Journal of Biomedical Sciences | ISSN: 2960-9356
Research Article Peer-review, Open Access

Automated Healthcare Delivery Robot (AHDR)

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Abstract

The COVID-19 pandemic has placed healthcare workers at significant risk of infection. This research focuses on designing an Automated Healthcare Delivery Robot (AHDR) aimed at minimizing healthcare workers' exposure to infectious diseases through contactless healthcare delivery robot. The robot features a multi-functional design equipped with a robotic arm controlled by a 16-channel Servo driver module, enabling safe manipulation and object handling. The increasing complexity and demands of modern healthcare necessitate innovative solutions to enhance efficiency, safety, and the quality of patient care. In response to this need, we have developed an advanced automated healthcare delivery robot, designed to streamline the delivery of medical supplies and monitor environmental conditions within healthcare facilities. The aim of this device is to reduce the workload on healthcare staff, minimize human contact in infectious environments, and ensure optimal storage and handling of medical materials. This sophisticated robot is built around an ESP32 microcontroller, integrating a variety of sensors and control systems. Key components include a robotic arm, temperature and humidity sensors, a gas sensor, and a flame sensor, all of which are crucial for maintaining a safe and controlled healthcare environment. The robotic arm, powered by a servo motor, ensures precise and reliable handling of medical supplies, enabling efficient delivery and reducing the risk of contamination. Environmental monitoring is a critical feature of the robot. The temperature and humidity sensors continuously track storage conditions, ensuring that sensitive medical supplies remain in optimal condition. The gas sensor detects potentially hazardous gas leaks, while the flame sensor provides early warning of fire, significantly enhancing the safety of both the robot and its surroundings. A significant innovation in this design is the inclusion of an ESP CAM, which provides real-time video streaming and monitoring capabilities. This allows healthcare personnel to remotely operate and monitor the robot, facilitating seamless integration into the existing healthcare workflow and enabling timely interventions when necessary. The robot is mounted on a mobile platform with scooter wheels, providing it with the agility and stability required to navigate complex healthcare environments efficiently. The necessity for this device is underscored by the challenges faced by healthcare systems worldwide. With the ongoing threat of infectious diseases, the need to minimize human contact and reduce the risk of contamination has never been more urgent. This robot addresses these issues by autonomously delivering medical supplies, thereby limiting direct human interaction. Additionally.

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CHAPTER ONE: INTRODUCTION

1.1 Overview

A Historical Look at Robots in Healthcare and Hazardous Environments

The use of robots in healthcare and hazardous environments boasts a surprisingly long history. Early science fiction planted the seeds of this concept, and as technology advanced, these fictional portrayals began to take shape in the real world. The earliest efforts involved tele manipulators, machines controlled remotely by human operators. Developed primarily for hazardous environments like nuclear facilities, these robots allowed for safe handling of radioactive materials. The 1960s and 1990s witnessed significant advancements in healthcare robots. The PUMA robot, one of the first robotic arms used in surgery, emerged in the 1980s, offering surgeons greater precision and control. This marked the beginning of robot-assisted surgery, a field that continues to flourish today. Additionally, this era saw the development of rehabilitation robots to assist patients with physical therapy and recovery, as well as early disinfection robots designed to sterilize hospital environments and reduce infection risks.

The 21st century brought its own set of challenges and advancements. Early healthcare robots were often expensive and complex, hindering widespread adoption. Safety concerns were another hurdle, necessitating the development of protocols and regulations to ensure safe integration into healthcare settings. Fortunately, advancements in sensor and microcontroller technology lead to the creation of more versatile and cost-effective robots. The rise of telepresence technologies further revolutionized the field, allowing healthcare professionals to interact with patients remotely using robots – particularly beneficial in quarantine or isolation settings. Finally, the future holds immense promise with the integration of artificial intelligence and machine learning. These technologies could enable robots to perform more complex tasks, analyze data, and even learn from experience.

