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COMATOSE PATIENT MONITORING SYSTEM USING (IOT)

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Master's Thesis

Supervisor

Asst. Prof. Dr. Mesut ÇEVİK

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DEDICATION

All appreciation to my family, they supported and encouraged me a lot, also my deep love for my faithful wife for her patience and great moral and psychological support. I cannot describe how grateful I am to you and the great role you played in my scientific and academic success. Thanks to your endless support and patience, I was finally able to Successful completion and submission a master's thesis. I know that success would not be possible without you. You have been my support throughout this long journey which has been an amazing and valuable experience. I am so proud and grateful that I come from a wonderful family full of love and dedication. I could not be happier without having you by my side, and I promise I will strive to make you proud of me in the future.

PREFACE

First, I thank God Almighty for His grace and generosity, as He made it possible for me to accomplish this work with His grace and success, so praise be to God first and foremost.

To Altınbaş University

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ABSTRACT

COMATOSE PATIENT MONITORING SYSTEM USING (IOT)

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Coma-patient monitoring is a critical aspect of healthcare, as patients in comatose states require constant monitoring and care, lately, IoT has shown as a promising technology for healthcare applications, offering the potential to improve the accuracy and efficiency of patient monitoring, In this study, we suggest an (IoT) based coma patient monitoring system, which utilizes wearable sensors and wireless communication to collect and transmit real-time data on the patient's vital signs, movements, and also others. The system incorporates data analytics, artificial intelligence, and machine learning algorithms to analyze the collected data and provide healthcare professionals with mentionable insights into the state of the patient, The system also utilizes cloud computing and telemedicine technologies to enable remote monitoring and consultation, reducing the need for on-site healthcare professionals, We feel that our suggested method has the potential to dramatically enhance coma patients' quality of care.

Keywords: (IoT) System, Arduino ESP32, Raspberry Pi4, Python, Image Processing**,** Webcam, Cloud Computing Platforms**.**

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ABBREVIATIONS

AI	:	Artificial Intelligence
IoT	:	Internet of Things
IoMT	:	The Internet of Medical Things
MCU	:	Microcontroller Unit
ECG	:	Electrocardiogram
MTCNN	:	Multi-Task Cascaded Convolution Networks
AWS	:	Amazon Web Service
CLMs	:	Constrained Local Models
A(SMS)	:	Active Shape Models
SVMs	:	Support Vector Machines
GCP	:	Google Cloud Platforms
IaaS	:	Infrastructure as a Service
PaaS	:	Platform as a Service
SaaS	:	Software as a Service
CRM	:	Customer Relationship Management

1. INTRODUCTION

1.1 COMA

A coma is a medical condition in which a person is in a prolonged state of unconsciousness. It is typically caused by a severe injury to the brain or by a medical condition that affects the brain, such as a stroke or a brain tumor. During a coma, a person is unable to respond to stimuli or communicate with others, and their brain activity is greatly reduced, Comas can last for a few days to several weeks or months, The duration of a coma can fluctuate based on the etiology and gravity of the injury or ailment [1]. A Coma and (IoT) may seem like an unlikely combination at first, but the truth is that (IoT) technology has an important role in the way we care for coma patients. Using (IoT) devices, doctors and nurses can monitor a patient's vital signs by connecting contact and non-contact sensors to the patient's body, such as heart rate, blood pressure, oxygen levels, and blood sugar, in real-time without having to be in the same room with the patient, This technology can also be used to track a patient's movements and adjust their position to prevent bedsores or other complications [2]. (IoT) sensors can also detect if a patient is trying to get out of bed, which can alert medical staff to prevent falls or other accidents. In addition, the Internet of Things can be used to provide a more comfortable and relaxing environment for coma patients. Smart lighting, temperature control, and sound systems can be set to create a calmer atmosphere, which can promote healing and reduce stress [3]. In conclusion, The integration of Internet of Things (IoT) technology in the management of comatose patients holds promise for substantially enhancing patient outcomes and elevating the overall standard of care delivered [4].

A coma patient monitoring system that uses image processing will provide high-quality health care in the future, To make medical monitoring easier and more thorough in large hospitals, where it's hard for staff to keep an eye on each patient is seen 24 hours a day, seven days a week [5]. The Intensive Care Unit (ICU), the Critical Care Unit (CCU), and hospital emergency rooms can all use the latest technology in their patient monitoring systems [6]. During treatment, the patient monitor keeps an eye on the unconscious patient and sends important information to the doctor; in an emergency, the doctor can also use the information. Monitoring a patient's condition efficiently saves time and effort and makes the healthcare system more effective [7]. This project uses the "Image Processing-Based Coma Patient Monitoring System" to look at the basic signs that show up in a coma patient, it does this by watching the patient's face with a digital camera and focusing on eye movement, which is thought to be one of the most important signs [8]. Eye movement is when the eyes are opened and closed, which is used to evaluate the health of comatose and unconscious patients [9]. The patient's eye movement is tracked by sending a red text alert message to the (LCD) monitor when the patient's eyes are opened, which is a good sign that the patient is coming out of his coma, or it constantly sends an alert text message to the person being watched from anywhere in the world through the cloud system.

1.2 MACHINE LEARNING TO IMPROVE COMATOSE PATIENT OUTCOMES

Machine learning is a branch of artificial intelligence that focuses on building algorithms that can learn and improve from experience, He has the potential to transform the field of medicine by providing insights and predictions that can help improve patient outcomes, Machine learning algorithms can be trained on data from comatose patients to predict their chances of recovery. This can be done by feeding the algorithm data about the patient's age, gender, medical history, and duration of coma [10]. The algorithm can then use this data to predict a patient's chances of recovery, Machine learning algorithms can also be used to monitor coma patients and detect any signs of improvement or worsening, This can be done by analyzing data from various sources such as EEG readings, blood pressure, and heart rate as well as observing the patient's eyes using facial expressions [11]. Machine learning algorithms can also be used to recommend treatments for comatose patients. This can be done by analyzing data from previous cases and recommending treatments that have been effective in similar cases [12]. Machine learning has the potential to transform the field of medicine by providing insights and predictions that can improve patient outcomes. In the case of comatose patients, machine learning can be used to predict recovery, monitor patients, and recommend treatments, While we are looking forward to find more researches but future looks promising for the use of machine learning in improving the outcomes of comatose patients [13].

1.3 PROBLEM STATEMENT

Recently, there have been major health problems in the presence of the number of observers from the health and medical staff in the intensive care unit resuscitation room, in addition to the increase in the number of the patient’s companions or visitors, which leads to instability of the patient’s health status or negatively affects the patient’s recovery and his response to treatment and medical care, as well as to reduce The rapid spread of communicable and respiratory diseases among patients and medical staff, especially after the emergence of the (covid19) pandemic, so there was a need to build an advanced monitoring system for coma patients based on IOT and artificial intelligence, The problem statement is to design and develop a monitoring system for patients in a coma. Coma patients need constant monitoring of their vital signs and other physiological parameters to ensure their safety and well-being. Traditional monitoring methods can be time-consuming and require frequent manual checks by healthcare professionals, Therefore, there is a need for a real-time monitoring system to continuously track a patient's vital signs and alert healthcare providers in the event of any health problem or development, The monitoring system must be non-invasive, accurate, and easy to use, it is able to monitor parameters such as heart rate, blood pressure, respiratory rate, oxygen saturation, and temperature, The system should also have the ability to track a patient's brain activity, detect any changes in the level of consciousness, and monitor the patient's facial and eye movements, The system should provide real-time data to healthcare professionals and alert them with warning messages in case of any abnormalities or emergencies, Alerts should be customizable and can be sent to different monitoring devices such as smartphones, tablets or pagers, to ensure a quick response.

1.4 THE MESSAGE OBJECTIVES

a. The objective of the comatose patient monitoring system is the continuous monitoring of the vital signs and neurological status of patients who are comatose or unconscious. The system is designed to alert medical staff if there are any changes in a patient's condition that could indicate life-threatening complications.
b. Building and designing a health system to monitor a coma patient until recovery, based on the Internet of Things and artificial intelligence.

c. Develop a reliable and effective monitoring system that can provide accurate and continuous data on the patient's vital signs and brain activity while he is in a coma in the intensive care room.

d. Employing the latest artificial intelligence techniques in addition to the Internet of Things (IoT) and advanced sensors to follow up on the coma patient's condition.

e. Access to health and medical distancing between patients and the supervised medical staff and to protect patients from the spread of communicable diseases.

2. LITERURE REIVEW

2.1 INTRODUCTION

In this chapter, we present a review of many research studies of previous years on the same topic, which aims to review scientific papers related to our research on monitoring coma patients based on the (IoT) and artificial intelligence, to obtain a scientific understanding of the problems in previous scientific research and find a solution to them and learn more in This topic, where many researches tried to solve this issue as well as identify gaps that require further investigation, where we will explain a comprehensive summary of previous studies by researchers and the ways used to monitor coma patients.

2.2 LITERURE REIVEW

In this study, we present a coma monitoring system based on (GSM) and (IoT), Vital data such as heart rate, eye gaze, accelerometer, and temperature are monitored and saved in the cloud in the suggested system, The suggested system analyses the parameter values, If these values are abnormal, the (GSM) module will send an (SMS) message to the phone number supplied [14]. The purpose of this study is to demonstrate continuous monitoring and recording of patient data in the absence of any human intervention, If any sudden changes occur in the normal range of body parameters, such as a drop in body temperature or a rise in body temperature, or an increase in blood pressure (B.P.), causing high or low (B.P), where both are not stable conditions for better health, then it can automatically alert the medical person, This is for the patient's protection, The objective of our proposed system is to create a design that facilitates the rapid transmission of vital patient information to the doctor, The designed model leads to improved and more effective healthcare services for the comatose [15].

(IoT)-based smart health monitoring systems can monitor patients 24/7,The (IoT) is transforming technology infrastructure, (IoT) makes it easy to implement complex systems like smart home appliances, smart traffic control systems, smart office systems, smart environments, smart vehicles, and smart temperature control systems in a small space, (IoT)'s health monitoring systems are notable , (IoT) health monitoring uses several designs and patterns, This study reviews (IoT)-based smart health monitoring solutions, Discussed are the latest (IoT)-based smart health monitoring system technologies and their pros and cons, This research highlights common design and implementation patterns of intelligent (IoT)-based patient health monitoring devices [16].

The Internet of Things (IoT) is a new technology that is growing quickly, all smart objects and smart gadgets are connected to the internet so that they can talk to each other, The Internet of Things is a driving force in healthcare and a very important part of a wide range of applications for tracking healthcare, Networked monitors that are worn on the body or built into homes can collect a lot of information about a person's physical and mental health, For example, they can measure the body's temperature, blood pressure, sugar level, and other things, The hardest part of the Internet of Things is getting this information to the doctor, making good decisions based on the information, and telling the patient, In this paper, the author focuses on a review of the (IoT)-based healthcare system and talks about the opportunities and problems that come with it [17].

Smart gadgets that are powered by the Internet of Things (IoT) are transforming human existence by facilitating the making of more informed decisions and providing users with responses based on an analysis of the data they provide, Patients require continual care and unbroken monitoring, in addition to meeting the requirements of other elements of life, The feasibility of real-time monitoring of patients' health issues is made possible by the Internet of Things. Specifically, health monitoring systems based on the Internet of Things offer an efficient option for patients and their physicians. The development of a soft real-time health monitoring system, based on an android application and a web-based monitoring portal, is the focus of this research, with a particular emphasis on comatose patients., a physician can keep track of their patient's conditions by using the newly devised method, a Raspberry Pi microcontroller and other sensors pertaining to health were utilized in the creation of the system, Using sensors, the system is able to gather information such as the rate of the heartbeat, blood pressure, the amount of urine present, the temperature, the humidity, and the detection of motion. It will notify the doctor if any parameter goes over the acceptable range, In addition to that, it refreshes the status of the database as well as the application that was constructed, Using Internet of Things technology, the suggested system is able to successfully monitor the patient's health status in real-time, even if the patient is unconscious [18].

Once comatose, a patient's recovery is hard to predict, It could take days, weeks, months, or years, This presents a challenge for hospital personnel in terms of patient monitoring, as subtle bodily movements, realistic physiological indicators, or unusual behavior may evade detection, The suggested technology uses many wearable sensors on the patient to prevent this, Flex, MEMS, accelerometer, heartbeat, (SPO2) oximeter, temperature, and IR goggles sensors are used, The sensors are utilized to observe the vital signs of the patient and subsequently record the information on a cloud-based server, which can be accessed through personal computers or smartphones, The parameters are put on a graph and analyzed to estimate the patient's recovery possibilities[19].

