power supply specs. You need to double-check your GSM module’s power requirements. In this tutorial, the GSM module requires a 12 volts input. So, we feed it using a 12V,1A DC power supply. I have seen GSM modules that require 15 volts and some other types which need only 5 volts of input. They differ with manufacturers. If you have a 5V module, you can power it directly from Arduino’s 5V out [21].

3.5 Performance Metrics

In this paper, we tried to s a low-cost monitor for Cholera patients through blood pressure and heart rate sensors and examining the patient's environment and dormitory room. In this system, it is possible to measure blood pressure and heart rate, continuously scan the patient's inpatient room, and be treated in time for severe disease. Actual vs. estimated heart rate data is displayed over a repeated period within 24 hours, and it is said that this monitor provides a lot of support to know the patient's current condition if there is no doctor or clinic nearby.

3.5.1 Blood pressure measurement

Systolic, and diastolic blood pressure and bias level for each measurement of blood pressure of essential measures in this work, accuracy is to compare the prediction of recommendations and results, and recall and deviation or bias, when the doctor takes the patient's blood pressure using the mercury meter, he does not care whether the patient suffers from (82/123 mm Hg, or 79/121 mm Hg) but the doctor's attention when the patient suffers from (82/123 mm Hg or 97/136 mmHg) so here the exact accuracy is less essential. Still, his prediction must be typical and often correct. Doctors may not trust such devices that work on learning algorithms that produce whether blood pressure is "normal" or "high" without reference to close measurement of the patient, and this is the most realistic professional goal for doctors, so accuracy is the predictive value of the region and positive, in IIHS model we take the values that are and determine the low blood pressure significantly through the sensor Mx10300, which calculates systolic and diastolic blood pressure.

3.5.2 Heartbeat measurement

Rapid heartbeat or low level dramatically affects the patient's health, resulting in other symptoms; bradycardia is a decrease in the speed of the heartbeat. In adults at rest, the heart rate is usually between 60 and 100 beats per minute. Therefore, the heart rate is less than 60 beats per minute, so the heart cannot pump enough oxygen-rich blood to the body's organs, leading to severe weakness, shortness of breath, fatigue, and other non-critical symptoms. A rapid heartbeat of more than 100 beats per minute may lead to multiple heart disorders.

The IIHS model continuously and systematically 24/7 monitors the rapid and low heart rate of cholera patients.

3.5.3 Environments measurement

Air purity from toxic gases such as methane, carbon dioxide, and hydrogen from emergency inpatient rooms, intensive care, and hospitals. Low energy cost and takes only a few minutes to be within a small percentage of the data. In general, the preheating time of the MQ-2 gas sensor can be used for both gas detection and also measure the level of butane and hydrogen gas in ppm

3.6 Summary

This chapter mentions the generalized model of the project. The architecture describes the inter-relationship among different modules or functional units of the project. The step-by-step control transfer from one module to another and the corresponding functioning of the system design have been mentioned.

Chapter 4

Model Implementation

4.1 Introduction

This chapter mentions the internal description of the project and the proposed mathematical model. It describes the workflow and step-by-step implementation of the project. It also mentions the specifications of the system.

Cholera disease has many symptoms divided into two parts common symptoms (watery diarrhea, nausea/vomiting, dehydration) and severe symptoms(low blood pressure and rapid heart rate), In this model, we are dependent on the severe symptoms of cholera only (low blood pressure and rapid heart rate) that monitoring patient to that's infected by cholera [63].

4.2 Design Development

This model was designed by Proteus 8 professional software to simulate the devices and sensors in Arduino and the work on them, The sensor elements are downloaded and then linked to each other according to their input, and output, we connected them with a power supply With the right electrical power for sensors and Arduino ship, the Arduino microcontroller is linked with the Arduino IDE program, and then they are linked through a virtual portal that works as a simulation of the basic port in the computer until the outputs are displayed on the output media.

We used Arduino IDE 2.0.1 software to write and identify devices, using the C language, which defined the libraries of all devices and sensors Heart rate, blood pressure, and gas test, with the Arduino Uno chip Then activating a virtual portal COM3, COM4 the outputs and values were displayed on the display screen and the virtual means of display

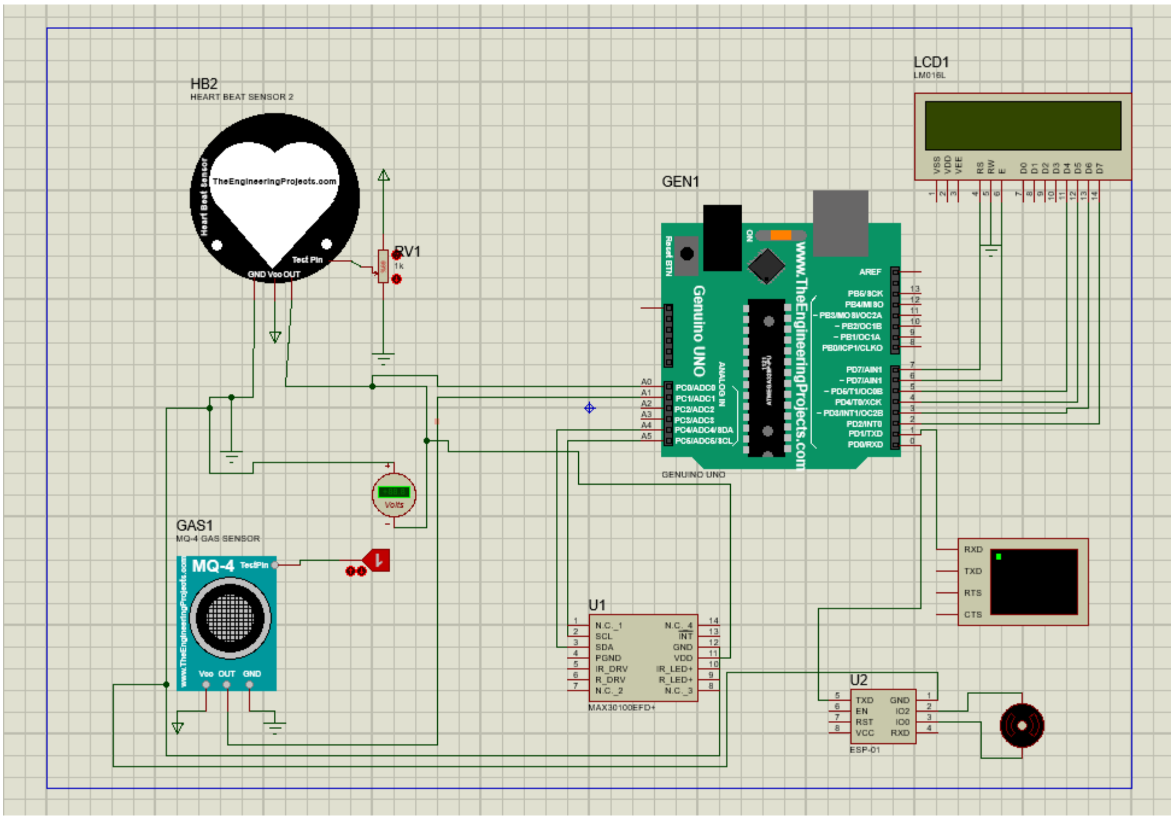


Figure 26: model schematic.

This system is designed as three steps detection of the environment, scan Heartbeat pulse and spo2, and blood pressure.

4.2.1 Oximeter oxygen (Spo2)

Monitoring oxygen levels in human blood and measuring pulse oxidation through medical electronic instruments that measure the oxygen saturation (Spo2) of arterial blood and pulse rate by smart wearable tools and technologies, medical devices allow rapid detection of oxygen status and hypoxia that can lead to death, hypoxia Blood tends to cause hypoxia in the blood, which is an abnormally low concentration of oxygen in the blood, and one of the dangerous symptoms of cholera patients or For people with chronic diseases, this project covers the basic principles of oxidation.

Designing oximeters and introducing the concept of oximetry through the tools used to design pulse oximetry, simulation software using Proteus, Arduino, a set of circuits, and the max30100edf pulse tester and blood oxygenation [64].

SpO2 has two components, S indicates saturation and P indicates pulse, also SP can stand for serum pressure and O2 is oxygen. In short, this reading indicates the amount of oxygen being carried by red blood cells. SpO2 indicates how effectively a patient is breathing and how well blood is being transported throughout the body. SpO2 uses a percentage to indicate this measurement (Table 4). The average reading for a normal, fit adult is 96 percent. The partial pressure of Oxygen in the blood (PaO2) facilitates the indirect assessment of PaO2 through the measurement of Spo2. The pulse oximeter (MAX30100) is a rapid diagnostic tool for measuring and monitoring oxygenation levels. A reduction of 3 percent or more SpO2, even if within normal saturations, is an indicator to perform a full assessment of the patient because this is evidence of illness [65].

SpO2 (%)	Recommended
>95	Normal
85-94	Hypoxic
<85	Severely hypoxic

Table 5: Observation of threshold values of SpO2 level.

Whereas:

$$Noraml\ = f(x) = \begin{cases} 0, & x < 99 \\ 1, & x > 95 \end{cases}$$

$$Hypoxic = f(x) = \begin{cases} 0 & x < 94 \\ 1 & x > 85 \end{cases}$$

$$Severely\ hypoxic = f(x) = \begin{cases} 1, & x < 85 \\ 0, & x > 95 \end{cases}$$

We used the max30100 sensor to simulate and examine the spo2 and blood pressure as flow chart 1 the sensor Initializing pulse oximeter using Arduino code (Serial. print("Initializing");Serial.print("Initializing pulse oximeter.."); Serial.println ("HeartRate , SpO2");) to read the input signal the check the value and validate the sensors is run success or not(if (!pox.begin()){ Serial.println("FAILED"); for(;;);} else { Serial.println("SUCCESS"); }) then read values and print the output for heart rate and blood pressure.

4.2.2 Blood pressure

(BP) blood pressure in the arteries of the conditions of the ritual that lead to cardiovascular disease, and increased or decreased blood pressure (HBP) leads to many diseases and complications, may lead to a heart attack or stroke or kidney damage, and has no clear symptoms or warning signs that are often called "silent killer" and that one of the dangerous symptoms in cholera patients is low blood pressure, which leads to the entry of patients into a coma or heart attack [66]. In this paper, we describe the cholera patient monitoring system by providing a monitoring device for dangerous symptoms in patients and monitoring blood pressure BP in terms of decrease as a basic criterion for the symptoms of cholera patients, the system depends on the method of waveforms of vibrational pressure with data displayed and sent to cloud computing using think speak.