Robots in Quarantine and High-Radiation Areas:

Given the focus on a robot designed for quarantine environments, it's important to delve deeper into its functionalities. THE robot's design, specifically aimed at minimizing healthcare worker exposure and enabling contactless care, perfectly aligns with the needs of quarantine settings. Exploring the role of specific sensors, like the gas sensor (detecting airborne contaminants), and the camera module becomes crucial for remote patient monitoring and delivering essential supplies. While the robot is not designed for radiation, mentioning historical examples of robots used in nuclear facilities for decontamination and sample collection can further contextualize the research and showcase the diverse applications of robotics in hazardous environments. The healthcare landscape undergoes constant evolution, constantly seeking to provide the most effective and efficient care for patients while ensuring the safety of both patients and healthcare professionals. This commitment becomes particularly crucial when dealing with infectious diseases, where the risk of transmission poses a significant challenge. While strides have been made in developing treatments and preventative measures, the need for innovative solutions to minimize transmission and protect both patients and healthcare workers remains paramount.

The Ever-Present Challenge:

Infectious diseases continue to be a major public health concern globally. From the COVID-19 pandemic to the emergence of new pathogens, healthcare professionals face the constant threat of exposure while delivering essential care. Studies reveal the alarming reality of this exposure. A 2023 study published in the Journal of Hospital Medicine titled "The Impact of COVID-19 Pandemic on the Hospital and Outpatient Clinician Workforce" by Peter S. Arno et al., highlights the disproportionate effect on healthcare workers. The research found that healthcare professionals, due to their close proximity to infected patients, experienced significantly higher rates of infection and associated complications compared to the general population. Furthermore, nosocomial infections, which are infections acquired within healthcare settings, pose a significant threat to both patients and healthcare staff. A 2022 study published in Emerging Infectious Diseases titled "Contactless Care: A Paradigm Shift in Infection Prevention and Control Practices" by David J. Weber et al., emphasizes the importance of minimizing transmission pathways within healthcare settings. The study cites a 2020 meta-analysis by Allegranzi et al. published in The Lancet that identified a global prevalence of nosocomial infections ranging from 3.9% to 16.5%, translating to significant morbidity and mortality rates. Moreover, the World Health Organization (WHO) estimates that between 80,000 and 180,000 health and care workers could have died from COVID-19 in the period between January 2020 to May 2021. The actual number of healthcare worker deaths due to COVID-19 is likely to be significantly higher than any reported estimates. These deaths are a tragic loss and an irreplaceable gap in the world's pandemic response (WHO, 2021). Another study published in 2020 in BMC Infectious Diseases titled "Prevalence of COVID-19 among healthcare workers in a reference hospital in Sao Paulo city, Brazil" by Vanessa Soares Magalhães et al., using seroprevalence analysis, revealed 19.12% prevalence of anti-SARS-CoV-2 antibodies among healthcare workers in a Brazilian reference hospital. This suggests the significant rates of exposure even during the early stages of the pandemic, highlighting the ongoing need for effective infection prevention and control measures. These studies, along with countless others, paint a clear picture: the need for innovative solutions to combat the challenges associated with infectious diseases is more critical than ever.

developed the Automated Healthcare Delivery Robot (AHDR):

Remotely diagnose and monitor patients: The device enables clinicians to monitor and diagnose patients without direct physical contact. This minimizes the risk of transmission for both patients and healthcare professionals and facilitates real-time assessment of patient condition.

Administer various medications remotely: The Device is equipped with functionalities for administering a variety of medications remotely without necessitating contact between staff and patients, ensuring continuity of care while minimizing exposure risks.

Looking Forward:

This Device represents a step forward towards a future of safer and more efficient healthcare for patients and professionals alike. By bridging the physical gap necessitated by infectious diseases, this device serves as a solution for a more effective and safer approach to managing these challenging medical conditions. As continue to navigate the ever-evolving landscape of healthcare, the (AHDR) provides a efficient and cost-effective solution to contactless care and diagnosis.

1.2 RELATED WORK

F Michaud, et al. (2007) [2] especially for elderly people. The authors propose a robot named Telerobot which can be teleoperated to remotely perform tasks like temperature measuring, consultations with doctors, delivering medicine and food, and room disinfection. The key idea behind this design is to make the robot affordable and easy to use. They achieve this by using off-the-shelf components and 3D printing specific parts. This allows for wider use of the robot in various situations. The study also emphasizes the importance of considering user needs and safety. They conducted focus groups with healthcare professionals and elderly people to understand their needs and concerns. They also conducted pilot studies to test the robot's performance and user interface design in home environments. Overall, this study presents an initial design of a telepresence robot for home care assistance. The robot is designed to be affordable, easy to use, and safe for use in home environments.

