

SMART PARALYSIS PATIENT HEALTHCARE SYSTEM USING RASPBERRY PI



A PROJECT REPORT

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ABSTRACT

We come across hospitals and NGOs serving paralytic patients who have their whole or partial body disabled by the Paralysis attack. These people in most cases are not able to convey their needs as they are neither able to speak properly nor do they convey through sign language due to loss in motor control by their brain. In such a situation we propose a system that helps disabled person in displaying a message over the LCD by just simple motion of any part of his body which has motion abilities. This system also takes care of the situation where in no one is present to attend the patient and thus sending a message through GSM of what he wants to convey in SMS. There are several instruction of movement gesture sensors presented in the paper in order to assist health officer in helping the paralyzed patient to complete their needs. The user now just needs to tilt the device in a particular angle to convey the message. Thus, by tilting device one can convey message easily. So, this system can help them out to convey a message.

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LIST OF ABBREVIATIONS

AI	- Artificial Intelligence
ALS	- Amyotrophic Lateral Sclerosis
ASIC	- Application-Specific Integrated Circuit
CD	- Compact Disc
CPU	- Central Processing Unit
DSP	- Digital Signal Processor
ECG	- ElectroCardioGram
FDMA	- Frequency Division Multiple Access
GIL	- Global Interpreter Lock
GPIO	- General Purpose Input/Output
GSM	- Global System for Mobile Communications
GPRS	- General Packet Radio Service
HDMI	- High-Definition Multimedia Interface
HVAC	- Heating, Ventilation, and Air Conditioning
I/O	- Input/Output
IoT	- Internet of Things
IRD	- Infrared Detector
IDLE	- Integrated Distributed Learning Environment
LCD	- Liquid Crystal Display
LTE	- Long-Term Evolution
ML	- Machine Learning
MSC	- Mobile Switching Center
MP3	- MPEG-1 Audio Layer 3
NGO	- Non-Governmental Organization
NTC	- Negative Temperature Coefficient
OS	- Operating System

PPG	- Photo Plethysmo Graphy
PTC	- Positive Temperature Coefficient
RAM	- Random Access Memory
RTD	- Resistance Temperature Detector
SMS	- Short Message Service
SVM	- Support Vector Machine
SIM	- Subscriber Identity Module
TDMA	- Time Division Multiple Access
USB	- Universal Serial Bus
UMTS	- Universal Mobile Telecommunications System
VCR	- Video Cassette Recorder

CHAPTER 1

INTRODUCTION

1. 1 GENERAL

Paralysis is the inability to move muscles on your own and with purpose. It can be temporary or 444 permanents. The most common causes are stroke, spinal cord injury, and multiple sclerosis. Paralysis can be a complete loss of movement known as plegia, or a significant weakness called paresis. Paralysis is most often caused by damage in the nervous system, especially the spinal cord. Other major causes are stroke, trauma with nerve injury, poliomyelitis, cerebral palsy, peripheral neuropathy, Parkinson's disease, ALS, botulism, spina bifida, multiple sclerosis, and Guillai-Barre syndrome. For example, monoplegia/ mono paresis is complete loss of movement or weakness of one limb. Hemiplegia/hemiparesis is complete loss of movement or weakness of arm and leg on same side of the body. Paraplegia/Para paresis is complete loss or weakening of both legs. Tetraplegia /tetra paresis or quadriplegia/quadruparesis is complete loss or weakness of both arms and both legs. Paralysis is caused by injury or disease affecting the central nervous system (brain and spinal cord) which means that the nerve signals sent to the muscles is interrupted. Paralysis can also cause a number of associated secondary conditions, such as urinary incontinence and bowel incontinence. Though, there are innovative approaches for curing or treating paralysis patients, but the aim of treatment is to help a person adapt to life with paralysis by making them as independent as possible. Where we see a problem with these types of devices that are being developed is that they are very large and expensive machines. They seem to be only available in hospitals and not able to be used at the patient's home or at their convenience. International Journal of Creative Research Thoughts (IJCRT) www.ijcrt.org b252 that will be able to retrain a patient's motion but have them be able to use the

device themselves and have it be cheap enough for them to afford without much debt.

1.2 EMBEDDED SYSTEMS

1.2.1 OVERVIEW OF EMBEDDED SYSTEMS

An embedded system is a special-purpose computer system designed to perform one or a few dedicated functions, often with real-time computing constraints. It is usually embedded as part of a complete device including hardware and mechanical parts. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems have become very important today as they control many of the common devices we use.

Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale.

Physically, embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Handheld computers share some elements with embedded systems — such as the operating systems and microprocessors which power them — but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected.

Embedded systems provide several functions

- ✓ Monitor the environment; embedded systems read data from input sensors. This data is then processed and the results displayed in some format to a user or users.
- ✓ Control the environment; embedded systems generate and transmit commands for actuators.
- ✓ Transform the information; embedded systems transform the data collected in some meaningful way, such as data compression/decompression

Although interaction with the external world via sensors and actuators is an important aspect of embedded systems, these systems also provide functionality specific to their applications. Embedded systems typically execute applications such as control laws, finite state machines, and signal processing algorithms. These systems must also detect and react to faults in both the internal computing environment as well as the surrounding electromechanical systems.

There are many categories of embedded systems, from communication devices to home appliances to control systems. Examples include;

- ✓ Communication devices
e.g.: modems, cellular phones
- ✓ Home Appliances
e.g.: CD player, VCR, microwave oven
- ✓ Control Systems
e.g.: Automobile anti-lock braking systems, robotics, and satellite control

1.2.2 BLOCK DIAGRAM OF AN EMBEDDED SYSTEM:

An embedded system usually contains an embedded processor. Many appliances that have a digital interface microwaves, VCRs, cars utilize

embedded systems. Some embedded systems include an operating system. Others are very specialized resulting in the entire logic being implemented as a single program. These systems are embedded into some device for some specific purpose other than to provide general purpose computing. A typical embedded system is shown in Fig 1.1

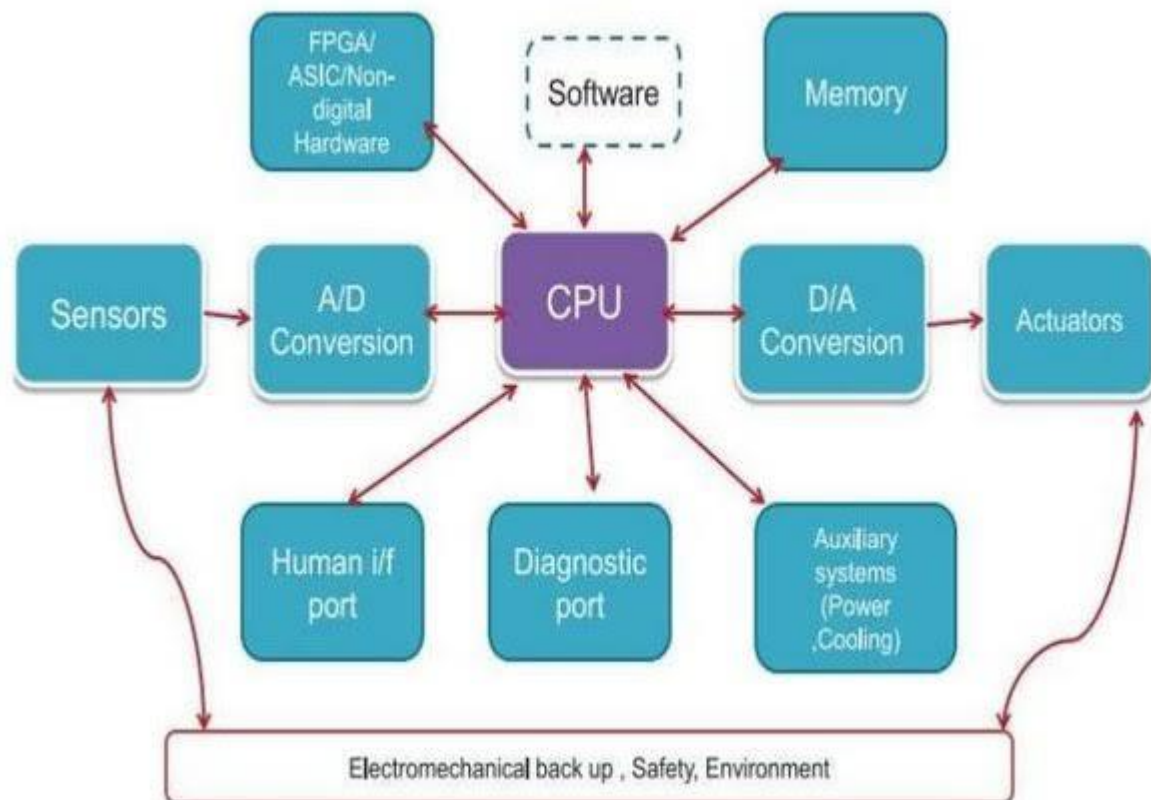


Fig 1.1 Block diagram of a typical embedded system

1.2.3 CHARACTERISTICS OF EMBEDDED SYSTEMS

Embedded systems are characterized by a unique set of characteristics. Each of these characteristics imposed a specific set of design constraints on embedded systems designers. The challenge to designing embedded systems is to conform to the specific set of constraints for the application.