Category	**Systolic**	**and/or**	**Diastolic**
Normal	< 120 mm Hg	and	< 80 mm Hg
Elevated (at risk, or prehypertension)	120-129 mm	and	< 80 mm Hg
Hypertension stage 1	130-139 mm	or	80-89 mm
Hypertension stage 2	> 140 mm Hg	or	> 90 mm Hg
Hypertensive crisis (emergency	> 180 mm Hg	and/or	> 120 mm

Table 6: Observation of blood pressure values and levels.

This max30100 (sensor) measures blood pressure and simulates a blood pressure monitor that contains a cuff that is inflated by an automatic diaphoretic pump, which works to stop the pulse when inflated enough, and the reading is taken either electronically or on an analog disk, The reading is expressed in terms of the pressure required to move the mercury around a tube against gravity, using millimeters of mercury.

The risk factors occur when the blood pressure becomes high and low according to the following:

4.2.2.1 Hight blood pressure

Age plays a big role in increasing blood pressure, as a person ages, blood pressure increases. the Men are more likely Trusted Source to have high blood pressure before the age of 55, but women are more likely than men to have the condition after the age of 55. Having a family member with high blood pressure increases a person's risk of developing hypertension in the future. also, the Obesity for a person who is overweight or obese is more likely to have high blood pressure. This is because more blood circulates through blood vessels to supply cells with oxygen and nutrients. Since there is more circulating blood, there is a higher pressure on the walls of the vessels. On Lifestyle habits A lack of physical activity, smoking tobacco (including second-hand smoking), drinking too much alcohol, consuming too much salt (sodium) or too little potassium, and stress may increase the risk. As well as Certain chronic conditions kidney disease, diabetes, and sleep apnea can increase the risk of high blood pressure [57].

4.2.2.2 Low blood pressure

Low blood pressure or hypotension occurs when a person has abnormally low blood pressure against the walls of their blood vessels.

Risk factors that increase a person’s chance of developing the condition include:

Age people over the age of 65 from a trusted source are more likely to develop low blood pressure while standing or after eating. Children and young people are more likely to experience rapid hypotension accompanied by dizziness, blurred vision, and fainting, which is known as neutral-mediated hypotension. Some medications. High blood pressure medications, including diuretics, can cause low blood pressure in Some diseases. Conditions such as Parkinson's, diabetes, and some heart disease increase the risk of low blood pressure and other factors. Pregnancy, standing in the heat, or standing still for long periods can also cause low blood pressure.

A person with mild low blood pressure may experience fatigue, fainting, or dizziness. More severe forms of low blood pressure can compromise oxygen-rich blood flow to the body's major organs, including the brain. If this happens, a person may feel sleepy, confused, or light-headed. In serious cases, this can evolve into heart or brain damage [57].

The flow chart explains how the sensor works to generate the values of blood pressure and initializing the sensor to turn on the start receiving values from the inputs, then verify that the sensor is working to print the outputs for the blood pressure values as shown in Figure 2 .

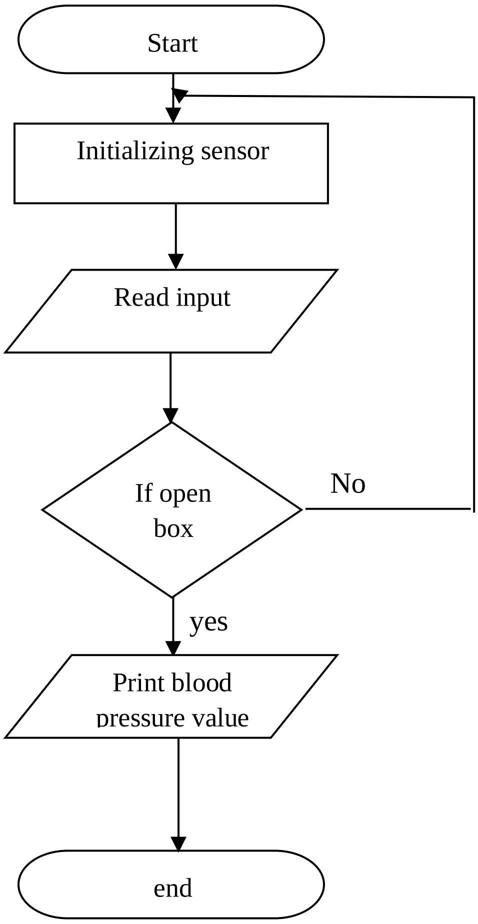


Figure 27 : blood pressure flow chart.

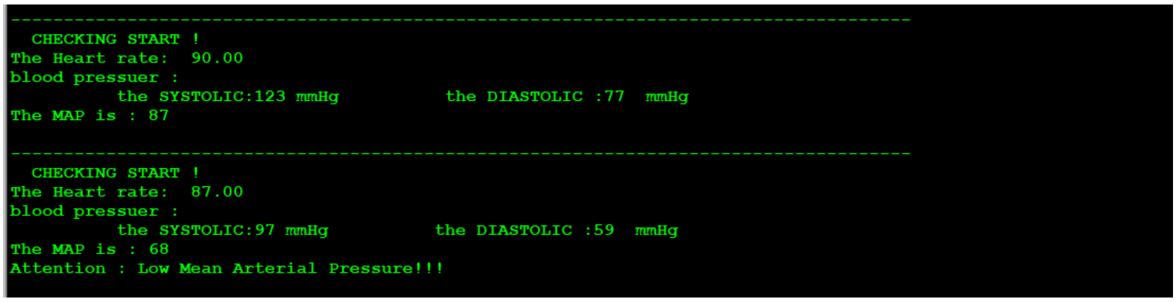


Figure 28: blood pressure and heartbeat pulse using a virtual terminal window.

4.2.3 Heart Beat pulse

The direction of blood pressure is not the same as absolute blood pressure measurement. BPT uses an algorithm to look at changes in the form of a PPG signal and correlate them to changes in BP from a particular standard baseline for BP. This is still useful because continuous blood pressure recordings cannot be taken from conventional cuff-based blood pressure monitors, and changes in the direction of BPT or BPT (BPT) prove valuable in cardiovascular care and monitoring high-risk patients.

The Heart Beat Sensor Integrated front end is suitable for heart rate monitoring through the bioelectricity signal of the heart fence. It aims to monitor various vital signs and is a simulated front end for heart rate monitoring, characterized by low power consumption and individual bullets. A heart rate sensor is used to measure the heartbeat, which is usually between 60-100 beats per minute. Heart rate is the heart rate measured by the number of heart contractions per minute, the figure shows the heartbeat sensor schematic.

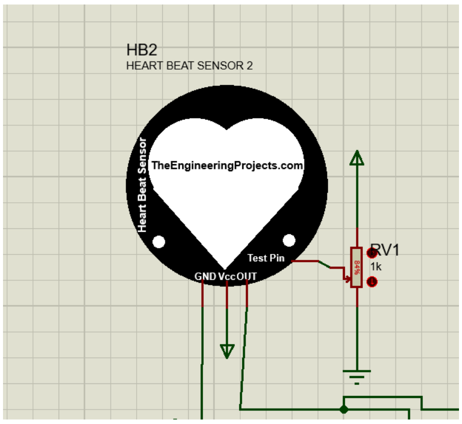


Figure 29: heartbeat sensor schematic.

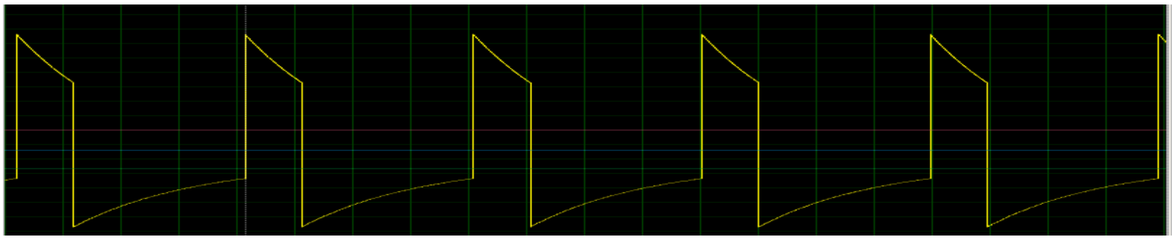


Figure 30: heartbeat pulse using a digital oscilloscope.

The flow chart explains how the sensor works to generate heart rate values, configure the heart rate sensor, read the input signals and check the input to respond, the output and values are printed in case the response and input is read correctly or the sensor is checked to check the input again as shown in Figure 6.

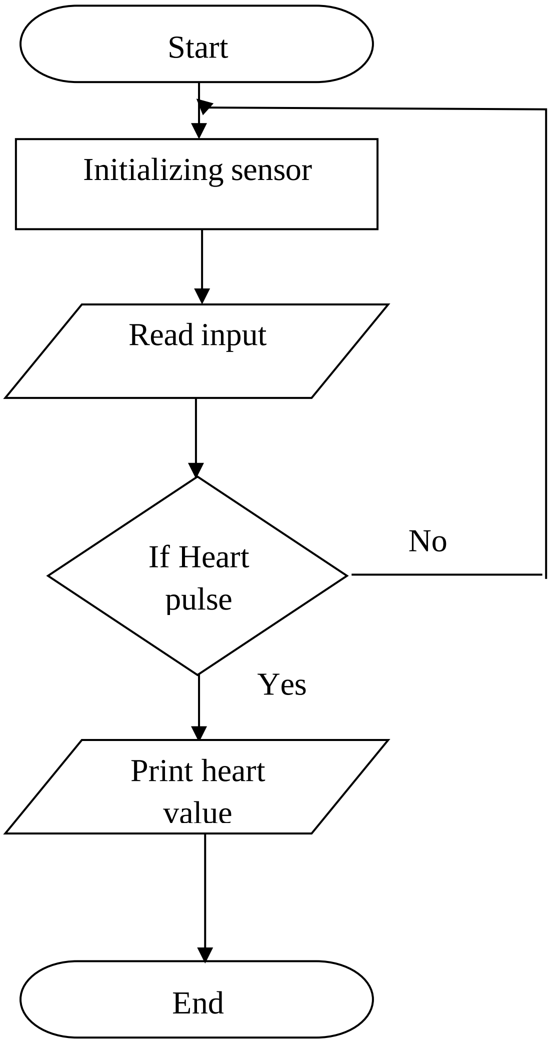


Figure 31: heartbeat pulse flow chart

4.2.4 Gas detection:

We used this sensor to examine the environment surrounding the disease in rooms, hospitals, or the care room to see if it contains toxic gases or is unhealthy for patients, which further aggravates their health condition.

