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# Design and Fabrication of Autonomous Service Robot

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## Abstract
*This study describes development and application of an autonomous service robot to improve productivity and patient care in hospitals. The robot can independently deliver necessary materials such as blankets, pillows, and medicines to patients, significantly reducing the pressure on medical staff. With a built-in voice assistant, the robot can easily communicate with patients, provide them with instant updates, and make their hospital stay more comfortable. The robot can work safely and efficiently in a dynamic medical environment, thanks to navigation technology, avoiding obstacles and ensuring accurate deliveries. The concept has been successfully tested in real-world conditions, demonstrating its ability to improve patient satisfaction, maintain strict hygiene standards, and increase operational efficiency. This publication describes the design of the robot.*

***Keywords:*** *Autonomous Service Robot, Healthcare Robotics, patient care, Voice assistant, ROS, Foxy 2.*

## 1. Introduction
Global medical institutions face enormous challenges caused by an aging population and increasing demands on healthcare systems. Hospitals face constant pressure to increase operational efficiency while adhering to strict patient care guidelines. The main problem is the manual provision of essential items such as blankets, pillows, and prescriptions to patients. This increases the workload of healthcare professionals and can cause them to neglect important care tasks. By performing repetitive activities independently, these robots are designed to reduce the workload of medical staff and utilize human resources more efficiently. This study presents the design and development of an autonomous service robot for delivering necessary goods and medicines to patients. This robot is special because it has a voice assistant that makes it easy to communicate with patients, improving engagement and the overall patient experience. The robot can answer patient questions, provide status updates, and provide more personal and reassuring communication through voice assistants. Avoid obstacles and enable accurate, efficient deliveries. This helps maintain hygiene standards while ensuring timely deliveries by reducing human contact with the delivered goods. The robot has been used successfully in hospital settings, demonstrating its potential to improve standards of care and improve the efficiency of healthcare services [1].

### 1.1 Problem Statement
Patient care is a hospital's top priority, but healthcare professionals sometimes struggle to balance providing quality care and managing tedious, repetitive tasks. Nurses and other hospital staff spend much of their time delivering supplies to patients' beds, including pillows, blankets, and prescriptions. This results in less time available to meet more urgent patient demands, increasing staff stress and fatigue and delaying the provision of critical care to patients. Furthermore, because staffing is limited, patients may not receive the immediate engagement, reassurance, or communication they need to feel comfortable and

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at ease. Currently, these procedures are performed manually, which is very labor-intensive and resource-intensive, especially in large healthcare facilities. A separate solution was needed to help perform these monotonous tasks while meeting the patient's emotional and communication needs. Additionally, patients must recuperate in a quiet and serene setting, which might be disturbed if necessary, services are delayed or if patients feel ignored because they are not interacting with personnel. By creating an autonomous service robot that can precisely locate patient beds and navigate hospital wards, this research seeks to overcome these difficulties. With the ability to provide patients pillows, blankets, medications, and other necessities, the robot will facilitate the work of medical staff and improve the overall operational efficiency. The robot will also have a voice assistant who will help create a quiet hospital atmosphere by talking to patients, giving directions, answering simple questions, and providing comfort. By automating these cumbersome processes and using voice integration to connect with patients, the system aims to improve patient well-being, reduce staff workload, and increase overall hospital efficiency while creating a calm, caring environment for patients. Figure 1 shows Autonomous and Navigation Control Architecture.