APPLICATION SPECIFIC SYSTEMS:

Embedded systems are not general-purpose computers. Embedded system designs are optimized for a specific application. Many of the job characteristics are known before the hardware is designed. This allows the designer to focus on the specific design constraints of a well-defined application. As such, there is limited user reprogram ability. Some embedded systems, however, require the flexibility of programmability. Programmable DSPs are common for such applications.

REACTIVE SYSTEMS

As mentioned earlier, a typical embedded systems model responds to the environment via sensors and control the environment using actuators. This requires embedded systems to run at the speed of the environment. This characteristic of embedded system is called “reactive”. Reactive computation means that the system (primarily the software component) executes in response to external events. External events can be either periodic or aperiodic. Periodic events make it easier to schedule processing to guarantee performance. Aperiodic events are harder to schedule. The maximum event arrival rate must be estimated in order to accommodate worst case situations. Most embedded systems have a significant reactive component. One of the biggest challenges for embedded system designers is performing an accurate worst case design analysis on systems with statistical performance characteristics (e.g., cache memory on a DSP or other embedded processor). Real time system operation means that the correctness of a computation depends, in part, on the time at which it is delivered. Systems with this requirement must often design to worst case performance. But accurately predicting the worst case may be difficult on complicated architectures. This often leads to overly pessimistic estimates erring on the side of caution. Many embedded systems have a significant requirement for real time operation in order

to meet external I/O and control stability requirements. Many real-time systems are also reactive systems.

DISTRIBUTED SYSTEMS

A common characteristic of an embedded system is one that consists of communicating processes executing on several CPUs or ASICs which are connected by communication links. The reason for this is economy. Economical 4 8-bit microcontrollers may be cheaper than a 32-bit processors. Even after adding the cost of the communication links, this approach may be preferable. In this approach, multiple processors are usually required to handle multiple time-critical tasks. Devices under control of embedded systems may also be physically distributed.

HETEROGENEOUS ARCHITECTURES

Embedded systems often are composed of heterogeneous architectures (Fig 1.2). They may contain different processors in the same system solution. They may also be mixed signal systems. The combination of I/O interfaces, local and remote memories, and sensors and actuators makes embedded system design truly unique. Embedded systems also have tight design constraints, and heterogeneity provides better design flexibility.

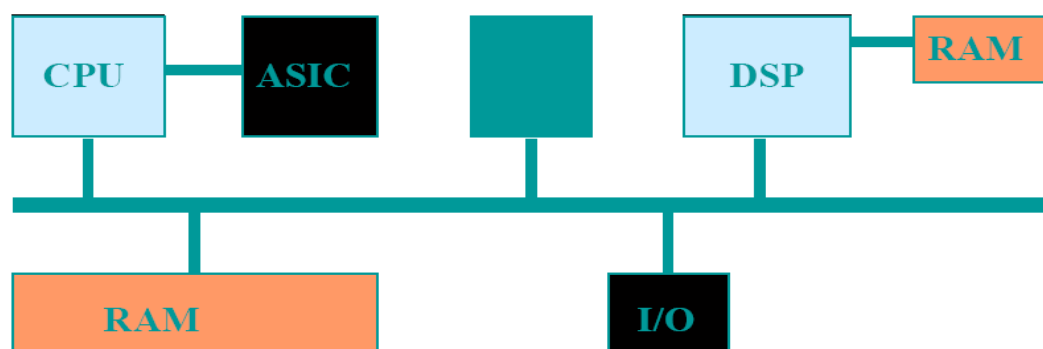


Fig 1.2 Embedded Systems having Heterogeneous Architectures

HARSH ENVIRONMENT

Many embedded systems do not operate in a controlled environment. Excessive heat is often a problem, especially in applications involving combustion (e.g., many transportation applications). Additional problems can be caused for embedded computing by a need for protection from vibration, shock, lightning, power supply fluctuations, water, corrosion, fire, and general physical abuse.

SYSTEM SAFETY AND RELIABILITY

As embedded system complexity and computing power continue to grow, they are starting to control more and more of the safety aspects of the overall system. These safety measures may be in the form of software as well as hardware control. Mechanical safety backups are normally activated when the computer system loses control in order to safely shut down system operation. Software safety and reliability is a bigger issue. Software doesn't normally "break" in the sense of hardware. However, software may be so complex that a set of unexpected circumstances can cause software failures leading to unsafe situations. Discussion of this topic is outside the scope of this book, but the challenges for embedded designers include designing reliable software and building cheap, available systems using unreliable components. The main challenge for embedded system designers is to obtain low-cost reliability with minimal redundancy.

CONTROL OF PHYSICAL SYSTEMS

One of the main reasons for embedding a computer is to interact with the environment. This is often done by monitoring and controlling external machinery. Embedded computers transform the analog signals from sensors into digital form for processing. Outputs must be transformed back to analog signal

levels. When controlling physical equipment, large current loads may need to be switched in order to operate motors and other actuators. To meet these needs, embedded systems may need large computer circuit boards with many non-digital components. Embedded system designers must carefully balance system tradeoffs among analog components, power, mechanical, network, and digital hardware with corresponding software.

SMALL AND LOW WEIGHT

Many embedded computers are physically located within some larger system. The form factor for the embedded system may be dictated by aesthetics. For example, the form factor for a missile may have to fit inside the nose of the missile. One of the challenges for embedded systems designers is to develop non-rectangular geometries for certain solutions. Weight can also be a critical constraint. Embedded automobile control systems, for example, must be light weight for fuel economy. Portable CD players must be light weight for portability purposes.

COST SENSITIVITY

Cost is an issue in most systems, but the sensitivity to cost changes can vary dramatically in embedded systems. This is mainly due to the effect of computer costs have on profitability and is more a function of the proportion of cost changes compared to the total system cost.

POWER MANAGEMENT

Embedded systems have strict constraints on power. Given the portability requirements of many embedded systems, the need to conserve power is important to maintain battery life as long as possible. Minimization of heat production is another obvious concern for embedded systems

1.3 MACHINE LEARNING

Machine learning is a subfield of artificial intelligence (AI) that focuses on developing algorithms and statistical models that enable computers to perform tasks without explicit programming. Instead of being explicitly programmed to perform a task, a machine learning system learns from data and experiences, adapting and improving its performance over time.

1.3.1 TYPES OF MACHINE LEARNING:

Supervised Learning: The algorithm is trained on a labeled dataset, where the input data is paired with corresponding output labels. The goal is to learn a mapping from inputs to outputs.

Unsupervised Learning: The algorithm is given unlabeled data and must find patterns or relationships within the data without explicit guidance.

Reinforcement Learning: The algorithm learns by interacting with an environment. It receives feedback in the form of rewards or penalties, allowing it to learn optimal behavior.

1.3.2 ALGORITHMS:

Decision Trees: Hierarchical tree-like structures that make decisions based on input features.

Support Vector Machines (SVM): Classify data by finding the hyperplane that best separates different classes.

Neural Networks: Computational models inspired by the structure and function of the human brain, particularly effective in complex tasks like image and speech recognition.

Clustering Algorithms: Group similar data points together, such as K-means clustering.

1.3.3 DEEP LEARNING:

- ✓ A subset of machine learning that focuses on neural networks with multiple layers (deep neural networks).
- ✓ Effective for tasks like image and speech recognition, natural language processing, and more.

FEATURE ENGINEERING:

The process of selecting, transforming, and creating features (input variables) to improve the performance of machine learning models.

EVALUATION METRICS:

Measures used to assess the performance of machine learning models, such as accuracy, precision, recall, F1 score, and others.

OVERFITTING AND UNDERFITTING:

Overfitting occurs when a model performs well on training data but poorly on new, unseen data. Underfitting occurs when a model is too simple to capture the underlying patterns in the data.

DATA PREPROCESSING:

Cleaning, transforming, and organizing data to prepare it for training and testing machine learning models.

ADVANTAGES OF MACHINE LEARNING:

- ✓ Machine learning allows for the automation of repetitive and time-consuming tasks, freeing up human resources for more complex and creative endeavors.
- ✓ ML algorithms can process and analyze large volumes of data, identifying patterns and extracting valuable insights that may be challenging for humans or traditional programming methods.

- ✓ Machine learning models can analyze data and provide predictions or decisions based on patterns and trends, often leading to more informed and accurate decision-making processes.
- ✓ ML models can adapt to new data and changing environments, making them versatile in various applications. They can also generalize patterns learned from training data to make predictions on new, unseen data.
- ✓ Automated learning processes can handle tasks at a much faster pace than human counterparts, making machine learning systems efficient for real-time applications.
- ✓ ML enables the creation of personalized user experiences, such as tailored recommendations in e-commerce, content recommendations, and personalized health insights.
- ✓ Machine learning models can improve over time as they are exposed to more data, allowing them to refine their predictions or classifications.