Figure: show the sensors of gas (MQ-4) that are used to examine the environment it has logic value (int gas_value = digitalRead(MQPin);if(gas_value==HIGH)) if the value is one (lcd.print("HEALTHY"); lcd.setCursor(3, 1); lcd.print("ENVIROMENT")) that mean gas not detected and the environment is healthy otherwise if the value is zore that is mean the environment is dirty. lcd.print ("DIARTY"); lcd.setCursor (3, 1); lcd.print ("ENVIROMENT");) as the figure below :

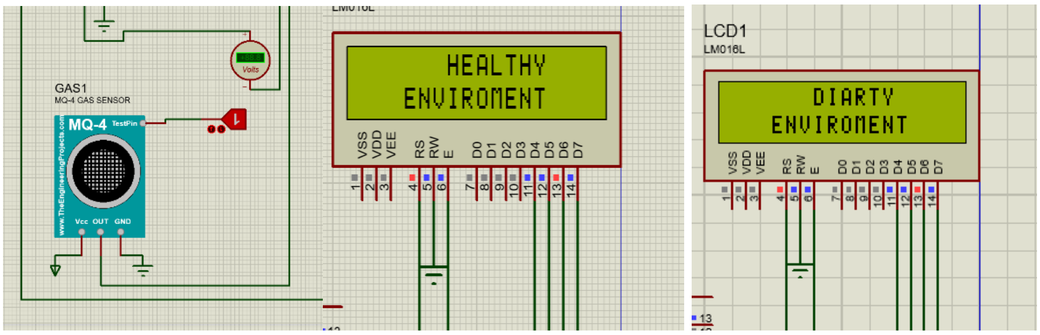


Figure 32: Gas Detection sensor (MQ-4)

The flow diagram explains how the sensor works to verify the presence of toxic gases in the environment by deterring the sensor and then receiving the values and checking whether the gases are present in the environment and then printing or sending an alert that the environment is unhealthy and if the gases are not present, a warning is sent that the environment is healthy as shown in Figure 8.

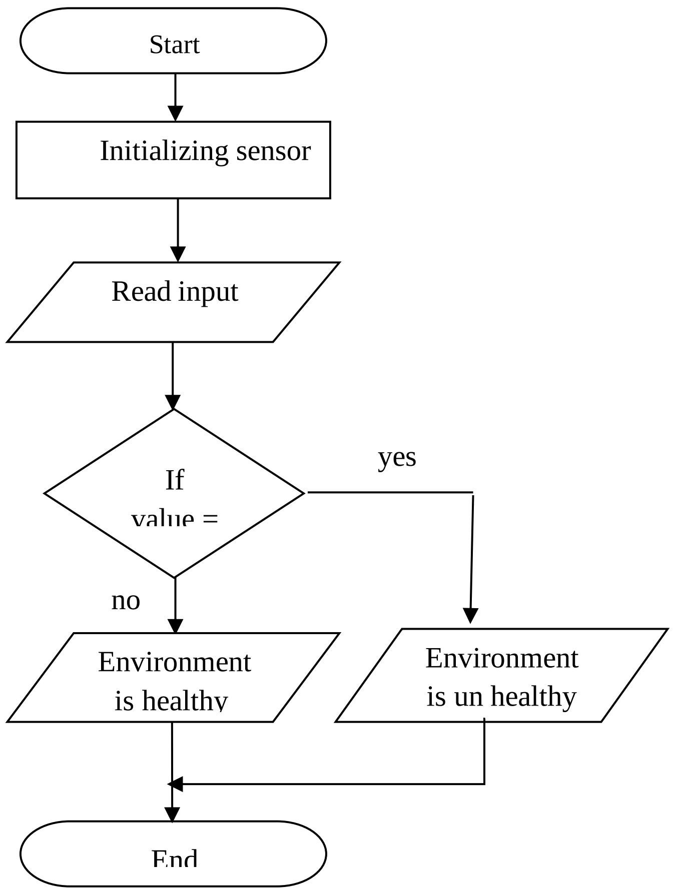


Figure 33: Gas detecting (MQ-4) flow chart

4.3 Summary

This chapter mentions the model based on the proteus and all parts of the model in addition to the flow diagram that shows the work of each sensor, and also shows the output obtained through the simulation of patients through the element POT, which generates random values that simulate patients randomly to obtain values for both heartbeat and blood pressure, and also shows the state of the environment through the MQ-4 sensor to examine ammonium gas and carbon dioxide in the environment. Surrounding the patient.

Chapter 5

Results and Discussion

5.1 Introduction

This chapter aims to explain the comparison between the proposed model IIHS and the existing study and explain the results of the study and display the outputs of the model IIHS.

5.2 A comparative study between the proposed model and previous studies.

Through the comparison Table 7 we found that the researcher[1] provided him with a patient observer and the discovery of the patients with Covid 19 disease based on the patient's indicators by measuring the temperature and by the controller Arduino Uno and it was limited only to those with the temperature only, and the researcher [2] made a research contribution to the health care system for humans in general by monitoring general symptoms such as temperature, oxygen saturation, falling, movement and heartbeat, and it was not intended for examining A specific disease based on the symptoms of the disease as Arduino Uno was used and the sensor was not used to check the environment from toxic gases, The researcher [3] also presented patient monitoring system during sleep by monitoring sounds and heart rate, and used the Android application and the Arduino Uno controller, as well as the sensors accelerometer, pulse oximeter and microphone amplifier.

He did not focus on toxic gases and oxygen purity in the patient's inpatient room. The researcher [4] provided a system to monitor the elderly through sensors and wearable devices to examine the fall and movement of the elderly using smartphone technology and RFID technology, and the researcher identifies the sensors for chronic diseases or symptoms in the elderly.The researcher [5] also presented the research contribution to monitor health care through sensors to check the pulse, oxygen levels in the blood and body temperature in general for all patients, and used temperature sensors, oxygen oximeter, heart rate, using Ardeunion Uno technology and ThinkSpec cloud platform, and the symptoms were not specifically examined for the disease or the environmental purity of toxic gases was examined. The researcher [6] provided a care system for infants and monitoring some symptoms such as temperature, as well as humidity and the detection of crying in children through temperature sensors and humidity detection, the sound sensor to detect children's crying by the controller Arduino Anno, and the examination of toxic gases in the room and oxygen purity was not addressed. The researcher [7] presented the monitoring system for pregnant women and children to monitor some symptoms such as temperature, humidity, pulse rate hazard, monitoring unexpected neurological activities using temperature and humidity sensors (DHT22), AD8232 (ECG sensor),GSR sensor The environment examination and identification of other symptoms such as blood pressure were not addressed. The researcher [8] provided a medical care system for Digital Pulse Oxygen Saturation Monitoring to examine the lack of oxygen in the blood through the oxygen oximeter max30100 and the control Arduino Uno and the symptoms of blood pressure were not addressed, as well as checking the purity of oxygen from toxic gases. Based on the Figure illustrated in Chapter 4, the IIHS model of intelligent health monitoring using the Internet of Things (IoT) and Arduino was successfully implemented using the Arduino Uno microcontroller. Arduino acts as the primary controller of the project, allowing it to communicate with all the equipment involved. It is able to measure and monitor basic human health using the heart rate sensor, which acts as a sensor to measure the heartbeat, and the MAX30100 sensor, which acts as a sphygmomanometer and oximeter sensor, which measures heart rate and detects oxygen levels in the blood. As well as the MQ-2 sensor, which measures the level of oxygen and gases in the patient's room, in addition, Arduino collects real-time health data via these sensors associated with Arduino. Moreover, Arduino is also responsible for data collection and real-time data display on a 20x4 LCD screen. Or through live viewing media This is useful for healthcare workers who monitor patients on-site. In this comparison, we find that the previous research did not meet the mechanism and methodology used in the proposed IIHS model, so the research contribution is clear.

5.3 Existing Methodology issue, sensors and applications

Ref	Issue	Sensors	Applications	Parameters analyzed	Methodology	Environmental Pollution Inspection
[1]	Classification and analysis of risk factors for the presence of a disease in a patient according to a set of medical health indicators.	• Temperature sensor	Covid-19	• Temperature	• Arduino UNO	Not Available
[2]	human health monitoring system	• LPC2148 • microcontroller DAQ • LM35 Temperature • Sensor • ADXL335 Tri-axial • Accelerometer • MAX30100 Pulse Oximeter • and Heart-Rate Sensor IC • GPS	General Patient Screening	• Temperature • Heart rate • Oxygen oximeter • Movement and falling	• Arduino UNO	Not Available
[3]	Sleep Quality Monitoring System	• accelerometer, • pulse oximeter • microphone amplifier	monitoring the patient's sleep	• Sound levels • Heart pulse	• Arduino UNO • Android app	Not Available
[4]	Elderly Monitoring System	• Wearable sensors	Elderly monitoring system	• Movement and falling	• Smartphone • RFID	Not Available

[5]	health monitoring sensor system	• blood saturation levels (SpO2) • heart rate and • body temperature	General Patient Screening	• Temperature • Heart rate • Oxygen oximeter	• Think speak • Arduino uno	Not Available
[6]	Infant Care System	• Temperature • moisture content • cry detection	baby monitoring system	• Body Temperature • Detect moisture content • cry detection and sound	• Arduino uno	Not Available
[7]	Health Monitoring System for Pregnant Women & Children	• Temperature and Humidity Sensor (DHT22), • AD8232 (ECG sensor), • GSR sensor	Pregnant Women & Children Health Monitoring system	• to measure temperature, humidity, fetal heart rate, and autonomic nervous activity respectively.	• Arduino uno	Not Available
[8]	Digital Pulse Oxygen Saturation Monitoring	• Max30100	low-cost pulse oxygen saturation measurement	• pulse oxygen	• Arduino uno	Not Available

Table 7 : Existing Methodology issue, sensors and applications.

5.4 Result Analysis

The values were taken in three stages at different times and by generating them randomly by the pot-HG data entry used in the model, and it was noted that there were actual values through the IIHS model for each of the MAX10300 extractors used to measure systolic and diastolic blood pressure mercury, as well as the heartbeat and determine its mechanism of action based on the specific symptoms of cholera or diseases that contain similar symptoms, and the MQ-2 sensor responsible for examining toxic gases that have an effect was also displayed. Great on patients in the inpatient room. The following tables show the stages and data generated through Model IIHS.