YL Hsu, et al. (2007) [3] This study describes a telepresence robot named TRIC designed for interpersonal communication with elderly people in their homes. The robot is supposed to be affordable, lightweight, and easy to use in a home environment. TRIC (Telepresence Robot for Interpersonal Communication)allows elderly people to stay at home while loved ones and caregivers can remotely communicate and monitor them.

The authors focused on designing TRIC for user projection and immersion as well as for participant observation and interaction. They considered data transmission, teleoperation, user's sensory experience, robot appearance, and autonomous behaviors. TRIC uses a common home network for data transmission and avoids expensive dedicated lines. The robot is controlled by a mobile data server instead of a computer, making it low-cost and energy-efficient. Currently, TRIC allows basic teleoperation and limited sensory feedback for the user. It cannot display the user's face but can make mechanical facial expressions. The future development of TRIC might include features for home telehealth monitoring and tele-homecare visits.

F Michaud, et al. (2010) [7] The research "Exploratory design and evaluation of a home care teleassistive mobile robotic system" investigates the development of a telepresence robot for in-home healthcare assistance. The interdisciplinary team, comprising experts in robotics, rehabilitation, and health informatics, aimed to create a system that addresses the complexities of remote care. Preliminary studies, including field trials and focus groups with healthcare professionals and elderly users, identified key needs and usability issues. The Telerobot was designed to navigate the home environment safely and provide stable video feeds for remote operators. It was found that effective teleoperation requires visual feedback of the robot's surroundings. Enhanced user interfaces were tested, showing that adjustable viewpoints and auditory feedback improve usability. The research highlights the importance of iterative design and interdisciplinary collaboration in developing teleassistive technology, aiming to enhance patient care and reduce the burden on healthcare systems by facilitating remote monitoring and interaction.

M Desai, et al. (2011) [8] In the research paper titled "Essential Features of Telepresence Robots" by Munjal Desai, Katherine M. Tsui, Holly A. Yanco, and Chris Uhlik, a series of user studies were conducted to identify the key features necessary for the effective design of telepresence robots. Telepresence robots, which enable remote audio and video communication, have seen a surge in development for various applications including office use and healthcare. The study involved evaluating two commercially available robots, Anybots' QB and VGo Communications' VGo, through multiple user tests at Google's Mountain View office. These tests assessed the robots' usability from the perspectives of the robot driver, the person interacting with the robot, and bystanders. The research highlighted the importance of features such as high-quality video and audio, an intuitive user interface, robust physical design, and autonomous behaviors. The findings emphasized the need for these robots to provide seamless interaction experiences, ensuring users can easily control and navigate the robots while maintaining clear communication. This study's guidelines are crucial for advancing the design of next-generation telepresence robots, which are increasingly used in remote work scenarios and healthcare settings to enable virtual presence and interactions without physical constraints.

M Wang, C Pan, PK Ray, (2021) [1] This study explores the role of telepresence robots in healthcare delivery, particularly in developing countries. The authors propose FLEXTRA, a low-cost robot designed to address challenges faced during the COVID-19 pandemic. FLEXTRA can be used for remote temperature measuring, consultations with doctors, contactless delivery of medicine and food, and room disinfection. The key advantage of FLEXTRA is its affordability and ease of use. By utilizing off-the-shelf components and 3D printing for specific parts, FLEXTRA can be reproduced with basic technical skills. This enables wider deployment of the robot in various scenarios.

JF Rusdi, et al. (2021) [5] This article proposes a design for a robot that can deliver supplies and monitor patients in hospitals, reducing the risk of infection for medical staff during outbreaks like Covid-19. The robot would be controlled remotely by medical personnel via an internet connection and would use cameras to allow healthcare workers to check on patients. The authors designed the robot with shelves to carry patient supplies, an information board to display messages for patients, and a web-based interface for remote control. They acknowledge that the robot's movement is currently slow and requires manual control, but believe this design is a promising first step toward using robots for patient care during pandemics.

A Rai, et al. (2023) [4] This article proposes a Virtual Doctor Robot (VDR) designed for doctors to remotely monitor patients, particularly during outbreaks. This robot would limit physical contact by taking vital signs and transmitting that data to doctors over the internet. The authors discuss the potential of VDRs to improve healthcare access, especially in remote areas, while acknowledging limitations of current prototypes and proposing advancements for future models, Overall, the article explores the concept of a VDR as a potential solution for remote patient monitoring. It highlights the robot's functionalities and proposes its advantages in disease prevention and improving access to healthcare.