Monitoring patients in a state of unconsciousness or coma is essential for learning more about their health, and movement detection owing to bodily changes is a powerful technique for doing so, The goal of this system is to provide constant monitoring in cases where it is necessary to keep tabs on vitals like a patient's heart rate, body temperature, and other indicators of health in order to provide the best care possible, Consciousness is tracked by tracking eye movement and body motion observed by wearing motion sensors, It aids medical professionals in keeping tabs on their patients' health and providing timely warnings when necessary, When the system detects that the patient's vital signs are out of the normal range, it will issue a warning to the attending physician, all of this data is transmitted wirelessly over the Internet of Things and shown on The computer and screen are utilized to promptly detect any unforeseen alterations in the patient's state [20].

Since the new coronavirus came out, every country now gives healthcare a lot of attention, So, from this point of view, an (IoT)-based health tracking system is the best way to deal with an epidemic lie this, The Internet of Things (IoT) represents the most recent transformation of the Internet, It is a growing area of study, especially in health care, With more people using smartphones and wearable sensors, remote healthcare tracking has changed so quickly, (IoT) tracking of health helps stop the spread of disease and get an accurate diagnosis of a person's health, even if the doctor is far away, in this study, a portable physiological checking framework is shown that can constantly check the patient's heartbeat, temperature, and other basic room parameters. We came up with an idea for a device that would keep an eye on a patient's health and store information about the patient on a server using Wi-Fi modules for remote communication, The concept of a remote health monitoring system is developed using the (IoT), Only authorized people can access the stored data using any (IoT) platform, and doctors can identify diseases based on the values they get [21].

Comatose patients benefit from faster response times thanks to the internet and improved communication because of the data obtained through the model's implementation, The Internet of Medical Things (IoMT) industry covers a wide range of smart devices, from those worn by patients to those used in hospitals, as well as the accompanying real-time location, telehealth, and other services, Thus, a doctor can use these tools to perform a thorough examination of a patient anywhere, at any time, The suggested system includes sensors to track vital signs like blood pressure and temperature, Comatose patients can be monitored for movement using movement sensors and eye blink sensors, a urine level is detected using an ultrasonic sensor, The developed solution is also patient-friendly in terms of cos [22].

The fact that health is regarded as one of individuals' fundamental rights demonstrates the significance of health care in society, Other (IoT) advancements for our safety include wearables, surgical robotics, and the integration of (AI), (AR), (ML), and big data with (IoT), We provide a new approach for collecting data on numerous health parameters such as pulse rate, body temperature, movement, eye blink, and so on in this work. We also highlighted the literature review that compared various solutions for resolving health-related issues using (IoT), We developed a system that uses the (IoT) platform "Thing Speak" to remotely monitor the coma patient, The repercussions include the guardian constantly monitoring the patient via the system, As a result, clinical personnel or accompanying individuals are not required to be physically present to care for the patient because a (GSM) module transmits (SMS) to the doctor and caretaker [23].

The Internet of Things (IoT) is a massive chapter of unique, social, and economic well-being assistance, (IoT) includes a variety of industries, such as medical situations, the environment, autos, manufacturing organizations, and so on, this healthcare (IoT) interface's basic technique for coma patients, a (DSNDV) Dynamic Service Non-Dependency Verification is now performed using (IoT), The key purpose of (IoT) is to put up an online application for coma patients to interact with a web server in a proven fashion, The proposed system employs heterogeneity between a sensor hub and an Internet hub, and this design is indefinite in the face of various conditions [24].

The Internet of Things and machine learning have the potential to usher in a new age in healthcare, The introduction of transformational technologies such as implantable and wearable medical devices (IWMDs) has made it possible to collect and analyze physiological signals from anybody, anywhere, at any time, Machine learning enables us to detect patterns in this information and generate healthcare predictions in both routine and clinical settings, this expands the scope of healthcare from traditional clinical settings to widespread everyday circumstances and from passive data collection to active decision-making, This project, an Internet-of-Things-Based Monitoring System for Comatose Patients, is a functioning model that includes sensors that measure body temperature, pulse rate, and movement, A microcontroller board analyzes the patient's inputs, and any irregularity detected by the monitoring system triggers an alarm, In addition, all process parameters are logged online within a user-selectable interval, This is extremely beneficial for future analysis and assessment of a patient's health status[25].

The Internet of Things (IoT) is essential in the healthcare industry, it is possible to connect medical devices to monitor biological signals and diagnose patients' illnesses without the need for human interaction, This is referred to as the "Internet of Medical Things" (IoMT), This article provides an overview of (IoT)-based remote healthcare, edible sensor tracking, mobile health, smart hospitals, and improved health management, The Internet of Medical Things (IoMT) Healthcare Monitoring System is designed to monitor a wide variety of patient health metrics and analyze and diagnose data in the patient monitoring system effortlessly and concurrently, Doctors can use the proposed system to monitor patients while they are receiving care, whether at home or in a hospital, To measure the two vital signs to be detected, this system includes a temperature sensor and a heart rate sensor [26].

A coma is an unconscious state in which a patient is unable to speak or move, these patients need immediate attention and close monitoring, We offer a system that continuously records and monitors patient data without the need for human interaction, it will automatically transmit notification if there are any abrupt changes in the range of typical bodily parameters, such as a rise or fall in body temperature or a decrease or increase in heart rate, A doctor and a caregiver can monitor a patient's condition by logging into the (IoT) Cayenne app, The primary goal of this project is to establish and construct a dependable patient monitoring system capable of transmitting real-time patient data, The patient's parameters are continuously measured via heartbeat, temperature, eye blink, urine level, conductivity, accelerometer sensor, and relayed over (IoT) and notified via call and (SMS) via (GSM) [27].

Coma can be divided into two stages: vegetative state (VS) and minimally highly aware state (MCS), (VS) is different from (MCS) in that there are no signs of awareness, The record of the comatose transition from (VS to MCS) is not kept well, In the gift hospital, a caretaker is needed to always watch the patient, Human mistakes make these kinds of supervision more dangerous, This effect can be avoided by using the planned system, which focuses on observation and notifying the guardian when the patient moves from (VS to MCS), The system also constantly monitors organs like the heartbeat and pulse using biometric sensing elements in comatose patients, The planned system will keep working even as it learns to analyze each piece's amount of muscle activity and sets up a mobile network using a well-known sensor integration platform, The method is helpful because it makes it easier to keep an eye on someone who is unconscious without having to do it all by hand, It also gives the doctor information about the unconscious person's health and level of consciousness by using a mobile app, It lets the doctor know if anything is wrong with the organs of the person who is unconscious, The planned system also takes care of analyzing information for future use, No one has a lot of time each day to give up enough things, so there is a lot of demand for embedded products that do what we want them to do, It also sends an (SMS) to the caretaker when the patient's body changes [28].

Modern technologies and smart devices have improved healthcare, These devices increased patient care in the (ICU), The Internet of Things connects devices, This allows caretakers and patients to communicate, Patient surveillance protects intensive care unit patients, This cloud-based system analyzes patient vitals and delivers reports to the doctor, The support vector machine algorithm compares data to a dataset, The server receives a warning if the comparison value exceeds or falls below the threshold, The server alerts the caregiver and provides first-aid instructions, Sensors are needed to get this essential data, These sensors monitor blood pressure, temperature, heart rate, and blood sugar levels, our three-axis accelerometer sensor measures every patient's movement, Pulse oximeters and blood pressure sensors detect heart rate and blood pressure, Sensors report regularly, this system sends emergency and precautionary messages to patients, The surveillance system decreases work pressure and solves the nursing staff shortage, The server sends patient biological data via the wireless communication network to the mobile phones or laptop's web browser, Our system's multitasking aids Intensive Care Unit care [29].

With the ageing of the global population, there is an increasing demand for specialized medical care, The potential of Internet of Things (IoT) technologies to address this demand is becoming increasingly evident, The present study offers a comprehensive analysis of the latest advancements, challenges, and prospects for forthcoming research endeavors in this particular domain, The article outlines the potential applications of (IoT)-based technology in improving healthcare for the elderly, ranging from remote monitoring and telemedicine to fall detection and prescription administration,. The study acknowledges that certain obstacles, such as data privacy and security, still require resolution, However, the potential advantages for the elderly population surpass the associated challenges, The impact of the industrial revolution on a progressively ageing demographic and the resulting need for elderly care are also examined, This article examines the current status and future potential of Internet of Things (IoT) technologies in geriatric healthcare, with a focus on meeting the needs of the ageing population and improving their quality of life [30].

Health screening and body condition are crucial for early detection and prevention, especially for comatose patients, some coma patients need close observation, Hospitals and clinics still use old technologies or cable media to share patient data, This project addresses all these difficulties, It used three sensors—pulse oximeter, temperature, and flex with Arduino IDE software to measure health parameters and embedded the Blynk (IoT) application, The Blynk cloud program will display coma sufferers' heart rate, oxygen level, body temperature, and movement, A 24-year-old healthy person is measured five times for one minute, Different bodily fitness might alter heart rate, Fitted subjects have 60–61 beats per minute, Below-average body types have heart rates of 72–78 beats per minute, The last unfit subject had a heart rate of 92–99 beats per minute, Three subjects have normal oxygen levels, Based on these three values, fitness can alter heart rate readings, and pulse oximeters perform normally with a minor mistake, This project is expected to measure remote monitoring system parameters and develop healthcare technologies [31].

The current healthcare system, which is based on hospitals, isn't good enough to treat conditions that need , There 24 hours a day, like When a person is in a coma or asleep, They are unable to respond to any internal or external stimuli., when this happens, patients have no direct control over their bodies, To save a patient's life, doctors must pay close attention to these cases and keep an eye on them all the time, there is a big problem with hospital nurses keeping an eye on these patients, and there aren't enough nurses for every patient, So, in this study, We propose a global system for autonomous health tracking systems based on mobile (GSM) and Internet of Things (IoT), In our health tracking system, we also use the (GSM) gadget to send a warning message to the doctor who will be taking care of the person, We use (IOT) monitors that are linked to the XBEE module to measure the heart rates and temperatures of our patients [32].

Healthcare has evolved greatly After COVID-19, several nations prioritized medical care, However, numerous nations have suffered from inadequate medical equipment and staff, Remote health monitoring will ease this process. Smart healthcare is now (IoT), and cloud based, Internet of Things sensors track patients' health and provide therapeutically useful data for processing. If we upload all raw sensor data to the cloud for bulk data processing and analysis to make real-time judgements, Latency, bandwidth congestion, network dependability, high storage costs, and security issues would harm the healthcare industry. "Edge Computing," a new technology that processes data closer to the data-producing equipment, solves the problems. We aim to strengthen the system. This study's system would continuously collect three important vital indicators from patients and analyze the data on both cloud and edge architectures to determine which technology is best for time-sensitive applications. [33].

3. METHODOLOGY

3.1 OVERVIEW

The scope of our thesis project is the Coma Patient Monitoring System Based on (IoT), in this section of the thesis, we will provide a detailed explanation of the practical and applied tools used in its implementation and operation, as well as an explanation of the Digital Controller (MCU), the digital controller we used, and the Arduino ESP32 microcontroller and its applications with body-contact sensors. The patient, a description of how the Raspberry Pi4 microcontroller works with a digital camera sensor that isn't in direct touch with the coma patient's body, and a description of how the cloud system shows the test results and medical reports work.

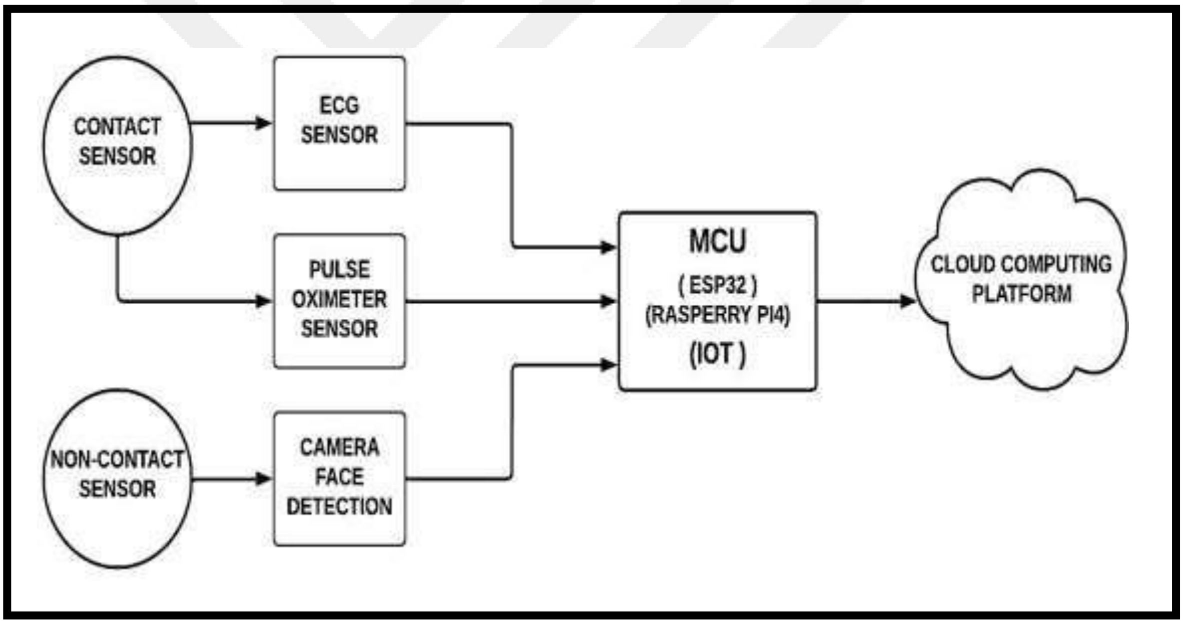

Figure 3.1: General System Proposed.