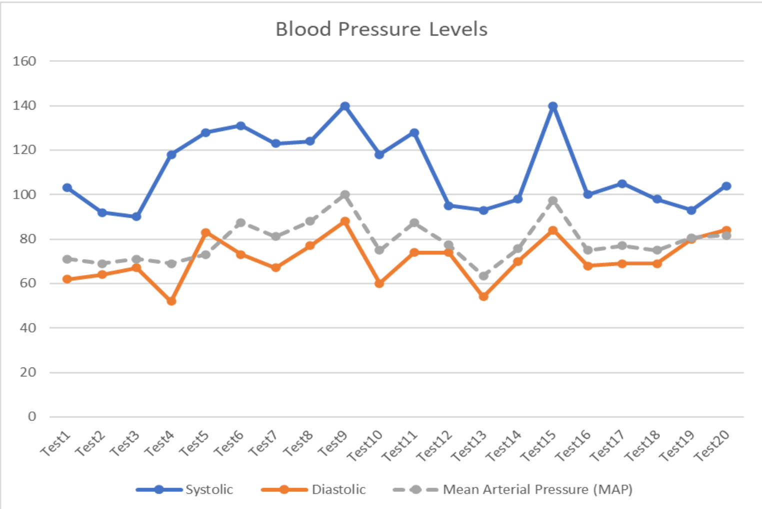
we collect the values of Target Blood Pressure Levels and Mean Arterial Pressure (MAP) using the formula MAP = DP + 1/3(SP – DP) or MAP = DP + 1/3(PP) to compare the result from IIHS model and the real Medical Pressure Measuring Devices Mercury as stage 1 bellow:

Stage 1 collecting data collected from Model IIHS.

Blood Pressure Levels				**Heart Rate Pulse (BPM)**		
persons	**Target Blood Pressure Levels**		**Mean Arterial Pressure (MAP)**	**Statues**	**Heart Rate Pulse (BPM)**	
	Systolic	**Diastolic**			**60 – 100 HRP**	**Status**
	120 mmHg	**80 mmHg**				
Test1	103	62	71	Normal	69	Normal
Test2	92	64	69	Low Map	61	Normal
Test3	90	67	71	Normal	60	Normal
Test4	118	52	69	Low Map	79	Normal
Test5	71	79	73	Normal	47	Worst HRP
Test6	131	73	87	Normal	87	Normal
Test7	123	67	81	Normal	82	Normal
Test8	124	77	88	Normal	83	Normal
Test9	140	88	100	High MAP	93	High HRP
Test10	118	60	75	Normal	79	Normal
Test11	128	74	87	Normal	85	Normal
Test12	95	74	77	Normal	63	Low HRP
Test13	93	54	64	Low Map	62	Low HRP

Test14	98	70	76	Normal	65	Low HRP
Test15	140	84	97	High MAP	93	Normal
Test16	128	80	91	Normal	85	Normal
Test17	105	69	77	Normal	70	Normal
Test18	81	69	70	Low Map	54	Worst HRP
Test19	93	80	81	Normal	62	Low HRP
Test20	104	84	82	Normal	69	Normal

Table7 : IIHS data generated on stage 1



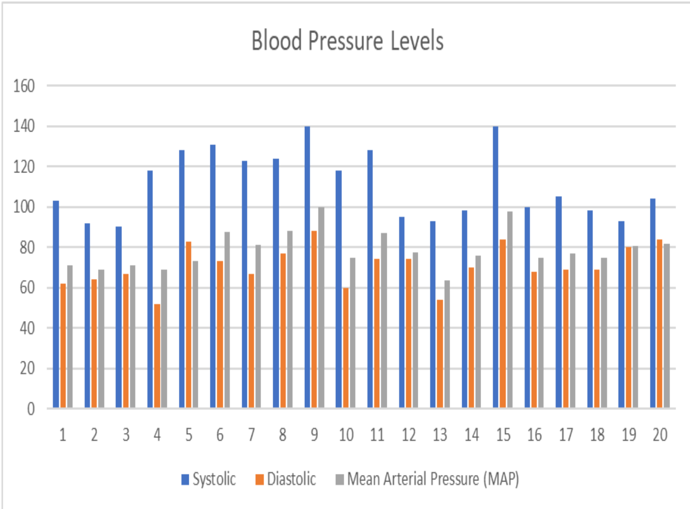
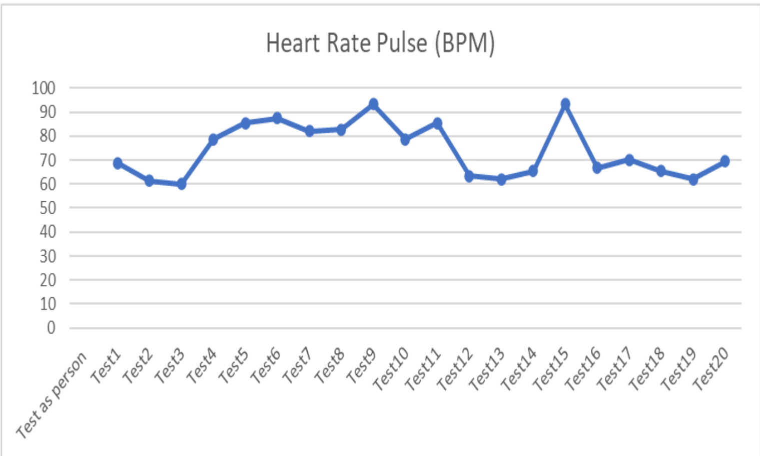


Figure34: Blood Pressure level chart (A) Figure35 : Blood Pressure level chart (B)



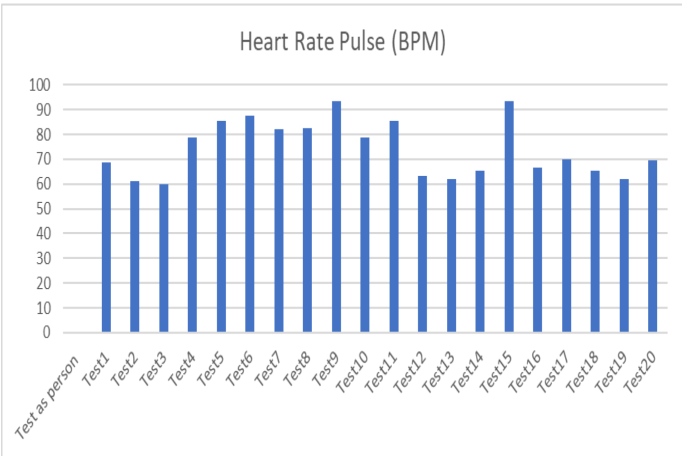


Figure36: Heart Rate Pulse (BPM) chart (A) Figure37: Heart Rate Pulse (BPM) chart (B)

Stage 2: Collecting data collected from Model IIHS.

Blood Pressure Levels				Heart Rate Pulse (BPM)		
persons	**Target Blood Pressure Levels**		**Mean Arterial Pressure (MAP)**	**Statues**	**Heart Rate Pulse (BPM)**	
	Systolic	**Diastolic**			**60 - 100HRP**	**Status**
	120 mmHg	**80 mmHg**				
Test1	133	50	71	Normal	89	Normal
Test2	63	41	69	Low Map	42	Worst HRP
Test3	134	47	71	Normal	74	Normal
Test4	115	67	69	Low Map	78	Normal
Test5	114	58	73	Normal	76	Normal
Test6	98	63	71	Normal	65	Low HRP
Test7	112	84	89	Normal	75	Normal
Test8	125	79	90	Normal	83	Normal
Test9	102	72	78	High MAP	68	High HRP
Test10	100	66	74	Normal	67	Low HRP
Test11	120	79	88	Normal	80	Normal
Test12	133	77	91	Normal	89	Normal
Test13	91	69	73	Low Map	61	Low HRP
Test14	114	72	82	Normal	76	Low HRP
Test15	107	52	66	High MAP	71	Normal
Test16	91	81	81	Low Map	61	Low HRP
Test17	90	62	68	Normal	60	Low HRP
Test18	84	83	80	Low Map	56	Worst HRP
Test19	92	75	77	Normal	61	Low HRP
Test20	108	69	74	Normal	72	Low HRP

Table 8: IIHS data generated on stage 2

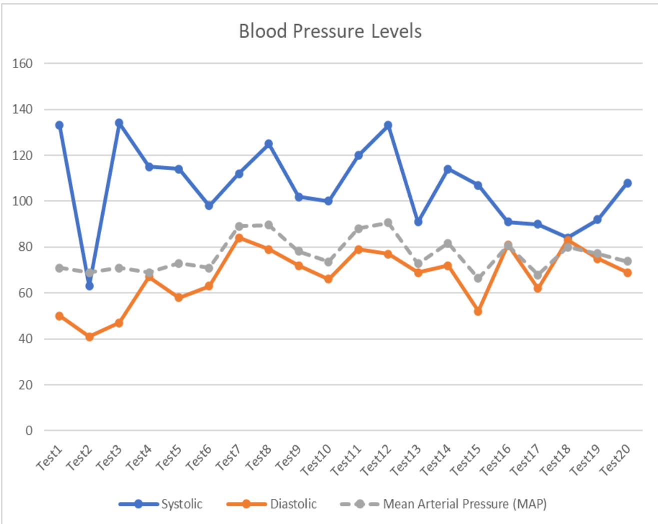


Figure37: Blood Pressure level chart (A)

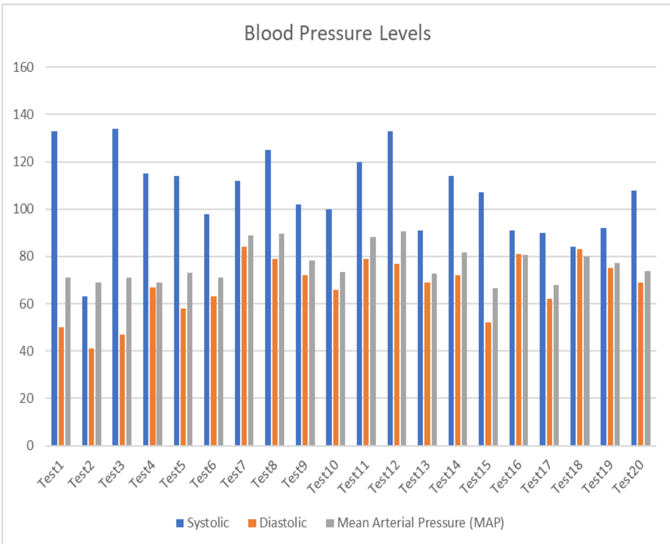


Figure38: Blood Pressure level chart (B)

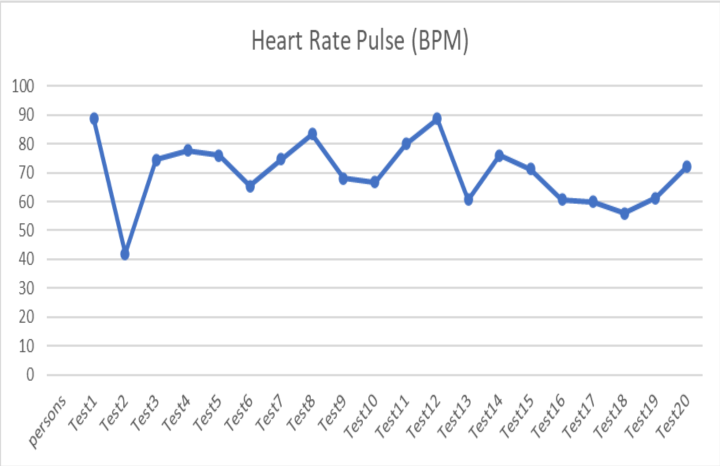


Figure39: Heart Rate Pulse (BPM) chart (A)

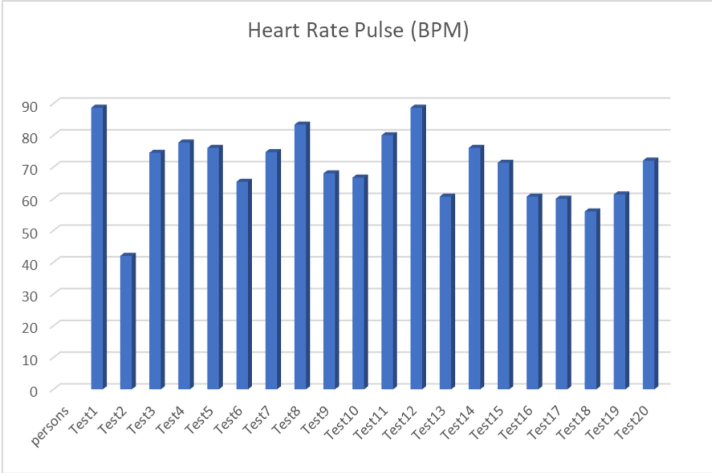


Figure40: Heart Rate Pulse (BPM) chart (B)

Stage 3: collecting data collected from Model IIHS.