DISADVANTAGES OF MACHINE LEARNING:

- ✓ ML models heavily rely on high-quality, relevant, and representative data. Biased or incomplete datasets can lead to biased and inaccurate predictions.
- ✓ Some machine learning models, especially complex ones like deep neural networks, lack transparency, making it difficult to understand and explain the reasons behind their decisions. This can be a challenge in critical applications where interpretability is essential.
- ✓ Machine learning models may become too specialized in the training data and fail to generalize well to new, unseen data, leading to overfitting.
- ✓ Training sophisticated machine learning models, particularly deep neural networks, can be computationally intensive and may require significant resources, including powerful hardware and large amounts of data.

- ✓ As machine learning systems are applied in various domains, concerns about privacy, security, and ethical considerations, such as bias in algorithms, have become more prominent.
- ✓ Machine learning models may lack domain-specific knowledge, and their success relies on the quality and relevance of the data provided during training.
- ✓ The choice of the machine learning algorithm is crucial, and different algorithms may perform better in different scenarios. Selecting the wrong algorithm for a particular task can lead to suboptimal results.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE SURVEY I:

D Shiva Rama Krishnan, Subhash Chand IOT based patient health monitoring system July 2018. Nowadays Healthcare Environment has developed science and knowledge based This system basically uses a sensor technology and internet to communicate message to their loved ones. It uses temperature and heartbeat Gupta, Tanu priya Choudhury on Wireless Sensing node Technology oriented. This is designed for monitoring patient's health and alerting their loved ones on the same. sensor to measure the rates and monitor the patient's health.

2.2 LITERATURE SURVEY II:

Jan Bandana Mallick Heartrate A measurement of It is supported by the principle of 2016 monitoring system heart rate through a photo plethysmography (PPG) that is using fingertip tip and Arduino. non- invasive methodology of measure through Arduino and processing software.the variation in blood volume in tissue employing a source of illumination and detector. The signal may be amplified and is shipped to Arduino with the assist of process computer code pulse watching and investigating is performed.

2.3 LITERATURE SURVEY III:

Kumara K R Sensor based Wearable system to assist paralytic patient with continuous health monitoring March 2017. In extreme case of paralysis, the patient may be speech impaired which makes it difficult to convey the message. So, this provides solutions to these inabilities. The patient is made to wear the sensor gloves. When the patient bends his/her fingers to express the requirements it will be interpreted into auditory speech through which the patient's caretaker can understand the needs of patient.

2.4 LITERATURE SURVEY IV:

Jaiee Sitaram Adivarkar Patient monitoring system using GSM technology July 2017. It is used to monitor the patient's heart rate and Heart rate is measured from the index finger using IRD (Infrared Device) sensor. The device alarms when heart temperature. rate and body temperature exceed the threshold value. The sensor measures the information and transmits through GSM modem

2.5 LITERATURE SURVEY V:

Another author, Anetha K.et.al., presented different ways to recognize hand gestures and sign language. It has been proposed by various researchers in the past. Sign language is the only option for the hearing impaired and mute communication. These disabled people use sign language to express their feelings and thoughts.

2.6 LITERATURE SURVEY VI:

The current system designed for real-time monitoring of paralysis patients leverages the NodeMCU platform for collecting and transmitting patient data. This data, crucial for monitoring patient health and providing timely medical interventions, is stored in cloud-based repositories for accessibility and scalability. While this architecture enables efficient data management and remote access for healthcare providers, it also presents inherent security vulnerabilities.

One of the primary concerns is the lack of preemptive measures against potential security threats. Without proactive security measures in place, the system is susceptible to various forms of cyberattacks, including malware infiltration, data breaches, and unauthorized access. Malicious actors could exploit vulnerabilities in the system's software, network infrastructure, or communication protocols to gain unauthorized access to sensitive patient data.

The absence of pre-emptive security measures means that the system's defenses are primarily reactive. In other words, security measures are only triggered in response to a security incident or breach. This reactive approach significantly increases the risk of data exposure and compromise before appropriate countermeasures can be implemented. Moreover, reactive responses to security incidents may not be timely or effective in mitigating the impact of an attack, potentially leading to prolonged exposure of patient data and heightened risks to patient privacy and safety.

Furthermore, the reactive nature of the system's security posture introduces significant delays in detecting, analyzing, and mitigating security threats. By the time a malware incident or data breach is detected, substantial damage may have already occurred, including unauthorized access to patient records, tampering with medical data, or disruption of critical healthcare services. These delays not only compromise the integrity and confidentiality of patient information but also undermine the reliability and trustworthiness of the healthcare monitoring system as a whole.

DISADVANTAGES

- ✓ The reactive approach leaves a wider window of vulnerability between the occurrence of a security threat and its detection, allowing attackers more time to exploit weaknesses undetected.
- ✓ Reactive responses may lack effectiveness in swiftly containing and mitigating security incidents, potentially leading to prolonged disruptions and data exposure.
- ✓ Delayed detection and response increase the likelihood of unauthorized access to sensitive patient data, compromising confidentiality and integrity.
- ✓ Absence of preemptive measures means missing opportunities to identify and address security vulnerabilities before they are exploited by malicious actors

- ✓ Reactive responses may result in greater damage to the organization's reputation and erode trust with patients, partners, and regulatory authorities.
- ✓ Failure to implement proactive security measures may lead to non-compliance with healthcare regulations and industry standards, exposing the organization to legal and financial penalties.
- ✓ Reacting to security incidents after they occur often entails higher operational costs associated with incident investigation, remediation, and potential legal repercussions

CHAPTER 3

PROPOSED SYSTEM

3.1 GENERAL

The proposed smart paralysis patient healthcare system aims to overcome the limitations of the existing setup by integrating robust security measures to safeguard patient data and ensure system integrity. while retaining the core functionality of real-time patient monitoring through nodemcu, the proposed system introduces several enhancements to fortify its security posture. one key aspect involves the implementation of additional layers of security protocols designed to prevent and mitigate potential malware attacks. these protocols include stringent access controls, encryption of data both during transmission and storage, and the deployment of intrusion detection systems to monitor network traffic for suspicious activities.

Furthermore, proactive precautionary steps are taken, such as conducting regular security audits and assessments to identify and address vulnerabilities before they can be exploited by malicious actors. additionally, machine learning algorithms are integrated into the system to analyze and identify abnormal data patterns indicative of a security breach. this proactive approach enables swift action to be taken to mitigate any potential compromise before it can cause harm. by incorporating these advanced security features, the proposed system not only enhances the protection of patient data and privacy but also strengthens the overall reliability and trustworthiness of the healthcare monitoring infrastructure.

Moreover, the implementation of such comprehensive security measures demonstrates a commitment to regulatory compliance and ensures that the system remains resilient against evolving cyber threats in the healthcare landscape. ultimately, the smart paralysis patient healthcare system aims to provide a secure and dependable platform for continuous patient monitoring, delivering peace of mind to both patients and healthcare providers alike.

