Journal of Electronics and Informatics (ISSN: 2582-3825)
www.irojournals.com/iroei/

MEDROBO: Automated Medicine Delivery and Patient Monitoring System

Kalpana G.[1], Sai Poojitha R.[2], Mukka Varun[3], Sriharsha P.[4]

[1]Assistant Professor, [2,3,4]UG Students, Department of Artificial Intelligence and Data Science, Nehru Institute of Engineering and Technology, Anna University, Coimbatore, India

E-mail: [1]nietkalpanagcse@nehrucolleges.com

Abstract

The research aims to develop an innovative solution to automate the delivery of medicine to patients and monitor their vital parameters in healthcare facilities. Traditional methods often rely on human interventions for medicine delivery and patient monitoring, leading to inefficiencies and potential errors. To address these challenges, the proposed study introduces a robotic system capable of line-following method and real-time health parameter monitoring. The core functionality of the system revolves around a robot equipped with various sensors. The robot navigates hospital corridors by following predefined lines, allowing it to reach patients' rooms without human assistance. RFID tags attached to patient beds facilitate the robot in identifying and locating specific patients, ensuring accurate medicine delivery. Furthermore, the robot integrates vital sign monitoring capabilities, including heart rate, Spo2, blood pressure, and temperature.

Keywords: Real-Time Health Monitoring, RFID Tags, Line-Following Robot, Sensors, Patients Vital Sign Monitoring, Autonomous Medicine Delivery

1. Introduction

MEDROBO is an innovative solution aimed at revolutionizing healthcare delivery through automation and remote monitoring. This system combines advanced robotics with cutting-edge monitoring technology to ensure efficient and accurate medicine delivery while providing real-time patient monitoring. By automating the medication dispensing process,

DOI: https://doi.org/10.36548/jei.2024.3.001
Received: 14.05.2024, received in revised form: 08.06.2024, accepted: 22.06.2024, published: 04.07.2024

MEDROBO minimizes errors and ensures patients receive their prescriptions on time. The core idea behind the proposed method is to develop a robotic system capable of navigating to the patients' rooms, delivering medications, and monitoring their vital parameters in real-time [7-9]. By leveraging advancements in robotics, sensor technology, and Internet of Things (IoT) connectivity, The proposed solution seeks to revolutionize the way healthcare services are delivered and managed.

2. Objectives

The objective of the "MEDROBO: Automated Medicine Delivery and Patient Monitoring System" is to revolutionize healthcare delivery by introducing an innovative solution that automates the processes of medication delivery and patient monitoring. Through the development and implementation of a sophisticated robotic system, the proposed solution aims to significantly enhance the efficiency, accuracy, and reliability of healthcare services provided in hospitals and other healthcare facilities.

- Design and implement a robust medication dispensing system capable of accurately dispensing prescribed medications according to specified schedules.
- Integrate sensors and monitoring devices to collect real-time data on patients' vital signs, including heart rate, blood pressure, temperature, and oxygen saturation.
- Doctors can remotely analyse and monitor the vital levels of patients from any location.
- Medications are delivered through an automated medicine dispensary box based on the doctor's prescription.

3. Materials and Methods

The MEDROBO system, designed for automated medicine delivery and patient monitoring, relies on a line-following mechanism to navigate within a healthcare environment. This system uses sensors to detect and follow lines, typically painted or taped on the floor, ensuring the robot can travel along a predefined path throughout the facility. The materials required for this functionality include line sensors, usually infrared (IR) sensors, which distinguish between the line and the surrounding floor.

- **Hardware Requirements:** Esp32, Motor driver, Servo motor, RFID reader and tags, Spo2 sensor, Blood pressure sensor, Heart rate sensor, Temperature sensor
- **Software Requirements**: Arduino IDE, Website (ThingSpeak), Mobile app(ThingView)

In addition to the line-following mechanism, the MEDROBO system uses RFID (Radio Frequency Identification) technology to identify specific locations or patients. RFID tags are strategically placed at key points along the robot's route. These tags contain unique identifiers that the robot can read with an onboard RFID reader, allowing it to determine its location or identify a particular patient or medication station. This technology is crucial for automating tasks like medication delivery and patient monitoring. The robot itself is constructed with a sturdy chassis and powered by a reliable battery. It uses wheels or tracks for movement and incorporates safety features such as bumpers and emergency stop mechanisms to ensure patient safety. The onboard processor governs the robot's operations, interpreting sensor data, controlling the robot's movements, and managing medication delivery. The medicine dispenser, designed to release precise doses of medication, is another essential component of the system.