Blood Pressure Levels				Heart Rate Pulse (BPM)		
persons	Target Blood Pressure Levels		Mean Arterial Pressure (MAP)	Statues	Heart Rate Pulse (BPM)	
	Systolic 120 mmHg	Diastolic 80 mmHg			60 – 100 HRP	Status
Test1	114	72	71	Normal	81	Normal
Test2	107	52	69	Low Map	78	Normal
Test3	98	81	71	Normal	76	Low HRP
Test4	90	62	69	Low Map	75	Low HRP
Test5	84	83	73	Normal	73	Low HRP
Test6	92	75	77	Normal	61	Low HRP
Test7	108	69	78	Normal	81	Normal
Test8	92	75	77	Normal	73	Low HRP
Test9	108	69	78	High MAP	72	Low HRP
Test10	107	52	66	Normal	71	Low HRP
Test11	98	81	83	Normal	64	Low HRP
Test12	90	62	68	Normal	60	Low HRP
Test13	84	83	80	Low Map	75	Low HRP
Test14	92	75	77	Normal	78	Low HRP
Test15	108	69	78	High MAP	72	Low HRP
Test16	92	85	84	Normal	61	Low HRP
Test17	133	45	70	Normal	89	Normal
Test18	101	73	78	Low Map	67	Low HRP
Test19	126	78	89	Normal	81	Low HRP
Test20	89	56	60	Normal	89	Normal

Table 9: IIHS data generated on stage 3

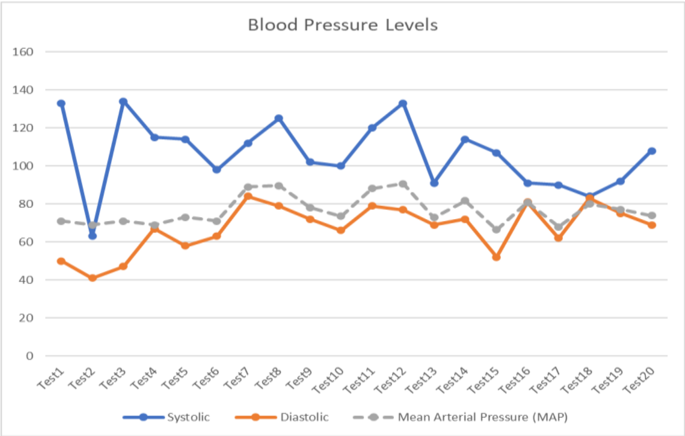


Figure41: Blood Pressure level chart (A)

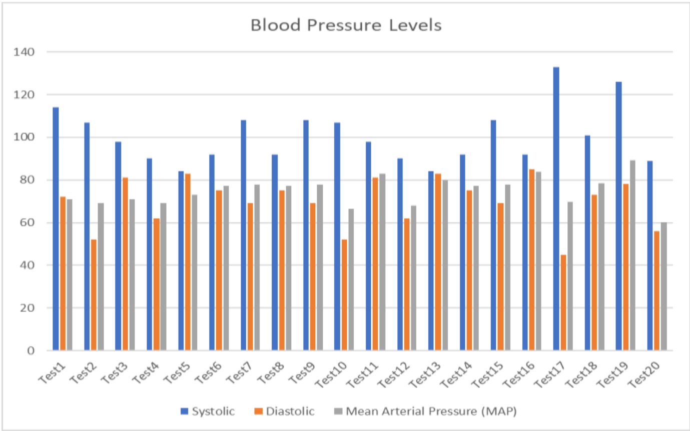


Figure42 : Blood Pressure level chart (B)

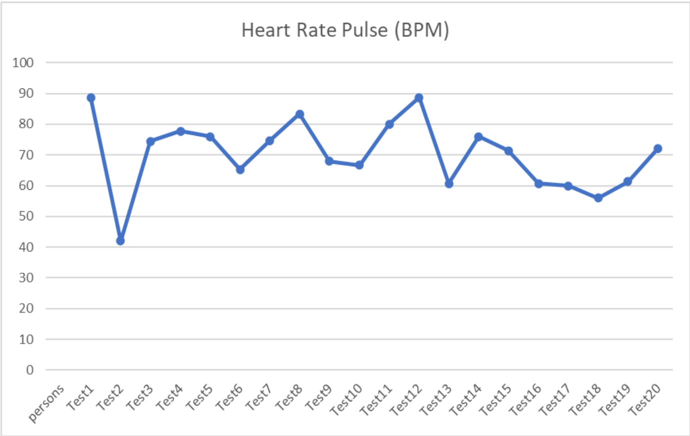


Figure43: Heart Rate Pulse (BPM) chart (A)

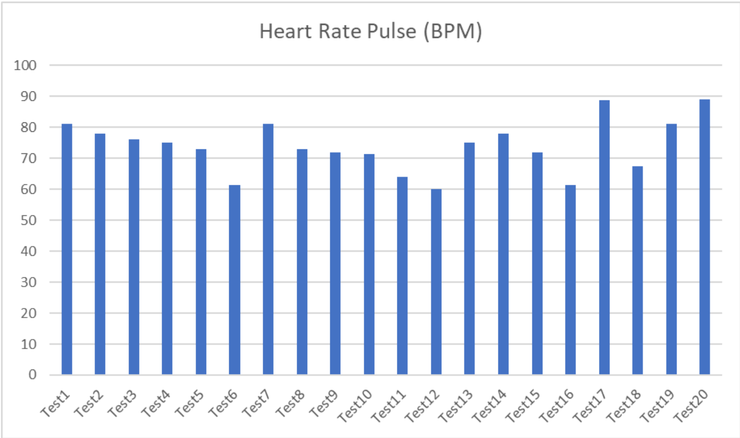


Figure44: Heart Rate Pulse (BPM) chart (B)

Chapter 6

Conclusion and Future Work

6.1 Introduction

This chapter aims to explain the field study's conclusion, recommendations, and future work.

6.2 Conclusion

The Internet of Things has played an important role in the field of health care and has provided many solutions for health care people from the elderly, people with special needs, and patients with chronic diseases, by monitoring health care through wearable devices or remote monitoring devices, and its use has increased recently with the emergence of the Corona pandemic, which helped reduce the spread of the epidemic through direct communication between both patients and doctors.

One of those chronic diseases is chlorine disease, an epidemic that is increasingly prevalent in conflicting countries through pollution or through the shortage of drinking water, which caused the death of many infected people during the past years [3], so the model provided to monitor cholera patients from entering into a dangerous situation that may lead to fulfillment by monitoring patients and monitoring the environment surrounding patients, the model proposed in this study provides checking the heartbeat(HB) through the heart rate sensor, and measuring the pressure Blood (PB) through the sensor MAX30100 as well as examining the environment surrounding patients, whether it is the intensive care rooms or the inpatient room, this model works by Arduino with the Proteus program through which the model was designed.

6.3 Future work

In the future, we can implement this model using less power and cost-effective devices such as LED, replacing the power supply with a rechargeable battery, and developing a smartphone API for real-time data analysis. Overall, our main goal of providing a simple, portable, and cost-effective heart rate and blood pressure measurement solution has been achieved for people with cholera from low- and middle-income countries such as Yemen.

Although the system looks rather bulky, it will be a small device with proper manufacturing in the near future.

You can add an application on mobile devices to monitor symptoms in real time, and you can also add a video-sharing feature for face-to-face consultation between doctors and patients. Some other measures that are very important to determine the patient's condition such as the appearance of other symptoms that differ from the serious symptoms of cholera, etc. can be treated as future work.

الخلاصة :

إنترنت الأشياء والتطبيقات الذكية هي نماذج سريع التطور يحول الحياة التقليدية إلى أسلوب عالي التقنية من خلال دمج الأجهزة والبرامج والأجهزة والحوسبة لتبادل البيانات والاتصالات. ويشمل ذلك الرعاية الصحية لذوي الاحتياجات الخاصة أو المصابين بأمراض مزمنة واحتياجاتهم من الرعاية والمراقبة عن بعد ، كما ان الحاجة الى مثل هذه الأنظمة في البلدان النامية التي تفتقر الى الموارد الطبية سيساهم في الحد من انتشار الأوبئة و سيساعد في تقليل الوفيات . إن إنترنت الأشياء و التطبيقات الذكية هي من المواضيع المثيرة للاهتمام في مجال أنظمة الرعاية الصحية. حيث توفر العديد من الخدمات الصحية التي تساعد على تحسين جودة الحياة ، من ناحية أخرى ، لا يزال إنترنت الأشياء يواجه العديد من التحديات والقضايا التي تحتاج إلى معالجة من أجل تحقيق إمكاناته الكاملة. ساهمنا في هذه الدراسة في إنشاء نموذج من أجل مراقبة المرضى المصابين بالكوليرا للحفاظ على حالتهم الصحية وعدم تفاقم حالتهم الصحية حتى تصل إلى الحالة الخطرة من خلال رصد الأعراض الخطيرة لمرض الكوليرا هناك العديد من الأعراض لمرض الكوليرا والتي يمكن تقسيمها إلى قسمين الأعراض الشائعة (الإسهال المائي ، الغثيان / القيء ، الجفاف) والأعراض الشديدة او الخطرة (انخفاض ضغط الدم وسرعة ضربات القلب) ، نعتمد في هذا النموذج على الأعراض الشديدة او الخطرة للكوليرا فقط (انخفاض ضغط الدم وسرعة ضربات القلب) التي تراقب المريض المصاب بالكوليرا تم تصميم هذا النموذج لمراقبة الحالة الصحية للمرضى من خلال مراقبة ضغط الدم، ونبضات القلب، وبما أن هذه الأعراض هي أعراض خطيرة للأشخاص المصابين بالكوليرا، يعمل هذا النموذج على مراقبة هذه الأعراض بشكل لحظي خلال طوال اليوم وارسال التقارير والتنبيهات للمراقبين كما يقوم هذا النموذج بفحص البيئة المحيطة بالمرضى من خلال فحص غاز الميثان أو غاز البترول المسال أو ثاني أكسيد الكربون والتنبيه إلى أن البيئة المحيطة صحية وغير ملوثة.