3.2 BLOCK DIAGRAM OF SMART PARALYSIS PATIENT HEALTHCARE SYSTEM

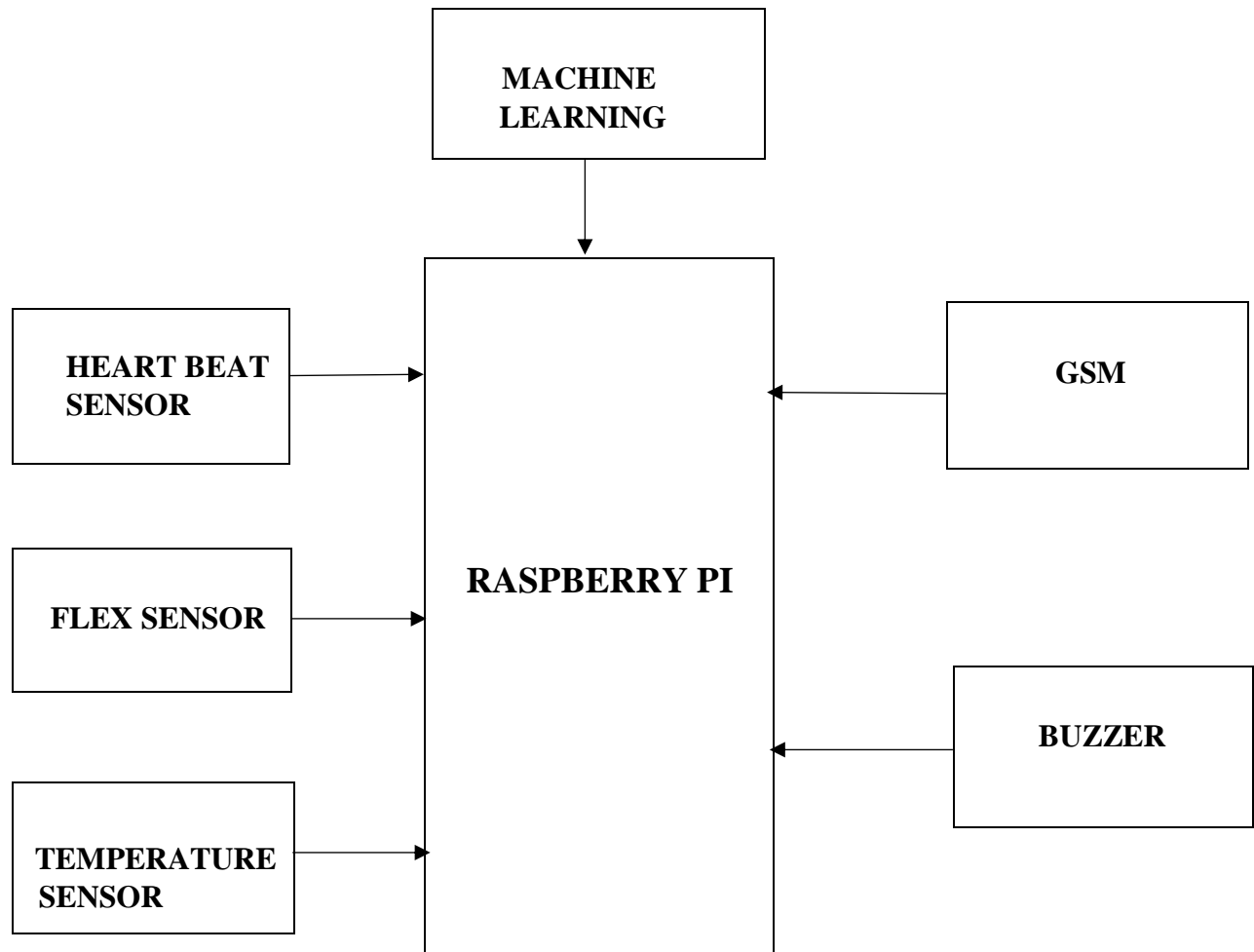


Fig 3.1 Block Diagram of Smart Paralysis Patient Healthcare System

ADVANTAGES:

- ✓ Proactive security measures reduce malware risks.
- ✓ Patient data safeguarded through precautionary steps.
- ✓ Enhanced response mechanisms bolster system integrity.
- ✓ Real-time monitoring fortified with advanced security.
- ✓ Swift threat detection ensures continuous reliability.
- ✓ Healthcare data integrity maintained with improved protocols.
- ✓ Patient trust fostered through robust security measures.
- ✓ System's resilience established for real-time patient monitoring.
- ✓ Precautionary steps mitigate potential security threats.
- ✓ Proposed system emerges as a secure healthcare monitoring solution.

The methodology for implementing the Smart Paralysis Patient Healthcare System follows a systematic approach that intertwines healthcare monitoring with cybersecurity measures. Initially, NodeMCU devices are deployed to facilitate real-time monitoring of paralysis patients, enabling the collection of crucial health data. Simultaneously, a secure cloud infrastructure is established to facilitate the seamless upload and storage of patient information, ensuring data integrity and confidentiality. To bolster the system's security, encryption protocols are implemented to safeguard data during transmission and storage.

Additionally, regular security audits are conducted to identify and address potential vulnerabilities proactively. Intrusion detection systems are integrated to monitor network traffic and detect any unauthorized access attempts or suspicious activities. Moreover, machine learning algorithms are employed to analyze patterns in health data, enabling the identification of anomalies that may indicate potential security threats. Continuous monitoring is essential to ensure the timely detection of any deviations from expected data patterns, allowing for swift response and mitigation of security risks. Through this comprehensive approach,

the Smart Paralysis Patient Healthcare System aims to deliver both effective patient monitoring and robust cybersecurity protection.

IMPLEMENTATION

The implementation phase of the Smart Paralysis Patient Healthcare System initiates with the strategic deployment of NodeMCU devices onto paralysis patients, facilitating the comprehensive collection of diverse health data. This data encompasses vital signs, mobility patterns, and various other pertinent health metrics crucial for monitoring patient well-being and facilitating informed medical interventions. Subsequently, the collected data is securely transmitted to the designated cloud infrastructure, where it undergoes rigorous real-time analysis facilitated by advanced machine learning algorithms.

Integral to this implementation is the stringent integration of robust security measures aimed at safeguarding the integrity and confidentiality of patient information throughout its journey from collection to analysis. Encryption protocols are meticulously implemented to ensure that data remains protected both during transmission over networks and storage within cloud repositories. Additionally, sophisticated intrusion detection systems are deployed to actively monitor network traffic, promptly identifying and responding to any unauthorized access attempts or suspicious activities that may compromise the security of patient data.

In the event that anomalous data patterns indicative of a potential security breach are detected, the system is designed to trigger immediate and decisive responses. These responses may include isolating affected components or segments of the system to prevent further unauthorized access or data compromise. Simultaneously, designated healthcare providers or system administrators are promptly notified, allowing for swift intervention and remediation efforts to mitigate any potential risks or damages to patient data and system integrity.

Furthermore, the implementation phase emphasizes the importance of ongoing maintenance and updates to ensure the system's resilience against the ever-evolving landscape of cybersecurity threats. Regularly scheduled maintenance activities, including software patches, system updates, and security audits, are meticulously conducted to fortify the system's defenses and address any emerging vulnerabilities promptly.

3.3 CONNECTION DIAGRAM OF SMART PARALYSIS PATIENT HEALTHCARE SYSTEM

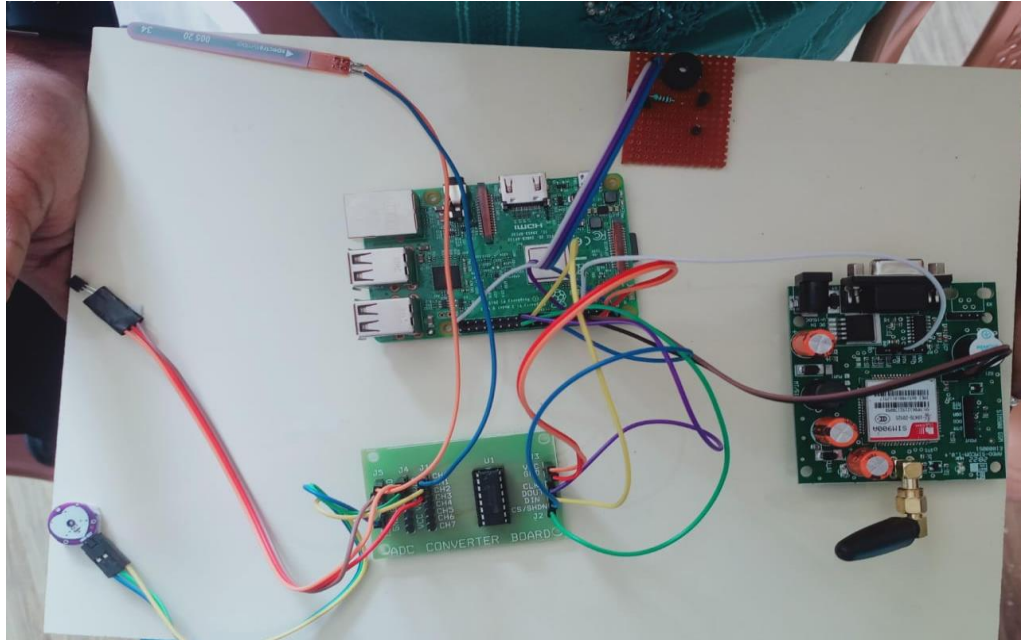


Fig 3.2 Connection Diagram of Smart Paralysis Patient Healthcare System

CHAPTER 4

HARDWARE DESCRIPTIONS

4.1 RASPBERRY Pi

Raspberry Pi is a series of small, single-board computers developed by the Raspberry Pi Foundation. These credit-card-sized computers are designed to promote learning about computer science and programming at an affordable cost. Raspberry Pi devices are known for their versatility, low power consumption, and the ability to connect to various peripherals, making them suitable for a wide range of applications.



Fig 4.1 Raspberry Pi

Affordability: Raspberry Pi devices are cost-effective, making them accessible for educational purposes and various DIY projects.

Hardware Variety: There are several models of Raspberry Pi, each with different specifications. The devices typically include USB ports, HDMI output, GPIO (General Purpose Input/Output) pins, audio output, and a variety of connectivity options.

Operating System Support: Raspberry Pi supports various operating systems, including Raspbian (now known as Raspberry Pi OS), Ubuntu, and others. The default Raspberry Pi OS comes with pre-installed applications and tools.

GPIO Pins: One of the standout features of Raspberry Pi is its GPIO pins. These pins allow users to interface the device with the physical world by connecting sensors, actuators, and other electronic components.