3.2 MICROCONTROLLER UNIT (MCU)

A microcontroller is a small computer that is built on a single Integrated Circuit (IC) and is used to control certain operations or functions. It has a (CPU), memory (RAM and ROM), Input/Output (I/O) ports, and numerous other peripherals such as timers, Analog-to-Digital Converters (ADCs), and communication interfaces. Microcontrollers are frequently used in embedded systems, which are computer systems embedded in other equipment or goods to accomplish certain functions. They can be found in a variety of domestic goods, autos, medical equipment, and industrial gear, One of the primary advantages of using a microcontroller is its simplicity and ease of use, It has the capability to be programmed for the purpose of executing a particular task, and once the program is loaded onto the microcontroller, it can operate independently without any need for further intervention, Another advantage is that microcontrollers are often very low-power devices, which means they can operate for extended periods of time using small batteries or other power sources. There are many different types of microcontrollers available, each with their own unique features and capabilities, some of the most popular microcontroller families include AVR, PIC, and ARM-based microcontrollers. These microcontrollers are often programmed using high-level languages like C or C++ or specialized programming languages like assembly language. Microcontrollers are a powerful and versatile tool for controlling and automating many devices and systems, and their use is likely to continue to grow as technology continues to advance, the following is an explanation of the types of microcontrollers used in our project.

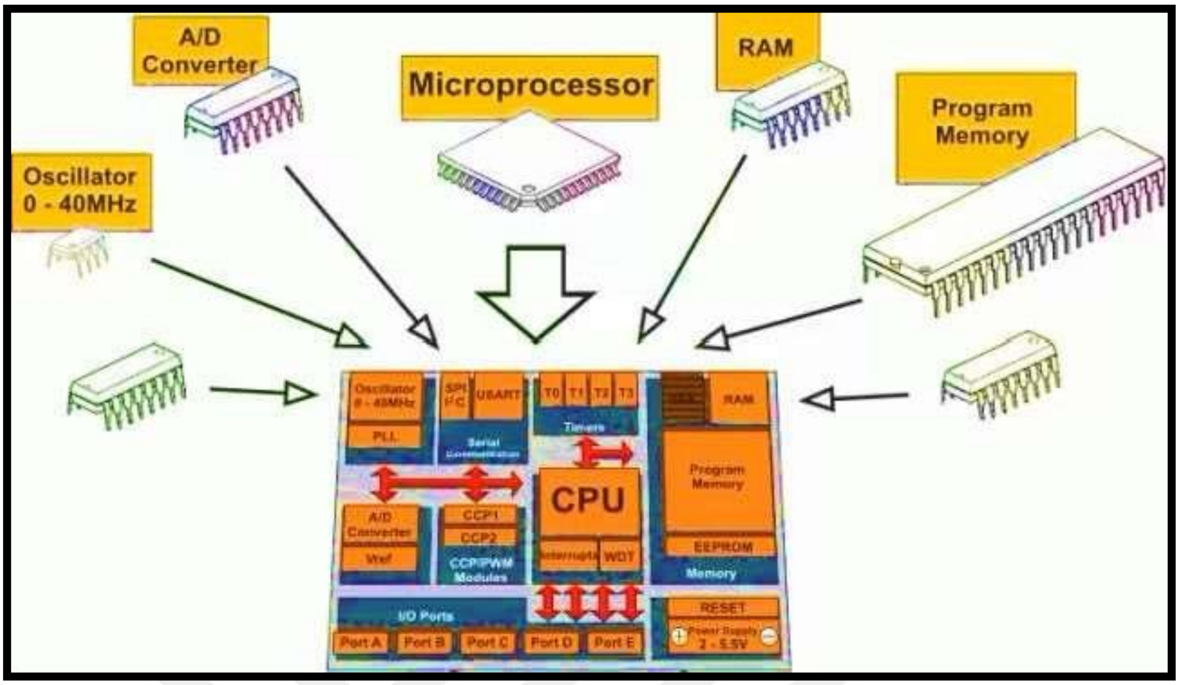

Figure 3.2: Microcontroller Unit (MCU).

3.3 ARDUINO (ESP32) MICROCONTROLLER UNIT

The Arduino ESP32 is a popular development board that combines the power of the ESP32 microcontroller with the Arduino programming language and development environment, The ESP32 is a microcontroller that has built-in Wi-Fi and Bluetooth capabilities in addition to its twin cores, making it a versatile platform for (IoT) and wireless communication projects, It has a wide range of peripherals, consisting of analog-to-digital and digital-to-

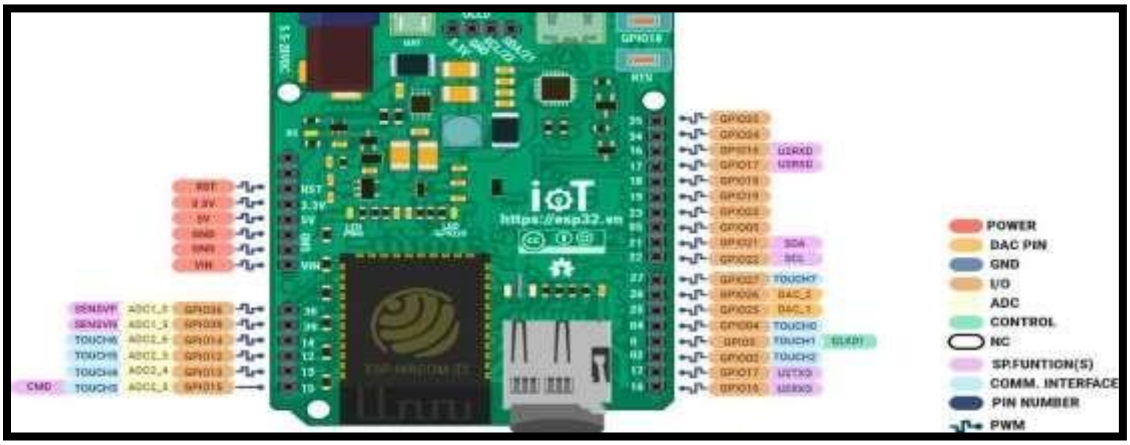

Figure 3.3: Arduino (ESP32).

analog converters, pulse-width modulation outputs, and many others, The Arduino (IDE) supports the ESP32 and allows you to program it using the familiar Arduino syntax, There are also many third-party libraries available that extend the functionality, The ESP32 facilitates the development of intricate projects, Some of the popular use cases for the Arduino ESP32 include home automation, robotics, environmental monitoring, and wearable devices. With its low cost, ease of use, and wide range of capabilities, the Arduino ESP32 is an excellent platform for hobbyists and professionals alike to create innovative projects.

The (ESP32) is a versatile microcontroller that comes with the following features: Dual-core processor for high performance, Built-in Wi-Fi and Bluetooth for wireless connectivity, Multiple power-saving modes for low power consumption, Analog and digital inputs and outputs for interfacing with sensors and actuators, Built-in sensors such as temperature, humidity, pressure, accelerometer, and gyroscope, Programmable using Arduino (IDE) for easy development, Supports other programming languages like Python and JavaScript, Large memory capacity of up to (520KB) internal (SRAM) and up to (16MB) external flash memory .

3.4 RASPBERRY PI4 MICROCONTROLLER UNIT

The Raspberry Pi4 is a single-board computer created by the Raspberry Pi Foundation, it is a low-cost, high-performance platform for diverse tasks, from basic computing tasks to more complex applications. The Raspberry Pi4 is powered by a Broadcom (BCM2711) quad-core (ARM Cortex-A72 (CPU) running at (1.5 GHz), making it the fastest Raspberry Pi to date. It also comes with up to (8GB) of (LPDDR4-3200 SDRAM), which provides plenty of memory for most projects. Additionally, the Raspberry Pi 4 features built-in wireless networking (802.11ac) and Bluetooth 5.0, which allows it to easily connect to other devices and the internet. The Raspberry Pi 4 has a wide range of ports and interfaces, including two (USB 3.0 ports), (two USB 2.0 ports), two (micro-HDMI ports) which support up to (4Kp60 resolution), a Gigabit Ethernet port, and a (3.5mm) audio jack. It also has a micro (SD) card slot for storing the operating system and user data.

The Raspberry Pi 4 runs a variety of operating systems, including Raspbian, Ubuntu, and various other Linux-based distributions. It can also run Windows 10 (IoT) Core and other specialized operating systems. The Raspberry Pi 4 is a versatile and powerful computer that can be used for a variety of applications, from basic home automation and media center applications to more complex robotics and (AI) projects. Its low cost, small form factor, and flexibility make it an ideal choice for hobbyists, students, and professionals alike.

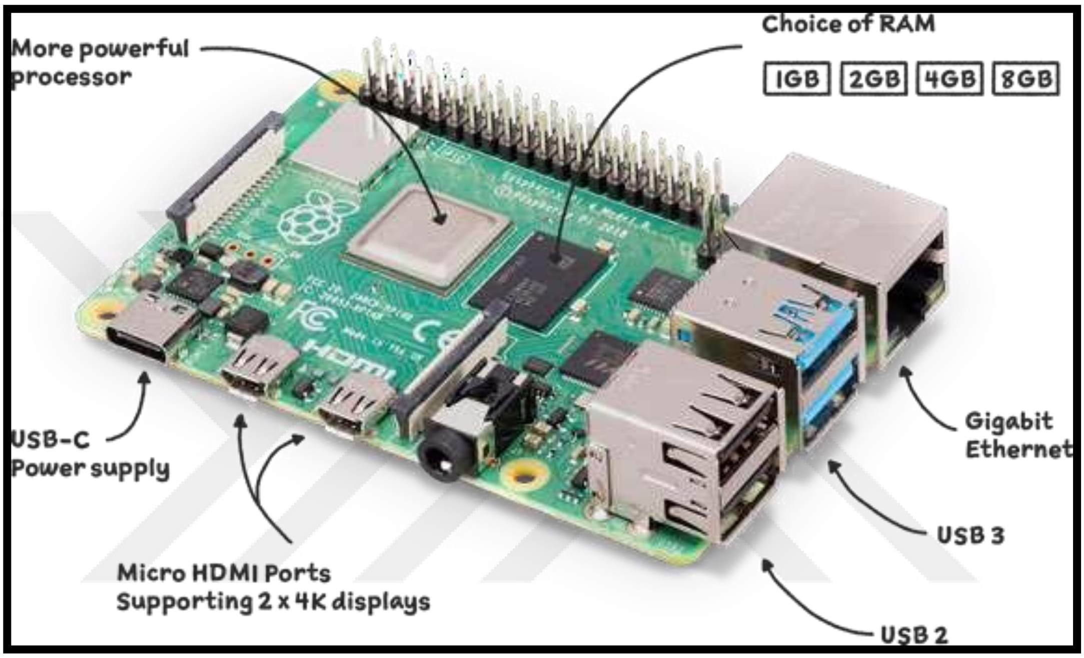

Figure 3.4: Raspberry pi4 (MCU).

Here are some of its main features: Quad-core(64-bit) processor for fast performance, Comes with (2 GB, 4 GB, or 8 GB) of memory (depending on the model), Supports dual-band Wi-Fi and Bluetooth connectivity, Has a Gigabit Ethernet port for fast-wired internet, Includes (2 USB 3.0) and (2 USB 2.0) ports for connecting peripherals, Supports dual (4K) displays with two (MICRO-HDMI) ports, Has ports for connecting a camera and a display, Has a (4-pole) stereo audio and composite video port, Supports high-quality graphics with H.265 and H.264 decoding and OpenGL ES 3.0 graphics. The Raspberry Pi 4 is an affordable and versatile computer that can be used for a wide range of projects, making it an ideal choice for hobbyists, students, and professionals.