The methods used in the MEDROBO system begin with the design and assembly of the robot, ensuring it can follow lines accurately and interact with RFID tags. The robot is programmed with a line-following algorithm, enabling it to navigate along the designated path. When the robot encounters an RFID tag, it reads the tag's identifier to determine its next action, such as stopping at a patient's room or delivering medication to a specific station.

The system also involves setting up RFID infrastructure throughout the facility, with tags placed at critical points along the robot's route. Calibration and testing are conducted to ensure the robot can accurately read the tags and follow the lines without deviation. The communication system allows the robot to connect with a central control system, providing real-time updates on its location and status [10-12].

4. Literature Survey

Robotic medication delivery systems represent a significant advancement in healthcare technology, offering automated solutions for dispensing medications to patients. This survey explores recent advancements in robotic medication delivery systems, discussing their potential to enhance medication adherence, reduce medication errors, and improve overall patient outcomes [1].

Artificial intelligence (AI) has the potential to revolutionize healthcare by enabling machines to perform tasks that traditionally required human intelligence. In healthcare, AI applications include diagnosis, treatment planning, and patient monitoring. This comprehensive survey explores the various applications of AI in healthcare, covering areas such as medical imaging, predictive analytics, and personalized medicine.

Internet of Things (IoT)-based healthcare systems integrate interconnected devices, sensors, and software applications to monitor patients, collect health data, and facilitate communication between healthcare providers and patients This review discusses IoT-based healthcare systems, focusing on their architecture, communication protocols, and security considerations [3].

Blockchain technology has the potential to transform healthcare by providing a secure and transparent platform for storing and sharing patient data. This review explores the use of blockchain technology in healthcare, discussing its potential 19 applications in areas such as electronic health records management, supply chain management, and clinical research. By leveraging blockchain technology, healthcare providers can improve data security, streamline operations, and enhance patient trust [4].

Wearable biosensors are devices that continuously monitor physiological parameters such as heart rate, blood pressure, and activity levels. This review discusses wearable biosensors used for continuous health monitoring, highlighting their applications, challenges, and future directions. By integrating wearable biosensors into healthcare systems, providers can monitor patients more effectively, detect health problems early, and improve overall patient outcomes [5].

The proposed method includes methods from existing work, such as sensors, IoT, and automation, to deliver medicines automatically. Integrating AI and blockchain technology will be a future aim of the research.

5. Proposed System

The proposed system outlines the innovative features, functionalities, and improvements over the existing system that address the identified shortcomings or limitations. In this context, the proposed system encompasses the design, development, and deployment of a comprehensive automated system that streamlines medicine delivery, enhances patient monitoring, and improves overall healthcare management. This system incorporates technologies such as robotics, IoT (Internet of Things) and data analytics to optimize efficiency, accuracy, and patient outcomes. Using line follower technology, the MEDROBO navigates through predefined paths to reach the patients' rooms autonomously. Equipped with sensors to detect and follow lines on the floor, the robot efficiently moves through hospital corridors to deliver medication or conduct patient monitoring tasks. The ESP32 onboard the robot handles the processing of line-following algorithms, enabling precise navigation and obstacle avoidance along the way.

