A DISSERTATION REPORT ON

Development of Healthcare Robot for Patient Vital Monitoring System

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ROBOTICS & AUTOMATION

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CERTIFICATE

The thesis entitled **"Development of Healthcare Robot for Patient Vital Monitoring System"** filed for the M.Tech to the Symbiosis Institute of Technology, Pune in Department of Robotics and Automation is based on my own work that I completed under the supervision of **Dr. Satish Kumar**, **Dr. Sameer Sayyad** The dissertation has not been submitted for consideration of any degree award anywhere.

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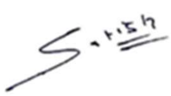

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Signature

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LIST OF ABBREVIATIONS

Abbreviation	Descriptions
AI	Artificial Intelligence
CGM	Continuous Glucose Monitoring
COVID	Coronavirus Diseases
CSI	Camera Serial Interface
DC	Direct Current
DSI	Display Serial Interface
ECG	Electrocardiogram
GPIO	General Purpose Input/Output
HDMI	High-Definition Multimedia Interface
HRI	Human Robot Interaction
IoRT	Internet of Robotics of Things
IoT	Internet of Things
IR	Infrared Radiation
IRQ	Interrupt Pin
JTAG	Joint Test Action Group
LED	Light Emitting Diode
MIPI	Mobile Industry Processor Interface
RFID	Radio Frequency Identification
RsT	Rest Pin
RTLS	Real-Time Location Systems
SCK	Serial Clock Pin
UV-C	Ultraviolet- C
Vcc	Voltage Common Collector

Abstract

"Development of Healthcare Robot for Patient Vital Monitoring System" is an innovative combination of cutting-edge technology, healthcare, and modern robotics. The goal of this ground-breaking research is to completely transform how people manage their health in social settings. It presents a multifunctional system with the potential to revolutionize health monitoring in social contexts by utilizing the capabilities of a Raspberry Pi-based robot, RFID technology, heartbeat and temperature sensors, line following mechanisms, obstacle detection systems, and cloud-based connectivity.

The project's primary objective is to build a flexible, intelligent robot that can carry out health checks and independently follow predetermined routes. The use of RFID technology enables the robot to stop at designated checkpoints for health evaluations, offering a thorough picture of a person's health by gathering data in real-time from temperature and cardiac sensors. The robot's obstacle detection algorithms contribute to a safe and dependable monitoring procedure by guaranteeing the safety of both the robot and its surroundings.

Centralized data storage and analysis are made possible by the easy transfer of the gathered health data to a cloud-based server. In order to provide prompt actions in emergency circumstances, an alert system is designed to notify pertinent stakeholders whenever health metrics surpass certain limits.

By automating and improving health monitoring in social situations, the "Social Robot Health Monitoring System" project shows how modern technology may improve healthcare procedures. In addition to advancing the field of health monitoring, it opens the way for further advancements in social robots and healthcare automation. Through the provision of proactive, efficient, and reliable health monitoring systems, this invention has the potential to have an important impact on healthcare facilities, caregivers, and people.

Chapter 1

Introduction

1.1 Context

The healthcare sector is about to undergo a revolution that will improve patient care and healthcare monitoring by combining state-of-the-art robotics, artificial intelligence (AI), and cutting-edge technology [1, 2]. The incorporation integration of social robots [3-9] into healthcare systems has become noticeable ground-breaking option in this era of fast technology innovation, opening the door for more efficient, paving the way for a more engaging, personalized method of monitoring healthcare.

1.2 Application of Smart Robot

A intelligent robot is an artificial intelligence (AI)-capable machine of acquiring knowledge from its environment and previous encounters. It then enhances its skills using the knowledge it has gained. These robots can collaborate with people in addition to working side by side with them, picking up on human behavior and refining their own knowledge and skills [10].

Smart robotics is now being used by conventional businesses outside of manufacturing and automation. A fast developing technology, smart robots is used in many industries, including banking, healthcare, retail, agriculture, and logistics. And with these developments, engineers and researchers are creating the next generation of intelligent robots [11].

The emergence of Industry 4.0 [12] has enhanced the industrial sector overall and led to the creation of Smart Spaces [13] and, more precisely, Smart Factories. Smart Spaces are mostly used to track activities and applications, including power consumption or sensor and actuator status, inside a specified regulated area. The use of Robotic technologies has bought forth considerable changes to many characteristics of human living [14]. Robots are used for a variety of hard and demanding tasks in both the industrial and academic realms, such as welding [15], packing [16], assembling [17], and more.

The notion behind Internet of Robotic Things (IoRT) is the most advanced robotics concept to date; it builds on the foundation of Cyber-Physical Systems (CPSs) to enable the Internet of Things (IoT) to be upgraded [18]. Contemporary robotics in IoRT systems, technologies have been amalgamated with networking, cloud computing [19], and IoT protocols. [14] to produce new technologies. This level of connectedness has made it possible for smart devices to keep an eye on happenings, integrate sensor information from several sources, as well as use both distributed additionally local knowledge to choose the most intelligent path of action [20]. This innovative strategy uses many technologies to complete challenging jobs and function in a variety of contexts [21].

Surveillance, education, and health care are three areas where IoRT systems are considered to be very beneficial. Specifically, IoRT can help people with special needs—such as individuals with mental illness, stroke survivors, the disabled community, amputees, and others—in numerous ways that benefits the economy, society, and health [22, 23]. Robots with sensors and Internet of Things (IoT) devices are combined with various advantages to diagnose patient concerns and provide up-to-date medical data, hence lowering the chance of human mistake, such as wrong medicine, dose, or procedure diagnosis [24]. In addition, the Internet of Things (IoRT) can be advantageous for several additional applications, including automated data gathering, personnel and patient tracking, sensing, and emergency tracking [25].

Smart robots have been adopted by many industries, increasing productivity and enhancing people's quality of life. A few well-known uses for smart robots are as follows [26]:

- **Manufacturing**: The integration of robotics in manufacturing processes aims to boost productivity and minimize expenses. These robots are designed to operate in challenging environments and undertake tasks like welding, packaging, and assembly.
- **Healthcare**: Within the healthcare sector, sophisticated robots lend support to surgeons during intricate procedures, aid patients with mobility issues, and automate various laboratory tasks.
- **Agriculture**: Robotics finds application in agriculture to optimize output and reduce labor costs. They undertake activities such as soil cultivation, harvesting, and crop monitoring.
- **Service Sector**: The service industry adopts smart robotic solutions to automate a range of tasks including surveillance, janitorial duties, and customer assistance.
- **Transportation**: Robotics is leveraged in transportation to enhance efficiency, cut down expenses, and bolster safety measures. This encompasses the deployment of autonomous vehicles and robotic systems for cargo handling.
- **Construction**: Smart robotics is increasingly utilized in construction to enhance productivity, mitigate costs, and improve workplace safety. They are involved in tasks such as site inspections and operating heavy machinery.

1.3 Importance

It's crucial to note that "smart robots" doesn't solely refer to advanced artificial intelligence (AI) systems depicted in science fiction films. Conversely, a sophisticated robot might be equipped with a greater range of devices that may not first appear to be "intelligent" [10]. A smart robot's behavior and decision-making might be influenced by the information it has acquired through machine learning or deep learning. When functioning, it uses data gathered from input sensors to guide its decisions.

A software-equipped, mechanically-built intelligent robot uses information from the past and present to make judgments. Interestingly, it took several generations of technological advancements to create "smart" robots. Smart robots are employed across a wide range of sectors, doing tasks including risky welding and providing instruction and stocking stores.

1.4 Healthcare Mobile Robot Market Size

The world has the robotics are projected starting to an estimated worth of $10.88 billion USD by 2030. The aging of the worldwide population, the introduction of advanced robotic technology within the medical field, the scarcity of trained nurses as well as other healthcare professionals, and the increase in healthcare expenses are all driving factors in the market's growth. Moreover, mobile robots improve patient care, offering significant benefits to the medical sector [27].

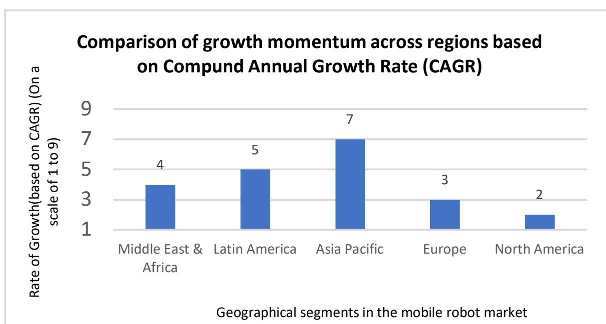


Fig.1. Assessing Regional Growth Momentum Through CAGR[27]

(Reference: Healthcare Mobile Robots Market Analysis,2022).

(Remark: Growth Momentum is shown in the CAGRs of both the entire market and specific segments)

Figure 1 above provides a graphical representation of a market study of the application of smart mobile unit of robotics in the medical care industry worldwide. With the use of intelligent robots on the move, growth momentum based on the CAGR% is provided for various global locations. The momentum of growth is evaluated on a scale from 1 to 9, with the Asia Pacific area having the highest growth momentum factor and the North American region having the lowest.

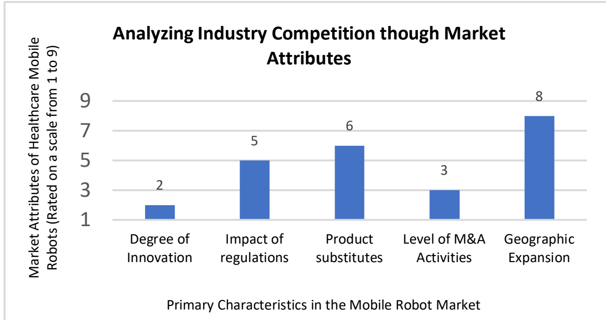


Fig. 2. Analyzing mobile robot market competition via industry-specific attributes [27]

(Courtesy: Analysis of the Healthcare Mobile Robots Market, 2022).

Figure 2 above provides a graphical representation of analysis of Market characteristics of Smart Mobile Robots in Healthcare. The image illustrates market characteristics across various attributes of smart mobile robots. The factor representing market characteristics is a scale from 1 to 9, with the Geographic Expansion characteristic having the highest factor and the Degree of Innovation factor having the lowest.

Their management of risky, labor-intensive, and repetitive tasks like delivering supplies and medication might lead to better patient outcomes and quicker responses. They can also provide employees more time to focus on other crucial tasks. Furthermore, mobile robots boost output by streamlining workflows, reducing errors, and finishing tasks quickly and precisely. For instance, they might accurately measure and classify drugs, preventing mistakes that often occur in medical facilities [27].

Leading industrial players place a high value on strategic partnerships, tactical cooperation, and expansion into growing and economically favorable regions. In October 2019, ABB Ltd. established its first global center for healthcare research at the Texas Medical Center (TMC) in Houston, Texas. The facility features a variety of cutting-edge technology, including a mobile robot named YuMi, which stands for "you and me." This robot is specifically made to help medical and laboratory workers by efficiently managing a variety of tasks related to logistics and laboratory operations in hospital environments. [27].

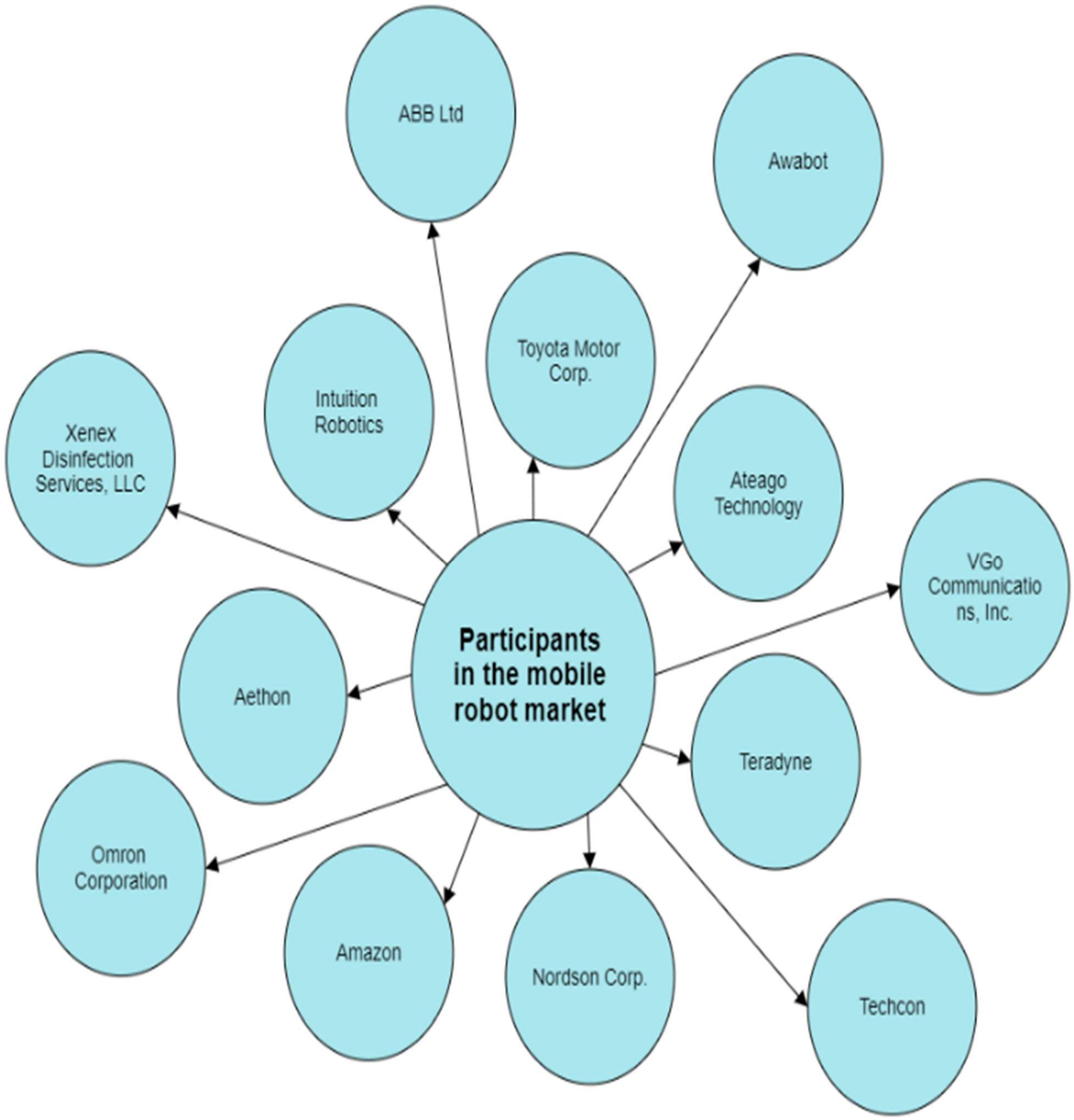


Fig.3. Major Participants in the Mobile Robot Market [27]

(Remark: Analysis of the Healthcare Mobile Robots Market, 2022).