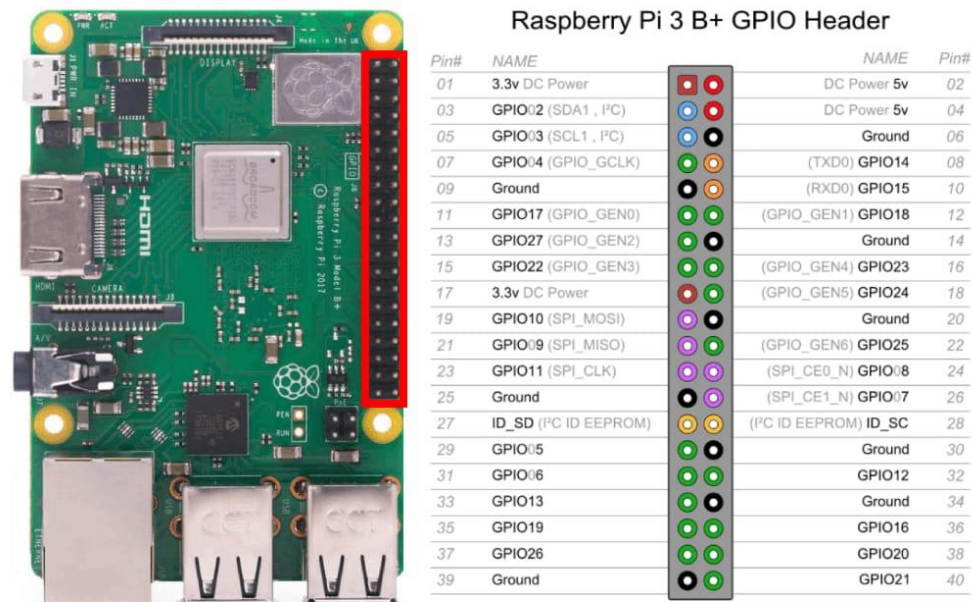


Fig 4.2 Raspberry Pi Pins

FUNCTIONS AND APPLICATIONS:

Educational Use: Raspberry Pi is widely used in educational settings to teach programming, electronics, and computer science. Its affordability and versatility make it an excellent tool for students to learn about hardware and software.

Home Automation: Raspberry Pi is often used in home automation projects. Users can build smart home systems to control lights, thermostats, and other devices using the GPIO pins and various sensors.

Media Center: Raspberry Pi can be transformed into a cost-effective media center using software like Kodi or Plex. This allows users to stream and organize multimedia content.

Server Applications: Raspberry Pi can be used as a lightweight server for tasks such as hosting websites, running a file server, or managing a small-scale database.

DIY Projects: The versatility of Raspberry Pi encourages a plethora of do-it-yourself (DIY) projects. These range from building retro gaming consoles and weather stations to creating network-attached storage (NAS) devices.

Robotics: Raspberry Pi is a popular choice for robotics enthusiasts. Its GPIO pins can be used to control motors and sensors, making it suitable for robot construction and experimentation.

Internet of Things (IoT): Given its small size and connectivity options, Raspberry Pi is commonly used in IoT projects. It can collect data from sensors and interact with the internet to create smart devices.

Programming and Coding: Raspberry Pi serves as an excellent platform for learning and practicing coding. Python, in particular, is often used due to its simplicity and versatility.

Raspberry Pi's combination of affordability, versatility, and a supportive community has made it a staple in both educational and hobbyist settings, fostering creativity and innovation in various fields.

4.2 HEART BEAT SENSOR

A heart rate sensor, often used in wearable devices and medical applications, is a technology that measures the heart rate or pulse rate of an individual. The heart rate is the number of heartbeats per minute and is an important physiological parameter used to assess overall health and fitness. Heart rate sensors are employed in various contexts, including fitness trackers, smartwatches, medical devices, and sports equipment. Here's an overview of how heart rate sensors work and their applications:

TYPES OF HEART RATE SENSORS:

Photoplethysmography (PPG): This is a commonly used technology in consumer wearables. It involves shining light into the skin and measuring the amount of light that is absorbed or reflected by blood vessels, providing information about blood volume changes with each heartbeat.

Electrocardiography (ECG or EKG): ECG sensors measure the electrical activity of the heart. While more accurate, ECG sensors are often found in medical-grade devices due to their higher complexity.

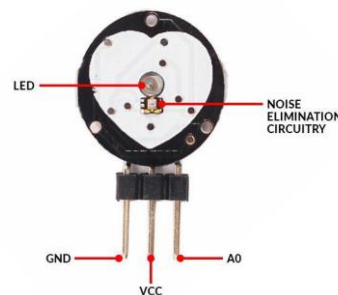


Fig 4.3 Heart Rate Sensor

WORKING OF PPG SENSOR:

In a typical PPG sensor, light-emitting diodes (LEDs) emit green or infrared light into the skin. Photodetectors measure the amount of light that passes through or is reflected back.

Blood absorbs light differently based on its oxygenation level. As blood volume changes with each heartbeat, the amount of light absorbed or reflected also varies.

The resulting data is processed to determine the pulse rate and, in some cases, additional information such as heart rate variability.

APPLICATIONS:

Fitness Tracking: Wearable devices, like fitness trackers and smartwatches, use heart rate sensors to monitor users' heart rates during physical activities, providing insights into their overall fitness and exertion levels.

Medical Monitoring: Heart rate sensors are integrated into medical devices for continuous monitoring of patients, especially those with cardiovascular conditions. This includes hospital-grade ECG monitors and portable devices for remote patient monitoring.

Sports Performance: Athletes use heart rate data to optimize their training routines, ensuring they exercise within target heart rate zones for maximum efficiency and safety.

Accuracy and Limitations:

The accuracy of heart rate sensors can vary depending on factors such as sensor type, placement, and environmental conditions.

Motion artifacts or poor contact with the skin can affect accuracy, especially during intense physical activities.

ECG sensors generally provide higher accuracy compared to PPG sensors.

CHALLENGES AND CONSIDERATIONS:

Battery Life: Continuous heart rate monitoring can impact the battery life of wearable devices, leading to the need for efficient power management.

Skin Contact: Reliable sensor readings require good skin contact, which may be challenging during certain activities or when the device is not worn snugly.

4.3 FLEX SENSOR

A flex sensor is a type of sensor that changes its electrical resistance when subjected to bending or flexing. It is designed to measure the amount of

deflection or bending in a physical structure and convert this mechanical deformation into an electrical signal.



Fig 4.4 Flex Sensor

Operating Principle:

Flex sensors typically utilize a flexible substrate containing a resistive material, often made of carbon. As the sensor bends, the resistive material undergoes compression or elongation, causing a change in its resistance.

Construction:

The flex sensor is usually a thin, flexible strip that can be attached to the surface of an object or integrated into a wearable device. The flexibility of the sensor allows it to conform to the shape of the object undergoing deformation.

Resistance Variation:

The resistance of the flex sensor changes linearly with the amount of bending or flexing. This relationship is often calibrated to provide accurate measurements of the angle or degree of bending.

Applications:

Robotics: Flex sensors are commonly used in robotics to measure joint angles and control the movement of robotic limbs or joints.

Prosthetics: In prosthetic devices, flex sensors can be integrated to capture natural movements and enhance the functionality of artificial limbs.
Gaming Controllers: Flex sensors find applications in gaming controllers, providing a means for detecting and responding to user gestures or movements.

Integration:

Due to their slim and flexible design, flex sensors can be easily integrated into various devices and systems, allowing for applications in diverse fields.

Signal Processing:

The electrical signal produced by the flex sensor is often processed to convert the resistance change into meaningful data, such as the angle of bending.

Limitations:

Flex sensors may have limitations, including a finite lifespan under repeated bending and the need for calibration to ensure accurate measurements.

Usage Considerations:

Proper installation and calibration are essential for accurate readings, and the sensor's mechanical properties must be considered in the design of the system.

4.4 TEMPERATURE SENSOR

A temperature sensor is a device designed to measure the temperature of an object, environment, or substance and convert this temperature into an electrical signal. There are various types of temperature sensors, each with its own principles of operation, accuracy, and applications.



Fig 4.5 Temperature Sensor

Types of Temperature Sensors:

Thermocouples: These sensors use the Seebeck effect, generating a voltage when two different metals are joined at one end and exposed to a temperature gradient. Thermocouples are commonly used in industrial applications due to their durability and wide temperature range.

Thermistors: Thermistors are resistive temperature devices that exhibit a significant change in resistance with temperature. They are available in two types: positive temperature coefficient (PTC) and negative temperature coefficient (NTC). Thermistors are often used in applications requiring high accuracy.

RTDs (Resistance Temperature Detectors): RTDs are temperature sensors based on the principle that the electrical resistance of certain metals increases predictably with temperature. Platinum is commonly used in RTDs for its stability and linearity.

Infrared Sensors: These sensors detect the infrared radiation emitted by an object to determine its temperature. Infrared sensors are contactless and find applications in temperature measurement without direct physical contact.

APPLICATIONS:

Climate Control: Temperature sensors are fundamental components in heating, ventilation, and air conditioning (HVAC) systems, ensuring that the environment is kept at a comfortable temperature.

Industrial Processes: Many industrial processes require precise temperature control for manufacturing, chemical reactions, and other applications.

Electronics: Temperature sensors are used in electronic devices to monitor and regulate temperature, preventing overheating and ensuring optimal performance.

Medical Devices: In medical applications, temperature sensors are employed for monitoring body temperature in devices such as thermometers.