5.1 Working of the Project

The MEDROBO operates with efficiency and precision, utilizing a line following method to navigate to the patient's room. Employing an RFID card, the system scans it with an RFID scanner upon arrival, triggering a buzzer sound after a brief delay, indicating successful navigation to the patient's location. Subsequently, vital signs including oxygen levels (SpO2), blood pressure, and heart rate are monitored using dedicated sensors, ensuring comprehensive patient health assessment. These parameters are seamlessly integrated into a user-friendly app interface, enabling healthcare professionals to access real-time data remotely for timely intervention and decision-making. Integral to the system's functionality is the servo motor, which acts as the medication box, precisely dispensing medications based on the RFID tag scanner's input. Upon RFID detection, the medication box opens, allowing patients to collect their medication, and automatically closes after a predetermined duration, ensuring medication safety and adherence. Following each parameter collection, a buzzer alert notifies the patient to retrieve their medication, enhancing patient engagement and adherence to treatment regimens. The app, equipped with a dedicated channel for the medical robot, displays patient-specific data including patient number, blood pressure, SpO2, temperature, and heart rate readings, enabling doctors to remotely monitor patient health status and make informed decisions from any location with internet access.

The proposed system streamlines medication delivery and patient monitoring through innovative technology integration. Leveraging RFID technology, sensor data collection, and precise medication dispensing mechanisms, the system enhances efficiency, accuracy, and patient care quality. Coupled with remote monitoring capabilities through the dedicated app interface, healthcare professionals can oversee patient health status in real-time, facilitating timely interventions and improving overall healthcare delivery. The Figure 1 shows the flowchart of the proposed.

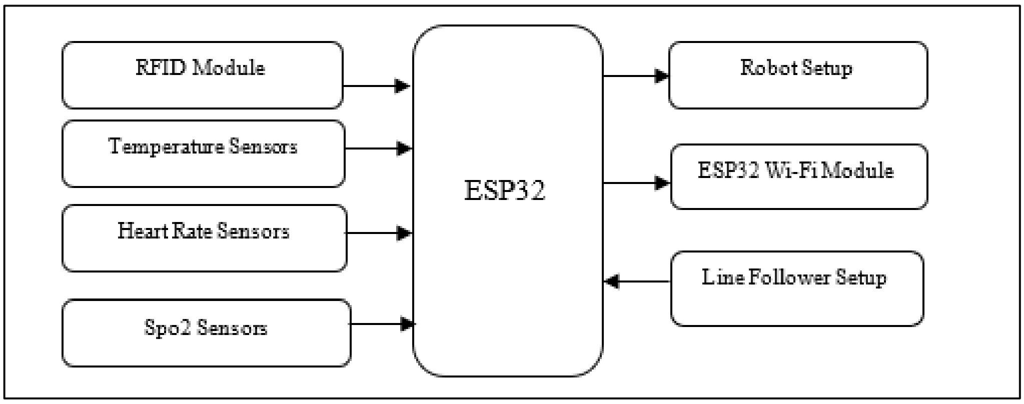


Figure 1. Flowchart of the System

6. Architecture

The MEDROBO system comprises several components, each interacting with the others to achieve automated medicine delivery and patient monitoring. The architecture is divided into three primary sections:

1.Robot Platform.

2.Sensors and Patient Monitoring.

3.Communication and Control.

6.1 Components and Connectivity

6.1.1 Robot Platform

- **Microcontroller**: The brain of the robot, controlling all functions.
- **Motors and Motor Drivers**: Responsible for the movement of the robot.
- **Line Following Sensors (TCRT5000 IR):** Detect and follow lines on the floor to navigate the hospital.
- **RFID Reader**: Reads RFID tags to determine the robot's location and identify patient rooms.
- **Medicine Compartment**: A secure compartment to store and deliver medicines.

6.1.2 Sensors and Patient Monitoring

- **Temperature Sensor (**DS18B20): Measures the patient's body temperature.
- **SpO2 Sensor (**MAX30100): Measures blood oxygen levels.
- **Blood Pressure Sensor (**BMP180): Measures the patient's blood pressure.
- **Heart Rate Sensor (**MAX30100): Measures the patient's heart rate.
- **Microcontroller (ESP32):** Processes sensor data before sending it to the cloud.

6.1.3 Communication and Control

- **Wi-Fi/Bluetooth Module**: The integrated Wi-Fi (802.11 b/g/n) and Bluetooth (BLE) capabilities of ESP32 facilitates wireless communication between the robot and the ThingSpeak app.
- **ThingSpeak Cloud**: A cloud platform to store and display patient data.
- **Doctor's Monitoring App**: An interface (using Thingspeak) where doctors can monitor patient vitals.