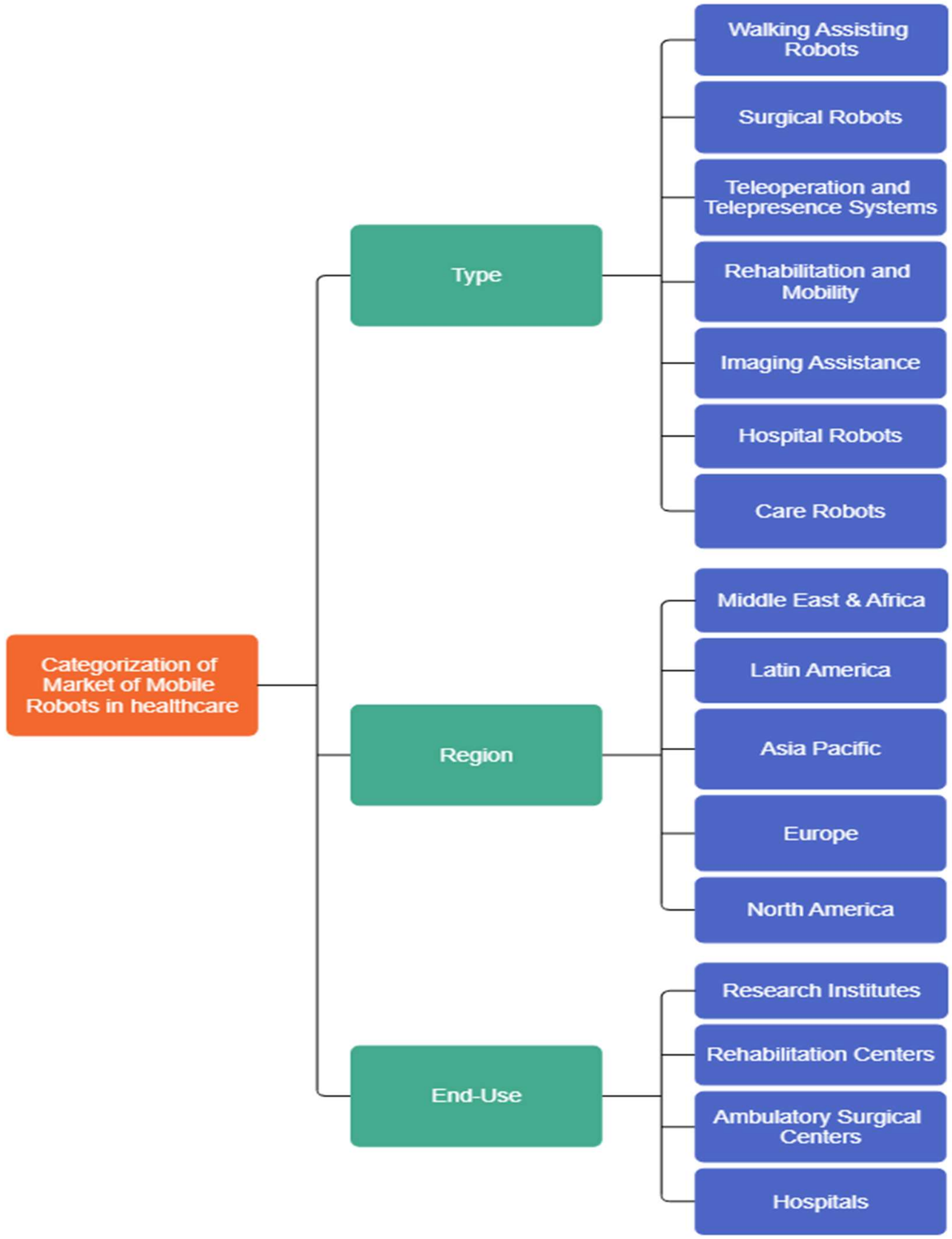


Fig.4. Classification of the Healthcare Mobile Robotics Market [27]

(Remark: Analysis of the Healthcare Mobile Robots Market, 2022).

1.5 Challenges

Like any new technology, smart robots has its share of issues as well as opportunity. Some of the main challenges are [26]:

1) *Impact on society*: While the precise implication of intelligent robots needs to be determined, they may have a big impact on issues such as job roles and the substitution of human labor.
2) *Technological Challenges:* The intricate technology behind smart robots poses a several obstacles that need to be surmounted. These comprise reliability, scalability,

and security-related problems.

3) *Cost:* Due to the high cost of developing and deploying smart robots, small business or developing nations may not be able to purchase them.

4) *Ethical Challenges:* Robotics may completely change the labor economy, raising ethical concerns about discrimination, privacy, and surveillance. Social robots should emerge as innocent and kind in an effort to lessen people's anxiety when they contact with them, particularly if they are used for strictly service purposes like assisting the elderly get up [28]. They also have to react to people behavior and human emotions, if at all feasible. As an illustration, they have to differentiate between an athlete in good condition recuperating from an injury and the requirements of a depressed patient [26]. Regarding whether social robots ought to be taught to emulate human emotions like smiling in order to promote nonverbal communication is raised here. Given that the robot's simulation lacks feeling, one may conclude that it is lying. Many scientists believe that "ethically correct robots" ought to be capable of making moral decisions [28]. But without the scientific underpinnings of the human brain, is it still possible to form moral judgments? [29].

1.6 How to Overcome the Above Challenges?

Now, let's explore strategies for overcoming the aforementioned challenges:

- To stream production information and address security issues, centralized authentication and permission processes, data fragments, monitored operator control, distributed responsibility, and granular authorization can all be employed.
- Ethical issues need to be carefully considered when creating the behavior of embedded AI and social robots. Here are a few more detailed suggestions on appropriate practices and resources. Typically, in order to teach a computer to converse with a human, one must grasp not only the rules and values that direct social interactions between people but also the thoughts, movements, and behaviors of people.
- Because smart robots can easily be scaled up or down to match the needs of the business, it's an economical alternative.
- The societal implications of robots make us consider how advancements in robotics will affect the economy.

1.7 Significance

The significance of robotics cannot be overstated. Numerous industries can change as a result of its capacity to raise efficiency, reduce prices, and enhance safety and accuracy.

From manufacturing to healthcare, smart robots has penetrated numerous industries, improving people's quality of life and overall productivity. Smart robots will have a big impact on the future developments due to the increasing demand for automation and advancements in technology. A thorough introduction to smart robotics is provided [26], together with details on its advancements, applications, benefits, potential, and challenges.
It is projected that intelligent robots will get engage in a play in a significant role in the following disciplines in the future [26]:

- **AI Integration**: Through the incorporation of AI, robots will undertake more complex tasks, acquire new skills, adapt to different scenarios, and make independent decisions.
- **IoT Integration**: Integration of IoT technology will further enhance the autonomy and adaptability of robots, allowing them to communicate and interact with more tools and frameworks seamlessly.
- **Human-Robot Collaboration**: With the development of more sophisticated and user-friendly interfaces, robots will collaborate with humans in a more productive in a more normal way.
- **Autonomous Vehicles**: The advancement of autonomous vehicles will rely heavily on smart robots, improving transportation Ensuring Safety and Efficiency.
- **Smart Cities**: Robots will play a vital role in enhancing the effectiveness and functionality of smart cities, contributing to tasks ranging maintenance.
- **Space Exploration**: Robots will be indispensable in endeavors, taking on tasks too perilous or challenging for humans.

1.8 Research Goal

This project aims to explore and create novel approaches for utilizing social robots in healthcare monitoring environments. The use of technology, especially social robots, offers a viable way to enhance patient outcomes and care quality in an era characterized by aging populations and rising healthcare needs [30]. The table I below contains the pertinent research questions.

TABLE I. RESEARCH QUESTION TABULATION AND DISCUSSION

Sr.No.	Research Question	Discussion
1	This survey paper aims to achieve several objectives, including?	This survey article seeks to examines using social robots in practise
2	The subject of this survey paper is the healthcare industry?	This survey article examines the application of social robots in the healthcare industry.
3	Which platform does this survey article discuss?	This survey article reviews how the Raspberry platform and social robots have merged.
4	What is the benefit of this survey?	The survey paper has enormous promise for transforming the healthcare sector.

1.9 Research Objectives

1) To develop of prototype healthcare focused robot.
2) To collect for different patients' vital signal and temperature using sensors.
3) To send the collected data to cloud and trigger alert if any fluctuation reported in the assigned and observed vital data.

1.10 Research Gaps

1) Inadequate exploration of privacy and security considerations in health data collection for social robots.
2) Scarcity of studies on real-time health data collection using social robots.
3) Limited research on integrating RFID technology for social robot health monitoring.

1.11 Paper Synopsis

In this section, we detail our survey, emphasizing the convergence of social robots, Raspberry Pi technology, and healthcare monitoring systems, as depicted in Figure 5 below.

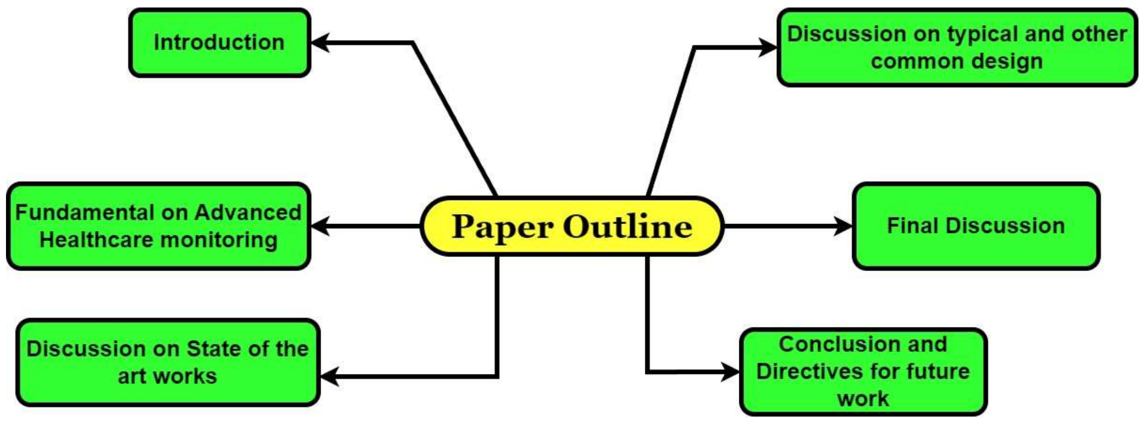


Fig. 5. Paper Synopsis

1.12 Paper Structure

In the upcoming sections, the manuscript will is organized as follows: Part II provides an exploration into the basics of advanced healthcare monitoring, covering topics such as sensor technologies, an overview of healthcare monitoring and its advancements, the evolution of this field, its application domains, key features, and the primary motivations behind the utilization social robots in the medical field. It also describes the requirements for social robot inclusion and exclusion. In Section 3, the state-of-the-art works as of right now are discussed in detail. After that, Section 4 examines typical and other common designs. Section 5 proceeds with the final discussion, while Section 6 wraps up the manuscript with the conclusion and offers directions for future research.

Chapter 2

Health Tech Revolution

2.1 Essentials of Advanced Healthcare Monitoring

Healthcare monitoring has advanced significantly beyond occasional monitoring. The emergence of the Internet of Things (IoT) has made have yet to fully harness the potential of integrated with sensors and devices [39].

The integration of social robots into healthcare facilitates remote care delivery by healthcare professionals, leading to cost reduction and increased accessibility. This technology enables patients to be monitored from the convenience of their homes, removing the requirement for frequent hospital stays or medical visits [40].

Currently, the delivery of social care stands at a crossroads where both technological and human-centric approaches can be integrated, prompting policymakers and practitioners to contemplate the digitization of the United Kingdom (UK) utilize digital technology in their operations, primarily for staff communication purposes, predominantly through cellphones. While the exploration of AT's potential and challenges is still in its early stages, its adoption remains widespread and consistent. [41, 46].

2.2 **Sensor Technologies**

Sensor technologies are indispensable across a range of applications, spanning from industrial automation to healthcare and consumer electronics [47]. Here's a detailed overview of each sensor technology, as illustrated in Figure 6:

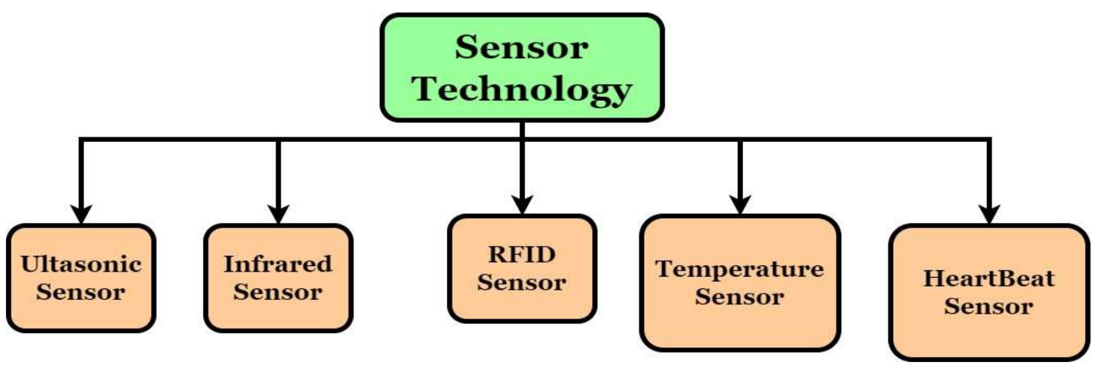


Fig.6. Various Sensors technology

1. **Ultrasonic Sensors:**

   Ultrasonic sensors are employed for measuring distance or detecting objects by emitting sound waves at frequencies beyond human hearing, typically ranging between 20 kHz to 65 kHz. These sensors operate on the principle of echolocation, similar to how bats navigate in the dark. The distance between ultrasonic sensors and an object is determined by calculating the time it takes for the sound waves to travel to the object and back to the sensor. By analyzing the duration of this round trip, the sensor can accurately measure the distance to the object with high precision.

2. **Infrared (IR) Sensors:**

   Infrared (IR) sensors utilize infrared light, which consists of capable for detecting variations in IR radiation, making them well-suited for applications such as motion-activated lighting and security systems. On the other hand, active IR sensors emit and receive IR radiation and are commonly found in devices.

3. **RFID Cards (Radio-Frequency Identification):**

   RFID cards utilize radio-frequency signals to wirelessly transmit data stored on a microchip, comprising a microchip that stores data and an antenna for transmitting and receiving radio-frequency signals. Commonly employed for access control, inventory management, contactless payment systems, and asset tracking, RFID cards provide convenience, security, and efficiency in diverse applications by swiftly and accurately identifying and tracking items.

4. **Temperature Sensors:**

   Temperature sensors are instrumental in measuring an providing information. Various types of temperature sensors exist, operating on distinct principles and accommodating different temperature ranges. These sensors find applications across a broad spectrum, from monitoring regulating temperatures.