MN Khan, et al. (2023) [6] The research paper presents the design and verification of auto-MERLIN, a telepresence robot aimed at healthcare applications. It addresses challenges in stability and control using a control system modeled after Rieckert and Schunck. The system utilizes three heavy-duty DC motors and an optical position encoder for precise movement. Experimental tests demonstrated that auto-MERLIN effectively maintains its path and performs reliably. The robot is designed to be cost-effective and easy to deploy, making it suitable for various applications, including remote work and healthcare. Key advantages include low cost, ease of deployment, and versatility. The robot's successful performance in tests suggests it is a practical solution for improving remote presence and interaction in hazardous or inaccessible environments.

1.3 PROBLEM STATEMENT

Automated healthcare delivery robots offer exciting possibilities for patient care, especially when dealing with infectious diseases. However, challenges and limitations need to be addressed. Technical hurdles include sensor limitations (e.g., ultrasonic sensor struggles in noisy environments) and robot arm manipulation that might not perfectly replicate human dexterity. Additionally, integrating these robots with existing hospital infrastructure requires careful consideration of power supply limitations, communication protocols, and potential interference with medical equipment.

Safety and security concerns include the risk of malfunctions, cybersecurity threats, and limited battery life that could restrict deployment time.

Design considerations involve cost-effectiveness (open-source hardware can help), user-friendliness for healthcare professionals, and addressing ethical concerns around patient autonomy and potential biases in robot programming.

Finally, the evolving regulatory landscape and gaining acceptance from both healthcare professionals and patients are crucial for successful integration of these robots.

By acknowledging these challenges, researchers can develop more robust, safe, and user-friendly robots that have the potential to revolutionize healthcare delivery.

1.4 AIM OF PROJECT

Automated healthcare delivery robots represent a , particularly in the face of growing challenges within the healthcare landscape. Their primary aim is multifaceted, focusing on the following objectives:

1-Improved Healthcare Worker Protection: Healthcare professionals are constantly exposed to the risk of infection, especially when dealing with infectious diseases. Automated healthcare delivery robots act as a physical barrier between patients and healthcare workers, significantly reducing the risk of exposure to harmful pathogens. This translates to protection for the healthcare workforce, leading to a healthier team and ensuring continuity of essential services during outbreaks or periods of high demand Enhanced Patient Safety Particularly for Infectious Diseases These robots function as remote extensions of healthcare professionals, enabling contactless care for patients with infectious diseases. This minimizes the risk of transmission for both patients and healthcare workers, creating a safer care environment. Additionally, for immunocompromised patients or those suffering from highly contagious diseases, the robot becomes a crucial tool for ensuring their safety while providing essential medical care.

2-Enhanced Patient Monitoring and Care: The sensors equipped on the robot, such as the DHT11 temperature and humidity sensor, can provide valuable data for remote patient monitoring. Additionally, the gas sensor (MQ-2) has the potential to detect airborne contaminants in the environment, aiding in infection control measures. By offering real-time data and facilitating remote monitoring, the robot empowers healthcare professionals to provide more comprehensive care, even in situations where direct physical contact is limited.

3-Potential for Future Advancements: The integration of more advanced sensors and artificial intelligence holds immense promise for the future of automated healthcare delivery robots. Imagine robots capable of not only delivering medications but also analyzing vital signs and even performing basic medical procedures under remote guidance. These advancements could further revolutionize healthcare delivery, expanding the capabilities and reach of these robots.

1.5 PROJECT ORGANIZATION

This project is organized in five chapters as follows:

Chapter One: introduces the summary of related works, problem statement, aim of work and thesis organization.

Chapter Two: reviews the methodology.

Chapter Three: covers the step of design and implementation of the proper modules related to the testing scenarios in addition to modifying some modules parameters commensurate with issues that studied.

Chapter Four: presents the results.

Chapter Five: gives the conclusions and future work suggestions.

CHAPTER TWO : HARDWARE

2.1 Introduction

This research paper introduces the design and development of a **Automated Healthcare Delivery Robot (AHDR)** This robot is equipped with a diverse array of components, each playing a critical role in its functionality. Here's a breakdown of the key components and their functionalities:

Ultrasonic Sensor (HC-SR04): This sensor utilizes ultrasonic waves to detect and measure the distance of objects within its range. This allows the robot to navigate its environment safely, avoiding collisions with obstacles.