كما يعمل هذا النموذج على عرض النتائج من خلال وسائل العرض المختلفة مثل الشاشة، المحطة الافتراضية، راسم الذبذبات، ويمكن تطوير هذا النموذج مستقبلا لإرسال البيانات من خلال تطبيق أندرويد لإرسال النتائج الحرجة إلى الطبيب أو المستشفى أو إلى وزارة الصحة.

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[98] F. I. Ohana, 'IoT Based Health Monitoring System for Pregnant Women & Children', p. 139.

Appendices

Appendix A : Heart beat pulse code :

```
#define USE_ARDUINO_INTERRUPTS true    // Set-up low-level interrupts for most acurate BPM math.
#include <PulseSensorPlayground.h>     // Includes the PulseSensorPlayground Library.
//  Variables
const int PulseWire = 5;       // PulseSensor PURPLE WIRE connected to ANALOG PIN 0
const int LED13 = 13;          // The on-board Arduino LED, close to PIN 13.
int Threshold = 550;           // Determine which Signal to "count as a beat" and which to ignore.
                               // Use the "Gettting Started Project" to fine-tune Threshold Value beyond default setting.
                               // Otherwise leave the default "550" value.

PulseSensorPlayground pulseSensor;  // Creates an instance of the PulseSensorPlayground object called
"pulseSensor"
void setup() {
  Serial.begin(9600);          // For Serial Monitor
  // Configure the PulseSensor object, by assigning our variables to it.
  pulseSensor.analogInput(PulseWire);
  pulseSensor.blinkOnPulse(LED13);       //auto-magically blink Arduino's LED with heartbeat.
  pulseSensor.setThreshold(Threshold);
  // Double-check the "pulseSensor" object was created and "began" seeing a signal.
   if (pulseSensor.begin()) {
    Serial.println("We created a pulseSensor Object !");  //This prints one time at Arduino power-up,  or on
Arduino reset.
  }}
void loop() {
 int myBPM = pulseSensor.getBeatsPerMinute();  // Calls function on our pulseSensor object that returns
BPM as an "int".
                                               // "myBPM" hold this BPM value now.

if (pulseSensor.sawStartOfBeat()) {            // Constantly test to see if "a beat happened".
 Serial.println("♥  A HeartBeat Happened ! "); // If test is "true", print a message "a heartbeat happened".
 Serial.print("BPM: ");                        // Print phrase "BPM: "
 Serial.println(myBPM);                        // Print the value inside of myBPM.
}
  delay(20);                    // considered best practice in a simple sketch.
}
```

Appendix B :

Gas detection code:

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
#define MQPin A1
#define buzzer 1
const int PulseWire = 0;      // PulseSensor PURPLE WIRE connected to ANALOG PIN 0

const int LED13 = 13;         // The on-board Arduino LED, close to PIN 13.
int Threshold = 550;          // Determine which Signal to "count as a beat" and which to ignore.
                              // Use the "Gettting Started Project" to fine-tune Threshold Value beyond default
          void setup() {
  lcd.begin(16, 2);
  pinMode(MQPin, INPUT_PULLUP);
  pinMode(buzzer, OUTPUT);
   lcd.setCursor(5, 0);
   lcd.print("GAS");
   lcd.setCursor(3, 1);
   lcd.print("DETECTOR");
   delay(1000);
   lcd.clear();
 }}
void loop() {
 int gas_value = digitalRead(MQPin);
if(gas_value==HIGH)
{  digitalWrite(buzzer, HIGH);
 lcd.setCursor(6, 0);
 lcd.print("HEALTHY");
  lcd.setCursor(3, 1);
 lcd.print("ENVIROMENT");
 delay(200);
 lcd.clear();
 delay(200);
 }else{
lcd.clear();
digitalWrite(buzzer, LOW);
lcd.setCursor(6, 0);
```

```
 lcd.print("DIARTY");
  lcd.setCursor(3, 1);
 lcd.print("ENVIROMENT");
 delay(200);
 lcd.clear();
 delay(200);
}
}
```

Appendix C:

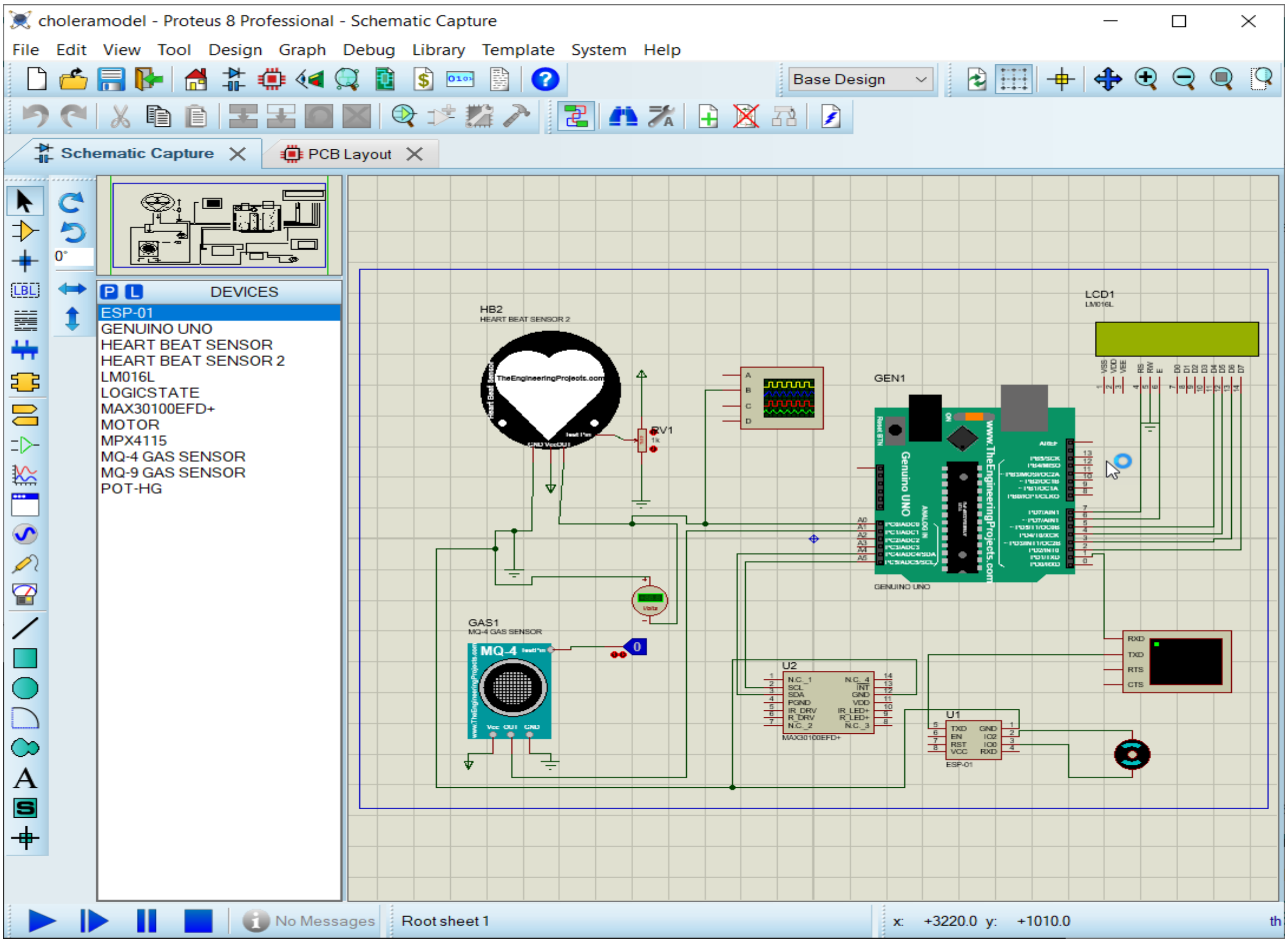
Max30100 code :

```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"