Accuracy and Calibration:

The accuracy of temperature sensors is crucial for their applications. Depending on the type of sensor, periodic calibration may be necessary to maintain precise temperature measurements.

Digital and Analog Sensors:

Temperature sensors can provide digital outputs, such as I2C or SPI, or analog signals. The choice depends on the specific requirements of the application and the level of precision needed.

Response Time:

Different temperature sensors have varying response times, which is the time it takes for the sensor to register a change in temperature. Fast response times are crucial in applications where quick temperature adjustments are necessary.

Environmental Considerations:

Some temperature sensors are more suitable for specific environments or conditions. For example, certain sensors may be designed to withstand harsh industrial environments, while others are intended for more controlled settings.

4.5 GSM

GSM, or Global System for Mobile Communications, is a standard for digital mobile communication widely used in mobile phones and other devices. Here are key points about GSM:



Fig 4.6 GSM

Network Standard:

GSM is a standard for the second generation (2G) of mobile networks. It was developed to provide a standardized platform for mobile communication across different countries and regions.

Architecture:

GSM networks consist of several components, including mobile stations (phones), base stations, mobile switching centers (MSCs), and various network elements. The architecture supports voice and data communication.

Frequency Bands:

GSM operates in various frequency bands around the world. Different regions may use different frequency allocations, such as GSM 850, GSM 900, GSM 1800, and GSM 1900.

Modulation Technique:

GSM uses a combination of time-division multiple access (TDMA) and frequency-division multiple access (FDMA) techniques. TDMA divides a radio frequency into time slots, allowing multiple users to share the same frequency channel.

Data Transfer:

GSM was initially designed for voice communication, but it also supports data services, including text messaging (SMS) and General Packet Radio Service (GPRS) for basic internet connectivity.

SIM Cards:

Subscriber Identity Module (SIM) cards are a fundamental component of GSM. They store user data, including subscriber information, contacts, and authentication keys, allowing users to easily switch devices while keeping their phone number and information.



Fig 4.7 Sim Card

Security:

GSM incorporates various security features, such as encryption and authentication, to protect communication between the mobile device and the network. However, certain vulnerabilities have been identified over the years.

Evolution to 3G and 4G:

While GSM served as the foundation for 2G networks, subsequent generations, such as 3G (UMTS) and 4G (LTE), brought improvements in data speeds, capacity, and advanced services. Many operators have transitioned or are transitioning to these newer technologies.

Legacy Support:

Despite the evolution to newer technologies, GSM networks continue to operate in many regions. This legacy support ensures backward compatibility for older devices and enables smooth transitions to newer technologies.

Global Standard:

GSM's status as a global standard has contributed to the widespread adoption of mobile communication technology, allowing users to use their devices seamlessly across different countries and networks.

Emergence of 5G:

As of my last knowledge update in January 2022, the telecommunications industry has been moving towards 5G technology, which offers even higher data speeds and improved network capabilities. 5G is designed to coexist with existing networks, including those based on GSM standards.

GSM has played a pivotal role in the development of mobile communication, providing a foundation for subsequent generations of mobile networks. While newer technologies have emerged, GSM remains an integral part of the global mobile infrastructure.

4.6 Buzzer

A buzzer is an electronic sound-making device that produces a buzzing or beeping sound. It is a simple and commonly used component in electronic circuits, devices, and systems for providing audible alerts, notifications, or alarms. Here are key points about buzzers.



Fig 4.8 Buzzer

Types of Buzzers:

Piezoelectric Buzzers: These buzzers generate sound through the piezoelectric effect. A piezoelectric crystal within the buzzer vibrates when an electrical signal is applied, producing sound waves.

Magnetic Buzzers: Magnetic buzzers use an electromagnet and a diaphragm to generate sound. When an electrical signal is applied, the diaphragm is attracted to the electromagnet, creating vibrations that produce sound.

Operating Principles:

Piezoelectric Buzzers: They convert electrical energy into mechanical vibrations, and the vibrations of the piezoelectric element generate sound waves.

Magnetic Buzzers: These buzzers use an electromagnetic coil to attract a diaphragm, causing it to vibrate and produce sound.

Applications:

Alarms and Notifications: Buzzers are commonly used in electronic devices, appliances, and systems to provide audible alerts or notifications.

Indicators: They are often used as indicators in electronic circuits to signal certain conditions, such as a button press or system malfunction.

Security Systems: Buzzers are integrated into security systems to signal breaches or unauthorized access.

Electronic Games: Buzzers are used in electronic games and quizzes to indicate correct or incorrect answers.

Types of Sounds:

Buzzers can produce different types of sounds, including continuous tones, intermittent beeps, or patterns of sounds, depending on the design and intended application.

Voltage and Frequency:

The operating voltage and frequency of buzzers can vary. It's essential to match the specifications of the buzzer with the requirements of the circuit or system in which it is used.

Integration in Circuits:

Buzzers are typically connected to a power source and a control circuit. The control circuit determines when the buzzer should produce sound.

Compact and Lightweight:

Buzzers are compact and lightweight, making them easy to integrate into various electronic devices without adding significant bulk or weight.

Passive vs. Active Buzzers:

Passive buzzers require an external oscillating signal to produce sound, while active buzzers have an integrated oscillating circuit, simplifying the control process.

CHAPTER 5

SOFTWARE DESCRIPTIONS

5.1 PYTHON IDLE

Python IDLE, which stands for Integrated Development and Learning Environment, is a user-friendly tool bundled with the Python programming language. It provides an intuitive interface for writing, testing, and debugging Python code. The IDLE editor supports essential features like syntax highlighting, code folding, and indentation, promoting a clean and readable coding environment. For beginners, the interactive shell within IDLE offers a quick and straightforward way to experiment with Python commands and learn the basics of the language in a hands-on manner.

One notable feature of Python IDLE is its integrated debugger, which assists developers in identifying and resolving errors in their code. The debugger allows users to set breakpoints, step through code execution, and inspect variables during runtime, streamlining the debugging process. This makes IDLE not only a tool for writing code but also a valuable resource for learning the intricacies of Python programming through practical application.

Additionally, Python IDLE serves as an excellent environment for quick prototyping, enabling developers to test code snippets and experiment with new ideas before incorporating them into larger projects. Its lightweight nature makes it suitable for various use cases, providing a balance between simplicity for beginners and functionality for more experienced programmers. Overall, Python IDLE plays a crucial role in the Python ecosystem, supporting both learning and development activities with its versatile and accessible features.

5.1.1 Code Context:

Python IDLE provides a unique feature called "Code Context," which displays a pop-up window showing the context of the current code block. This is particularly helpful for understanding the structure of your code and navigating through complex projects.

5.1.2 Auto-Completion:

IDLE supports auto-completion, making coding more efficient. By pressing the Tab key, developers can autocomplete variable and function names, reducing the chances of typos and improving productivity.

5.1.3 Multi-Window Support:

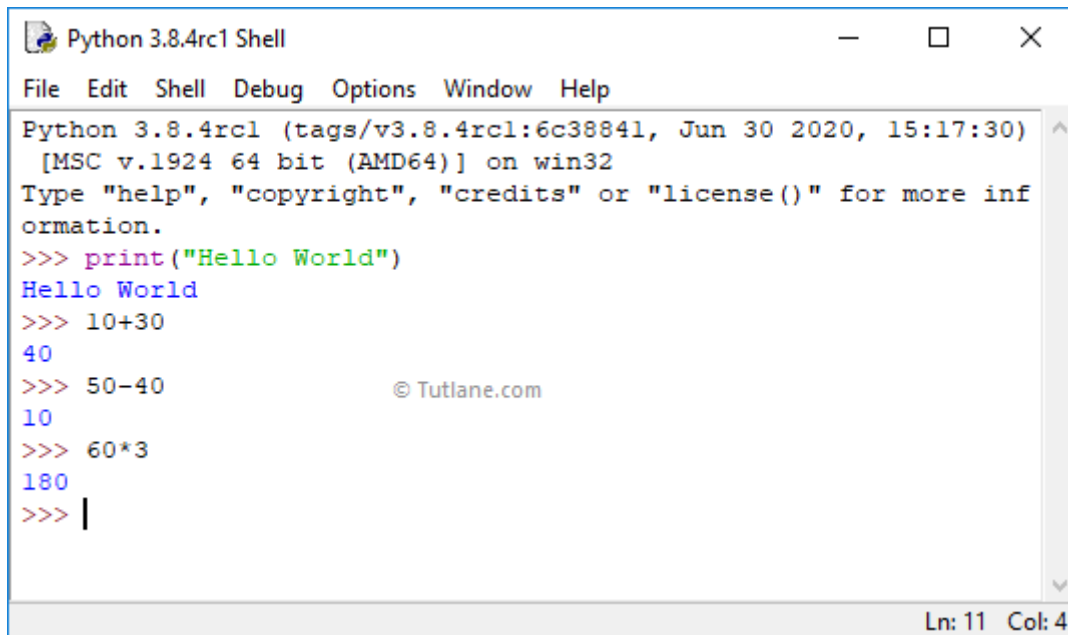
Users can work with multiple Python shells or script editor windows simultaneously in IDLE. This allows for better organization of code, facilitating the development and testing of various components within the same IDE instance.