## 1.2 Figures

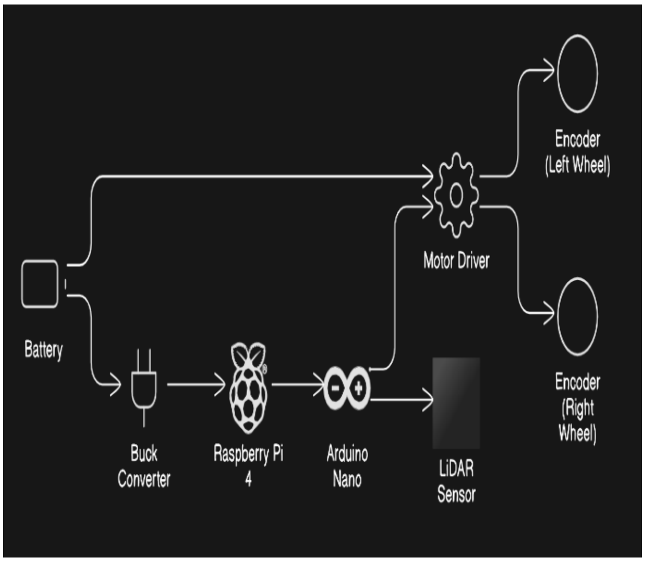


**Figure 1 Autonomous and Navigation Control Architecture**

The power source for this autonomous service robot system is a 24V 20Ah battery, which is then sent through a buck converter that can step down to 40V 20Ah to provide a stable voltage supply to the electronic parts. The Raspberry Pi 4, which acts as the central control unit, is then supplied with the converted electricity. Arduino Nano and Raspberry PI 4 interfaces to treat movement control and sensor input, as well as general treatment and decision - AKKER RASTRY PI 4 Control System. The engine driver, in turn, controls the engine to power the robot wheel, especially in Arduino Nano. In addition, the motor driver also adjusts the wheel encoder to ensure precise movement by continuously feedbacking the wheel position and speed. The robot cannot explore its surroundings on its own, it requires a LiDAR sensor connected to an Arduino Nano for obstacle detection and navigation. Given all factors, the system is built for automatic mobility.
one.

## 1.3 Battery

A durable 24V, 20Ah battery powers the robot, ensuring long life and reliable operation. This high-capacity battery is equipped with a buck converter that reduces the voltage to a level suitable for the robot's electronics. The battery holds Raspberry Pi 4, Arduino Nano and other parts driven steadily, guaranteeing navigation, obstacle detection and the robot's delivery systems that run consistently and unbroken.

## 1.4 Buck Converter

The system uses a buck converter to regulate the voltage provided by the 24V, 20Ah battery. This converter effectively reduces the battery's higher voltage to a lower regulated voltage required by the robot's electrical components. The buck converter improves the overall performance and reliability of the autonomous service robot by precisely regulating the voltage to ensure uninterrupted power supply to sensitive electronics such as the Raspberry Pi 4, Arduino Nano, and more.

## 1.5 Raspberry Pi 4

The Autonomous Service Bot Central Control Device Raspberry PI 4 provides an effective function of computing power. It manages data entry from Arduino Nano, which controls the detection of motor

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operations and obstacles and processes a connection to sensors, including Lidar. The Raspberry Pi 4 guarantees seamless operation of navigation algorithms, voice assistant integration, and real-time decision-making thanks to its quad-core CPU and generous memory. Because of its performance and adaptability, it is perfect for coordinating the several systems that allow the robot to move autonomously and deliver items in hospital settings [2][3].

## 1.6 LiDAR Sensor

The autonomous service robot's LiDAR sensor is essential for accurate obstacle identification and environmental mapping. The LiDAR sensor builds an intricate 360-degree image of the robot's environment by firing laser beams and timing how long it takes for them to return after colliding with surrounding objects. Rasperry Pi 4 and Arduino Nano process this data, allowing the robot to safely move around a complex medical environment, avoid obstacles and make real -time changes. Its extreme accuracy and reliability is essential for guaranteeing the robot's independent and invisible function in a dynamic environment.

## 1.7 Arduino Nano

As an interface between Raspberry Pi 4 and Robot Hardwar parts, Arduino Nano is important for independent service robots. It is responsible for guiding the motor driven, and the latter then regulates the movement of the Left wheel engine. To ensure accurate navigation, the Arduino Nano further analyzes information from encoders mounted on the wheels and provides real-time feedback on position and velocity. It also manages sensor data, which includes LiDAR data, allowing the robot to respond to its environment. The efficiency and small size of Arduino nano make it an ideal choice to control this important low -level operation in the robot.