5. **Heartbeat Sensors:**

   Heartbeat sensors, commonly known as heart rate monitors, allow individuals to accurately measure their heart rate or pulse. These sensors employ optical or electrical techniques to track blood flow and detect the pulsing of blood vessels. Widely used in wearable fitness trackers, medical devices, and sports equipment, heartbeat sensors enable users to effectively monitor their heart rate during various physical activities.

These sensor technologies serve a wide range of functions and are essential in many areas of modern life. They play a crucial role in enhancing safety, convenience, and advancements in healthcare and industrial processes.

2.3 An overview of healthcare monitoring and its progress

The healthcare sector has witnessed significant progress, with technology playing a central role in enhancing patient care, diagnosis, and treatment. One notable innovation in this regard is the emergence of social robots, which hold promise in revolutionizing healthcare practices. These robots are designed to support patients, healthcare providers, and caregivers by providing companionship, monitoring vital signs, and aiding in various healthcare tasks. Additionally, the integration of IoT technologies like ThingSpeak and Raspberry Pi has bolstered the functionalities of social robots in healthcare monitoring. [48].

Healthcare monitoring holds immense significance in patient care, particularly for individuals managing chronic illnesses or the elderly [49]. It entails the continuous monitoring and measurement of various health indicators, especially critical in severely ill patients, encompassing blood-oxygen saturation, vital signs, respiration rate, and temperature [50]. Access to precise and timely information is essential for prompt decision-making to deliver optimal patient care.

Regular monitoring of vital indicators, medication adherence, and overall health, including heart rate, respiration rate, and temperature, is crucial for early intervention and enhancing

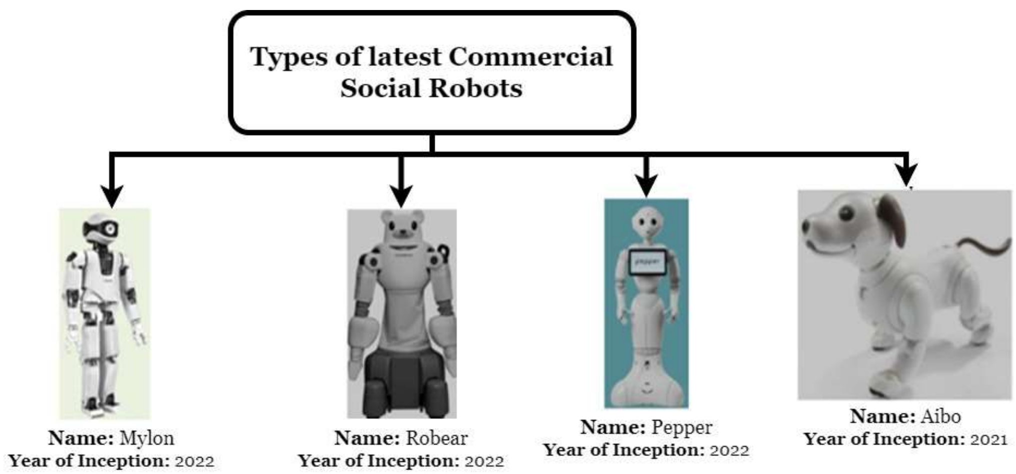


Fig. 7. Instances of commercially accessible social robots.

2.4 Social Robots Evolution

In the Human-Robot communication literature, researchers have coined several phrases to characterize sociable robots, such as:

1 **Socially Evocative Robots**: These robots leverage humans' inclination to anthropomorphize, eliciting emotions when individuals nurture, care for, or engage with them [54].

2 **Robots in a Social Setting:** These robots are situated within a social environment, perceiving and reacting to the social cues and objects in their surroundings. They can differentiate between different environmental items and other social agents [55].

3 **Friendly Robots**: In order to satisfy internal social goals, such as urges or emotions, sociable robots actively interact with people. To properly engage, they need complex social cognition models. [54, 55].

4 **Socially Sensitive Robots**: These robots exhibit characteristics of human-style social intelligence, drawing from potentially intricate models of social skills and human cognition [56].

5 **Socially Engaging Robots**: Socially interactive robots give priority to peer-to-peer interaction, in contrast to those employed in traditional Human-Robot Interaction situations. They have a unique function in human-robot interaction, especially when teleoperation is not used. [39]

2.5 Motivations for Healthcare Monitoring

The significant transformation due to factors such as the aging of the world's population, the increase in chronic illness prevalence, and the expanding need for high-quality healthcare services [63, 64]. These issues often overwhelm traditional healthcare models, necessitating innovative solutions to improve treatment quality while easing the burden on medical staff. Social robots equipped with ThingSpeak and Raspberry Pi technology appear to offer a viable solution to address these challenges [54].

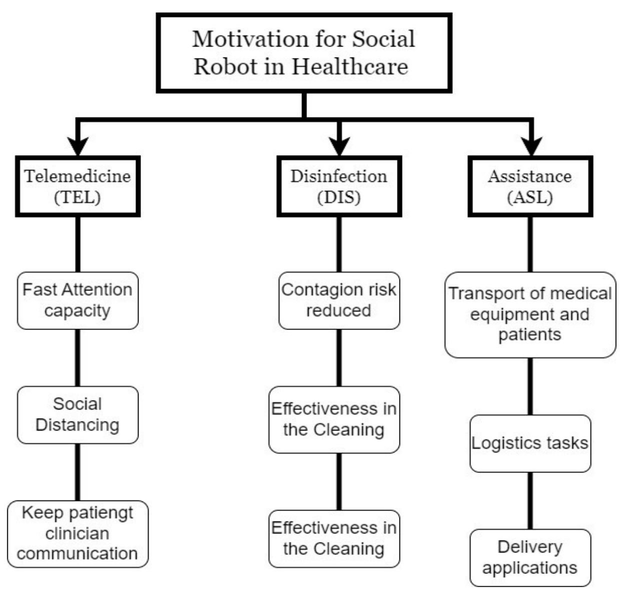


Fig. 8. Motivation for RoboCare Connect

2.6 Inclusion and exclusion

The inclusion and exclusion criteria play a critical role in research projects and programs utilizing social robots in healthcare monitoring. These standards provide a constant selection of participants in line with the goals of the study. The following are some instances of inclusion and exclusion standards for the use of social robots in medical monitoring:

Inclusion Criteria

- Age: Participants must be within a specified age range, such as adults aged 18 and above.
- Medical Condition: Participants must have a specific medical condition relevant to the study, such as chronic illness or mobility impairment.
- Consent: Participants must provide informed permission to take part in the research and interact with the social robots.
- Language Proficiency: Participants must have a sufficient level of language proficiency to communicate effectively with the social robots.
- Availability: Participants must be available and willing to commit to the study's schedule and duration.

Exclusion Criteria:

- Deficit in Computational Ability: People with serious cognitive disabilities may find it difficult to engage in meaningful interaction with the social robots.
- Severe Medical Conditions: Participants with severe medical conditions that may pose risks to their safety or interfere with the study's objectives.
- Language Barriers: Individuals with limited language proficiency that may hinder their comprehension of and capacity to react to the social robots' instructions or prompts.
- Lack of Consent: Participants who are unable or unwilling to provide informed consent to participate in the study.
- Conflicting Commitments: Individuals with conflicting commitments or obligations that may prevent them from fully participating in the study.

TABLE II. INCLUSION AND EXCLUSION CRITERIA TABLE

Inclusion criteria	Exclusion criteria
Articles based on user research with seniors Proof from user studies including participants younger than 65 years of age Articles about robots that can telepresence Articles based on user research with seniors	Proof from user studies including participants younger than 65 years of age
Articles about robots that can telepresence	Evidence centered on technological innovations other than telepresence robots.
Articles emphasized the importance of social interaction in a medical context where paid personnel give formal treatment.Articles about robots that can telepresence Articles emphasized the importance of social interaction in a medical context where paid personnel give formal treatment.	Research centered on environments with no official care (home care, for example).
online versions of peer-reviewed journal papers or complete reports	There are just abstracts available.
English-language publications	Publications in languages other than English

Chapter 3

Literature Review

3.1 Discussion on State of the Art Works

The integration of IoT technology is heralded as the next technological revolution, facilitating the interconnection and smart capabilities of various objects. In the realm of healthcare, Smart rehabilitation systems based on IoT are emerging as a promising solution to tackle challenges linked with aging populations and a scarcity of healthcare professionals. Despite their potential, there are significant difficulties in automating these systems' configuration and design in order to react quickly to patient demands.

A work that suggests an Automated Design Methodology (ADM) for smart rehabilitation systems in the Internet of Things is one strategy to deal with these issues. Through the use of ontology, this technique improves computers' comprehension of symptoms and medical resources, allowing for the automatic reconfiguration of medical resources to suit the needs of individual patients as well as the development of rehabilitation programs. IoT also provides a useful platform for resource interconnection and instantaneous information sharing. Clinical testing and preliminary research show that this approach is feasible, quick, and efficient. [71].

Another article discusses the development of System leverages the human body occurs due to its electrical properties. Data processing is carried out on the user's smartphone, and an Android application is developed to raise an alarm in case of a detected heart attack. The system's functionality is validated through three real-life user case scenarios. [72].

Furthermore, there is a significant issue regarding the particularly the poor documentation of respiratory rate, is a notable issue. Abnormal respiratory rates serve as predictors of potentially serious clinical events, highlighting the importance of appropriate responses to elevated respiratory rates and other abnormal vital signs. Hospital systems that promote such responses can be quickly implemented [73].

A great deal of research has been done on the use of IoT in healthcare with the goal of connecting medical resources and offering patients with chronic diseases and the elderly trustworthy and efficient healthcare services. The developments of IoT in healthcare systems are identified through a thorough literature study, which also covers IoT-based smart devices and systems, supporting technologies and approaches, and a variety of applications in the healthcare sector. The difficulties and opportunities facing the study also covers the development of IoT-based healthcare systems. [74].

Moreover, various technologies, such as the medical Internet of Things (mIoT) and big data analytics, are explored for their potential to reduce overall costs in chronic illness prevention and management. Mobile applications (apps) integrated with mIoT are increasingly used by patients to manage health needs and are integrated with telemedicine and telehealth services. This integration allows for productivity improvements, cost containment, and enhanced customer experiences in healthcare delivery [75].

Lastly, an innovative project aims to address the lack of routine health monitoring among busy individuals by developing a system to monitor health parameters such as temperature, heartbeat, and pulse using biomedical sensors connected to an Arduino Uno. The information is shown on a Liquid Crystal Display (LCD) or serial monitor for easy access [76].

Let's now display the analysis and key findings from the significant research projects [32, 71-75, 77, 78] in table III below.

3.2 Current Trends

In "Health Monitoring Technologies" encompass a dynamic and evolving landscape in healthcare. It's crucial to understand these trends to contextualize the development and significance of the "Social Robot Health Monitoring System." Here's a detailed exploration of current trends in health monitoring technologies:

1. **Wearable Health Devices**: Wearable technology has revolutionized personal health monitoring. Devices like smartwatches, fitness trackers, and even smart clothing able to monitor a range of health indicators, including heart rate, activity level, sleep habits, and more. Because of how convenient these gadgets are, people have been using them to continually and real-time check their health.
2. **Remote Patient Surveillance**: Remote patient monitoring has grown in importance with the development of telemedicine and the Internet of Things. There is no longer a need for regular hospital trips because patients may now be monitored from the comfort of their homes. By remotely monitoring patients' vital signs, chronic diseases, and adherence to treatment recommendations, medical providers can enhance patient outcomes and save healthcare expenditures.
3. **Mobile Health (mHealth) Applications**: The proliferation of smartphones has led to the development of a vast array of mobile health applications. These apps help individuals monitor their health, providing resources for fitness, nutrition, medication reminders, and symptom tracking. They also facilitate communication with healthcare providers and offer access to telemedicine services.

4. **Artificial Intelligence and Data Analytics**: Combining data analytics with artificial intelligence (AI) has enhanced health monitoring and diagnostics. AI algorithms can analyze large datasets, identify trends, and provide insights into a patient's health. Machine learning models can predict disease progression and suggest personalized treatment plans, ultimately leading to more effective healthcare.
5. **Internet of Things (IoT)**: IoT devices have found extensive applications in health monitoring. These interconnected devices can collect and transmit health data to central systems. Examples include smart scales, blood pressure monitors, and glucometers that automatically share data with healthcare providers, ensuring that any critical changes in a patient's condition are quickly identified and addressed.
6. **Personalized and Predictive Healthcare**: Health monitoring is increasingly shifting towards personalization. Rather than one-size-fits-all approaches, healthcare is becoming more tailored to individual needs. Predictive analytics can anticipate health issues, enabling early intervention. Personalized health plans and treatments improve outcomes by accounting for an individual's unique genetic, lifestyle, and environmental factors.
7. **Virtual and Telemedicine Health:** The COVID-19 epidemic hastened the acceptance of of telemedicine and virtual health services. Remote consultations with healthcare professionals, prescription management, and remote monitoring have all become standard practices. This trend is likely to continue as it provides accessible and efficient healthcare services.
8. **Continuous Glucose Monitoring (CGM) for Diabetics**: For individuals with diabetes, continuous glucose monitoring (CGM) devices have become a game-changer. These devices track blood glucose levels in real-time and provide alerts when levels are too high or too low. They not only improve diabetes management but also enhance quality of life. 5
9. **Non-Invasive Health Monitoring**: Technological developments in non-invasive monitoring have allowed for the measure various health parameters without the need for invasive procedures. For instance, non-invasive blood pressure monitors, smart thermometers, and wearable electrocardiogram (ECG) devices offer convenient and comfortable monitoring options.
10. **Mental Health Monitoring**: Mental health monitoring is gaining recognition as an essential component of overall health. Mobile Wearable technology and applications are being created to track emotional well-being, stress levels, and sleep quality. These technologies are contributing to improved mental health awareness and support.

Understanding these trends in health monitoring technologies is critical because the "Social Robot Health Monitoring System" fits into this dynamic landscape. It leverages these trends by providing a socially interactive, autonomous robot capable of integrating wearable health sensors and delivering real-time health assessments. It aligns with the direction of healthcare and technology by offering a proactive and innovative approach to health monitoring in social settings.

3.3 Principles and Operation

The "Social Robot for Health Monitoring System" operates on the principles of integrated sensor technology, automation, and data analysis to provide comprehensive health monitoring and support in social settings.