5.1.4 Integrated Help:

Python IDLE integrates a comprehensive help system. Users can access documentation, module information, and function details directly from the IDE. This feature promotes a self-contained development environment, reducing the need to switch between different resources.

5.1.5 Extension and Plugin Support:

While not as extensible as some other IDEs, Python IDLE does support basic extensions and plugins. Developers can enhance the functionality of IDLE by adding extensions or plugins to cater to specific needs, making it a more adaptable tool for different coding scenarios.

A screenshot of a Python 3.8.4rc1 Shell window. The window has a title bar with the text "Python 3.8.4rc1 Shell" and standard window controls (minimize, maximize, close). Below the title bar is a menu bar with "File", "Edit", "Shell", "Debug", "Options", "Window", and "Help". The main text area contains the following text:

```
Python 3.8.4rc1 (tags/v3.8.4rc1:6c38841, Jun 30 2020, 15:17:30) ^
[MSC v.1924 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more inf
ormation.
>>> print("Hello World")
Hello World
>>> 10+30
40
>>> 50-40
10
>>> 60*3
180
>>> |
```

A copyright notice "© Tutlane.com" is visible in the background. The status bar at the bottom right shows "Ln: 11 Col: 4".

Fig 5.1 Extension and Plugin Support

Here are a few key versions of Python that were relevant around that time

Python 3.8: This version introduced various features and optimizations, including the walrus operator (`:=`), positional-only parameters, and the future module to ease the migration to future Python versions.

Python 3.9: Released in October 2020, Python 3.9 included improvements like the introduction of the `zoneinfo` module for time zone support, new syntax features, and various optimizations.

Python 3.10: Python 3.10 was in development around my last update, with a planned release for later in 2021. It was expected to bring new syntax features, improvements to error messages, and other enhancements.

Advantages:

Readability and Simplicity:

Python emphasizes code readability and simplicity, making it an excellent language for beginners and professionals alike. The clean and straightforward syntax reduces the cost of program maintenance and development.

Extensive Libraries and Frameworks:

Python has a vast standard library and a rich ecosystem of third-party libraries and frameworks. This wealth of resources simplifies development tasks and accelerates project timelines.

Community and Documentation:

Python has a large and active community of developers. This community support, along with extensive documentation, makes it easier to find solutions to problems, seek advice, and stay updated on best practices.

Versatility:

Python is a versatile language used in various domains, including web development, data science, artificial intelligence, automation, and more. Its versatility makes it suitable for a wide range of applications.

Interpreted Language:

Being an interpreted language, Python allows for rapid development and testing. Developers can execute and test code without the need for compilation, resulting in a shorter development cycle.

Integration Capabilities:

Python seamlessly integrates with other languages like C and C++, facilitating the incorporation of existing codebases into Python applications. It also interfaces well with web services and databases.

Disadvantages:**Performance:**

Compared to compiled languages like C or C++, Python can be slower in execution. While this might not be a significant issue for many applications, it can be a concern for performance-critical tasks.

Global Interpreter Lock (GIL):

Python's Global Interpreter Lock can limit the execution of multiple threads in a multi-core system, affecting parallel processing performance. This can be a drawback for CPU-bound and multi-threaded applications.

Mobile Computing:

Python is not as prominent in mobile app development as some other languages. While frameworks like Kivy and BeeWare exist, they might not offer the same level of maturity or community support as those for other languages.

Design Restrictions:

Python's design philosophy may limit some developers who come from a background of languages with different paradigms. For example, its enforced indentation and whitespace can be a departure for developers accustomed to using braces for block delimitation.

Packaging Issues:

Managing dependencies and packaging in Python can sometimes be challenging. While tools like pip are helpful, dependency conflicts and versioning issues can still arise.

Not Ideal for Mobile and Game Development:

While Python is used in some mobile and game development scenarios, it's not as prevalent as languages like Java or Swift for mobile apps and C++ for game development.

5.2 PYTHON

Python is a high-level, general-purpose programming language known for its readability, simplicity, and versatility. Guido van Rossum initiated its development in the late 1980s, and it has since evolved into one of the most popular programming languages. Python's syntax emphasizes code readability with its use of whitespace and avoids the use of curly brackets, making it an ideal language for both beginners and experienced developers.

One of Python's key strengths lies in its extensive standard library and a thriving ecosystem of third-party packages and frameworks. This vast collection of resources simplifies development tasks, ranging from web development to data science, artificial intelligence, machine learning, and automation. The availability of tools like Django for web development, NumPy and pandas for data manipulation, and TensorFlow for machine learning underscores Python's adaptability to various domains.

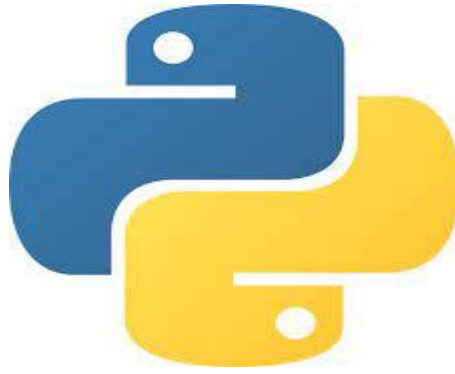


Fig 5.2 Python

Python's interpreted nature allows for quick development and testing cycles. The language supports multiple programming paradigms, including procedural, object-oriented, and functional programming, providing developers with flexibility in their coding approaches. Its dynamic typing system and automatic memory management contribute to a more straightforward and expressive coding experience.

The Python community is renowned for its size, diversity, and active participation. This community support, coupled with comprehensive documentation, enables developers to easily find solutions to problems and stay up-to-date with best practices. Python's simplicity and readability have also made it an excellent language for teaching programming concepts in educational settings.

However, Python does have some drawbacks. Its interpreted nature can result in slower execution speeds compared to compiled languages, which may be a concern for performance-critical applications. The Global Interpreter Lock (GIL) can limit the execution of multiple threads, affecting the performance of multi-core systems. Despite these limitations, Python remains a powerful and widely adopted language, continually evolving to meet the demands of modern software development. Its balance of simplicity, versatility, and community support contributes to its sustained popularity among developers worldwide.

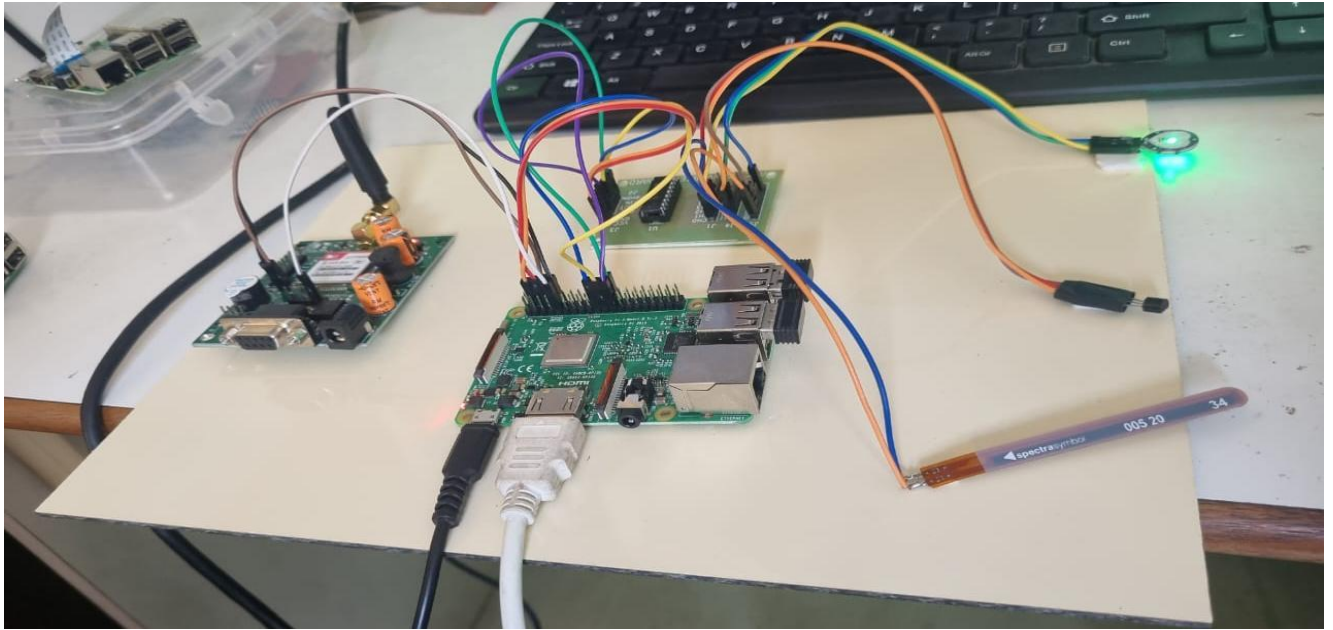
CHAPTER 6

CONCLUSION

In conclusion, the "Smart Paralysis Patient Healthcare System using Machine Learning Model" represents a groundbreaking advancement in paralysis patient care, offering a comprehensive and forward-thinking approach to addressing the unique needs of these individuals. Through the utilization of machine learning algorithms, the system delivers a dynamic and personalized healthcare solution tailored to each patient's specific requirements, thereby significantly enhancing patient outcomes and quality of life. By leveraging advanced technologies, such as real-time monitoring and data analysis, the system not only improves the efficiency of healthcare delivery but also alleviates the burden on caregivers and healthcare facilities by streamlining processes and facilitating proactive interventions. Moreover, the integration of machine learning fosters a more patient-centric approach to healthcare, empowering individuals living with paralysis to actively participate in their treatment and management. Overall, the Smart Paralysis Patient Healthcare System represents a paradigm shift towards preventative and proactive healthcare, ushering in a new era of innovation and excellence in patient care for this vulnerable population.