3.5 ELECTROCARDDIOGRAM (ECG) SENSOR

The (AD8232) is a bio-electrical signal conditioning and monitoring chip that is designed to measure electrocardiogram (ECG) signals, It can be used as the core component of an (ECG) sensor for monitoring the heart's electrical activity, The (AD8232) (ECG) sensor consists of three electrodes: positive, negative, and reference electrodes, The positive and negative electrodes are placed on the patient's chest, and the reference electrode is placed on a neutral point, such as the patient's leg, The (ECG) sensor measures the difference in voltage between the positive and negative electrodes, and then amplifies and filters the signal to produce a clear (ECG) waveform, The (AD8232) (ECG) sensor is a compact, low-power, and low-noise device, which makes it ideal for portable or wearable (ECG) monitoring applications, The chip also includes features such as a fast recovery function, a low-pass filter, and a right-leg drive circuit, which help to reduce common-mode interference and improve signal quality.

The (AD8232) (ECG) sensor is a highly integrated solution for measuring (ECG) signals, which can be applied to many different healthcare applications, such as patient monitoring, disease diagnosis, and medical research.

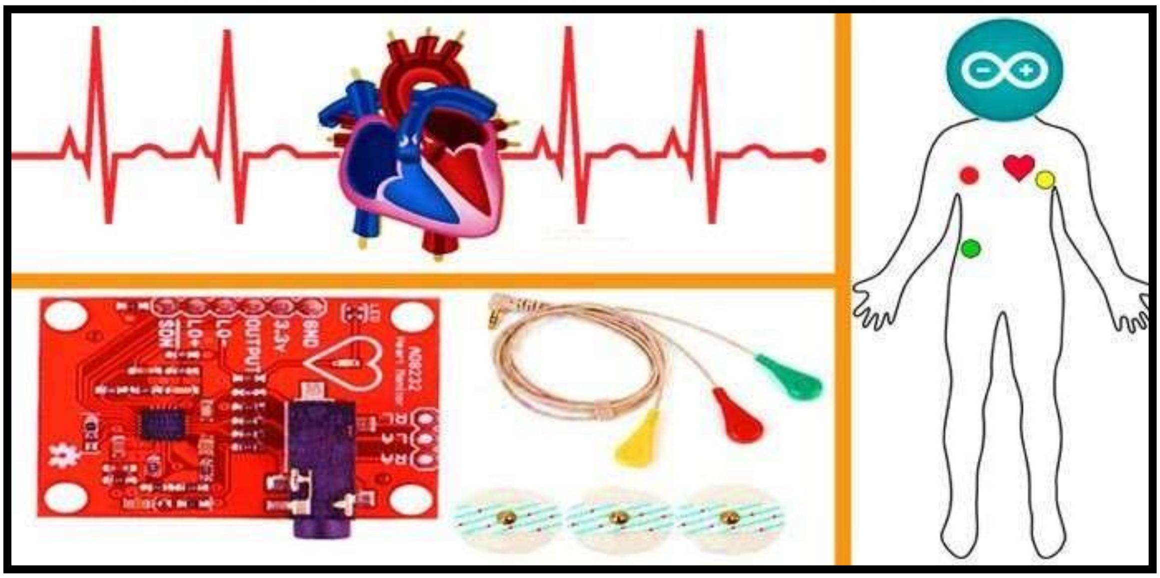

Figure 3.5: (ECG) Sensor.

3.6 PULSE OXIMETER (SPO2) SENSOR

The oximeter is a medical apparatus utilized for the purpose of quantifying the level of oxygen saturation (SPO2) present in the bloodstream, The (Max30100) is a specific type of oximeter sensor that uses photoplethysmography (PPG) technology to measure (SPO2), (PPG) works by emitting light into the skin, which is then absorbed by the blood vessels and tissues, The amount of light that is absorbed is then measured by the sensor, and this information is used to calculate the (SPO2) level, The (Max30100) oximeter sensor is an integrated module that includes both red and infrared (LEDs) and a photodetector, It also has a built-in signal processing circuit that can filter out any noise or interference from the signal, Oximeters work by emitting light into the skin, which is then absorbed by the blood vessels and tissues, The amount of light that is absorbed is then measured by the sensor, and this information is used to calculate the (SPO2) level, A healthy person's normal (SPO2) level is normally between (95% and 100%), To use the (Max30100) oximeter sensor, it needs to be connected to a microcontroller or a computer, The sensor outputs the raw data in the form of a digital signal, which then needs to be processed and analyzed to calculate the (SPO2) level.

This is typically done using specialized software or algorithms. Oximeters are often used to monitor the oxygen levels of patients with respiratory or cardiac disorders in hospitals, clinics, and other medical settings, They can also be used at home for individuals with chronic respiratory or cardiovascular conditions, or for athletes and fitness enthusiasts who want to monitor their oxygen levels during exercise, the (Max30100) oximeter sensor is a reliable and accurate way to measure (SPO2) levels, and It has several uses in the medical field, including in the monitoring of patients, sleep apnea testing, and fitness tracking, Patient Blood Management, sometimes known as (PBM), is a complete method to controlling a patient's blood health, during, and after medical procedures, (PBM) aims to optimize a patient's own blood volume, minimize blood loss during procedures, and reduce the need for blood transfusions, Therefore, the term "oximeter (PBM)" likely refers to the use of oximetry as a tool in implementing a (PBM) strategy, By monitoring a patient's oxygen saturation levels, healthcare providers can identify early signs of hypoxemia (low oxygen levels in the blood), which can lead to complications and increase the risk of requiring a blood transfusion, By identifying and addressing these issues early on, (PBM) strategies aim to improve patient outcomes and reduce the need for blood transfusions.

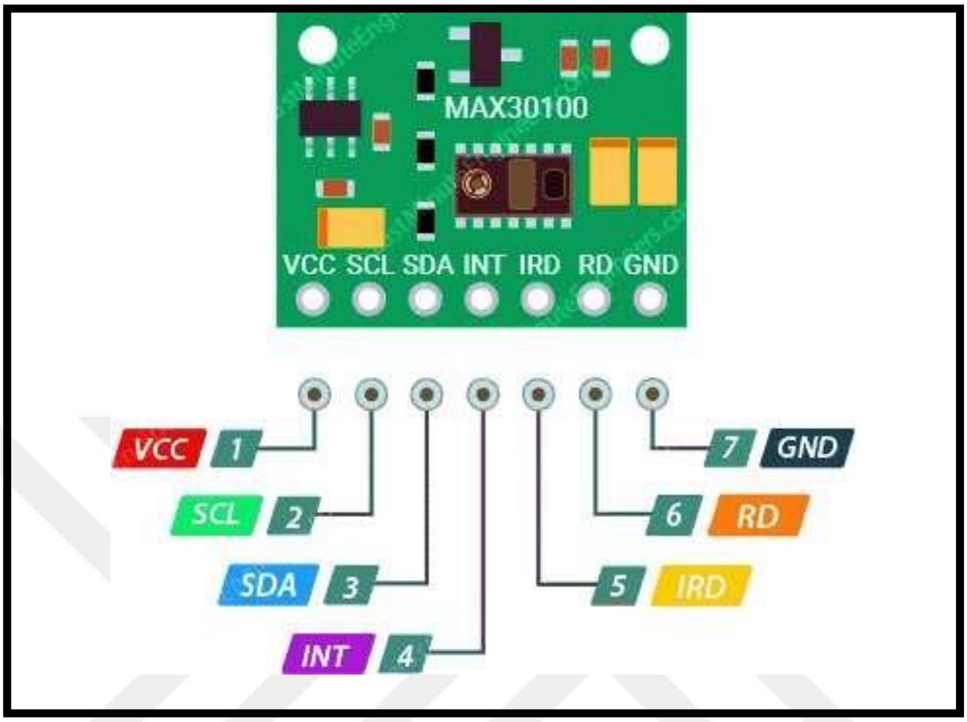

Figure 3.6: Pulse Oximeter (spo2) Sensor.

3.7 CAMER AS A SENSOR LOGITECH HD PRO WEBCAM (C920)

In a digital camera, the image sensor is the component that captures light and converts it into digital data that can be stored on a memory card or other storage device. Image sensors in digital cameras are classified into two types: charge-coupled device (CCD) and complementary metal-oxide-semiconductor (CMOS), sensors work by converting light into electrical charges, which are then read out and converted into digital data. They tend to be more sensitive to light and produce higher-quality images, but they can be more expensive and power-hungry than (CMOS) sensors, (CMOS) sensors, on the other hand, convert light into electrical signals using a different process. They tend to be less expensive and more power-efficient than (CCD) sensors but may not perform as well in low-light conditions and may produce lower-quality images. Both (CCD) and (CMOS) sensors come in different sizes and resolutions, with larger sensors generally producing better image quality, The type of sensor used in a digital camera will affect its performance in terms of image quality, sensitivity to light, and other factors.

Figure 3.7: Logitech HD Pro Webcam (C920).

3.8 COMPUTER VISION AND IMAGE PROCESSING

Computer vision and image processing are two related fields of study that deal with the acquisition, analysis, and interpretation of images and video, Computer vision focuses on the automated extraction of information from images and video, while image processing deals with the manipulation and enhancement of images for various purposes, Computer vision involves the use of algorithms and mathematical models to interpret and analyze digital images and videos, This can include tasks such as image segmentation, object recognition, and tracking, and can be used in a variety of applications, such as self-driving cars, facial recognition, and medical imaging, Image processing, on the other hand, involves manipulating and enhancing images to improve their quality, extracting information, or prepare them for further analysis. This can include tasks such as noise reduction, contrast enhancement, and image restoration. Both computer vision and image processing rely on a range of techniques, including machine learning, statistical analysis, and signal processing, they are utilized in numerous disciplines, such as healthcare, security, entertainment, and scientific research.

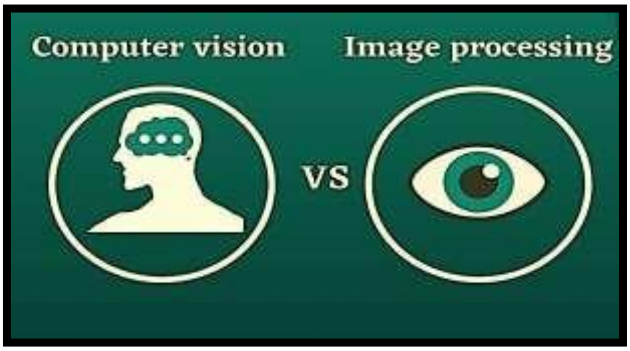

Figure 3.8: Computer Vision VS Image Processing**.**

3.9 ALGORITHMS

An algorithm is a set of step-by-step instructions that a computer program follows to accomplish a specific task or solve a particular problem, Algorithms are employed in many different domains, such as computer science, mathematics, engineering, and artificial intelligence. Algorithms are essential in the design and development of software applications in computer science, programs to process data, perform calculations, and automate tasks, in mathematics, algorithms are used to solve complex problems and make predictions based on data. In engineering, algorithms are used to design and optimize systems and processes, The effectiveness of an algorithm depends on how well it is designed to solve a specific problem and how efficiently it can be executed by a computer program. In artificial intelligence, an algorithm refers to a set of rules or instructions that a computer program follows to perform a specific task or solve a particular problem. These algorithms are designed to enable machines to learn from data, recognize patterns, make predictions, and make decisions. In other words, algorithms form the core of many (AI) applications and are what enable machines to "think" and "learn" in a way that is like how humans do, the algorithm chosen is determined by the specific task at hand as well as the type of data accessible.

3.9.1 Face Detection Algorithm

Face detection is the process of identifying human faces in an image or video stream and locating their position and size, It is a fundamental computer vision task and has numerous applications in various fields, such as security, entertainment, and human-computer interaction, There are different approaches to face detection, including traditional computer vision methods and deep learning-based methods, Traditional methods rely on handcrafted features and algorithms such as (HAAR) cascades, while deep learning-based approaches, use convolutional neural networks (CNNs) to automatically learn features from data. Deep learning-based approaches have demonstrated greater performance on face detection challenges in recent years. The Viola-Jones technique, Multi-Task Cascaded Convolutional Networks (MTCNN), and Single Shot (MultiBox) Detector (SSD) are all popular face identification algorithms. Face detection tech methods are used in many applications, for example security systems, automated attendance systems, social media platforms, and mobile applications. It has also raised concerns about privacy and ethics, as it can potentially be used for unauthorized surveillance and tracking of individuals.

Our smartphones could only be unlocked with a password until recently. Now, we can use our faces as a password. Just like fingerprints, each face is different because it has millions of tiny details that make it special. We humans might not always see it, but computers put together and review every little bit of data, which makes them more accurate, this algorithm can find picture features in real-time. Even though Viola Jones is an old system, it is still very powerful, and its use in real-time face recognition has been very successful.

Detection Viola Jones was designed for frontal faces; thus, it detects faces that are looking straight ahead more accurately than those that are looking sideways, up, or down. Before finding a face, the image is converted to grayscale, which makes it easier to work with and needs less processing, The Viola-Jones method locates the face in the grayscale image first, then in the color image, A lot of boxes locate features that look like faces (HAAR-like features) with smaller steps, and the information from all of these boxes helps the computer figure out where the face is. Face-finding and -identification devices have gone a long way in recent years, when we take a picture with our phones, we can see a box around their faces. Even though more complex facial recognition algorithms, such as those that use deep learning, are now available, the Viola-Jones method, which was released in 2001, was a significant step forward in this field.