1. **Sensor Integration**: The core principle is the integration of multiple sensors, including RFID technology for navigation, heartbeat and temperature sensors for 10 health data collection, and ultrasonic sensors for obstacle detection. These sensors work collectively to provide real-time data and ensure the robot's safe navigation.
2. **Navigation and Localization:** The robot uses RFID technology to navigate predefined routes. RFID tags serve as checkpoints, allowing the robot to stop at predetermined locations for health assessments. This principle ensures the robot moves efficiently and accurately within the environment.
3. **Health Data Collection:** The robot's heartbeat and temperature sensors are made to gather essential health information. from individuals. These sensors are non-invasive, making the health assessment process comfortable for the user.
4. **Obstacle Detection and Response**: The robot's ultrasonic sensors detect obstacles in its path and trigger a response, ensuring the safety of both the robot and the individuals in its vicinity.
5. **Data Analysis and Connectivity:** Health data collected by the robot is analyzed and transmitted to a web server, ensuring centralized data storage and easy access for healthcare professionals and caregivers. This principle ensures that health data is readily available for analysis and decision-making.
6. **Alert System:** An alert system is integrated to notify relevant parties when health parameters surpass predefined thresholds. This principle provides timely intervention in case of critical health events.

The operation of the "Social Robot for Health Monitoring System" revolves around these principles, enabling the robot to autonomously navigate, conduct health assessments, ensure safety, and provide a centralized platform for health data storage and analysis. This innovative approach aims to enhance health monitoring in social settings, improving the well-being of individuals and supporting healthcare professionals and caregivers in their roles.

3.4 Use Cases

The "Social Robot for Health Monitoring System" offers an extensive variety of usage cases in diverse healthcare and social settings, making it a versatile tool for proactive health management and support. Some key use cases include:

1. **Hospitals and Clinics**: In healthcare institutions, the robot can conduct routine health assessments for patients, monitor vital signs, and alert healthcare professionals when critical thresholds are reached, enhancing patient care.
2. **Assisted Living and Nursing Home Facilities**: The robot is able to offer company to residents, assist with daily tasks, and continuously monitor their health, reducing feelings of isolation and ensuring timely care.
3. **Home Healthcare**: For individuals receiving home healthcare, the robot can collect health data, remind patients to take medication, and offer a connection to healthcare providers through telemedicine.
4. **Rehabilitation Centers**: In rehabilitation settings, the robot can guide patients through exercises, track progress, and provide emotional support during recovery.
5. **Schools and Special Education Centers**: The robot can help monitor the health of students, particularly those with special needs, ensuring their safety and well being.
6. **Disaster Response**: In disaster-stricken areas, the robot can assist in providing healthcare services, monitor the health of survivors, and relay vital information to emergency responders.
7. **Elderly Companionship**: The robot can serve as a friendly companion for elderly individuals, engaging in conversations and activities to reduce loneliness.
8. **Remote Health Monitoring**: In remote or underserved areas, the robot can autonomously navigate and conduct health assessments, serving as a telemedicine hub.
9. **Health and Wellness Promotion**: The robot can promote healthy lifestyles by offering exercise guidance, nutritional advice, and monitoring progress for individuals looking to improve their overall health.
10. **Research and Data Collection**: The robot can be deployed for health-related research, collecting valuable data and contributing to the advancement of healthcare knowledge.

The "Social Robot for Health Monitoring System" demonstrates its adaptability and potential across a spectrum of healthcare and social scenarios, enhancing the quality of care, ensuring patient safety, and supporting healthcare professionals and caregivers in various environments.

Chapter 4

Methodology

4.1 Research Design

Among the duties carried out by the social robot in healthcare monitoring are drug delivery, vital sign recording, and patient companionship [40]. It lets medical staff concentrate on important duties while maintaining a safe and effective environment. The information gathered from the different devices to server, where it may be examined to find trends, patterns, or abnormalities in the health of the patients. Improves patient care gives those in need a measure of freedom and support, which raises the standard of healthcare services in the end.

4.1.1 Discussion on typical design

Important components of this design (shown in figure 9 below) include the following: they ensure patient safety, collect and analyze vital data, and improve overall healthcare service delivery to create a versatile and responsive social robot that can improve healthcare monitoring and patient care.

- **Ultrasonic Sensor**: Utilized for obstacle detection, the ultrasonic sensor ensures the robot navigates its environment safely, avoiding.
- **Infrared Sensor**: It track the motion, by enabling machine to react to response more effectively [69].
- **RFID Cards**: RFID technology enables personalized care by allowing the robot to identify patients via RFID cards they wear.
- **Temperature Sensor**: Crucial for healthcare, temperature sensors enable the robot to monitor patient well-being and detect anomalies [81, 82].
- **Heartbeat Sensor**: Used for real-time monitoring of vital signs, the heartbeat sensor alerts healthcare providers to irregularities in the patient's condition [83].

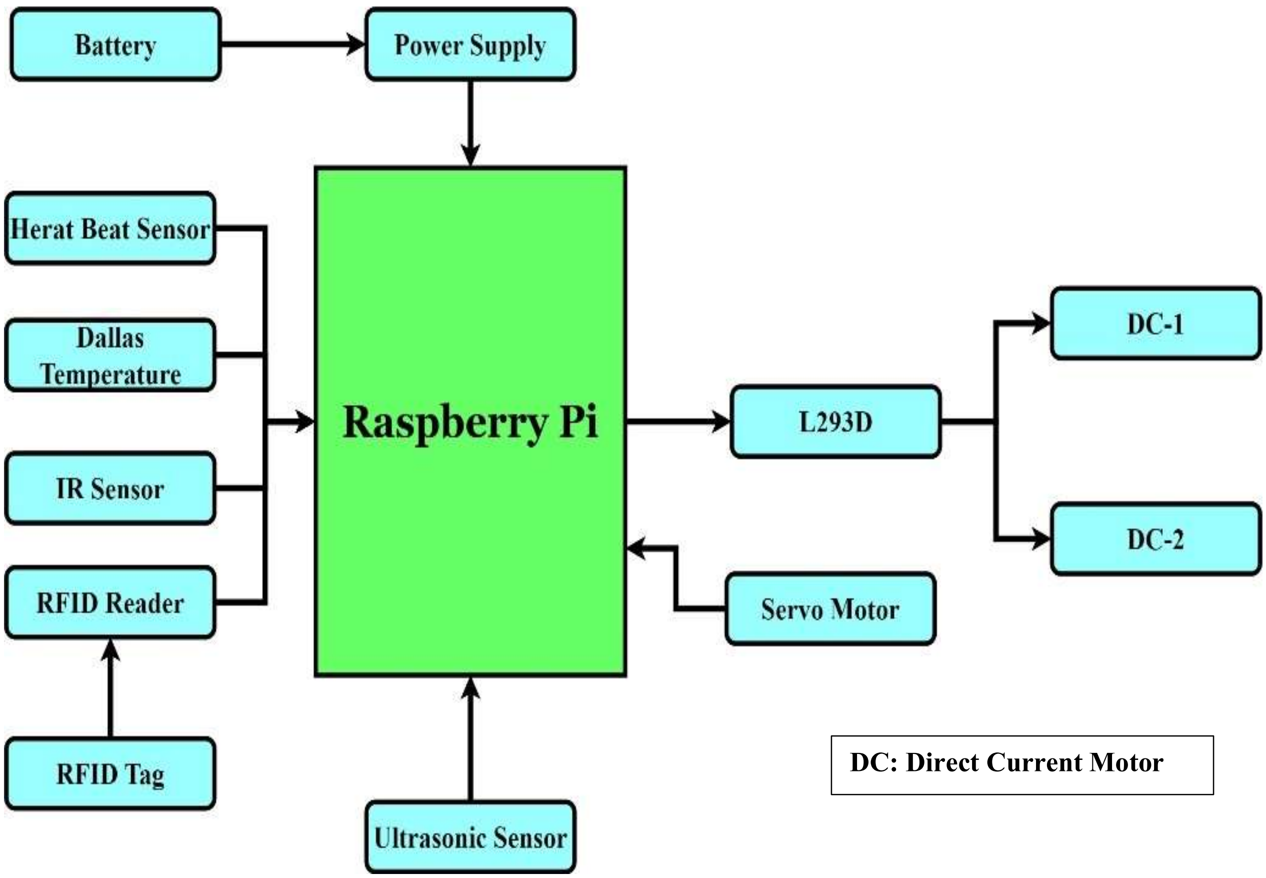


Fig. 9. Architecture representation of overall layout

4.1.2 Comments on related technologies

1) ***Design 1*:** proposes equipped with devices. This machine utilizes sensors to detect the hurdles and react to response accordingly. If the distance between any two hurdles falls below a predefined threshold, the robot will move to the other side to maintain social distancing.cc In case of violation of this rule, the robot will read the RFID tag of the patient ID. Intelligent physical robots, driven by AI, have the potential to revolutionize healthcare services. While previous research has explored the use of intelligent physical robots in healthcare from various angles, there is a gap in the literature regarding an overview of the antecedents and consequences of their use in healthcare contexts.

2) ***Design 2***: introduces a smart alarm system aimed at monitoring post-Coronary Artery Bypass Graft (post-CABG) surgery patients, addressing the lack of social distance monitoring systems discussed in the previous method [76].

- Unlike conventional methods where individuals need to monitor patients in queues and manually alert others to maintain a safe distance, the Smart Alarms system features an alert system for patient monitoring that takes into account several vital indicators.
- The system utilizes Radio Frequency 433 (RF433) Megahertz (MHz) transmitter and receiver modules for wireless communication, facilitating data transmission from the rover to collect patient data.
- In addition, the ESP8266 is highlighted as a crucial component in health monitoring systems.

The social robots in healthcare is contingent upon several key factors, including their ability to engage in human-like interaction, adapt to diverse situations, maintain reliability, and adhere to ethical standards. To truly excel in their role, these robots profound, respect, and seamlessly integrate established.

Achieving necessitates procedures, refinement, and strict. By prioritizing these aspects, social robots can contribute significantly to enhancing patient outcomes, alleviating healthcare burdens, and complementing the efforts of human care providers effectively.

4.2 System Architecture

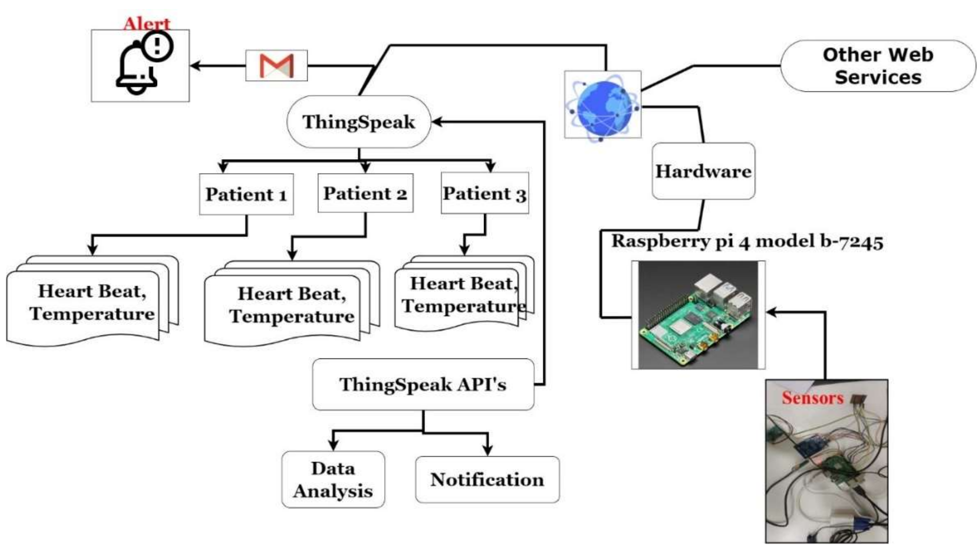


Fig. 10. Proposed Architecture for Research Study

4.2.1 Hardware Components

With reference to Figure 6, the hardware components of the system comprise the social robot's physical infrastructure. This comprises the power system, wheels, motors, and chassis of the robot, as well as a variety of sensors including the RFID reader, temperature sensor, heartbeat sensor, and ultrasonic sensor. Carefully considered design ensures that the hardware components are sturdy, portable, and capable of withstanding the rigors of social and healthcare contexts. The sensors are placed carefully for best data gathering and obstacle detection, and the chassis is frequently built for stability and mobility.

4.2.2 Software Components

With reference to Figure 6, the social robot's brain is made up of software components. Important components include the operating system, communication protocols, and control algorithms. The platform required to run control algorithms and manage data is provided by the operating system. Obstacle avoidance, autonomous navigation, and health assessment processes are made possible by control algorithms. In order to send health data to a centralized server for real-time monitoring and analysis, communication protocols are essential.

4.2.3 Interactions

With reference to Figure 6, Interactions comprise the manner in which the social robot interacts with people in its surroundings. This includes voice recognition, gesture interpretation, and emotional response systems in human-robot interactions. The goal of the robot's interactions is to improve the user experience in social and medical contexts by being approachable and sympathetic. In addition, the system's interactions involve reacting to barriers found while navigating, guaranteeing the security of the robot and its environment.

4.3 Development Process

4.3.1 Hardware Design

The actual robot is created during the hardware design phase. This entails building the chassis with stability and mobility in mind, choosing wheels and motors that make navigating easier, and setting up the power supply to run continuously. The integration and layout of sensors are carefully considered in order to align them for optimal data collecting and obstacle detection efficiency. For hardware design to result in a well-organized and working robot, rigorous planning and prototyping are necessary.

4.3.2 Sensor Integration

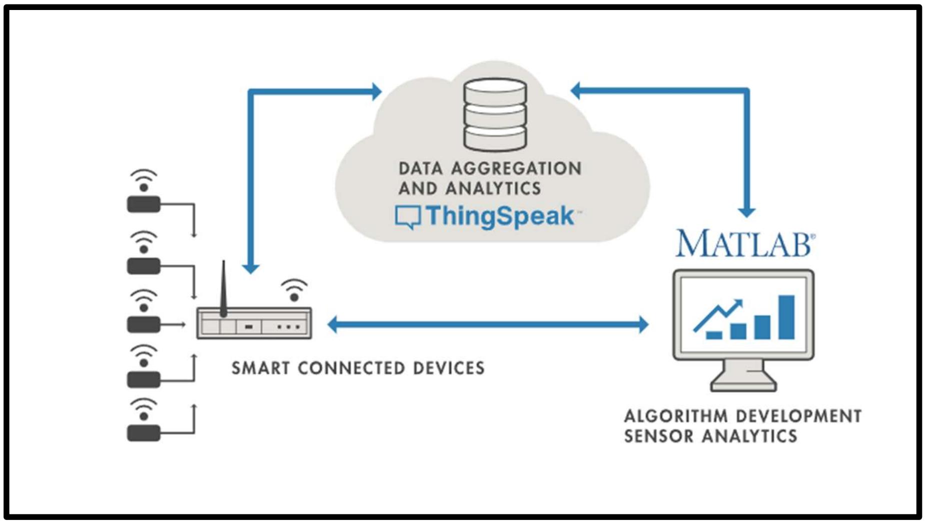


Fig.11. Block Diagram of Sensor Integration with MATLAB

A critical phase in the development process is the integration of sensors. Every sensor—heartbeat, temperature, RFID, and ultrasonic—needs to be properly included into the hardware and software elements. To guarantee reliable data gathering and obstacle detection, calibration and testing are essential. In order to provide safe navigation and efficient health monitoring, sensor integration also entails establishing sensor parameters and algorithms.