CHAPTER 7

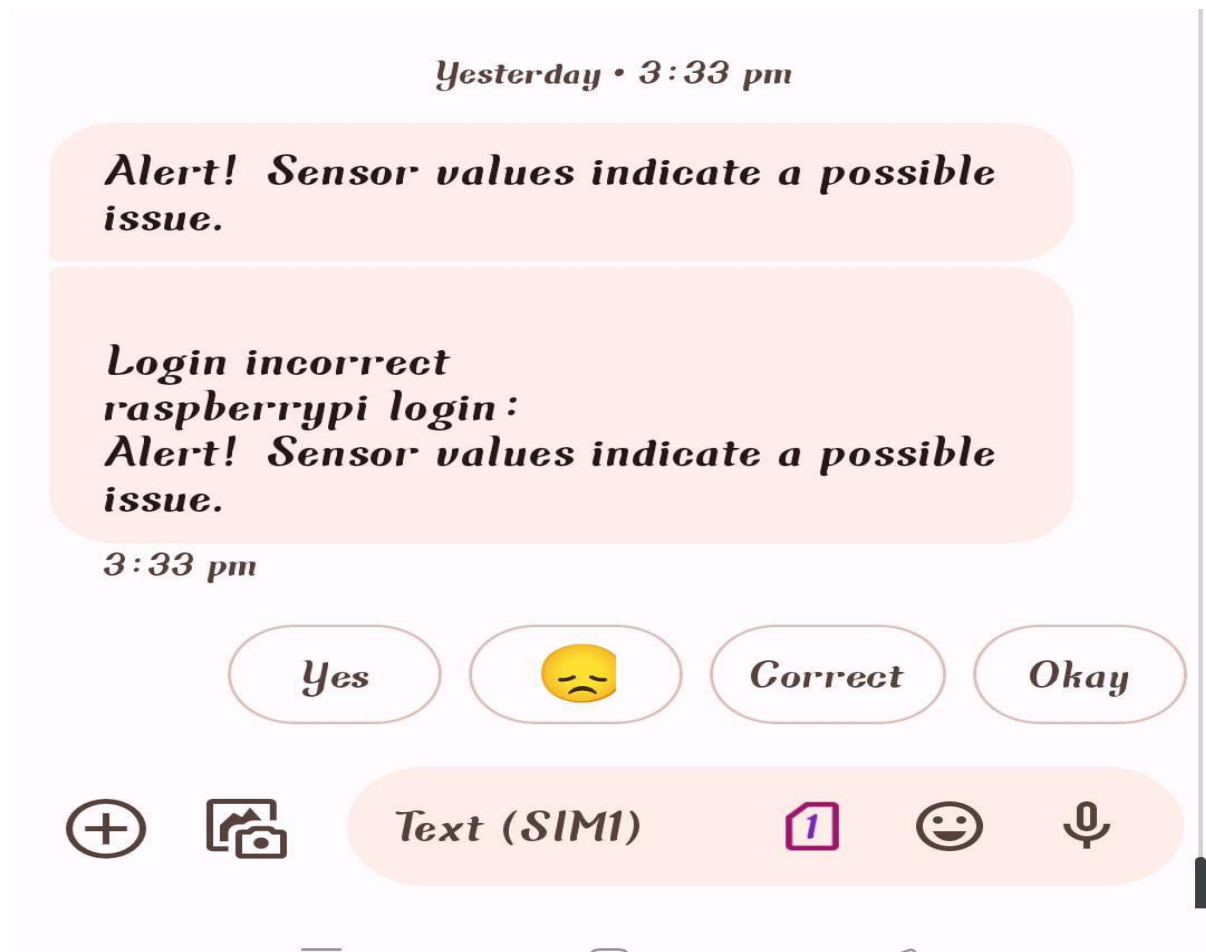
HARDWARE IMPLEMENTATION OF SMART PARALYSIS PATIENT HEALTHCARE SYSTEM



**Fig 7.1 Hardware Implementation of Smart Paralysis
Patient Healthcare System**

CHAPTER 8

OUTPUT OF SMART PARALYSIS PATIENT HEALTHCARE SYSTEM



**Fig 8.1 Output of Smart Paralysis
Patient Healthcare System**

CHAPTER 9

APPENDIX

```
import time
import RPi.GPIO as GPIO
import spidev
import numpy as np
import serial
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score
import warnings
warnings.filterwarnings("ignore")
# Initialize GPIO
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)
# Define pin numbers for SPI
SCLK = 11 # Clock
MISO = 9 # Master In Slave Out
MOSI = 10 # Master Out Slave In
CS = 8 # Chip Select
# Define pin for the buzzer
buzzer_pin = 18
GPIO.setup(buzzer_pin, GPIO.OUT)
```

```

# Setup SPI
spi = spidev.SpiDev()
spi.open(0, 0) # Open SPI bus 0, device 0
spi.max_speed_hz = 5000 # Set SPI speed (5 kHz)
# Function to read ADC value using SPI
def read_adc(channel):
    # MCP3008 supports 8 channels (0-7)
    if channel > 7 or channel < 0:
        return -1
    adc = spi.xfer2([1, (8 + channel) << 4, 0])
    data = ((adc[1] & 3) << 8) + adc[2]
    return data
# Function to read temperature from LM35 sensor
def read_temperature():
    # Read analog value from LM35 sensor connected to channel 2
    analog_value = read_adc(2)
    # Convert analog value to Celsius temperature
    temperature = (analog_value * 3.3 / 1023) * 100
    return temperature
# Function to read flex sensor
def read_flex_sensor():
    value = read_adc(0) # Assuming flex sensor is connected to channel 0
    return value
# Function to read heartbeat sensor
def read_heartbeat_sensor():
    value = read_adc(1) # Assuming heartbeat sensor is connected to channel 1
    return value

```

```

# Function to train the machine learning model
def train_model(data):
    X = data[['Heartbeat', 'Flex Sensor', 'Temperature']]
    y = data['Label']

    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,
random_state=42)

    model = RandomForestClassifier()
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    accuracy = accuracy_score(y_test, y_pred)
    return model, accuracy

# Read dataset from CSV file
data = pd.read_csv('sensor_data.csv')

# Main loop
try:
    while True:
        heartbeat = read_heartbeat_sensor()
        flex_sensor = read_flex_sensor()
        temperature = read_temperature()

        # Check conditions for buzzer
        if heartbeat > 550 or flex_sensor > 20 or temperature > 255.0: # Adjust the
thresholds as needed

            GPIO.output(buzzer_pin, GPIO.HIGH)
            print("Alert! Sensor values indicate a possible issue.")
            sms_content = "Alert! Sensor values indicate a possible issue."

            # Open serial connection
            ser = serial.Serial("/dev/serial0", baudrate=9600, timeout=1)

            # Send SMS

```

```

ser.write("AT\r\n".encode())
time.sleep(1)
ser.write('AT+CMGF=1\r\n'.encode()) # Set SMS mode to text mode
time.sleep(1)
ser.write('AT+CMGS="+919361589755"\r\n'.encode()) # Replace with
recipient's phone number
time.sleep(1)
ser.write((sms_content + chr(26)).encode()) # Send the message and the
Ctrl+Z character (ASCII 26)
time.sleep(1)
ser.close() # Close serial connection
print("SMS sent successfully!")
else:
    GPIO.output(buzzer_pin, GPIO.LOW)
    print("Sensor values normal.")
    # Print sensor values
    print(f"Heartbeat: {heartbeat}, Flex Sensor: {flex_sensor}, Temperature:
{temperature}")
    # Add data to DataFrame
    data = data.append({'Heartbeat': heartbeat, 'Flex Sensor': flex_sensor,
'Temperature': temperature, 'Label': 1 if GPIO.input(buzzer_pin) else 0},
ignore_index=True)
    # Train model every 10 samples
    if len(data) % 10 == 0:
        model, accuracy = train_model(data)
        print(f"Model trained with accuracy: {accuracy}")

time.sleep(1)
except KeyboardInterrupt:

```

```
print("Cleaning up")  
spi.close()  
GPIO.cleanup()
```

CHAPTER 10

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