## 1.8 Motor driver

The autonomous service robot's motor driver regulates the left and right wheel motors to provide accurate movement and navigation. It gets instructions from the Arduino Nano to control the motors' direction and speed in response to data from the wheel encoders and LiDAR sensor. The robot can maneuver through intricate settings and avoid obstacles because the motor driver provides smooth acceleration, deceleration, and turning. It's vital to controlling the power going to the motors so the robot can move on its own and carry out its delivery duties effectively in medical environments.

## 1.9 Encoders

Real-time feedback on the location, speed, and rotational direction of the wheels is provided by the encoders that are fastened to the robot's wheel motors. The Arduino Nano receives exact data from these encoders and utilizes it to guarantee perfect movement control for the robot. The encoders assist the robot maintain a steady pace, correct navigational errors, and make smooth turns and modifications by continually monitoring the rotation of the wheels. For the robot to navigate autonomously and maneuver effectively and accurately in changing healthcare contexts, real-time input is essential. Figure 2 shows Voice Assistant.

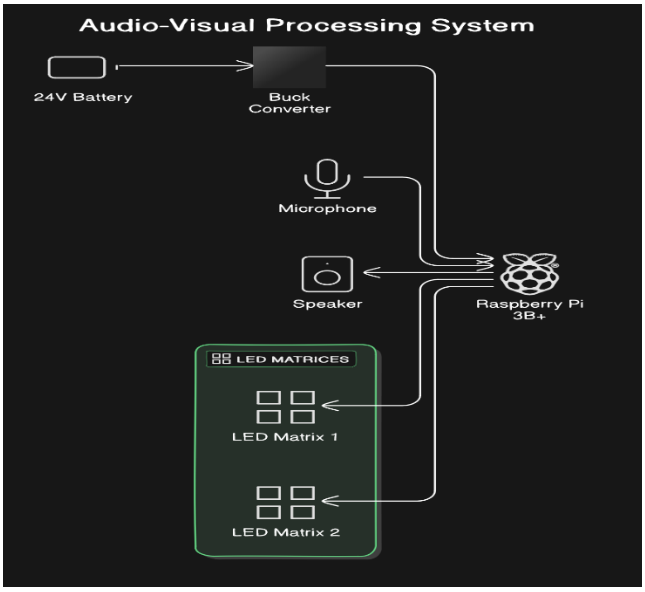


**Figure 2 Voice Assistant**

The Audio-Visual Processing System for robots combines several essential components: a battery with a buck converter to reduce voltage for the Raspberry Pi 3B+ and other parts, a microphone to capture spoken instructions, and voice assistant software on the Raspberry Pi to process and respond to audio inputs. The responses are replayed through a speaker, while LED matrices serve as the robot's "eyes," providing visual cues to indicate different

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states such as listening, processing, or reacting. This integration of auditory and visual elements enhances human-robot interaction, making the system well-suited for applications requiring dynamic communication. Figure 3 shows Side View and Front View