4.3.3 Software Development

The development of the robot's control algorithms, which enable smooth autonomous navigation, health assessment processes, and obstacle avoidance, is the main goal of the software development process. Programming, artificial intelligence and machine learning proficiency are necessary for this phase. Developing secure communication protocols to transfer data to a central server—a crucial part of the system—is another step in the software development process.

4.3.4 Connectivity Setup

Configuring the robot making a connection to a web server or cloud platform is part of the connection configuration. This entails putting in place authentication procedures, creating secure data transmission routes, and making sure that data privacy and security laws are followed. Setting up connectivity is essential for collecting and analyzing data in real-time, giving caregivers and medical professionals access to the most recent health information, and allowing alarm systems.

4.3.5 Data Collection and Analysis

The process of obtaining health information from people during health assessments is known as data collection and analysis. Heart rate, temperature, and other pertinent variables are included in this data. After gathering, the data is sent to a cloud platform or centralized server for analysis. In order to understand the data, identify patterns, and provide insights, the analysis phase makes use of machine learning and data analytics tools. It makes it possible to identify aberrant health markers, which may lead to alarms and early actions. The system's primary function is to provide real-time health monitoring and assistance. This is accomplished through data collecting and analysis.

4.4 Validation and Testing

The Validation and testing phase is crucial to ensure the system's functionality, dependability, and safety. It involves a series of tests, including:

1. **Functionality Testing**: To assess whether the robot can autonomously navigate, stop at RFID checkpoints, collect health data accurately, and respond to obstacles.
2. **Safety Testing:** To confirm that the robot's obstacle detection system operates effectively and that it poses no harm to users.
3. **Data Accuracy Testing:** To verify the accuracy of health data gathered from the sensors on the robot.
4. **Connectivity Testing**: To ensure that data is successfully transmitted to the centralized server for analysis.
5. **User Experience Testing**: To evaluate the robot's interactions with users, including its ability to provide a friendly and empathetic experience.
6. **Long-Term Performance Testing**: To assess the robot's durability and performance over extended periods of operation.

Testing and validation are iterative processes that help identify and rectify issues, ensuring the system meets the intended goals and standards of operation.

Chapter 5

System Design and Implementation

5.1 Robot Hardware

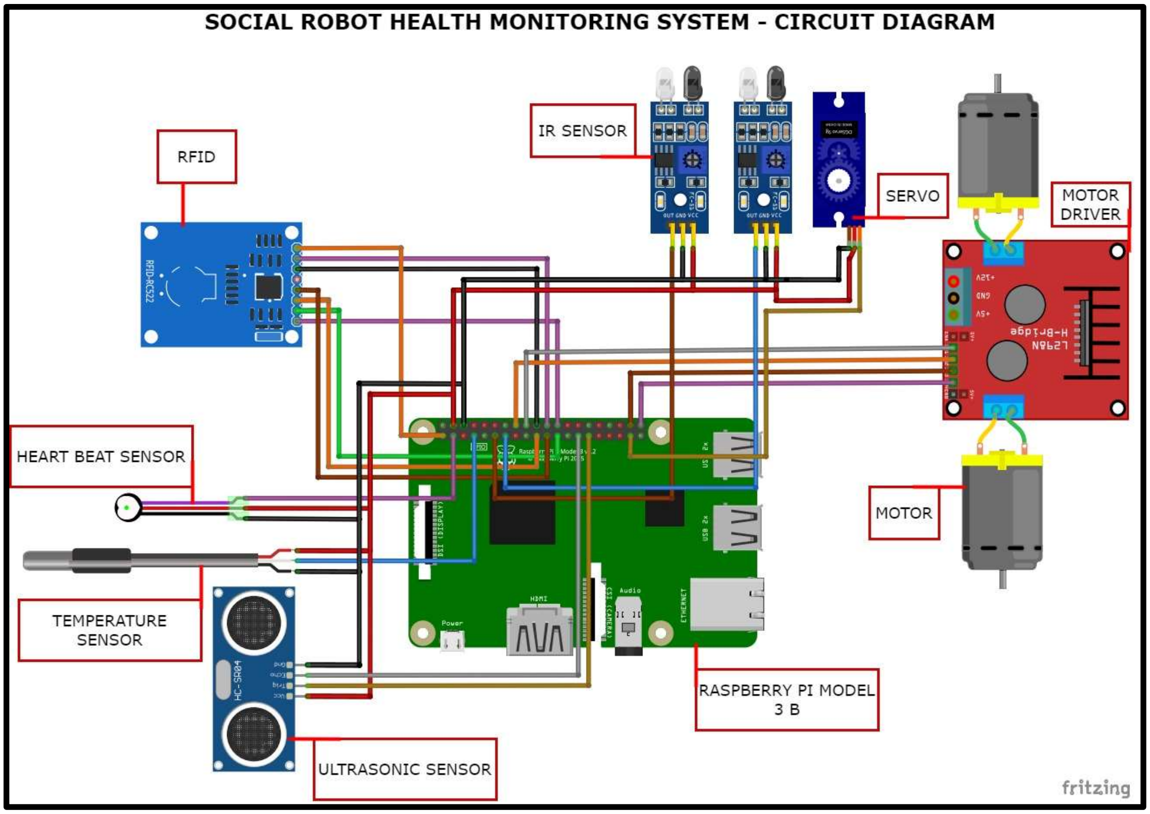


Fig. 12. Social Robot Health Monitoring System Circuit Diagram

5.1.1 Chassis

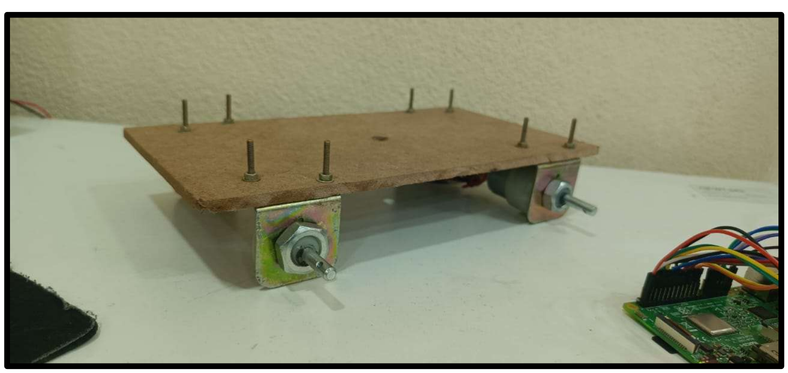


Fig. 13. Vehicle BodyFrame

The physical framework that serves as the health monitoring robot's base is called the chassis. Because of its stability, robustness, and mobility, the robot can move through social and medical settings with ease. In addition to having wheels that allow for mobility, the chassis may also have shock absorption or suspension systems to improve stability and reduce vibrations. The weight, strength, and general performance of the robot are all impacted by the materials chosen, therefore selection is crucial. The chassis serves as a strong basis for the system and is carefully designed and tested to guarantee that it can endure the rigors of healthcare and social environments.

5.1.2 Motors and Wheels

Fig. 14. White Robotic Wheel (70mm x 35mm)

TABLE IV. WHEEL SPECIFIFCATION TABLE

Sr. No.	Details	Specification
1	Color	White
2	Diameter	70mm x 35mm
3	Material	Plastic
4	Shape	Round
5	Wheel Coating Material	Silicon Rubber

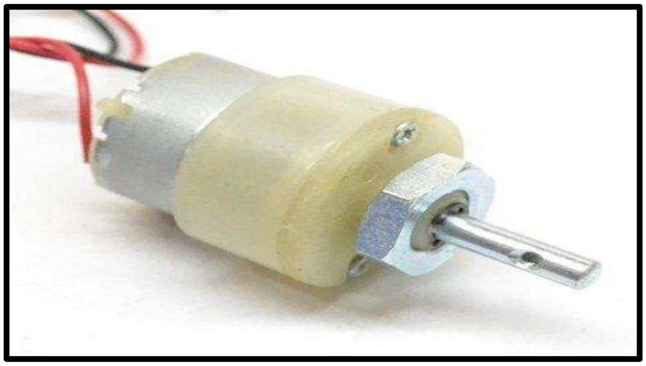


Fig. 15. 12 Volts Direct Current Motor

TABLE V. DIRECT CURRENT MOTOR SPECIFICATION TABLE

Sr. No.	Details	Specification
1	Revolutions per Minute	100
2	Shaft Diameter	6mm (with internal hole)
3	Shaft Length	15mm
4	Motor Diameter	28.5mm
5	Torque	12 kg-cm
6	Voltage	6 to 24

Motors and wheels are integral components of the robot's hardware, enabling movement and navigation. Motors are carefully selected to provide precise control over the robot's speed and direction. Wheels are designed for optimal traction and maneuverability, allowing the robot to traverse different surfaces and environments. The design of the motors and wheels is tailored to facilitate smooth and accurate movement, critical for the robot's ability to autonomously navigate predefined routes, stop at RFID checkpoints, and respond to obstacles. Robust motor and wheel systems are essential to the reliability and efficiency of the robot.

5.1.3 Power System

Fig. 16. 12 Volts Direct Current Battery

The parts of the robot that provide and control electrical energy are referred to as its power system. Batteries or other power sources, circuits for power control, and charging systems fall within this category. The power system is built to run continuously, allowing the robot to travel and conduct health checks for the duration of its allotted operational period. Furthermore, the power supply is designed to be as energy-efficient as possible, extending the robot's use before it has to be recharged. To ensure that the robot can finish its work, redundancy and fail-safes are frequently built to prevent unexpected shutdowns. The goal of the power system design is to achieve a balance between operational dependability and energy autonomy.

5.2 Sensor Integration

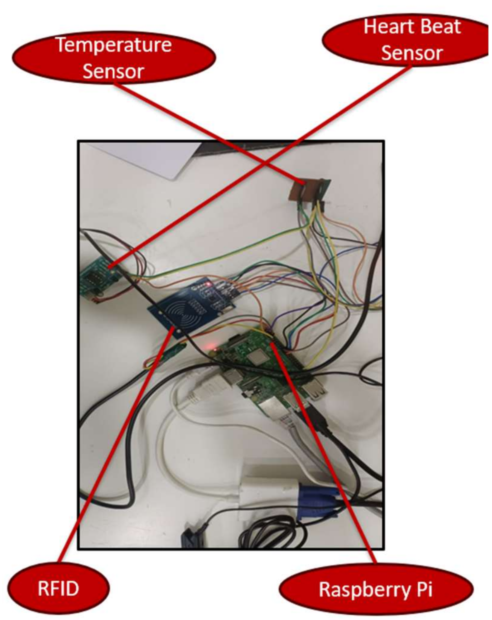


Fig. 17. Sensors Integration

5.2.1 RFID Reader

Fig. 18. Radio Frequency Identification

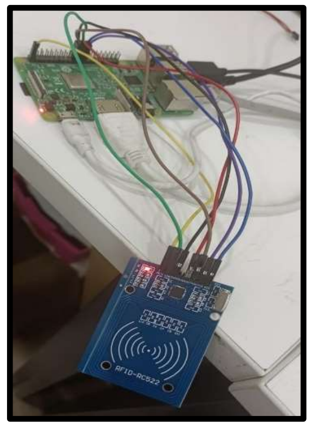


Fig. 19. Interfacing of Radio frequency Identification with Raspberry Pi Model 3 B

An essential sensor for the health monitoring robot is the RFID reader. Its purpose is to scan RFID tags positioned within the robot's working area at prearranged checkpoints. The antennae and communication modules required for the RFID reader to interact with the tags are installed. In order to guarantee that the robot can precisely stop at specified checkpoints for health checks, its design strives to maximize reading accuracy and range. Careful placement is required to line the RFID reader with the RFID tag locations during integration, allowing for easy navigation and health data gathering.

TABLE VI. RC522 Pin Configuration

Number	Name	Description
1	Vcc	3.3V Used to power the module
2	RST	Used to reset or power down the module.
3	Ground	Connected to Ground of system
4	IRQ	Activates the module upon detection of a nearby device.
5	MISO/SCL/Tx	When used for SPI communication, serves as MISO; acts as Tx for UART and SCL for I2C.
6	MOSI	Serves as the Slave In, Master Out pin for SPI connection
7	SCK	Provides the clock source through the Serial Clock pin
8	SS/SDA/Rx	Functions as Rx for UART, SDA for I2C, and SS for SPI connection.

What is RFID technology, and what is its mechanism?

The two primary parts of an RFID system are a transponder or Radio Frequency Identification system, which is a tag connected to an object that needs to be identified, and a transceiver, which is also referred to as an interrogator or reader.

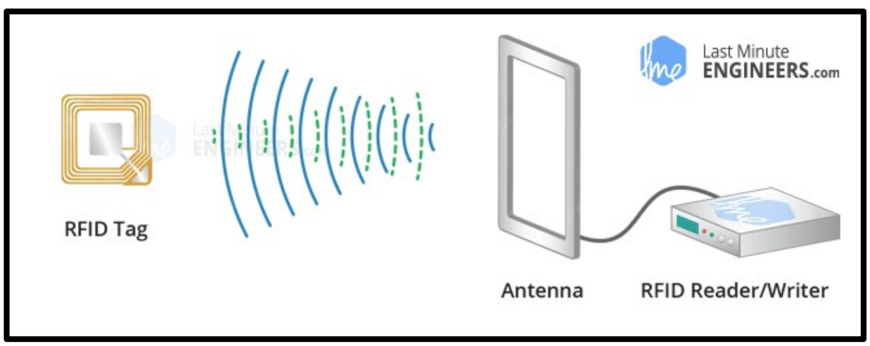


Fig. 20. Radio frequency Identification Working

A tag is put near the reader (it need not be in the reader's direct line of sight) in order to read the information encoded on it. Electrons when a reader, the powered chip in the tag sends containing. We refer to this as backscatter.

5.2.2 Heartbeat Sensor

Fig. 21. Heart Beat Sensor

The heartbeat sensor is a necessary part of the system for gathering important health information. It is intended to assess a person's heart rate non-invasively. Sensor location, measurement methods, and data transfer systems are all included in the design. Accurate and up-to-date heart rate data should be provided by the heartbeat sensor. This sensor's integration requires that it be in close proximity to the patient throughout health evaluations in order to guarantee that the data acquired is accurate.

- **The Heartbeat Sensor Principle**

The principle behind the working of the Heartbeat Sensor is Photo plethysmograph. According to this principle, the changes in the volume of blood in an organ is measured by the changes in the intensity of the light passing through that organ.

Usually, the source of light in a heartbeat sensor would be an IR LED and the detector would be any Photo Detector like a Photo Diode, an LDR (Light Dependent Resistor) or a Photo Transistor.

With these two i.e. a light source and a detector, we can arrange them in two ways: A Transmissive Sensor and a Reflective Sensor.

In a Transmissive Sensor, the light source and the detector are place facing each other and the finger of the person must be placed in between the transmitter and receiver.