6.2 Data Flow

6.2.1 Robot Navigation and Medicine Delivery

- The robot follows a predefined path using the line following sensors.
- Upon encountering an RFID tag, the RFID reader identifies the room and stops the robot.
- The robot's microcontroller signals the medicine compartment to open, allowing medicine delivery.

6.2.2 Patient Monitoring

- The sensors (Temperature, SpO2, Blood Pressure, Heart Rate) continuously collect patient data.
- The microcontroller processes this data and sends it to the Thingspeak cloud through the Wi-Fi/Bluetooth module.

6.2.3 Doctor Monitoring

- The ThingSpeak cloud collects data from the robot and sensors.
- Doctors access the ThingSpeak app to monitor real-time data of patients.

The key components are interconnected to facilitate seamless operation and data transmission. Firstly, the temperature sensor, SpO2 sensor, heart rate sensor, blood pressure sensor, and servo motor are all directly connected to the ESP32 microcontroller. This central hub serves as the brain of the system, coordinating sensor data collection and controlling the medication dispensing mechanism through the servo motor. By consolidating these components onto a single platform, the ESP32 streamlines data processing and ensures efficient communication between the various subsystems.

Table .1 shows the specification of the ESP32 and the hardware components used.

Table 1. Hardware Components used

Component	Purpose	Configuration
ESP32 Microcontroller	Main control unit	Board: ESP32 Dev Board: ESP32 Dual core - Clock Frequency: Up to 240 MHz - Operating Voltage: 3.3V
Wi-Fi Module	Communication with Server	Protocol: Wi-Fi (802.11 b/g/n)-Frequency:2.4 GHz - Encryption: WPA2-PSK
Bluetooth Module	Communication with Mobile app	Protocol: Bluetooth Low Energy (BLE) - Version:4.2 or higher - Range: Up to 30 meters
Motor Drivers	Control of medicine dispensing mechanism	Type: Stepper Motor Driver - Voltage: 5V - Maximum Current: Depends on the stepper motor specifications
Sensors	Monitoring patient vitals	Pulse Oximeter:MAX30100 - Temperature: DS18B20 - Heart Rate: MAX30100 - Blood Pressure:BMP180
Display	User interface for feedback	Type: OLED Display - Resolution: 128x64 pixels - Interface:12C
Power Supply	Powering the system components	Input voltage: 5V DC - Output Voltage: 3.3V(for ESP32) – Capacity: Sufficient for continuous operation
Memory	Storage of program and data	Flash Memory: 4MB - RAM: 520KB - EEPROM: 4KB (internal) - SD Card Slot (optional)

Real-Time Clock (RTC)	Timekeeping for scheduling	Type: DS3231 - Accuracy ±2ppm (±3.5 seconds/month) - Interface: 12C
Indicator LEDs	Status indication	Type: RGB LEDs - Colours: Red, Green, Blue - Patterns: Blinking, Solid, Pulsating
Push Buttons	User input for manual control	Type: Tactile Switches - Functions: Start/Stop, Emergency Stop, Mode Selection

7. Software used

7.1 Arduino IDE

In the MEDROBO, the Arduino Integrated Development Environment (IDE) plays a crucial role in developing, programming, and controlling the robotic system that automates medicine delivery and patient monitoring. The Arduino IDE serves as the primary platform for writing and uploading code to the microcontrollers embedded in MEDROBO. These microcontrollers control the robot's movements, sensor readings, and communication processes. Using the Arduino IDE, code is written to ensure that the robot navigates accurately, delivers medications precisely, and monitors vital signs effectively. The IDE's user-friendly interface and extensive libraries simplify the integration of the various sensors and actuators, facilitating the seamless operation of MEDROBO. By leveraging the capabilities of the Arduino IDE, the project can efficiently implement complex tasks like real-time monitoring and autonomous navigation, ensuring a reliable and innovative solution for healthcare automation.