## 2. Design

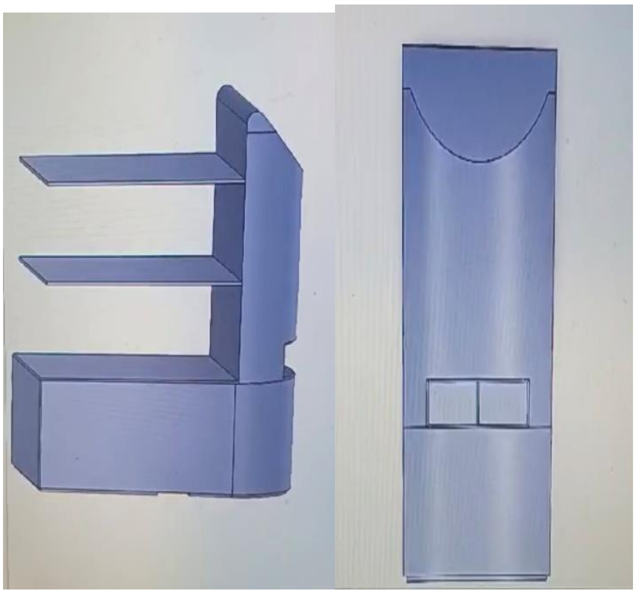

**Figure 3 Side View and Front View**

### 2.1 The Robot's Front View Displays A Sleek, Contemporary Style

**Important Components Consist of**

- **Curved Upper Section:** The robot's upper body has a rounded, seamless shape. In addition to being aesthetically pleasing, this lowers the chance of damage in settings where people interact. Because it routinely interacts with patients and personnel in healthcare settings, the robot's curvature gives it a kind and accessible aspect.
- **Dual Compartments:** The robot's front has two storage compartments located beneath the curving top. These pockets are made to store and move things like prescription drugs, medical equipment, or personal belongings for patients. The compartments are fastened to keep goods steady while in motion, reducing the possibility of spillage or displacement—especially over rough terrain.
- **Ergonomic Consideration:** The compartments' height and arrangement are made for comfortable access. Because the robot is taller than both patients and personnel, it is easier to fetch goods without stooping or straining, which increases user comfort and convenience.

### 2.2 The Side View of The Robot Reveals Its Key Functional Components

- **Two-Tier Shelving System:** The robot's central structure is supported by two horizontal shelves. Greater storage space is available for bulkier things like blankets, pillows, and medical supplies on these shelves. Since the shelves are open, it is simple to swiftly add and remove objects. Because of its robust construction, the robot can support a large weight without losing stability or mobility.
- **Enclosed Rear Housing:** The robot has an enclosed rear compartment in the back that holds necessary hardware and electronics, such as sensors, control systems, and maybe the voice assistant. The robot's curving enclosure keeps its essential parts shielded from rain, dust, and exterior damage while allowing it to have a small overall footprint. Additionally, by isolating the robot's internal systems from hospital environment elements, this improves endurance.

## 3. Results and Conclusion

Using SolidWorks, the autonomous service robot was successfully modeled and constructed to satisfy the unique needs of medical surroundings. Its design combines aesthetics, safety, and utility to provide effective service delivery and a non-obtrusive, welcoming look that is appropriate for patient engagement. A number of medical supplies, personal belongings, and equipment may be transported by the robot to and from patients and workers due to important design elements like the front compartments and two-tier storage system. Furthermore, the robot's ergonomic height and sturdy foundation increase its dependability and usage. The robot is fully integrated with ROS 2 Foxy, leveraging its advanced middleware framework for communication and control. Using ROS 2 Foxy, the robot can efficiently handle real-time data processing, manage sensor inputs, and perform navigation tasks. This allows the robot to autonomously move within a hospital environment, avoiding obstacles and delivering supplies to designated locations.ROS 2 Foxy's Navigation Stack (Nav2) has been implemented to enable the robot to navigate autonomously. Through the use of sensors and LIDAR, the robot maps its surroundings and plans optimal routes while ensuring safety through collision avoidance. The robot's voice assistant, developed with ROS 2 Foxy, facilitates human-robot interaction.

**Figure 4 Front View and Side View (After Fabrication)**

It allows the robot to communicate with patients and healthcare professionals, providing instructions or responding to basic commands. This improves the robot's ability to assist in daily tasks, such as delivering medication or supplies. Figure 4 shows Front View and Side View (After Fabrication).

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[8]. The paper by Iroju Olaronke, Ojerinde Oluwaseun, and Ikono Rhoda, titled "State of the Art: A Study of Human-Robot Interaction in Healthcare," published in *Information Engineering and Electronic Business* in May 2017, examines the latest advancements in human-robot interaction (HRI) within healthcare. It discusses the various roles of robots in assisting medical staff and patients, and explores the challenges and future directions of improving HRI to enhance healthcare services.