Reflective Sensor, on the other hand, has the light source and the detector adjacent to each other and the finger of the person must be placed in front of the sensor.

5.2.3 Temperature Sensor

Fig. 22. Temperature Sensor

Another essential part of health monitoring is the temperature sensor. Its design entails choosing and incorporating temperature-sensitive parts that offer accurate temperature readings. To obtain an accurate reading of a person's body temperature, the sensor has to be positioned correctly. Temperature range, calibration, and data transfer methods are design factors. The incorporation of a temperature sensor guarantees that the robot can obtain dependable temperature readings while doing health evaluations.

TABLE VII. TEMPERATURE SENSOR

Number	Name	Description
1	Ground	Attach to the circuit's ground.
2	Vcc	Powers the sensor; 3.3V or 5V can be used.
3	Data	The temperature value output from this pin can be read using the 1-wire method.

- **Features**

  The following are some of the sensor's specifications:

  1. This temperature sensor is digital and programmable.
  2. The 1-Wire technique can be used to communicate with this sensor.
  3. The power supply has a range of 3.0V to 5.5V.
  4. The range of Fahrenheit is -67°F to +257°F.
  5. This sensor has an accuracy of ±0.5°C.
  6. There will be a 9-bit to 12-bit o/p resolution.

- **Operational Concept**

  The working principle of this DS18B20 temperature sensor is like a temperature sensor. The resolution of this sensor ranges from 9-bits to 12-

bits. But the default resolution which is used to power-up is 12-bit. This sensor gets power within a low-power inactive condition.

5.2.4 Ultrasonic Sensor

The identification and avoidance of obstacles is greatly aided by ultrasonic sensors. They are designed to generate obstacle data for the control system, calculate distances to obstacles, and transmit and receive ultrasonic waves. The use of ultrasonic sensors necessitates exact placement across the robot's range of motion. The robot can react to impediments in its path with more effectiveness because to the design, which maximizes the sensor's precision and range. The use of ultrasonic sensors augments the security of both the robot and others within its vicinity.

5.2.5 Servo Motor

Fig. 23. Servo Motor

The ultrasonic sensor's movement is managed by the servo motor. It increases the sensor's field of vision for obstacle detection by enabling it to tilt or pan. Accurate calibration is part of integration, which guarantees the sensor's responsiveness to any obstructions.

- **The Principle of Operation of Servo Motor:**

A servo consists of a Motor (DC or AC), a potentiometer, gear assembly, and a controlling circuit. First of all, we use gear assembly to reduce RPM and to increase torque of the motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier. Now the difference between these two signals, one comes from the potentiometer and another comes from other sources, will be processed in a feedback mechanism and output will be provided in terms of error signal. This error signal acts as the input for motor and motor starts rotating. Now motor shaft is connected with the potentiometer and as the motor rotates so the potentiometer and it will generate a signal. So as the potentiometer's angular position changes, its output feedback signal changes. After sometime the position of potentiometer reaches at a position that the output of potentiometer is same as external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

5.2.6 Infrared Sensor

For safety and proximity detection, infrared sensors are used. They aid in the robot's detection of surrounding objects or people, particularly during close quarters exchanges. Integration guarantees that the robot's control system receives real-time data from the infrared sensors.

5.2.7 Raspberry Pi

Fig. 24. Raspberry Pi Model 3B

The Raspberry Pi Model 3 B serves as the robot's primary processor. It handles communication, runs control algorithms, and analyzes data from several sensors. Configuring the Raspberry Pi, installing the operating system, and establishing communication with sensors and external devices are all part of integration.

Description of each component:

1. **Source of Power:**

   The Pi is a gadget that uses 3W, or 700mA, of electricity. Either the GPIO header or a Micro USB charger power it. You can power the Pi with any decent smartphone charger.

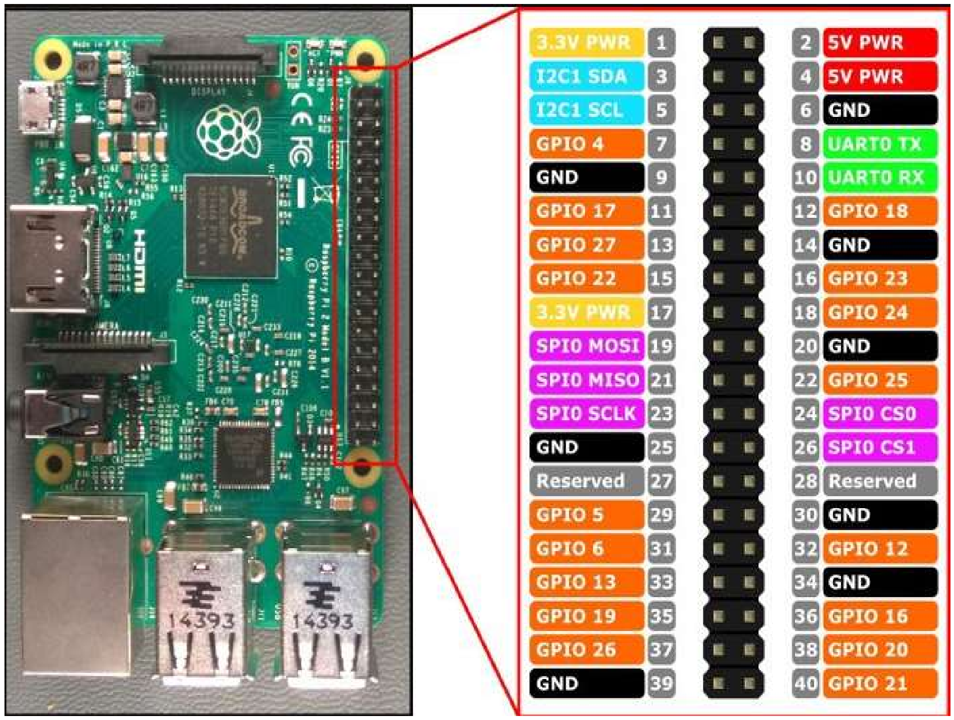


Fig. 25. GPIO Pin Architecture of Raspberry Pi Model 3B

2. **Display Serial Interface connector:**

   The Display Serial Interface (DSI) is a specification by the Mobile Industry Processor Interface (MIPI) Alliance aimed at reducing the cost of display controllers in a mobile device. It is commonly targeted at LCD and similar display technologies. It defines a serial bus and a communication protocol between the host and the device. A DSI compatible LCD screen can be connected through the DSI connector, although it may require additional drivers to drive the display.

3. **Radio Corporation of America Video (RCA):**

   All versions of Raspberry Pi offer PAL and NTSC video outputs from the Radio Corporation of America. This enables connectivity with an RCA jack-equipped television or screen.

Fig. 26. RCA Video Connector

4. **Music Jack:**

   The Raspberry Pi has an ordinary 3.5 mm TRS connection for stereo audio output. You may connect straight through any 3.5mm audio cable or headphone. USB sound cards or microphones can be used with this connector, even though audio input cannot be received through it.

5. **Status Light Emitting Diode (LED):**

   There are 5 status LEDs on the RPi that show the status of various activities. They are "OK" ,"ACT" „"POWER" (PWR),Full Duplex ("FDX"),"LNK" (Link/Activity), "10M/100" which are shown in figure below.

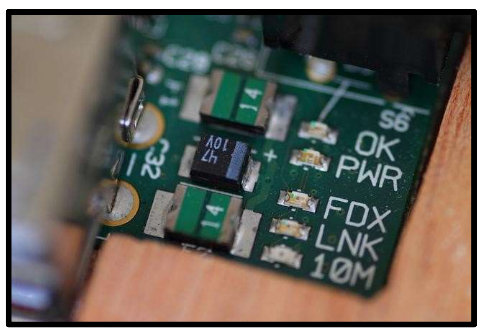


Fig.27. Status of Light Emitting Diode

5.3 Software Development

5.3.1 Operating Temperature

The fundamental software framework for the health monitoring robot's operation is provided by its operating system. To assist the control algorithms, sensor integration, and data exchange, it is either carefully chosen or created. The operating system has to be sturdy, dependable, and appropriate for the particular hardware parts and sensors that the system makes use of. This decision guarantees that control algorithms and data management procedures are carried out effectively. Additionally, it offers a steady setting for the real-time gathering of health data and the identification of obstacles.

5.3.2 Control Algorithms

The foundation of the robot's software development are control algorithms. They are in charge of obstacle avoidance, autonomous navigation, RFID checkpoint identification, and health assessment protocols. Robotic control algorithms are carefully crafted to maximize navigation, guaranteeing that the robot can adhere to pre-established paths, stop at RFID checkpoints, and react to obstructions instantly. The algorithms are also in charge of arranging how the robot interacts with people while doing health checks, making the process intuitive an

5.4 Connectivity and Data Management

5.4.1 Internet of Things (IoT) Integrations

The main goal of the IoT integration is to link the robot to central servers and the internet so that data can be transmitted and analyzed. In order to send health data and robot status information to a centralized server or cloud platform, secure communication methods must be configured. IoT connection guarantees that health data is accessible for caregivers and medical experts to monitor in real-time. Additionally, it enables the robot's actions to be managed and controlled remotely.

5.4.2 Data Storage and Analysis

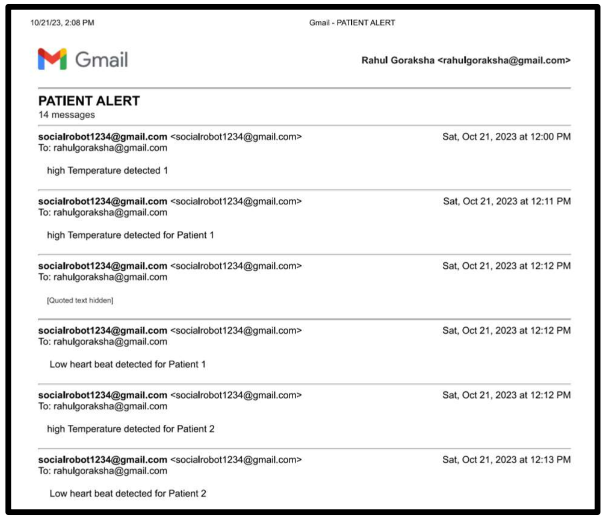
Components for data analysis and storage are essential to the software development of the system. Mechanisms for safely storing health data on a centralized server or cloud platform are included in the architecture. Algorithms for data analysis are used to understand health data, find trends, and produce insights. This makes it possible to find anomalous health metrics that might set off alarms. The foundation of the system's capacity to offer real-time health monitoring and support is data storage and processing.

5.5 Alert System

5.5.1 Threshold Definitions

The design of the alarm system includes setting thresholds for important health parameters. Heart rate and temperature are two examples of health measurements that have thresholds defined. Medical guidelines and the patient's medical history are used to set these levels. The alarm system is set off when certain predetermined thresholds are reached or exceeded by health metrics. This notifies the appropriate parties to take prompt action.

5.5.2 Alert Generation


10/21/23, 2:08 PM Gmail - PATIENT ALERT

Gmail Rahul Goraksha <rahulgoraksha@gmail.com>

PATIENT ALERT
14 messages

socialrobot1234@gmail.com <socialrobot1234@gmail.com> Sat, Oct 21, 2023 at 12:00 PM
To: rahulgoraksha@gmail.com

high Temperature detected 1

socialrobot1234@gmail.com <socialrobot1234@gmail.com> Sat, Oct 21, 2023 at 12:11 PM
To: rahulgoraksha@gmail.com

high Temperature detected for Patient 1

socialrobot1234@gmail.com <socialrobot1234@gmail.com> Sat, Oct 21, 2023 at 12:12 PM
To: rahulgoraksha@gmail.com

[Quoted text hidden]

socialrobot1234@gmail.com <socialrobot1234@gmail.com> Sat, Oct 21, 2023 at 12:12 PM
To: rahulgoraksha@gmail.com

Low heart beat detected for Patient 1

socialrobot1234@gmail.com <socialrobot1234@gmail.com> Sat, Oct 21, 2023 at 12:12 PM
To: rahulgoraksha@gmail.com

high Temperature detected for Patient 2

socialrobot1234@gmail.com <socialrobot1234@gmail.com> Sat, Oct 21, 2023 at 12:13 PM
To: rahulgoraksha@gmail.com

Low heart beat detected for Patient 2

Fig. 28.: Email alert is triggered by threshold breach.

Mechanisms for generating alerts are built to make sure that when crucial health thresholds are exceeded, a quick alarm is produced. The design incorporates alert communication techniques, such email messages to caregivers and medical experts. Additionally, the system has to give contextual information about the user's location and health status so that it can react appropriately and quickly to important health occurrences.

The "Social Robot for Health Monitoring System" component elaborations offer insights into the whole system design and execution, which includes data management, hardware, connection, software development, sensor integration, and hardware integration. Together, these parts guarantee the robot's durability, dependability, and capacity to offer real-time health monitoring and assistance in medical and social environments.

Chapter 6

Results

6.1 Autonomous Navigation

The Social Robot Health Monitor project successfully achieved autonomous navigation capabilities. Leveraging the Raspberry Pi as its central processing unit, the robot can navigate predefined routes within a controlled environment. This autonomy is facilitated by a combination of sensors and actuators, allowing the robot to follow paths, stop at RFID checkpoints, and assess individuals' health. The implementation of advanced algorithms ensures that the robot can adapt to its surroundings, making it a versatile tool for various social settings. Its ability to move independently while avoiding obstacles makes it user-friendly and suitable for a wide range of applications, from healthcare facilities to educational institutions

6.2 RFID Checkpoint Integration

The project seamlessly integrated RFID checkpoint technology, enabling the robot to stop at predefined locations for health assessments. This technology not only adds a layer of efficiency but also facilitates structured data collection. By stopping at RFID checkpoints, the robot can accurately identify the location of each assessment, ensuring that health data is correctly associated with the individual being monitored. The use of RFID cards as checkpoints enhances the overall precision and reliability of the system, contributing to its effectiveness in social environments.

6.3 Health Data Collection

The robot's health data collection capabilities are a fundamental component of the project's success. Equipped with heartbeat and temperature sensors, the robot collects vital health data from individuals in real-time. These sensors provide accurate and valuable information about an individual's well-being. The project has demonstrated that it can efficiently and consistently capture this data, which is essential for monitoring and assessing an individual's health status. The data collected forms the basis for health analysis and alerts, contributing to proactive health management.

6.4 Obstacle Detection and Response

Safety is paramount in the Social Robot Health Monitor project, and the inclusion of obstacle detection and response mechanisms ensures safe operation. A servo motor-mounted ultrasonic sensor equips the robot to detect obstacles in its path. When an obstacle is detected, the robot promptly responds by coming to a stop. This feature not only protects the robot from potential damage but also safeguards individuals in the robot's vicinity. The obstacle detection and response system functions seamlessly, guaranteeing that the robot can navigate social environments without posing any harm or disruption.