8. Results

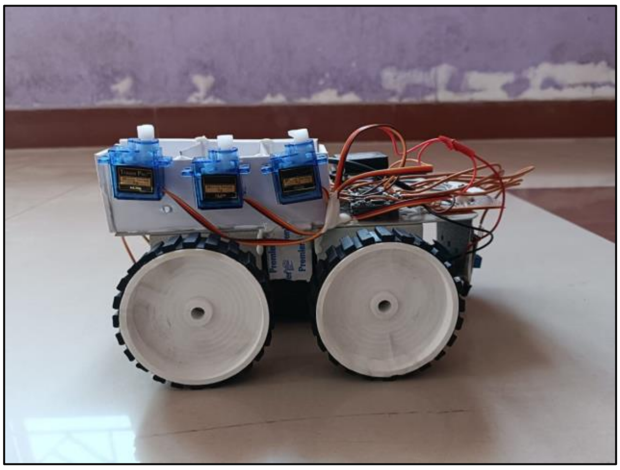


Figure 2. Product Design (Right Side View)

The four-wheeled medical robot is designed to navigate autonomously using line-following sensors, allowing it to move efficiently within medical facilities. Equipped with various vital sign sensors, such as temperature, SpO2, heart rate, and blood pressure monitors, it can provide real-time health data of patients. An RFID reader is integrated to identify and track patients or medical equipment, ensuring accurate monitoring and record-keeping. The motor driver, controlling the DC motors, facilitates smooth and precise movements of the robot. A switch is incorporated for easy control and operation of the device, making it user friendly for healthcare professionals. The Figure 2,3, and 4 shows the prototype of the proposed.

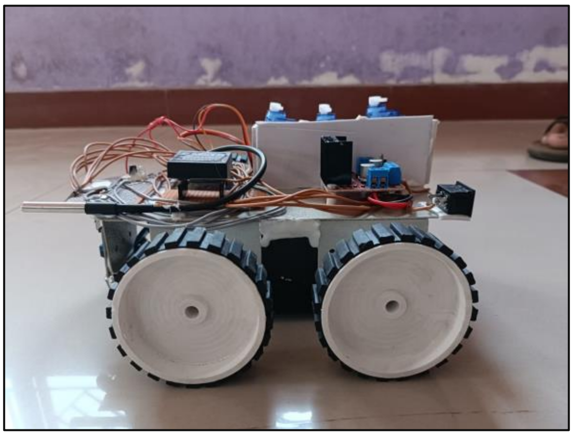


Figure 3. Product Design (Left Side View)