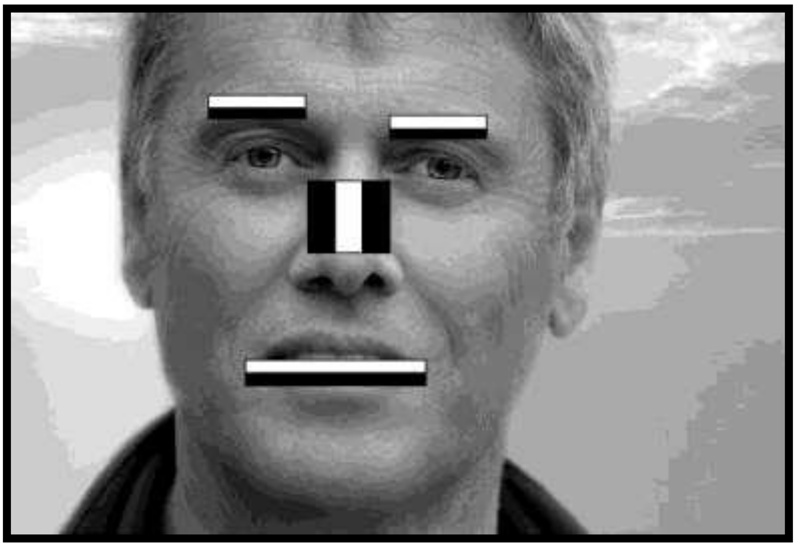

Figure 3.9: Face Detection.

3.9.2 Facial Landmark Detection Algorithm

Facial landmark detection is the process of identifying and locating specific points on a face, known as facial landmarks or feature points. These landmarks are used to analyze and track facial expressions, facial movements, and other facial features, Facial landmark detection can be performed using various algorithms and techniques, One popular approach is to use machine learning algorithms, to find face features, such as convolutional neural networks (CNNs) or support vector machines (SVMs), These algorithms are trained on large datasets of facial images, where each image is annotated with the location of the facial landmarks, Another approach is to use shape models, Active Shape Models (ASM) and Constrained Local Models (CLMs) are two examples, to detect facial landmarks, These models are created by analyzing the statistical shape variations of facial features and can be used to predict the location of facial landmarks based on the observed facial features, Facial landmark detection can be performed in real-time using cameras or video streams and is widely used in software for facial recognition and emotion recognition, and virtual reality. Many popular computer vision libraries, such as OpenCV and DLIB, provide pre-trained facial landmark detection models that can be easily integrated into applications.

The DLIB library can be used to find 68 facial features on a face that has been found in a picture.

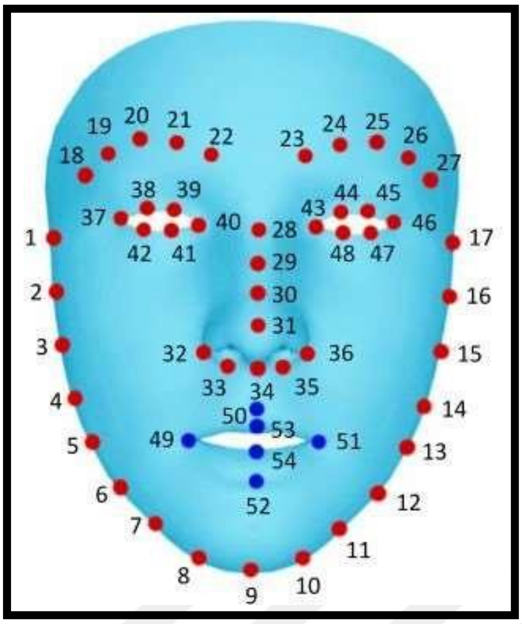

Figure 3.10: Facial Landmark.

I will refrain from providing an in-depth explanation regarding the mechanism by which the system can detect a human face and identify its distinctive characteristics. Irrespective of the size of the image or the facial features, the sequence of the recognized facial landmarks remains consistent. It can be inferred that the facial outline will consistently be represented by numbers 1 through 17. The numerical values ranging from 43 to 48 consistently indicate the left eye. In the subsequent section of this guide, the precise code for accomplishing this task will be presented.

3.9.3 Features Extraction (Haar) Algorithm

HAA-R is a type of feature used in computer vision and image processing for recognizing things, particularly faces, It is named after the Hungarian mathematician Alfréd (HAAR), who developed a wavelet-based method for signal analysis in the early 20th century, In image processing, (HAAR) features are described as rectangular features that are calculated by subtracting the total of pixel values in two rectangular regions of an image, The difference is then used as a feature to distinguish between different objects or parts of an object, The (HAAR) feature extraction process involves sliding a window of varying sizes over an image

and computing the (HAAR) features at each window location, These features are then machine learning algorithm input, such as the AdaBoost algorithm, to classify objects or regions of an image as positive or negative examples, The (HAAR) cascade classifier, which was introduced by Viola and Jones in 2001, is a popular method for face detection that uses a series of (HAAR) like features and a cascade of classifiers to efficiently detect faces in real-time, It is still used today as a basic building block in many face detection algorithms.
(HAAR)-like features are called after (Alfred HAAR), a Hungarian mathematician who created the notion of (HAAR) wavelets (the progenitor of (HAAR)-like features) in the nineteenth century, The detection of significant elements in the human face such as eyes, brows, nose, and lips is the most important part of facial recognition, So, how can we identify these traits in real-time or in images, (HAAR) Wavelets or (HAAR) Features are the answer, The algorithm utilized is known as the Viola-Jones Algorithm.
The features below depict a box with a bright and dark side, which the machine uses to identify what the feature is, as in the edge of a forehead, one side may be brighter than the other, the center region may be shinier than the surrounding boxes on occasion, which may be seen as a nose.

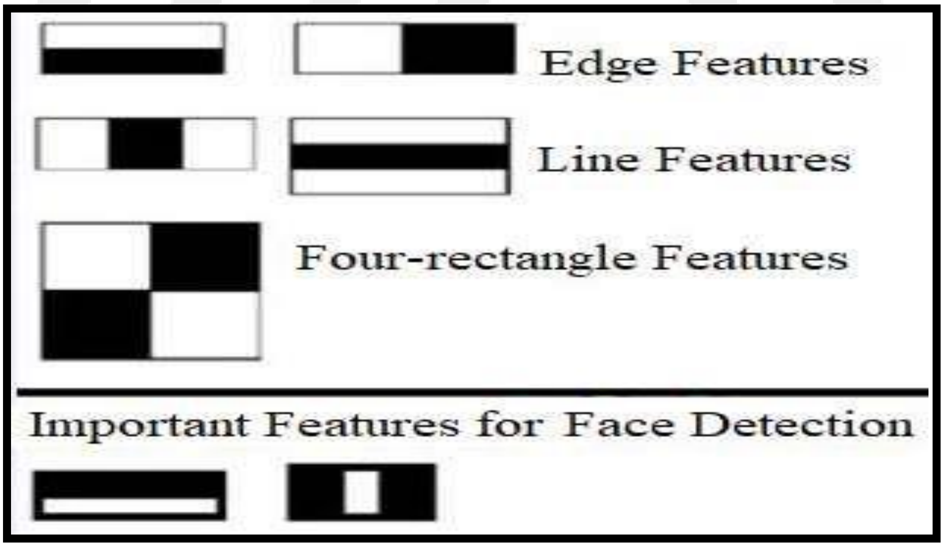

Figure 3.11: (HAAR) -Like Features.

Pixel values for black and white photographs are (0 or 1) (ideal circumstance), however in practice, we have normalized greyscale images as seen in the bottom box storing pixel values.

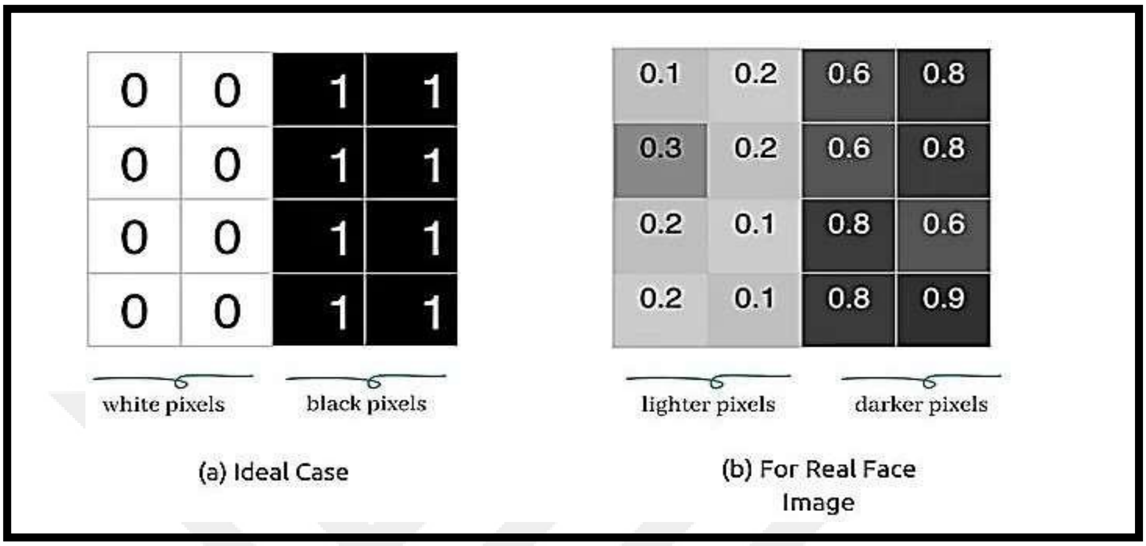

Figure 3.12: Ideal Circumstance.

To detect (HAAR)-like characteristics in a picture using the Viola-Jonas method, the following formula should yield a value closer to 1. The closer the number is to 1, the more likely it is to identify the (HAAR) feature in a picture, As shown in the following equation.

$$ii(x, y) = \sum_{x' \le x, y' \le y} i(x', y') \tag{3.1}$$

Viola-Jones draws a box (as seen on the right) and searches within it for a face, it is essentially searching for (HAAR)-like characteristics, which will be explored further below. The box moves one step to the right after passing through. In smaller phases, a few boxes identify face-like attributes (HAAR-like features), and the data from all of those boxes combined helps the computer determine where the face is, They are a set of classifiers or features (as discussed above) that are used to identify objects in an image, Detecting a face or not using sliding windows and a number of (HAAR) traits (grows as the number of steps increases), The Viola Jonas Method consists of 38 distinct steps, At a particular level, several features and faces can be detected depending on the sliding window size and face placement.

3.9.4 Convolutional Neural Networks (CNNs) Algorithm

In computer vision, CNNs are used for picture categorization, object recognition, and segmentation. Inspired by the human brain's visual cortex, they have many layers of neurons that process information hierarchically. Convolutional, pooling, and fully connected layers make up a (CNN). Convolutional layers use filters to extract edges, corners, and textures from the input image. Pooling layers down samples feature spatial size, making the model more tolerant to translation and rotation. Finally, completely linked layers classify or regress using features from previous levels. Backpropagation, a gradient-based optimization method that adjusts network weights to minimize a loss function, trains (CNNs). CNNs, which learn convolutional filter weights from millions of photos, perform well in computer vision applications like picture classification, object recognition, and segmentation. Natural language processing and speech recognition employ them too.

3.9.5 Multi -Task Cascaded Convolutional Networks (MTCNN) Algorithm

MTCNN stands for Multi-Task Cascaded Convolutional Networks, it is a popular deep learning-based face detection algorithm that was proposed by Zhang et al. in 2016, (MTCNN) consists of three stages of convolutional neural networks, each performing a different task in the face detection process, The first stage of (MTCNN) is a convolutional network that proposes candidate face regions by generating bounding box proposals, It uses a technique called the "Proposal Network" (P-Net) to generate a set of candidate bounding boxes at different scales and aspect ratios. The second stage of (MTCNN), called the "Refine Network" (R-Net), filters out false positives and further refines the bounding box proposals generated by the (P-Net). (R-Net) takes the candidate bounding boxes from the first stage as input and predicts more accurate bounding boxes and facial landmarks, The third stage, called the "Output Network" (O-Net), further refines the bounding box proposals generated by the (R-Net) and produces the final face detection results, it also predicts facial landmarks with high accuracy, such as the location of the eyes, nose, and mouth. (MTCNN) is known for its high accuracy and robustness in detecting faces in challenging scenarios, such as occlusions, pose variations, and low-resolution images, it is widely utilized in a wide range of applications, including facial recognition, video surveillance, and augmented reality.