6.5 Data Upload and Storage

The project has successfully implemented data upload to a web server, ensuring centralized health data storage and analysis. This feature provides a secure and accessible platform for storing and managing the health data collected by the robot. By uploading this data to a web server, it becomes available for healthcare professionals, caregivers, and other relevant stakeholders. The centralized approach streamlines data management and allows for real-time analysis, which can aid in proactive health monitoring and early intervention.

6.6 Alert System Performance

The alert system is a critical component of the Social Robot Health Monitor project, and its performance has been demonstrated effectively. When the robot records health parameters that exceed predefined thresholds, an automated alert system is triggered. This system promptly notifies relevant stakeholders, such as healthcare professionals or caregivers, about potential health issues. The system's accuracy and reliability in generating alerts ensure that individuals under the robot's care receive timely attention and assistance when needed. This feature greatly enhances the project's capacity for proactive health management and intervention, showcasing its potential to positively impact healthcare and social settings.

Chapter 7
Discussion

7.1 Role of Social Robots in Healthcare

Social robots' place in healthcare is rapidly evolving, and the "Health Monitoring Robot Project" exemplifies the significant contributions they can make. These robots act as versatile healthcare assistants, capable of conducting health assessments, interacting with patients, and providing valuable support to healthcare professionals. They bridge the gap between technology and human touch, offering companionship and a sense of connectedness for individuals in healthcare settings. By automating routine health assessments, they allow allowing medical personnel to concentrate on more difficult jobs, which will increase efficiency and quality of patient care. Moreover, social robots could help with the scarcity of medical experts, particularly in scenarios where there is a high demand for health monitoring. Social robots will probably play a bigger part in healthcare as technology develops, providing a new dimension to patient care and support.

7.1.1 Human Interaction

Human interaction is a fundamental aspect of the "Health Monitoring Robot Project." The project recognizes the importance of creating a positive and empathetic communication between the robot and the individuals it serves. The robot's ability to engage in friendly, non-invasive interactions is crucial, especially when dealing with vulnerable populations such as the elderly or individuals with special needs. The project emphasizes the development of human-like behaviors and responses, including speech recognition and emotional expression. These interactions contribute to the well-being of the individuals being monitored, providing not only health data but also emotional support and companionship, reducing feelings of isolation and loneliness. The careful consideration of human interaction is central to the project's goal of not just monitoring health but also enhancing the overall experience for the individuals involved.

7.1.2 Support for Healthcare Professionals

The "Health Monitoring Robot Project" is designed to be a valuable tool for healthcare professionals. By automating routine health assessments and providing real-time health data, the robot assists healthcare staff in their duties. It reduces the burden of repetitive tasks, allowing healthcare professionals to focus on more complex and critical aspects of patient care. This support enhances the efficiency of healthcare delivery and enables professionals to make more informed decisions. Additionally, the robot's early warning system, which triggers alerts when health parameters exceed predefined thresholds, provides an extra layer of safety and prompt intervention, further supporting the work of healthcare professionals. In the future, the project may also enable telemedicine services, extending the reach of healthcare professionals to remote and underserved areas, and contributing to improved healthcare access.

7.2 Advancements in Health Monitoring

The "Social Robot Health Monitor" project is a noteworthy development in the realm of health monitoring. This innovative system combines robotics and healthcare to create a powerful tool with far-reaching implications.

One of the key advancements lies in the system's ability to provide continuous and non-intrusive health monitoring. Traditional health assessments often require individuals to visit healthcare facilities, which may be difficult and time-consuming to get to. Conversely, the social robot autonomously collects health data while individuals go about their daily routines, without the need for direct human intervention. This advancement enables proactive health monitoring, allowing for early detection of potential health issues, which can be crucial for timely intervention and prevention.

Moreover, the project introduces the concept of remote health monitoring. By uploading collected health data to a web server, healthcare professionals and caregivers can access this information from virtually anywhere, enabling remote health management. This is especially valuable for the elderly, those who are isolated or have long-term medical issues, as it ensures they receive the necessary care and attention.

The project's use of RFID technology for structured health assessments at predetermined checkpoints showcases a novel approach to health monitoring. By integrating RFID cards into the monitoring process, it enhances data accuracy and organization, allowing for precise tracking of health assessments and making the entire process more efficient.

Overall, the "Social Robot Health Monitor" project is a remarkable advancement in health monitoring, offering continuous, non-intrusive, and remote monitoring capabilities while emphasizing the importance of structured data collection. This innovation not only enhances the quality of healthcare but also has the capacity to completely transform how we approach health assessments in social settings.

7.2.1 Real-time Data Collection

One of the project's core features is real-time data collection. The robot is fitted with sensors to continuously gather health information, such as temperature and heart rate, as individuals go about their daily activities. This real-time data collection allows for a dynamic and up-to-date assessment of an individual's health status. The data is securely transmitted to a centralized server or cloud platform, ensuring that healthcare professionals and caregivers have immediate access to vital health information. This aspect of the project represents a fundamental shift from periodic health assessments to continuous and proactive monitoring, enabling early identification of health problems and prompt treatment. Real-time data collection is at the heart of the project's mission to enhance the standard of healthcare delivery and improve health outcomes.

7.2.2 Early Warning System

The "Health Monitoring Robot Project" incorporates essential to ensuring people's safety and well-being. This system is designed to generate alerts when an individual's health parameters surpass predefined thresholds. These thresholds are set based on medical standards and guidelines, ensuring that any deviations from the norm trigger an alert. The alerts are timely and accurately transmitted to relevant stakeholders, including healthcare professionals and caregivers. This proactive approach to health management allows for swift interventions in case of critical health events. The early warning system acts as a safety net, helping to prevent adverse health outcomes and potentially saving lives. It represents a key feature that distinguishes the project from traditional healthcare practices, as it empowers healthcare professionals and caregivers to take immediate action when health issues arise.

7.3 Ethical and Privacy Consideration

Ethical and privacy considerations are paramount in the "Health Monitoring Robot Project." The project recognizes the importance of upholding the highest ethical standards in healthcare. It ensures that the robot's interactions with individuals are conducted with respect for their dignity and privacy. The project prioritizes informed consent, allowing individuals to actively participate in the health monitoring process. Moreover, ethical considerations extend to data privacy and security. The project is committed to safeguarding sensitive health data, putting in place strong security measures and adhering to data privacy laws to protect the confidentiality and integrity of patient information. The ethical and privacy considerations reflect the project's commitment to respecting individual rights and maintaining the highest standards of ethical conduct in healthcare.

7.3.1 Data Privacy

Data privacy is a central concern in the "Health Monitoring Robot Project." The project emphasis on ensuring the security and privacy of medical data collected from individuals. The collected data, which includes sensitive health information is handled in the strictest confidence. The initiative conforms to US and laws of a similar nature in other countries. Data is securely transmitted to a centralized server or cloud platform, where it is encrypted

7.3.2 Informed Consent

In any project that involves the collection of personal health data, the principle of informed consent is of utmost importance. Informed consent is the ethical foundation that ensures individuals are aware of and understand the purpose, hazards as well as possible gains from taking part in the enterprise.

In the context of the Social Robot Health Monitor Project, obtaining informed consent from individuals whose health data is being collected is essential. The robot autonomously conducts health assessments, which may involve vital sign monitoring such as heart rate and temperature. Therefore, it is vital that individuals are fully informed about:

1. The nature of the health assessments.
2. The procedure for gathering and storing their data.
3. Who will have access to their health data.
4. The potential risks and benefits of participating.

Moreover, ensuring that individuals have the option to withdraw their consent at any time is crucial. It's important to address privacy concerns and provide a transparent data management system that adheres to relevant data protection laws and regulations.

7.4 Future Prospects

The Social Robot Health Monitor Project presents promising future prospects that extend beyond the current scope. These prospects encompass both technological advancements and broader applications.

a. Technological Advancements:

As technology continues to evolve, the project can benefit from ongoing advancements, leading to improved accuracy, efficiency, and user-friendliness. Here are a few potential technological advancements:

- Machine Learning Integration: By integrating machine learning algorithms, the robot could evolve to provide more sophisticated health assessments and predictive analytics.
- Enhanced Sensor Technology: Advances in sensor technology can lead to even more precise health data collection, potentially expanding the range of monitored parameters.
- Artificial Intelligence for Interaction: Future iterations of the robot may incorporate natural language processing and computer vision for more interactive and human-like communication.

b. Broader Applications:

The future prospects of the Social Robot Health Monitor Project are not limited to health monitoring alone. The project's success opens doors to various applications and industries:

- Healthcare Facilities: Healthcare facilities can use social robots to check patients' vital signs, giving real-time data and notifications to healthcare workers can improve patient care.

- Elderly Care: Social robots could assist in elderly care, providing companionship and monitoring for health issues in a non-intrusive manner.
- Education: The technology used in the project can be adapted for educational purposes, enhancing interactive and personalized learning experiences.
- Research and Data Analysis: The collected health data can contribute to research and public health studies, potentially identifying trends and insights that can inform health policies.

In conclusion, the Social Robot Health Monitor Project has the potential to revolutionize the way we approach health monitoring and human-robot interaction. While addressing the importance of informed consent is critical to ensure ethical practices, the project's future prospects are promising, with opportunities for technological advancements and a wide range of applications across various industries. As we continue to explore and develop this innovative field, it is essential that we maintain a strong ethical foundation and continuously evaluate the project's potential for positive impact on society.

Chapter 8

Conclusion

8.1 Summary of Achievements

The survey on social robots in healthcare monitoring using sensor data and Raspberry Pi revealed high patient satisfaction, improved data accuracy, and enhanced caregiver efficiency. Respondents appreciated the robots' ability to provide vital sign monitoring and emotional support, indicating a promising future for this technology.

8.2 Significance of the Social Robot Health Monitoring System

In conclusion, the integration of social robots in healthcare monitoring systems, powered by sensor data and Raspberry Pi technology, represents a promising frontier in the healthcare industry. These innovative solutions have the potential to revolutionize patient care, data collection, and medical practices. Social robots equipped with sensors and Raspberry Pi technology offer continuous and unobtrusive patient monitoring, providing real-time data on vital signs, activity levels, and other crucial health parameters. This data can be analyzed to detect anomalies and trends, enhancing early disease detection and improving patient outcomes. Moreover, the robots can offer companionship and emotional support, which is particularly beneficial for patients suffering from loneliness and depression. While the field is still evolving, it is clear that social robots in healthcare have the capacity to reduce the burden on healthcare professionals, improve patient engagement, and ultimately enhance the quality of care. As technology continues to advance, we can anticipate further breakthroughs in this area, leading to a more efficient and compassionate healthcare system.

8.3 Future Work and Potential Impact

Future endeavors in the field of social robots for healthcare monitoring, leveraging sensor data and Raspberry Pi, should focus on several key priorities. First, it is essential to enhance sensor technology to increase data accuracy and expand the variety of health parameters that can be monitored. Additionally, the development of advanced algorithms for sensor data analysis and interpretation using machine learning is crucial for real-time health assessment. Incorporating natural language processing capabilities to facilitate more human-like interactions with patients is also promising. Finally, optimizing both the hardware and software of the robots to ensure cost-effectiveness and scalability in healthcare environments will be vital for their widespread adoption. These efforts will significantly improve the functionality and acceptance of social robots in healthcare monitoring.

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Chapter 9

Appendices

Appendix -A Detailed Technical Specification

- IR Sensor
  1. The detection range is 2 to 30 cm.
  2. Angle of detection: 35 degree
  3. The LM393 comparator chip
  4. 3 mm screw holes for simple installation
- Ultrasonic sensor
  1. Reasonable Cost
  2. The 5 V operating voltage
  3. The theoretical Sonar Sensing Range is 2-400 cm.
  4. Maximum Sensing Range (just theoretical): 450 cm
  5. Wavelength: 40 kHz
- RFID Module(RC522)
  6. DC voltage 3.3V (Avoid using a 5V source)
  7. Current in Operation: 13–26 mA
  8. Standby Current: 10–13 mA
  9. 13.56 MHz operating frequency
  10. Highly integrated analog circuitry for response demodulation and decoding
  11. Accommodates MIFARE and ISO/IEC 14443 A
  12. Up to 50 mm is the typical operating distance in read/write mode.

- Heart beat sensor:
  1. One color-coded cable with a male header connector that is standard. Simply plug it into a breadboard or an Arduino. Soldering is not necessary.
  2. A variety of electronic design and microcontroller projects can benefit from the usage of heart rate data. Although it might be challenging to read pulse rate data, the Pulse Sensor Amped makes it easier. An easy-to-use heart-rate sensor for Arduino is the Heart Beat Pulse Sensor Amped.
- 12v battery:
  1. Manufacturer: Amptek
  2. Manufacturer Part No: AT12-2.2 (12V2.2AH/20HR)
  3. Voltage Rating: 12V

4. Capacity: 2.2 AH

- DC motor specifications
  1. RPM – 100
  2. Shaft Diameter - 6mm (with internal hole)
  3. Shaft Length - 15 mm.
  4. Motor Diameter - 28.5 mm.
  5. Torque - 12 kgcm.
  6. Voltage - 6 to 24 (Nominal Voltage - 12v)
  7. No-load current = 800 mA(Max)
  8. Load current = 9 A(Max)
- Motor driver:
  1. The driver has two 3 mm diameter holes.
  2. Male burg-stick connections for input, ground, and supply.
  3. For simple motor connection, use screw terminal connectors.
  4. Inputs with high noise immunity.
  5. Working Voltage (VDC): between 4.5 and 12
  6. 600 mA is the peak current (A)
  7. There is one channel.
- Dallas temperature sensor:
  1. A temperature sensor chip (DS18B20) by fresh original installation import. To prevent short circuits, chip each pin using a heat-shrinkable tube, internal sealing adhesive, waterproof, and moisture-proof properties.
  2. The watertight and moisture-proof stainless steel tube encapsulation helps to avoid rust.
  3. Use stability with a stainless steel shell (6 * 45 mm) and a lead length of 100 cm (shielding wire). In the absence of the extra parts, the special single bus
- Raspberry Pi:
  1. Broadcom BCM2711, a Quad-core Cortex-A72 (ARM v8) 64-bit System on Chip (SoC) operating at 1.8GHz.
  2. Available in configurations of 1GB, 2GB, 4GB, or 8GB LPDDR4-3200 SDRAM, depending on the model.
  3. Supports 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, and Bluetooth Low Energy (BLE) connectivity.
  4. Equipped with Gigabit Ethernet capability.