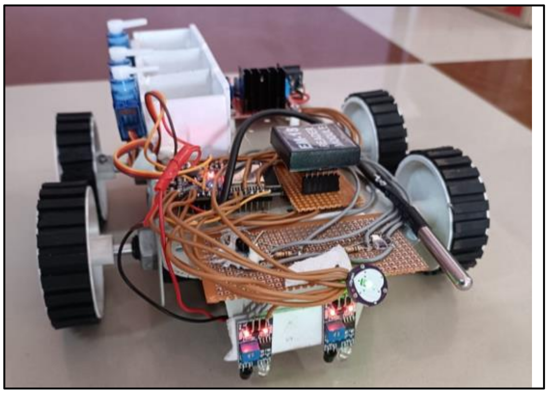
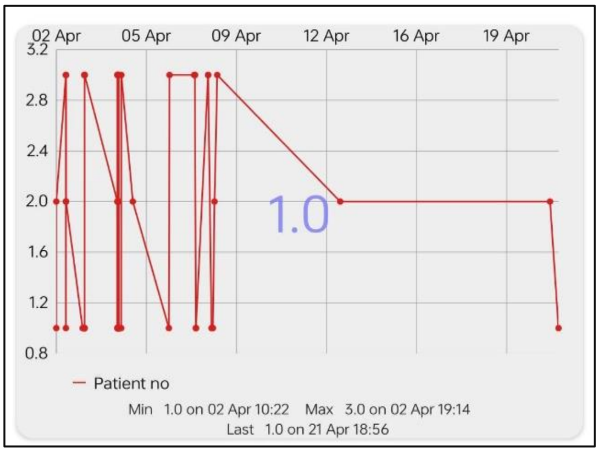
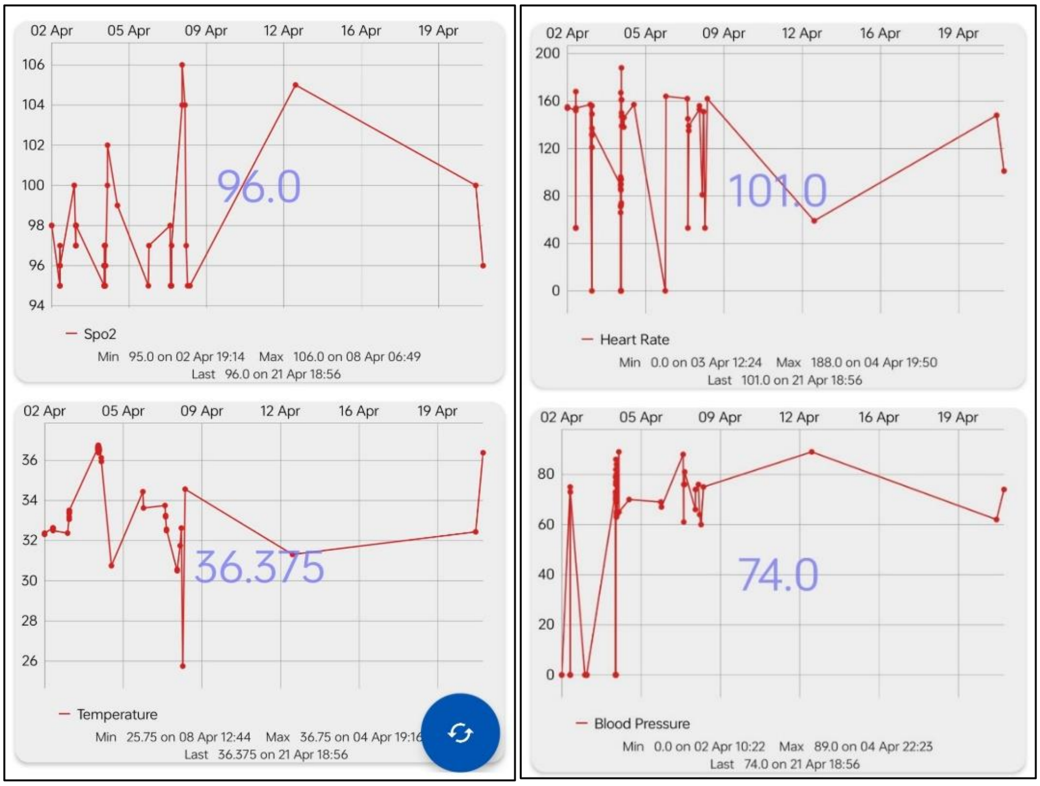


Figure 4. Product Design (Front View)

In addition to its navigational and monitoring capabilities, the four-wheeled medical robot is designed to enhance patient care and operational efficiency in healthcare environments. The line-following sensors ensure the robot can autonomously navigate complex hospital layouts, avoiding obstacles and ensuring timely delivery of medical supplies. The integrated vital sign sensors continuously monitor patients' health, providing alerts for any critical changes, thus facilitating prompt medical intervention. The RFID reader not only tracks patients and equipment but also streamlines inventory management, reducing human error in record-keeping. The motor driver ensures the robot's movements are both precise and adaptive to various terrains within medical facilities. The switch control provides healthcare professionals with an easy-to-use interface, making the robot simpler to operate. This reduces the learning time, enabling doctors to respond quickly in urgent situations. Figure .5 shows the visualization of the vital signs sensed.



(a)



(b) (c)

Figure 5. Display Values of (a) Patient Number, (b) Spo2 and Temperature, (c) Heart Rate and Blood Pressure

The graphs content which it is displayed in the app shows the status of the vital parameters of the patient and in a similar way time and the last seen and min and max range of the parameters and the fluctuations of up and down will describe about the decrease and increase of the heart rate.