3.9.6 Single Shot Multibox Detector (SSD) Algorithm

SSD is an abbreviation for Single Shot (MultiBox) Detector, a common object detection technique used in computer vision. As the name implies, (SSD) can detect multiple items in a single shot, which means it can detect numerous things in a single picture or video frame without the need for successive passes. (SSD) is built on a deep convolutional neural network with a single feed-forward pass that predicts the locations of different objects in a picture as well as their related class labels. This is accomplished by dividing the input image into various grids and predicting a predetermined number of bounding boxes in each grid cell with different aspect ratios and sizes. Following the prediction of these bounding boxes, non-maximum suppression (NMS) is used to eliminate redundant detections and retain only the most confident ones. The end output is a set of bounding boxes representing the objects recognized in the input image, along with their class labels and confidence scores. (SSD) has demonstrated excellent performance on a variety of object detection applications, including face detection. It has been employed in a variety of applications, including self-driving, surveillance, and robots.

3.9.7 Viola-Jones Algorithm

Viola-Jones is a famous face detection method that was created in 2001 by Paul Viola and Michael Jones, to recognize faces in images, the method employs (HAAR)-like features and a machine-learning approach, (HAAR)- like features are small rectangular areas in an image that are used to identify specific patterns, these patterns can be used to detect the presence of faces, The Viola-Jones algorithm trains a classifier using a set of positive and negative training images, The positive images contain faces, while the negative images do not, the algorithm uses the (HAAR)-like features to identify patterns in the images and then uses the classifier to determine if the pattern represents a face or not, The Viola-Jones algorithm is fast and can recognize faces in real time. It has been employed in many systems and applications, such as security systems, digital cameras, and cellphones, However, it does have some limitations, for example, it can struggle to detect faces in images that are heavily occluded or have complex backgrounds.

3.10 PYTHON LANGUAGE

Python is an interpreted high-level programming language that was initially introduced in 1991, It is intended to be simple to learn and use, with a focus on code readability and straightforward syntax, Python's adaptability is one of its primary features; it can be used for a wide range of tasks, from web development to data research to machine learning, Python is also frequently used in scientific computing, with libraries such as NumPy, Pandas, TensorFlow, and Matplotlib offering strong data processing and visualization capabilities, Python's success has been fueled by its huge and active developer community, which has produced a vast ecosystem of third-party libraries and tools, This contains popular web frameworks such as Django and Flask, as well as scientific computing, machine learning, and other tools, Python is also well-known for its readability and ease of use, with a clear and consistent syntax that makes it straightforward to develop and understand code, Python is a robust and adaptable programming language with a strong emphasis on readability, ease of use, and flexibility, making it a popular choice for both novices and experienced professionals, It is utilized in a wide range of industries and applications, and its popularity is growing as more developers learn about its advantages, I utilized the libraries listed below.

3.11 NUMPY PYTHON LIBRARY

NumPy is a Python library for manipulating arrays. "Numerical Python" is the abbreviation. "NumPy" is built on top of the Python programming language, which allows for efficient computations with large datasets, The main object provided by NumPy is the (ND array) (N-dimensional array) which is a multidimensional array of elements of the same type, It is like a list in Python, but with some additional features such as element-wise operations and efficient mathematical operations, "NumPy" also has a number of functions for carrying out mathematical operations on arrays, such as linear algebra, Fourier transforms, and random number generation. It also includes tools for integrating with other languages, such as(C/C++), and for reading and writing data to disk. NumPy is widely used in scientific computing, data analysis, and machine learning.

3.12 TENSORFLOW LIBRARY

TensorFlow is an open-source software library for dataflow and differentiable programming that may be used to perform a variety of tasks, Google created it, and it is highly used for machine learning and deep learning applications, especially in the field of artificial neural networks. TensorFlow allows users to construct and execute tensor calculations, which are multidimensional arrays with a set number of dimensions. These tensors can represent a wide variety of data types, including images, audio, text, and numerical data. TensorFlow's capacity to design and train deep neural networks is one of its core characteristics. TensorFlow provides a high-level (API) for building and training neural networks, as well as a lower level (API) for implementing custom neural network topologies. TensorFlow also supports distributed computing, allowing users to train and deploy models on numerous machines at the same time. TensorFlow, in addition to deep learning, may be used for other machine learning tasks such as regression, clustering, and classification, It supports numerous programming languages (Python, C++, Java, and Go) and can run on a number of platforms (CPUs, GPUs, and TPUs).

3.13 DLIB PYTHON LIBRARY

Dlib is a free and open-source C++ library that contains machine learning methods and tools for creating complicated software in the fields of computer vision and image processing, It was created by Davis King and is widely used in both academic and industrial settings, Dlib provides a wide range of tools and algorithms, including facial landmark detection, object detection and tracking, image segmentation, clustering, regression, and classification, It also includes tools for optimization, numerical computing, and matrix manipulation. Additionally, Dlib has interfaces to work with other popular machine-learning libraries, such as TensorFlow and (PyTorch), Dlib is highly optimized and efficient, making it suitable for both desktop and embedded applications, it has a big and active community of users and contributors, making it a popular alternative for computer vision and machine learning researchers and developers.

3.14 EAR – DLIB LIBRARY

EAR-Dlib (eye aspect ratio using Dlib) is a computer vision technique used to detect eye blinking and estimate a person's level of sleepiness, It entails determining the (eye aspect ratio) EAR), which is a measure of eye shape, and using this to determine whether the eyes are closed or partially closed, EAR is calculated using the ratio of the distances between the vertical landmarks of the eye and the horizontal landmarks of the eye, Feature detection is usually done using the Dlib library, which provides a set of pre-trained face feature detectors. By monitoring the EAR over time, it is possible to detect when a person blinks or when their eyes are closed for an extended period. This information can be used to alert a person or supervisor when they are at risk of falling asleep or drowsy, particularly in safety-critical environments such as driving or monitoring comatose, hospitalized, and unconscious patients. EAR-Dlib is a useful technology for monitoring eye movements and detecting patterns that may indicate fatigue or sleepiness in a person or for use in other applications.

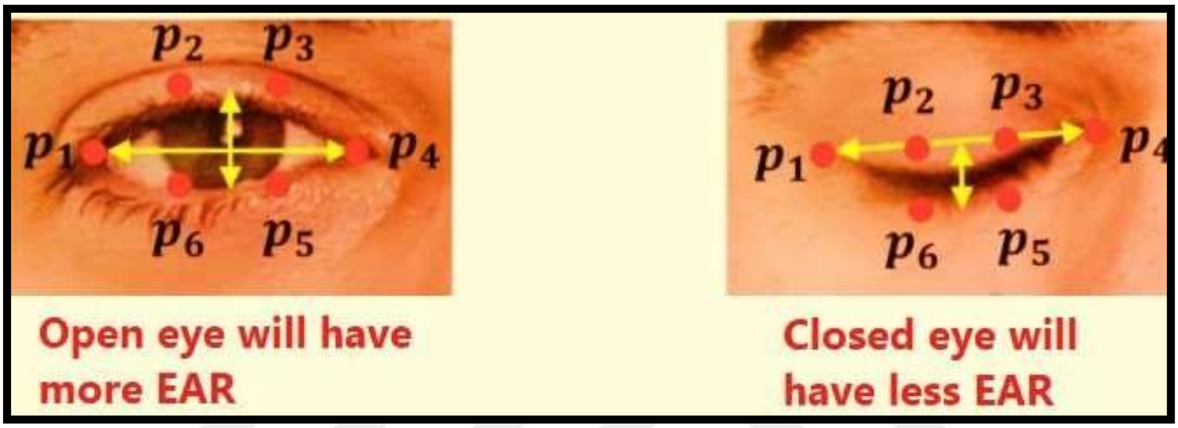

Figure 3.13: Open Eye & Closed Eye.

The EAR is a mathematical formula commonly used in computer vision and facial recognition algorithms to detect and track eyes in images or videos. It is particularly useful in applications such as blink detection, drowsiness detection, and gaze tracking.

The EAR algorithm calculates the ratio of the vertical distance to the horizontal distance between a few key landmarks on the human eye, typically the inner and outer corners of the eye (also known as canthus points) and the top and bottom points of the eye region. By measuring changes in the EAR over time, it is possible to infer eye-related events such as blinks.

The formula for calculating EAR is as follows:

$$EAR = (||p2 - p6|| + ||p3 - p5||) / (2 * ||p1 - p4||) \quad (3.2)$$

In the formula, p1 and p4 represent the coordinates of the top point of the eye region, p2 and p6 represent the coordinates of the inner and outer corners of the eye, and p3 and p5 represent the coordinates of the bottom point of the eye region. The || || denotes the Euclidean distance between two points.

The EAR value typically falls within a specific range, with a higher value indicating that the eye is open and a lower value indicating that the eye is closed. By setting a threshold, it becomes possible to classify eye states, such as open, closed, or partially closed, based on the EAR value. It should be noted that the precise numbers and thresholds for EAR may differ based on the specific implementation or application, as multiple algorithms and techniques may be utilized**.**

3.15 THE CLOUD SYSYTEM

A cloud system, also known as cloud computing, means the delivery of computing resources, software, storage, and processing power, over the Internet, In other words, it's a way to use computer services and resources without having to own the physical infrastructure required to provide those services, Instead of running software or storing data on a local machine, cloud systems enable users to access resources and services remotely, often through a web browser or a specialized application, These resources can be scaled up or down as needed, give users the ability to pay only for what they use, and can be accessed from anywhere with an internet connection, Cloud systems can be used for a wide variety of purposes, including data storage and backup, software development and testing, application hosting, among other things, Amazon Web Services (AWS), Azure by Microsoft, and Google Cloud Platform (also known as GCP) are some of the most popular cloud platforms. Blynk is a cloud computing system.

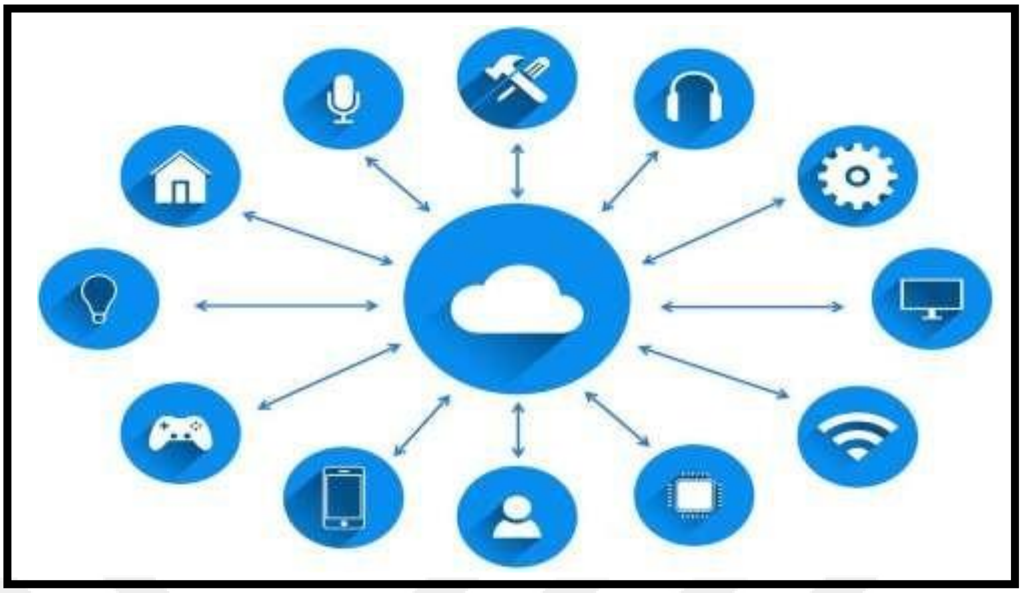

Figure 3.14: The Cloud System Platform.

Cloud computing refers to the distribution of computing resources such as servers, storage, databases, software, analytics, and other services via the internet ("the cloud"), Rather than owning and maintaining their own physical computing infrastructure, organizations can use third-party cloud computing services to access these resources on demand and pay only for what they use, Cloud computing has become an essential component of modern IT infrastructure, with many organizations adopting it to improve efficiency, reduce costs, and increase agility, Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP) are all popular cloud computing services, Cloud computing has various advantages over traditional on-premises computing, including: Scalability: Cloud computing resources may be swiftly and easily scaled up or down to suit changing demands without the need for costly investments in physical infrastructure. Cost savings: Because using it will cancel the need of maintain, and upgrade their own gear and software, it saves money. Accessibility: Because cloud computing resources can be accessible from anywhere with an internet connection, distant workers may collaborate and access the resources they require more easily, Service level agreements (SLAs) that guarantee a particular degree of availability are common among cloud computing companies.