 #define REPORTING_PERIOD_MS 1000
     PulseOximeter pox;
    uint32_t tsLastReport = 0;
     void onBeatDetected()  {
        Serial.println("Beat!");
       }
      void setup()
      {  Serial.begin(9600);
       Serial.print("Initializing");
      Serial.print("Initializing pulse oximeter..");
 Serial.println("HeartRate , SpO2");
  if (!pox.begin())
    {  Serial.println("FAILED");
     for(;;);
} else { Serial.println("SUCCESS");
}
 pox.setOnBeatDetectedCallback(onBeatDetected);
    }
  void loop()  {
   pox.update();
  if (millis() - tsLastReport > REPORTING_PERIOD_MS)
 {
  Serial.print(",");
 Serial.print(pox.getHeartRate());
 // printing heart rate value in serial monitor
Serial.print(",");
Serial.print(pox.getSpO2()); // printing SpO2 value in serial monitor
Serial.println("%");
 tsLastReport = millis(); // readings taken at 1 second interval
}
 Serial.print("HR:");
  Serial.println(pox.getHeartRate());
```

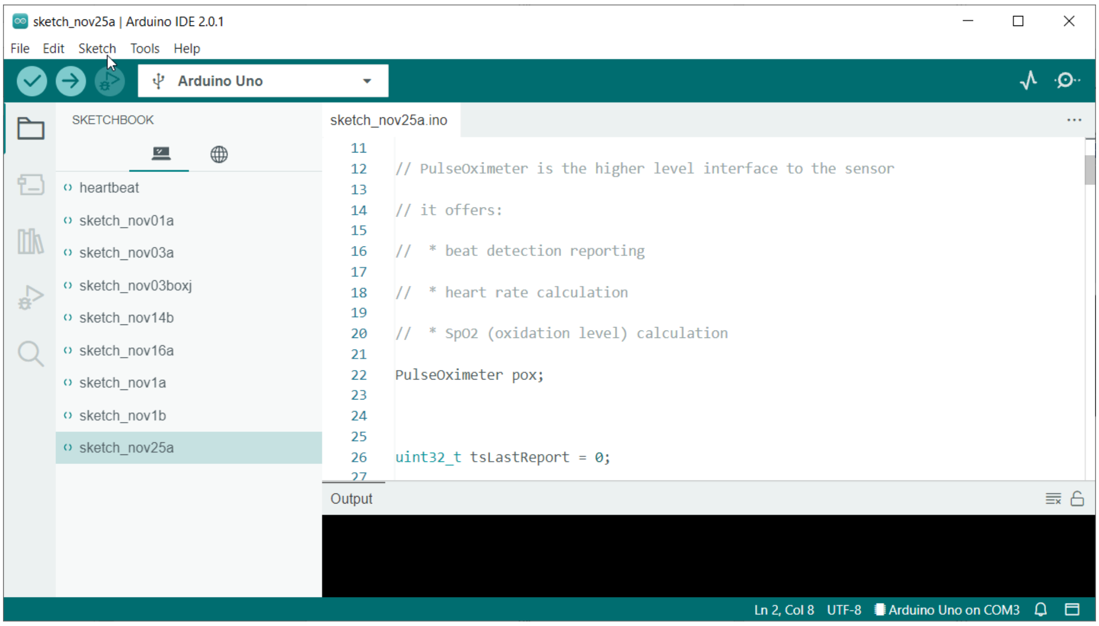
```
 Serial.print("SpO2:");
 Serial.print(pox.getSpO2());
delay(1000);
          }
```

Appendix C: Software

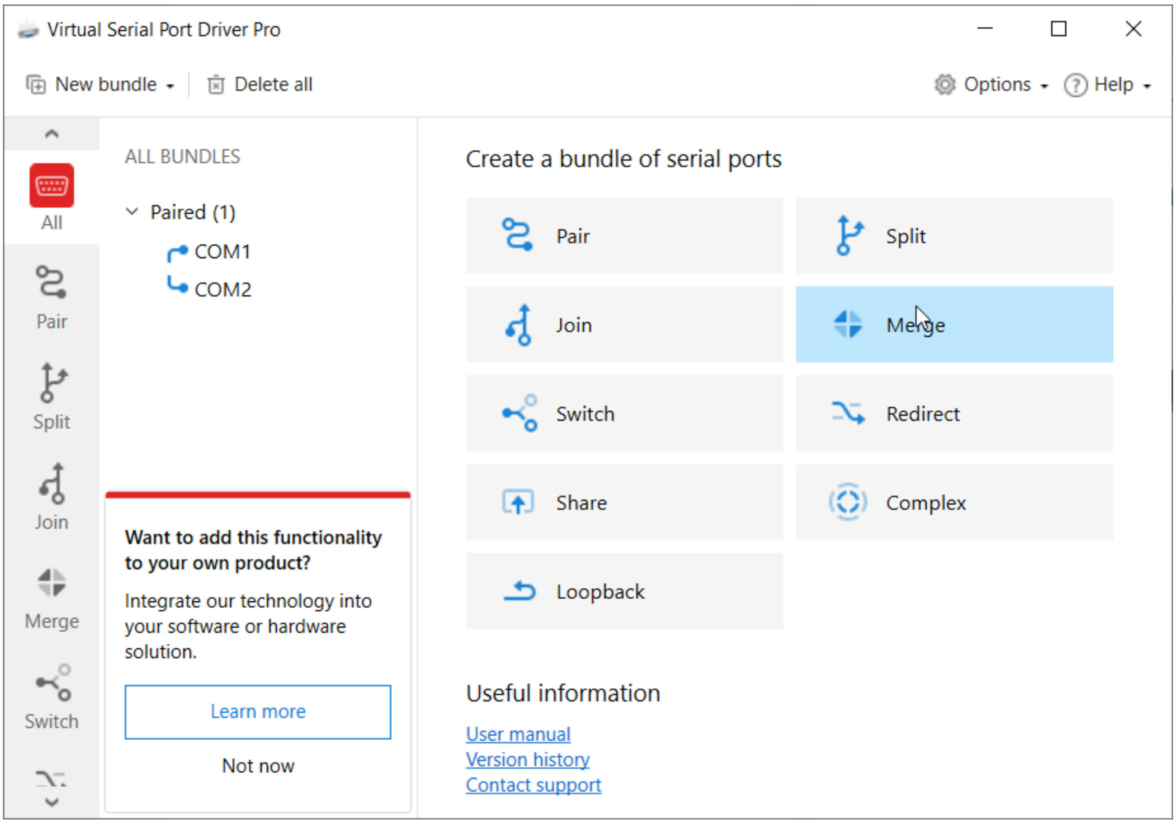
Porteus 8 provisional software :



Arduino IDE software :

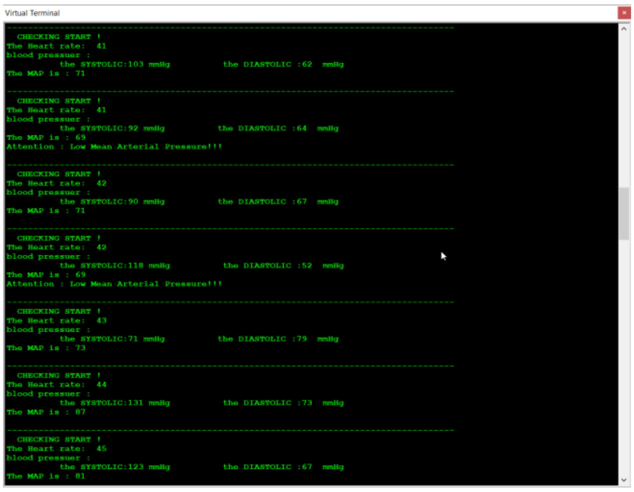


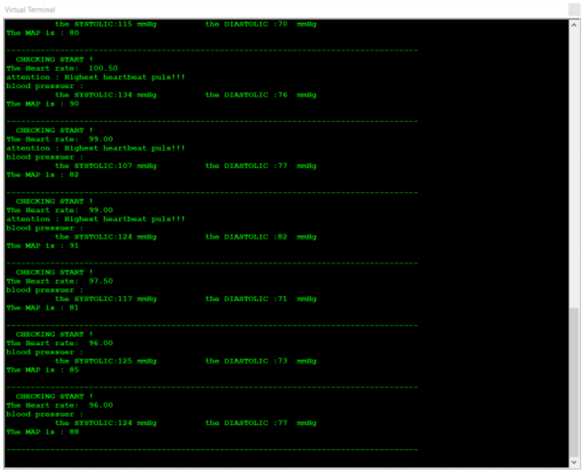
Virtual Serial Port Driver software:

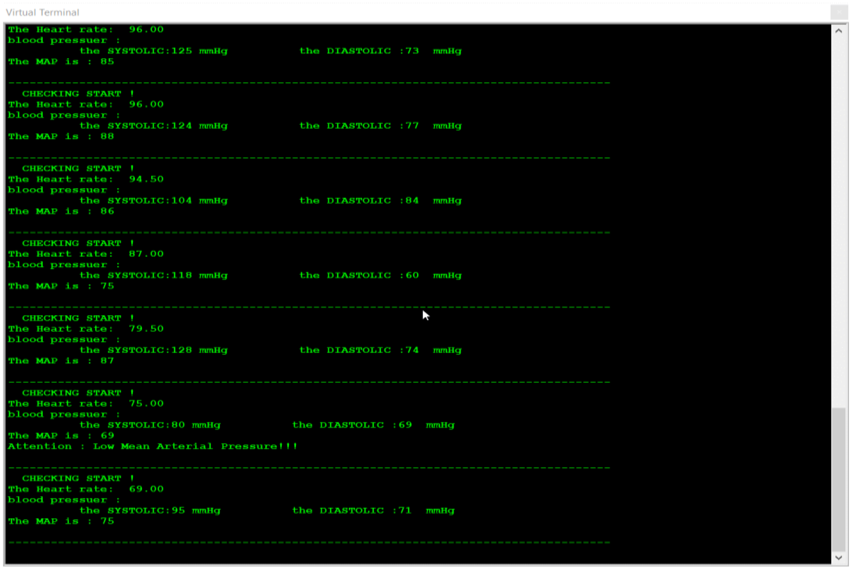


Appendix D:the data sets and collection

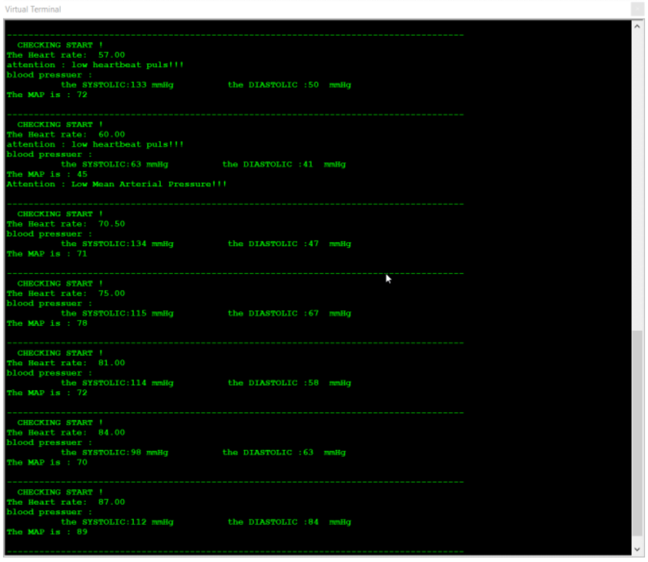
stage 1	Blood Pressure Levels						Heart Rate Pulse (BPM)			
persons	Target Blood Pressure Levels		Mean Arterial Pressure	Statuse	rmal Blood Pressure Lev		Heart Rate Pulse (BPM)	Statuse	ormal Heart Rate Leve	
	Systolic	Diastolic			Systolic	Diastolic			Low	High
	120 mmHg	80 mmHg								
Test1	103	62	71	Normal	120 mmHg	80 mmHg	69	Normal	60 HRP	100 HRP
Test2	92	64	69	Low Map			61	Normal		
Test3	90	67	71	Normal			60	Normal		
Test4	118	52	69	Low Map			79	Normal		
Test5	71	79	73	Normal			47	worst HRP		
Test6	131	73	87	Normal			87	Normal		
Test7	123	67	81	Normal			82	Normal		
Test8	124	77	88	Normal			83	Normal		
Test9	140	88	100	High MAP			93	High HRP		
Test10	118	60	75	Normal			79	Normal		
Test11	128	74	87	Normal			85	Normal		
Test12	95	74	77	Normal			63	Low HRP		
Test13	93	54	64	Low Map			62	Low HRP		
Test14	98	70	76	Normal			65	Low HRP		
Test15	140	84	97	High MAP			93	Normal		
Test16	128	80	91	Normal			85	Normal		
Test17	105	69	77	Normal			70	Normal		
Test18	81	69	70	Low Map			54	worst HRP		
Test19	93	80	81	Normal			62	Low HRP		
Test20	104	84	82	Normal			69	Normal		





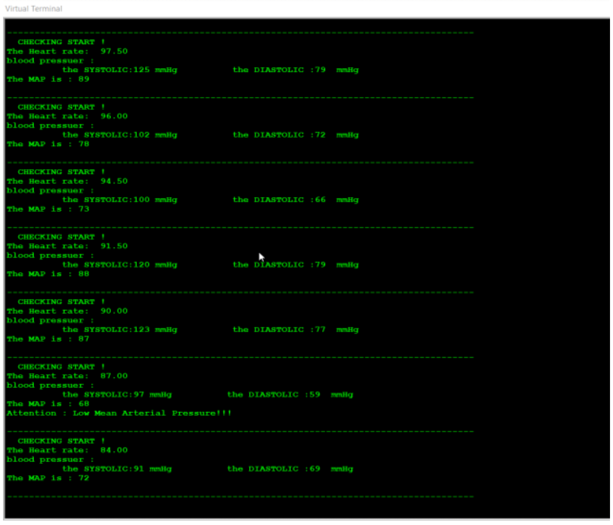


51	Stage 2	Blood Pressure Levels							Heart Rate Pulse (BPM)			
52		persons	Target Blood Pressure Levels		Mean Arterial Pressu	Statuse	rmal Blood Pressure Lev		Heart Rate Pulse (BPM)	Statuse	ormal Heart Rate Leve	
53			Systolic	Diastolic			Systolic	Diastolic			Low	High
54			120 mmHg	80 mmHg								
55		Test1	133	50	73	Normal			89	Normal		
56		Test2	63	41	46	worst MAP			42	worst HRP		
57		Test3	134	47	71	Normal			74	Normal		
58		Test4	115	67	79	Low MAP			78	Normal		
59		Test5	114	58	72	Low MAP			76	Normal		
60		Test6	98	63	71	Low MAP			65	Low HRP		
61		Test7	112	84	89	Normal			75	Normal		
62		Test8	125	79	90	Normal			83	Normal		
63		Test9	102	72	78	Low MAP			68	High HRP		
64		Test10	100	66	74	Low MAP	120 mmHg	80 mmHg	67	Low HRP	60 HRP	100 HRP
65		Test11	120	79	88	High MAP			80	Normal		
66		Test12	133	77	91	High MAP			89	Normal		
67		Test13	91	69	73	Low Map			61	Low HRP		
68		Test14	114	72	82	Normal			76	Low HRP		
69		Test15	107	52	66	Low MAP			71	Normal		
70		Test16	91	81	81	Normal			61	Low HRP		
71		Test17	90	62	68	Low MAP			60	Low HRP		
72		Test18	84	83	80	Low Map			56	worst HRP		
73		Test19	92	75	77	Normal			61	Low HRP		
74		Test20	108	69	78	Normal			72	Low HRP		



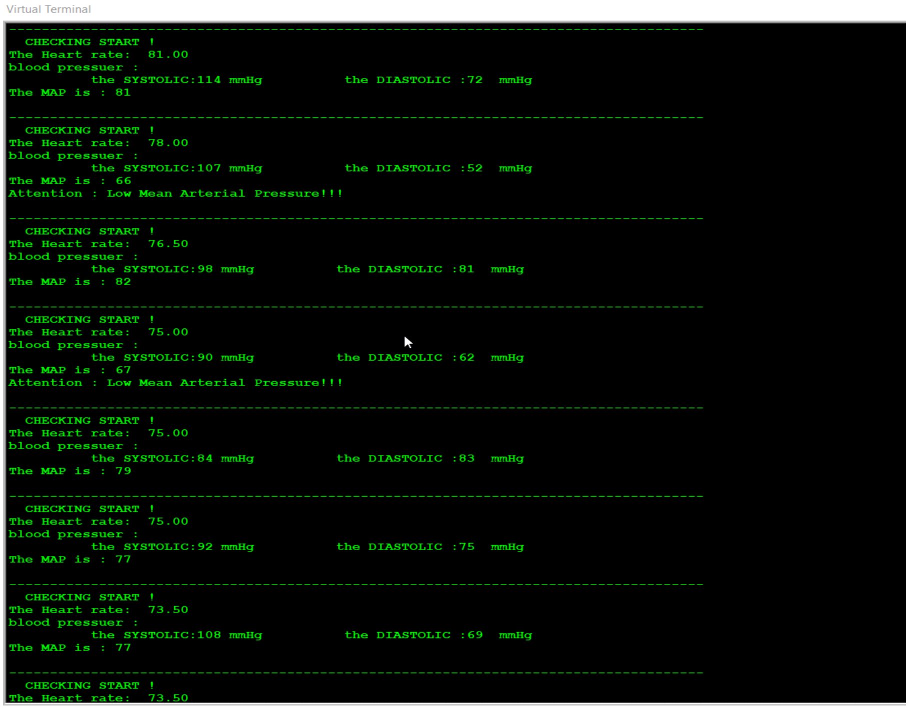
Virtual Terminal