8.1 Discussion

Initially, the research aimed to streamline these processes to reduce errors and improve efficiency. By employing a line-following mechanism and RFID technology, MEDROBO could navigate hospitals and deliver medication to the correct locations while monitoring patients' conditions. The proposed methods outcomes generally aligned with these goals, demonstrate the feasibility of automated healthcare robots in medical settings.

Despite the successful implementation, several challenges emerged. Technical issues with the line-following mechanism occasionally caused navigation errors, particularly in areas with uneven or reflective surfaces. Additionally, RFID tags were sometimes difficult to read due to placement or interference. These issues required adjustments in the robot's sensors and programming to ensure reliable operation

9. Conclusion

In conclusion, the "Medicine Delivering and Patient Parameter Monitoring Robot" represents a ground-breaking innovation in healthcare technology, offering a comprehensive solution to automate medication delivery and patient monitoring processes in hospital settings. By integrating advanced robotics, sensor technology, and IoT connectivity, the system streamlines workflows, enhances efficiency, and improves patient safety and outcomes. With precise navigation, accurate medication dispensing, continuous vital parameter monitoring, and seamless data transmission, the proposed work addresses the key challenges faced by healthcare providers, ensuring timely intervention and personalized care.

References

[1] S. S. Chempolil, R. Melvinia Basaiawmoit, S. Saji and K. R. V, "Design of a Medical Prototype Robot for Nurse Assistance," 2021 Seventh International conference on Bio Signals, Images, and Instrumentation (ICBSII), Chennai, India, 2021, pp. 1-5.

[2] Chen, Mei, and Michel Decary. "Artificial intelligence in healthcare: An essential guide for health leaders." In Healthcare management forum, Sage CA: Los Angeles, CA: SAGE Publications, 2020. vol. 33, no. 1, pp. 10-18

[3] Nazir, Shah, Yasir Ali, Naeem Ullah, and Iván García-Magariño. "Internet of things for healthcare using effects of mobile computing: a systematic literature review." Wireless Communications and Mobile Computing 2019, no. 1 (2019): 5931315.

[4] Agbo, Cornelius C., Qusay H. Mahmoud, and J. Mikael Eklund. "Blockchain technology in healthcare: a systematic review" In Healthcare, vol. 7, no. 2, MDPI, 2019. p. 56.

[5] Sharma, Atul, Mihaela Badea, Swapnil Tiwari, and Jean Louis Marty, “Wearable biosensors: an alternative and practical approach in healthcare and disease monitoring” Molecules 26, no. 3 (2021): 748.

[6] Vandemeulebroucke, Tijs, Bernadette Dierckx De Casterlé, and Chris Gastmans. "The use of care robots in aged care: A systematic review of argument-based ethics literature." Archives of gerontology and geriatrics 74 (2018): 15-25.

[7] Holland, Jane, Liz Kingston, Conor McCarthy, Eddie Armstrong, Peter O’Dwyer, Fionn Merz, and Mark McConnell. "Service robots in the healthcare sector." Robotics 10, no. 1 (2021): 47.

[8] Pigini, Lucia, David Facal, Lorenzo Blasi, and Renzo Andrich. "Service robots in elderly care at home: Users' needs and perceptions as a basis for concept development." Technology and Disability 24, no. 4 (2012): 303-311.

[9] Shishehgar, Majid, Donald Kerr, and Jacqueline Blake. "A systematic review of research into how robotic technology can help older people." Smart Health 7 (2018): 1-18.

[10] Han, Shuaishuai, Haoping Wang, and Haoyong Yu. "Human–robot interaction evaluation-based AAN control for upper limb rehabilitation robots driven by series elastic actuators." IEEE Transactions on Robotics (2023) PP(99):1-15

[11] Organisation for Economic Co-Operation and Development. Workforce and safety in long-term care during the COVID-19 pandemic. OECD Publishing, 2020.https://www.oecd-ilibrary.org/social-issues-migration-health/workforce-and-safety-in-long-term-care-during-the-covid-19-pandemic_43fc5d50-en

[12] Broadbent, Elizabeth, Rebecca Stafford, and Bruce MacDonald. "Acceptance of healthcare robots for the older population: Review and future directions." International journal of social robotics 1 (2009): 319-330.