Cloud computing services come in a variety of flavors, including:

Infrastructure as a Service (IaaS): Providers provide virtualized computing resources such as servers, storage, and networking that organizations can use to create their own unique applications and services. Platform as a Service (PaaS): Providers provide a platform for businesses to design, run, and manage their own apps without worrying about the underlying infrastructure. Software as a Service (SaaS): Providers offer pre-built software programs such as email, customer relationship management (CRM), and productivity tools that organizations can access and use through the internet.

3.15.1 The Cloud System Platforms With (IoT)

(IoT) cloud computing platforms combine the features of cloud computing and (((IoT))) and give them as a full-service option, People also call them by other names, like Cloud Service ((IoT)) Platform. With so many devices linked to the Internet these days, it's getting easier to collect a lot of data from these sources and use different programs to study it well, The (IoT) cloud platform provides a usable, adaptable, and scalable foundation for all the services and infrastructure that enterprises with limited resources need to handle all the (IoT) tools and apps, (IoT) clouds let businesses grow quickly and cheaply without having to build the infrastructure and services they need from start.

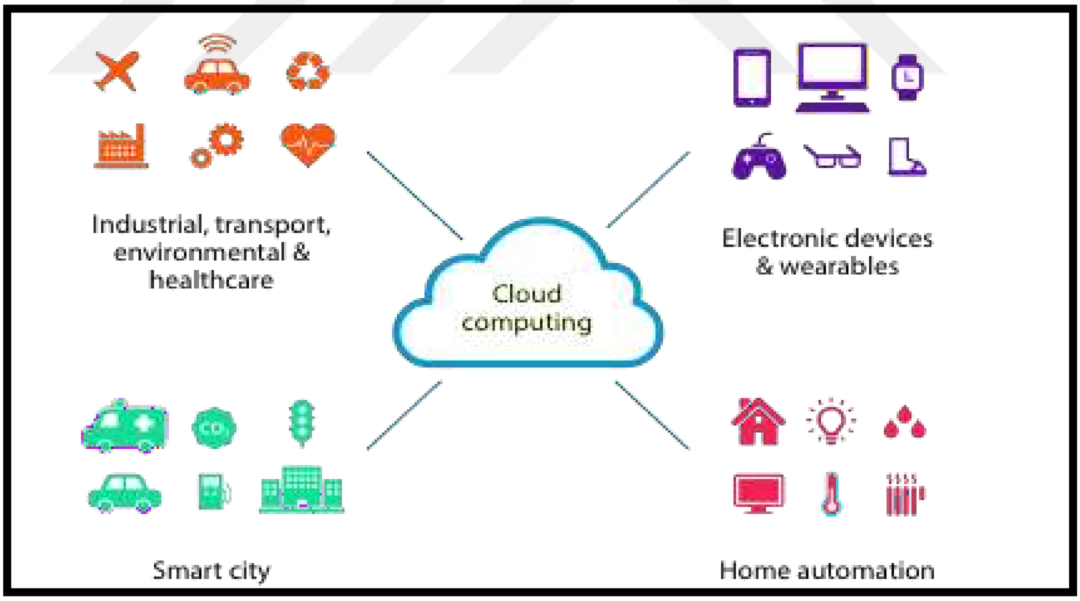

Figure 3.15: The Cloud System With (IoT).

3.15.2 The Blynk Cloud System

The Blynk cloud system is a cloud based platform that allows users to create and control (IoT) Internet of Things devices using a smartphone or tablet, The platform is designed to be flexible and easy to use, allowing users to quickly create custom apps that can interact with a wide range of (IoT) devices, The Blynk cloud system consists of two main components: the Blynk app and the Blynk cloud service, The Blynk app is available for both iOS and Android devices and provides a user-friendly interface for controlling (IoT) devices and collecting data from them, The Blynk cloud service provides the infrastructure for communicating with (IoT) devices and includes a range of features and tools to help users manage their devices, These features include real-time data visualization, device management and monitoring, and analytics tools, The Blynk cloud system supports Wi-Fi, Ethernet, Bluetooth, and more, which is a major benefit. This makes connecting various devices to the platform and creating bespoke apps that interact with them straightforward.

Figure 3.16: Logo The Blynk Cloud System.

3.15.3 The Blynk Platform With (IoT)

Blynk, the most popular (IoT) platform, was created. It stores, visualizes, displays sensor data, remotely controls hardware, and does many more amazing things. The Blynk Library connects over 400 hardware models to the Blynk Cloud, including the ESP8266, ESP32, Node (MCU), all Arduinos, Raspberry Pi, Particle, Texas Instruments, and more.

The platform has three main parts:

Blynk App's various widgets let you create attractive project interfaces. Blynk Server manages smartphone-hardware communication, and it can run on a Raspberry Pi, manage thousands of devices, and is free. Blynk Libraries handle all server interactions and commands for all major hardware platforms.

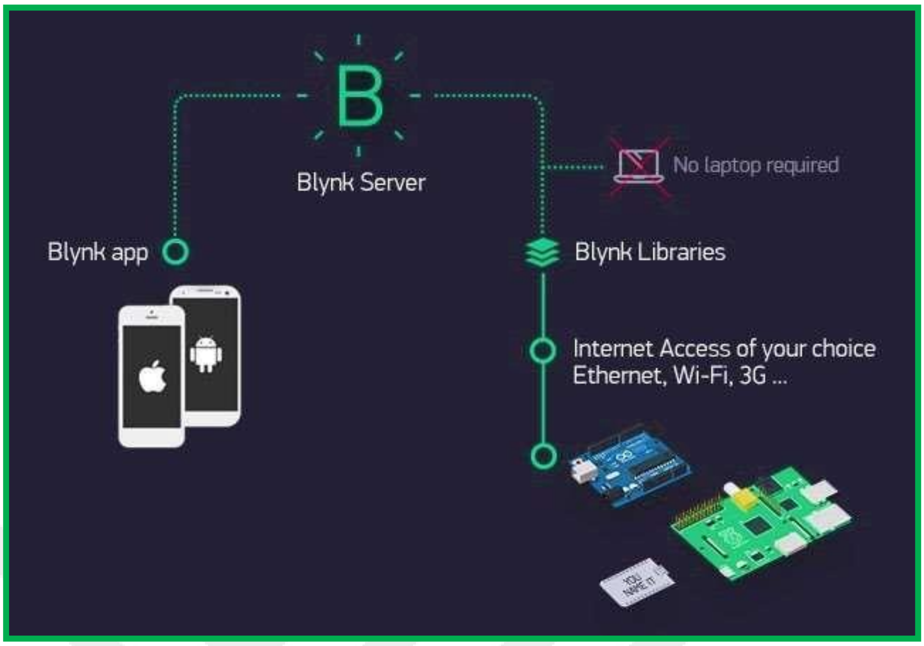

Figure 3.17: The Blynk Platform With (IoT).

4.RESULTS

4.1 THE PROPOSED SYSTEM

The health monitoring system, which was constructed and designed to monitor the coma patient's health condition, is made up of a few touch and non-contact sensors that work interactively with the patient's health status and response while at the same time reading and recording data and sending it continuously according to the patient's development on the health monitor screen, The system monitored the coma patient's health, These sensors cooperate with one another and are linked through a processing unit and a main control node (MCU), which records and stores data before uploading it through the cloud system. This allows the monitoring doctor to follow up continuously via a smartphone or computer about the health status of coma patients according to the condition recorded in the intensive care room, which requires instantaneous monitoring from anywhere and at any time possible and send alert messages.

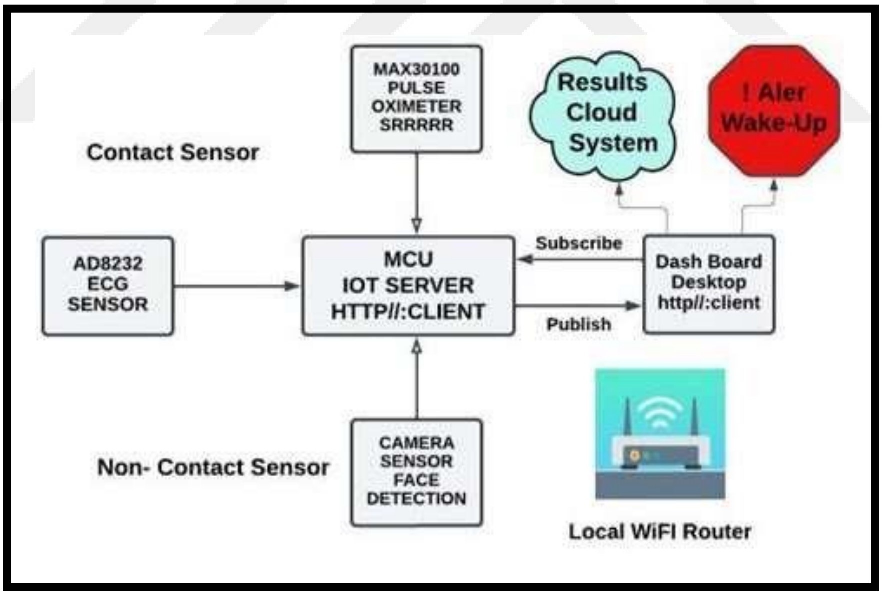

Figure 4.1: The Proposed System Block Diagram.

The sensors that make up the proposed health monitoring system can be either contact or non-contact. In the first phase, the patient's vitals are monitored with the use of touch sensors while they are in a coma. We have been monitoring both the heart's electrical activity using an (ECG) sensor and the blood's oxygen level with an (SPO2) sensor. The coma patient's body is in touch with these sensors, and the findings are shown instantly on the screen and sent to the cloud. Part two involved the employment of an (AI)-compatible digital camera sensor. An external LED screen receives a text alarm signal from a remote sensor that continuously monitors the coma patient's eye movement. Coma patients who experience anxiety and distress upon awakening may feel more at ease with the placement of these non-contact sensors on their body until they come to. To provide reliable findings, we plan to monitor the comatose patient remotely using sensors. And number seven, if the patient is a young child, it might help to ease their anxiety. This information is continually logged. to learn how a coma patient's body functions and to indicate to the doctors and nurses monitoring the coma patient whether the patient's health is stable or whether there are negative results that require immediate medical attention to take more important or therapeutic steps.

The Microcontroller Unit (MCU) serves as the foundation for our research work and allows us to apply and implement any practical idea pertaining to scientific research because it is a cutting-edge and practical open-source unit with multiple ports, accepts modern programming languages, is easy to use and reasonably priced, and could accept most electronic components that we can add to it.

We picked the advanced Arduino ESP-32 type for this since it is one of the most technologically advanced components of the current Arduino models and has a number of functions, including 32 open-source ports, Bluetooth, and Wi-Fi, as well as serving as a server, we chose this microcontroller since there are many ways it may be used and implemented. This is particularly true when using the Wi-Fi capability of the Arduino ESP32, which sends the results to the (IoT) cloud and enables a computer, tablet, or smartphone to display them, to link the touch sensors that this microcontroller works with in a way that makes it simple to show the results.

In the early phase of our research, we used touch sensors for the body, such as the ESP32 or Arduino-compatible (ECG) AD8232 cardiac electrical sensor, we used the (SPO2) oximeter sensor is capable of measuring heart rate, detecting the Oxygen percentage in the blood, and monitoring the pulse. It analyses the information and wirelessly uploads it to the cloud so that the coma patient's monitor screen can display it.

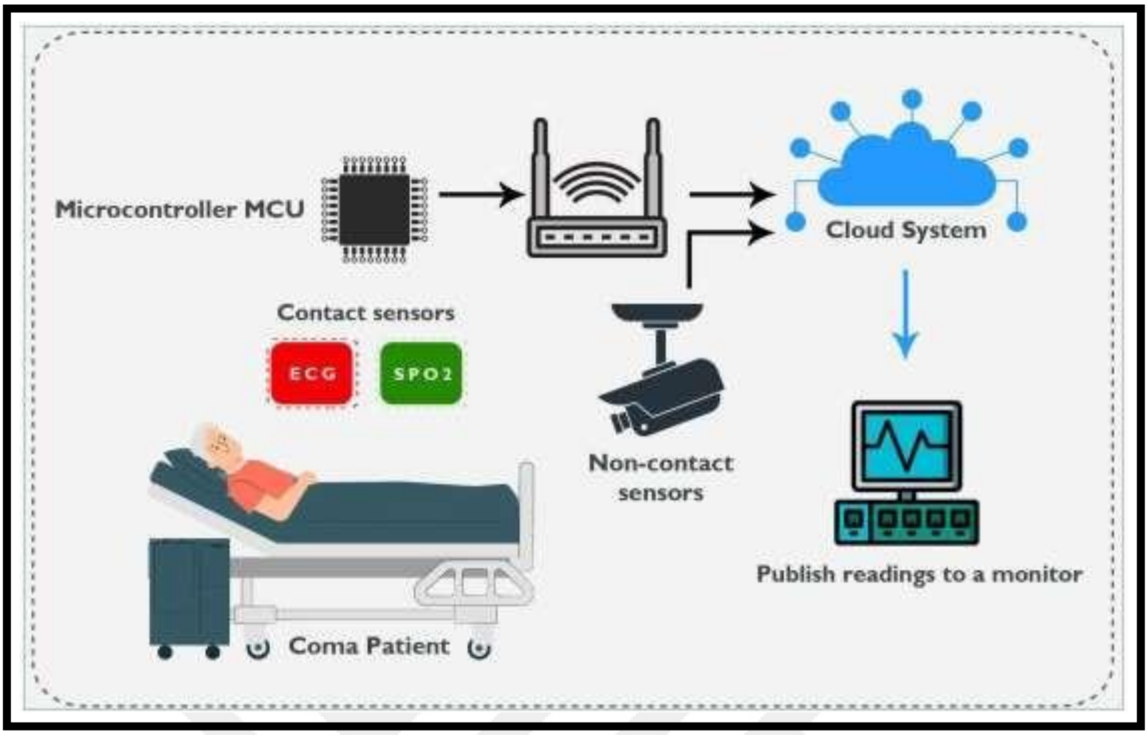

Figure 4.2: Comatose Patient Using (IoT).