```
  CHECKING START !
The Heart rate:  57.00
attention : low heartbeat puls!!!
blood pressuer :
          the SYSTOLIC:133 mmHg          the DIASTOLIC :50  mmHg
The MAP is : 72

  CHECKING START !
The Heart rate:  60.00
attention : low heartbeat puls!!!
blood pressuer :
          the SYSTOLIC:63 mmHg          the DIASTOLIC :41  mmHg
The MAP is : 45
Attention : Low Mean Arterial Pressure!!!

  CHECKING START !
The Heart rate:  70.50
blood pressuer :
          the SYSTOLIC:134 mmHg          the DIASTOLIC :47  mmHg
The MAP is : 71

  CHECKING START !
The Heart rate:  75.00
blood pressuer :
          the SYSTOLIC:115 mmHg          the DIASTOLIC :67  mmHg
The MAP is : 78

  CHECKING START !
The Heart rate:  81.00
blood pressuer :
          the SYSTOLIC:114 mmHg          the DIASTOLIC :58  mmHg
The MAP is : 72

  CHECKING START !
The Heart rate:  84.00
blood pressuer :
          the SYSTOLIC:98 mmHg          the DIASTOLIC :63  mmHg
The MAP is : 70

  CHECKING START !
The Heart rate:  87.00
blood pressuer :
          the SYSTOLIC:112 mmHg          the DIASTOLIC :84  mmHg
The MAP is : 89
```



Virtual Terminal

```
  CHECKING START !
The Heart rate:  97.50
blood pressuer :
          the SYSTOLIC:125 mmHg          the DIASTOLIC :79  mmHg
The MAP is : 89

  CHECKING START !
The Heart rate:  96.00
blood pressuer :
          the SYSTOLIC:102 mmHg          the DIASTOLIC :72  mmHg
The MAP is : 78

  CHECKING START !
The Heart rate:  94.50
blood pressuer :
          the SYSTOLIC:100 mmHg          the DIASTOLIC :66  mmHg
The MAP is : 73

  CHECKING START !
The Heart rate:  91.50
blood pressuer :
          the SYSTOLIC:120 mmHg          the DIASTOLIC :79  mmHg
The MAP is : 88

  CHECKING START !
The Heart rate:  90.00
blood pressuer :
          the SYSTOLIC:123 mmHg          the DIASTOLIC :77  mmHg
The MAP is : 87

  CHECKING START !
The Heart rate:  87.00
blood pressuer :
          the SYSTOLIC:97 mmHg          the DIASTOLIC :59  mmHg
The MAP is : 68
Attention : Low Mean Arterial Pressure!!!

  CHECKING START !
The Heart rate:  84.00
blood pressuer :
          the SYSTOLIC:91 mmHg          the DIASTOLIC :69  mmHg
The MAP is : 72
```



Virtual Terminal

```
  CHECKING START !
The Heart rate:  81.00
blood pressuer :
          the SYSTOLIC:114 mmHg          the DIASTOLIC :72  mmHg
The MAP is : 81

  CHECKING START !
The Heart rate:  78.00
blood pressuer :
          the SYSTOLIC:107 mmHg          the DIASTOLIC :52  mmHg
The MAP is : 66
Attention : Low Mean Arterial Pressure!!!

  CHECKING START !
The Heart rate:  76.50
blood pressuer :
          the SYSTOLIC:98 mmHg          the DIASTOLIC :81  mmHg
The MAP is : 82

  CHECKING START !
The Heart rate:  75.00
blood pressuer :
          the SYSTOLIC:90 mmHg          the DIASTOLIC :62  mmHg
The MAP is : 67
Attention : Low Mean Arterial Pressure!!!

  CHECKING START !
The Heart rate:  75.00
blood pressuer :
          the SYSTOLIC:84 mmHg          the DIASTOLIC :83  mmHg
The MAP is : 79

  CHECKING START !
The Heart rate:  75.00
blood pressuer :
          the SYSTOLIC:92 mmHg          the DIASTOLIC :75  mmHg
The MAP is : 77

  CHECKING START !
The Heart rate:  73.50
blood pressuer :
          the SYSTOLIC:108 mmHg          the DIASTOLIC :69  mmHg
The MAP is : 77

  CHECKING START !
The Heart rate:  73.50
```

Appendices

Stage 3	Blood Pressure Levels							Heart Rate Pulse (BPM)			
	persons	Target Blood Pressure Levels		Mean Arterial Pressure	Statuse	Normal Blood Pressure Levels		Heart Rate Pulse (BPM)	Statuse	Normal Heart Rate Levels	
		Systolic	Diastolic			Systolic	Diastolic			Low	High
		120 mmHg	80 mmHg			120 mmHg	80 mmHg			60 HRP	100 HRP
	Test1	114	72	77	Normal			81	Normal		
	Test2	107	52	66	Low Map			78	Normal		
	Test3	98	81	83	Normal			76	Low HRP		
	Test4	90	62	68	Low Map			75	Low HRP		
	Test5	84	83	80	Normal			73	Low HRP		
	Test6	92	75	77	Low Map			61	Low HRP		
	Test7	108	69	78	Low Map			81	Normal		
	Test8	92	75	77	Low Map			73	Low HRP		
	Test9	108	69	78	Low Map			72	Low HRP		
	Test10	107	52	66	Low Map			71	Low HRP		
	Test11	98	81	83	Normal			64	Low HRP		
	Test12	90	62	68	Low Map			60	Low HRP		
	Test13	84	83	80	Low Map			75	Low HRP		
	Test14	92	75	77	Low Map			78	Low HRP		
	Test15	108	69	78	Low Map			72	Low HRP		
	Test16	92	85	84	Normal			61	Low HRP		
	Test17	133	45	70	Low Map			89	Normal		
	Test18	101	73	78	Low Map			67	Low HRP		
	Test19	126	78	89	Normal			81	Low HRP		
	Test20	89	56	64	Low Map			89	Normal