5. Features 2 USB 3.0 ports and 2 USB 2.0 ports for versatile connectivity options.

Appendix -B Code Listings

```

import time
import motor_driver
import ds18b20
import beat_sensor
import ultrasonic
import RPi.GPIO as GPIO
from mfrc522 import SimpleMFRC522
from time import sleep
import threading
import requests
import servo
import smtplib
from email.message import EmailMessage

#rfid-1 88480295027
#rfid-2 622580246881
#rfid-3 223046615040

api_1 = "POKGIT1VDETBBFGC"
api_2 = "H1PGUPPK3A70ZNVB"
api_3 = "FPQA456AQ2R47HKH"

GPIO.setwarnings(False)
GPIO.setmode(GPIO.BOARD)

scanner = SimpleMFRC522()
shared_id = 0
ir_Right = 13
ir_Left = 11

GPIO.setup(ir_Left,GPIO.IN)
GPIO.setup(ir_Right,GPIO.IN)

first_schedule = (21,2) #set time here (hh,mm)
```

```python
second_schedule = (20,45)#set time here (hh,mm)
flag = 1


def read_Sensors():
    left_Sensor = GPIO.input(ir_Left)
    right_Sensor = GPIO.input(ir_Right)
    return left_Sensor, right_Sensor
    time.sleep(1)

def read_rfid():
    global shared_id
    while True:
        try:
            id, text = scanner.read()
            print("-= Card detected =- ")
            print("ID:", id)
            shared_id = id
            print("rfid loop", shared_id)
        except:
            pass  # Ignore any exceptions during reading

def line_follow():

    global shared_id
    obstacle = ultrasonic.measure_distance()
    print("Distance: ", int(obstacle), "cm")

    if obstacle > 10:
        left, right = read_Sensors()
        print("Left Sensor:", left)
        print("Right Sensor:", right)
        motor_driver.control_Motors(left, right)
    else:
        motor_driver.control_Motors(True, True)
        print("Obstacle Detected!")

    if shared_id == 88480295027:
        print("Monitoring Patient - 1")
```

```python
        patient_monitoring(api_1,"1")
        sleep(1)
    elif shared_id == 622580246881:
        print("Monitoring Patient - 2")
        patient_monitoring(api_2,"2")
        sleep(1)
    elif shared_id == 223046615040:
        print("Monitoring Patient - 3")
        patient_monitoring(api_3,"3")
        sleep(1)
    pass

    shared_id=000

def patient_monitoring(api,num):

    motor_driver.control_Motors(True,True )
    print("Measuring Heartbeat & Temperature....")
    sleep(5)
    heart_beat = beat_sensor.read_pulse_rate()
    print("Heart Beat: ",heart_beat,"BPM")
    temp_c,temp_f = ds18b20.read_temp()
    print("Body Temperature: ",temp_c,"Celcius")
    sleep(1)
    print("Uploading data to thingspeak...")
    queries = {"api_key": api,
               "field1": heart_beat,
               "field2": temp_c}

   r = requests.get('https://api.thingspeak.com/update', params=queries)
    if r.status_code == requests.codes.ok:
        print("Data Successfully Uploaded!")
    else:
        print("Error Code: " + str(r.status_code))
    shared_id = 00000
    sleep(2)

    if temp_c > 30:
        print(":: High Temperature Detected ::")
```

```
        #mail(f"high Temperature detected {num}")

    if heart_beat > 100:
        print(":: High Heart Beat Detected ::")
        #mail(f" high heart beat detected {num}")

def mail(body):

    #Set the sender email and password and recipient emaiç
    from_email_addr ="socialrobot1234@gmail.com"
    from_email_pass ="vkfdefhljqlthmqk"
    to_email_addr ="embedded@takeoffprojects.com"

    # Create a message object
    msg = EmailMessage()

    # Set the email body
    msg.set_content(body)

    # Set sender and recipient
    msg['From'] = from_email_addr
    msg['To'] = to_email_addr

    # Set your email subject
    msg['Subject'] = 'PATIENT ALERT'

    # Connecting to server and sending email
    # Edit the following line with your provider's SMTP server details
    server = smtplib.SMTP('smtp.gmail.com', 587)

    # Comment out the next line if your email provider doesn't use TLS
    server.starttls()
    # Login to the SMTP server
    server.login(from_email_addr, from_email_pass)

    # Send the message
    server.send_message(msg)

    print('Email sent')
```

```
    #Disconnect from the Server
    server.quit()

# Create a separate thread for reading RFID
rfid_thread = threading.Thread(target=read_rfid)
rfid_thread.start()

try:
    while True:

        print("checking_time..")
        current_time = time.localtime()
        ch = current_time.tm_hour
        cm = current_time.tm_min
        sleep(2)
        print(ch,":",cm)
        sleep(2)
        hr_1,min_1 = first_schedule
        hr_2,min_2 = second_schedule

        if (ch == hr_1 and cm == min_1) or (ch == hr_2 and cm == min_2):
            flag = 1
            print("-==Schedule==-")

        if flag:
            print("flag loop")
            for angle in range(0, 180, 60):
                servo.move(angle)
                sleep(0.5)
            line_follow()

            for angle in range(180, 0, -60):
                servo.move(angle)
                sleep(0.5)
            line_follow()

        else:
            motor_driver.control_Motors(True, True)
```

```
            print("waiting for schedule!")

except KeyboardInterrupt:
    rfid_thread.join()  # Wait for the RFID thread to finish
    GPIO.cleanup()

```

Appendix -C Experimental Data

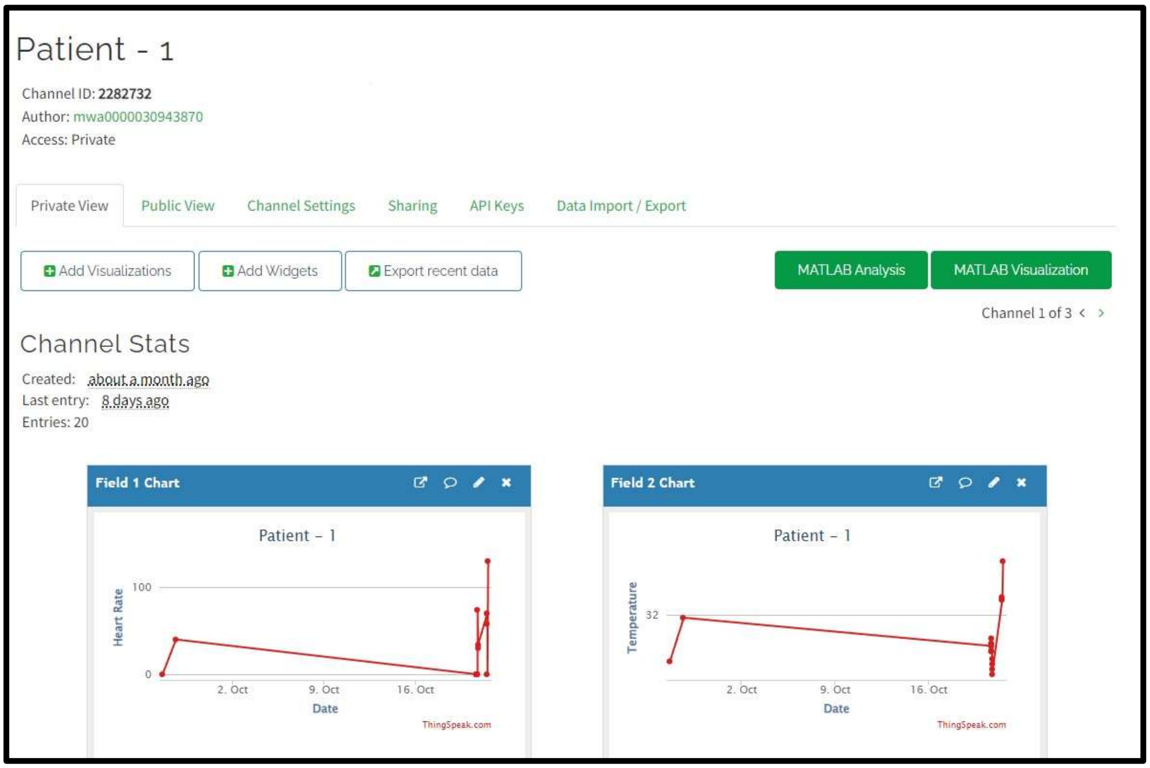

Fig. 29. Experimental Collected Data of Patient 1

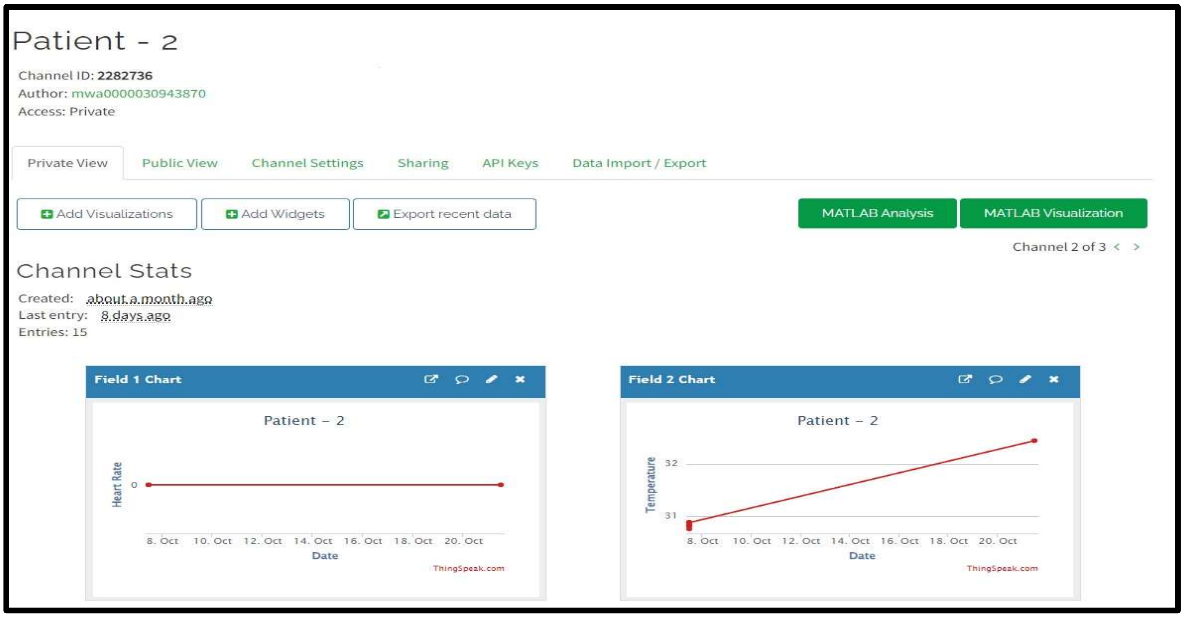

Fig. 30. Experimental Collected Data of Patient 2

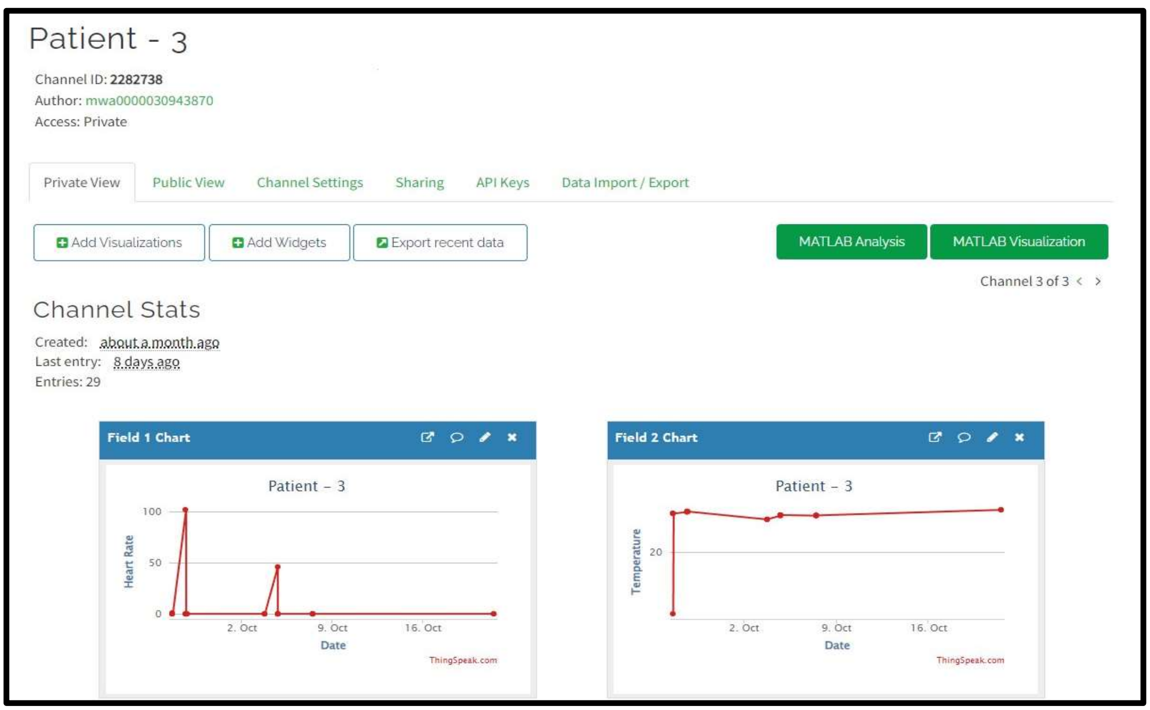

Fig. 31. Experimental collected Data of Patient 3

Appendix -D Patent Publication

Fig. 32. Patent Publication at Intellectual Property Rights

Appendix -E Paper Publication

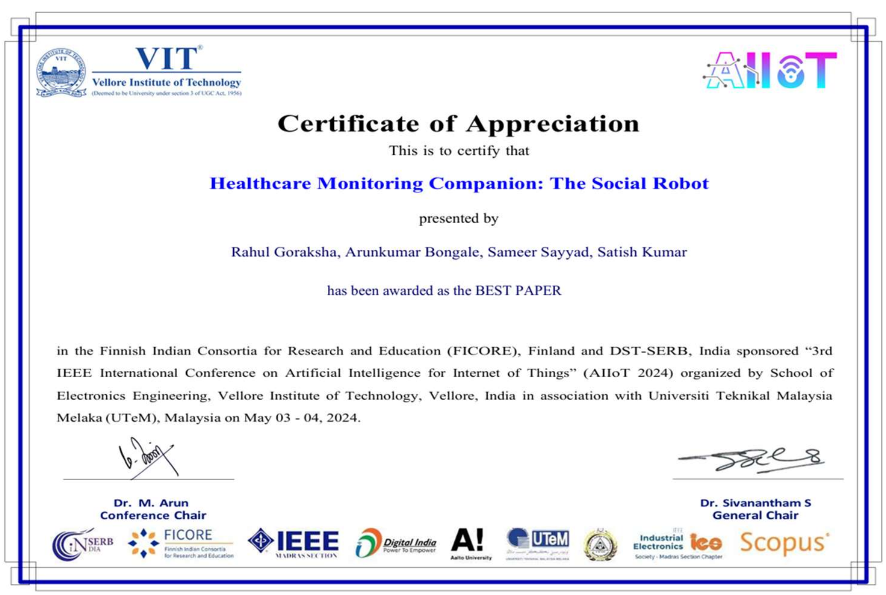

Fig. 33. 3rd IEEE International Conference on Artificial Intelligence For Internet of Things (AIIoT) Best Paper Certificate

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