In addition, we used a different, more sophisticated microprocessor (the Raspberry Pi 4) for our research that supports computer vision, Connecting non-contact sensors aids in our research; we have used a digital camera that integrates artificial intelligence to serve as a sensor that does not require touch that monitors and senses a patient's eyes while they are in a coma until they awaken, The Dlib Python library was used to build the wake-up monitoring system, which uses facial landmark detection to determine whether the patient's eyes are open or closed and alerts the physician. Our scientific study on the coma patient monitoring system has two parts: the first part is for sensors that touch the coma patient's body, and the second part is for sensors that don't touch the patient, both parts are part of an integrated control system that checks on the coma patient's condition. Even the patient wakes up from a coma thanks to the Internet of Things and a digital camera that uses artificial intelligence in computer vision to show continuous health and medical reports, This helps and alerts the supervising medical team without them having to be in the intensive care room, Reports are sent to the patient's smartphone or computer through the cloud system, which is meant to give the comatose patient a sense of complete calm.

4.2 EXPERMENTEL WORK AND RESULTS

This section provides an explanation of the findings of the experiment and a discussion of the data acquired by the comatose patient's contact and non-contact sensors, which were shown on the monitoring screen using a Blynk cloud system, This system, which is a platform for (IoT), shows all of the health metrics, and the attending physician may get the health reports of the coma patient by using this application on their smartphone or by viewing the monitoring screen in the room where the coma patient is being monitored, In a situation in which practical results were recorded for a number of comatose and unconscious patients from within the intensive care rooms, with the number of people not surpassing 10, and samples were collected for the results through the monitoring screen, and these are the results of particular samples obtained from the patients.

Figure 4.3: displays the actual data that was recorded on the screen of the (ECG) AD8232 contact sensor during various practical readings of the patient who was in a coma to monitor the (ECG) and provide the physician with a complete medical report continuously, moment by moment, or in the form of scheduled operation results according to time, date, and days. This was done to monitor the (ECG) and provide the physician with the ability to monitor the (ECG) and provide the physician with a complete medical report. An electrocardiogram (ECG) measurement taken by the Blynk cloud system is depicted as an example in the following image.

Figure 4.3: (ECG) Sensor Chart.

Figure 4.4: displays the (PLUSE OXIMETER) sensor, which is a second contact sensor on the (IoT) circuit, This sensor detects and stores data for two distinct readings, namely the percentage of oxygen (SPO2) in the patient's blood as well as the heartbeat rate (PBM),

Using these readings, the attending physician is able to assess, via the cloud system that is presented on the screen of the monitor, if the patient's current state of health has improved or deteriorated.

Figure 4.4: Pulse Oximeter (SPO2) and (PBM) Sensor.

Figure 4.5,6: is a practical experimental image recorded to observe the coma patient's eye when it opens and closes. This was accomplished by connecting an artificial intelligence digital camera inside an (IoT) circuit linked with the Raspberry Pi. is a non-contact sensor that gives the result on a cloud system after observing and recording the movement of the coma patient's eye as shown in the figure below.

percentage

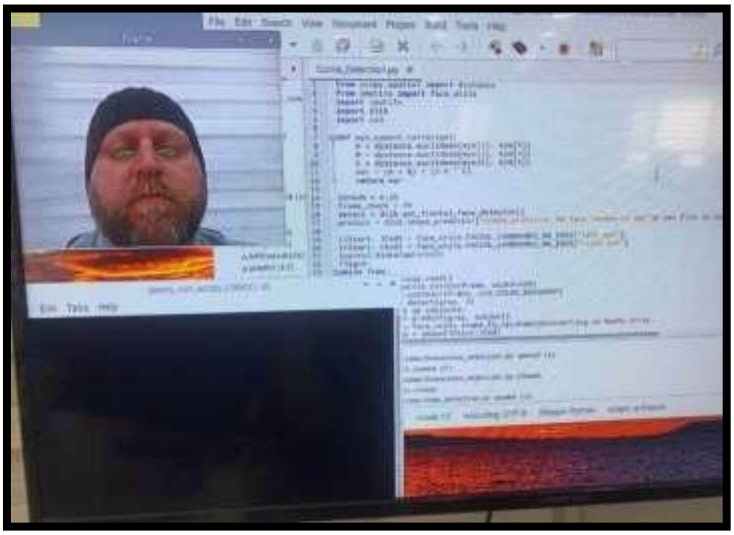

Figure 4.5: Camera sensor close eye (The Patient is in a Coma).

Figure 4.6: Camera sensor open eye (Wakeup Comatose Patient).

The performance of the coma patients monitoring system was tested in real, in order to see the success and effectiveness of the system, on a group of adults, the number of ten people, eight of whom were healthy and two of them were sick in the recovery room after the operation, the response rate of the system was very high and we got satisfactory and acceptable results Fit the health status of monitoring coma patients after recovery, the following chart illustrates this

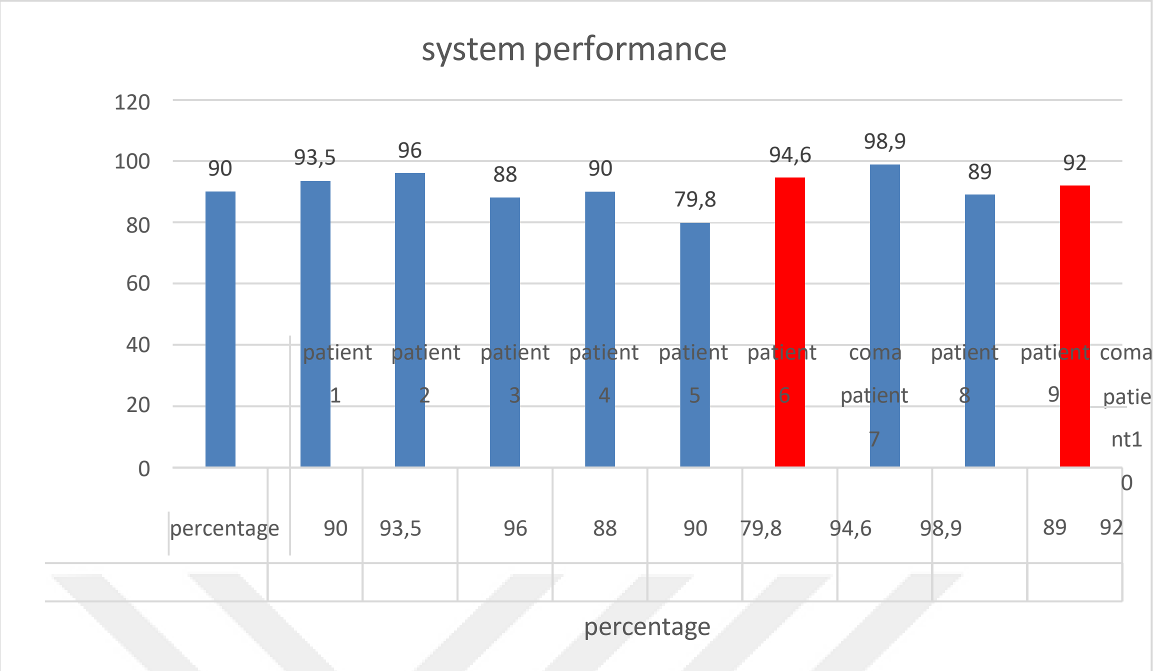

Chart 4.1: System Performance.

4.3 RESULTS AND COMPARISON WITH OTHER WORKS

Table 4.1: Results And Comparison With Other Works.

References	(IoT) System	Computer Vision	Method
[1]	YES	NO	This solution makes use of Wi-Fi for (IoT) and "Thing speak" to allow for online patient monitoring from a mobile device.
[4]	YES	NO	he integration of healthcare with the (IoT) has led to the development of wireless sensor networks and body area networks.
[2]	YES	NO	hing Speak is the (IoT) (API) softwar that we use, (IOMT) Health Monitoring, Twilio

e

Table 4.1: Results And Comparison With Other Works. "Table Continued".

[5]	YES	NO	he study pertains to the utilization of real-time mobile applications in onjunction with Firebase for the purpose of health monitoring within the Internet of Things (IoT) framework.
[34]	YES	NO	Wearable sensors analyze environmental and physiological factors in the proposed network system. A heterogeneous (IoT) platform with Bluetooth based medical signal detecting network and wearable sensors on various people may communicate and send data to a gateway through a (LoRa network).
[35]	YES	NO	Here, we talk about the Well Phone, a smartphone with healthmonitoring software. Used Pulse oximeter, glucometer, accelerometer, blood pressure sensor, and body weight sensor.
[6]	YES	NO	The patient's vital signs are tracked and updated on the patient's web page. Using a Wi-Fi gadget and the cloud. Sensors are put on the body of thepatient.
[8]	YES	NO	Authorized workers can access the collected data from anywhere using any (IoT) platform in the suggested system for health monitoring. Diseases can be remotely diagnosed by clinicians based on the obtained values.
[11]	YES	NO	The system under consideration employs a heterogeneous formula. The delineation between the sensor hub, internet hub, and this plan remains undefined under varying circumstances.

Table 4.1: Results And Comparison With Other Works. "Table Continued".

Our Work	YES	YES	The work is split into a multi-sensor system that checks the patient's heart rate, oxygen level, (ECG), and eye movement using an (AI)- powered digital camera. An integrated system that checks on the patient's health and tells the nurse if there is any critical situation.

5. CONCLUSION AND FUTURE WORK

In this study, we present a system to monitor comatose patients in a way that makes it simple for medical information to be transmitted to a doctor in real-time, the developed methodology results in a useful and efficient health monitoring service for those who are unconscious or in a coma, The Internet of Things market includes a wide range of smart interactive devices, such as smart wearable screens and biomedical screens, medical wristwatches, for use in the home or hospital, etc., which can collect and store data in both contact and non-contact ways, thanks to cutting-edge computer vision and image processing enabled by artificial intelligence delivered via the cloud system. With the use of these devices, a doctor may maintain tabs on a patient from any place by receiving updates via the cloud system and using features like real-time location services and telemedicine treatment, as part of this suggested system, we focused on electrical monitoring of the heart, monitoring and measuring blood oxygen levels, and monitoring the patient's heartbeat and open eyes. To sum up, all these indicators are aimed at letting the attending physician know that his patient is improving, since it relies mostly on image processing with industrial irons, they accomplish this through the screen of the monitoring system, which either saves the data with reports or sends a red alarm message to the screen when the patient awakens, It is believed that this system performs admirably, requires minimal financial outlay, and has room for improvement as technology develops.

5.1 FUTURE WORK

Future work should explore standard protocols and data exchange formats to establish a secure and interoperable connection between the monitoring system and EHR platforms. This integration would enhance the efficiency of medical professionals and facilitate data-driven decision-making, Wireless Communication and Mobility: Enabling wireless communication between the monitoring system and healthcare providers can enhance mobility and patient comfort, Future work should focus on developing robust wireless communication protocols and optimizing the system's hardware for reduced power consumption, By doing so, doctors could remotely access up-to-date patient information, improving response times and overall patient management. Predictive Analytics and

Decision Support: Leveraging historical patient data and machine learning techniques, future work should aim to develop predictive analytics models that can assist healthcare providers in making informed decisions. These models could help forecast potential complications, estimate recovery timelines, and recommend personalized treatment plans based on individual patient characteristics and trends identified from the collected data. Human-Machine Interface and Usability: Ensuring a user-friendly interface and efficient interaction between healthcare providers and the monitoring system is essential, Future work should focus on designing intuitive interfaces that display relevant patient information in a concise and easily interpretable manner. Additionally, incorporating feedback from healthcare professionals through user studies and iterative design processes would further enhance usability and acceptance of the system.

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