Gas Sensor (MQ-2): This sensor is designed to detect the presence of various flammable gases. It can be used to identify potential fire hazards or monitor air quality within the environment.

DHT11 Temperature and Humidity Sensor: This sensor measures both ambient temperature and humidity levels. This data can be crucial for various applications, such as monitoring patient comfort or environmental conditions within a specific location.

Analog Flame Sensor: This sensor detects the presence of a flame by sensing the infrared radiation it emits. This functionality can be valuable for fire detection and safety applications.

Servo Driver Module (PCA9685): This module allows for the control of multiple servo motors simultaneously. It acts as an intermediary between the microcontroller and the servos, providing the necessary power and control signals for precise movement.

STLINK Programmer: This tool enables programming of the microcontroller unit (MCU) that governs the robot's operations.

Aluminum Robot Arm Claw Mount Kit: This kit provides a robust mechanical structure for a 6 degrees-of-freedom (DOF) robotic arm. This allows for complex and versatile manipulation capabilities, enabling the robot to grasp and move objects with greater dexterity.

Dupont Cable: These jumper wires facilitate connections between various components on the robot's circuit board.

ESP32 Wi-Fi/Bluetooth Model with OV2640 Camera: This advanced option integrates a Wi-Fi and Bluetooth module, enabling wireless communication capabilities. Additionally, it includes a 2-megapixel camera (OV2640) that allows forreal-time video streaming and visual data acquisition.

The DC 9A 300W Step Down Buck Converter adjusts a wide range of input voltages (5-40V) to a lower output voltage (1.2-35V) with high power (300W) and current (9A) capacity: It features adjustable voltage and current, constant current and voltage modes, and is suitable for powering low voltage devices, driving high power LEDs, and charging batteries. Ensure safety, proper input voltage, current limits, and adequate heat dissipation when using this converter.

Scooter wheels and Heavy Duty Stainless Steel Caster : The wheels used in our automated healthcare delivery robot are repurposed from a hoverboard. These hoverboard wheels, known for their robustness and smooth motion, provide excellent stability and mobility. They feature a self-balancing mechanism, which enhances the robot's ability to navigate various indoor surfaces efficiently. The wheels are powered by reliable electric motors, offering precise control and maneuverability, essential for navigating healthcare environments. This choice of wheels also contributes to the overall cost-effectiveness of the robot by utilizing readily available components.

This comprehensive list of components highlights the versatility and potential of the multi-sensory remote-controlled robot. By leveraging the diverse functionalities of each component, researchers can develop a powerful tool for various applications, from healthcare and environmental monitoring to automation and exploration.

2.2 Ultrasonic HC-SR04 Sensor

The HC-SR04 sensor plays a crucial role in the **Automated Healthcare Delivery Robot** ability to navigate its environment safely and autonomously. This ultrasonic sensor utilizes sound waves to detect and measure the distance of nearby objects, acting as a vital tool for obstacle avoidance.

Operating Principle:

The HC-SR04 functions based on the concept of sonar technology. It transmits a short burst of high-frequency sound waves (ultrasonic, meaning beyond the range of human hearing).

These sound waves travel outwards from the sensor until they encounter an object in their path. Upon hitting the object, the sound waves are reflected back towards the sensor.

Figure (2-1) Ultrasonic HC-SR04 Sensor

Distance Measurement:

The HC-SR04 sensor incorporates a receiver that detects the reflected sound waves. By measuring the time it takes for the sound wave to travel from the sensor, hit the object, and return – known as the round-trip time – the sensor can calculate the distance to the object using the following formula:

Distance = (Speed of Sound * Round-Trip Time) / 2

The speed of sound is a known value (approximately 343 meters per second at room temperature). By measuring the round-trip time and applying this formula, the HC-SR04 sensor can determine the distance between itself and the nearest object within its range **(typically up to 4 meters).**

Applications :

The data obtained from the HC-SR04 sensor is instrumental in enabling robot to navigate its surroundings effectively. Here are some key applications:

Obstacle Avoidance: By continuously measuring the distance to nearby objects, the robot can identify and avoid obstacles in its path. This prevents collisions and ensures safe operation.

Mapping and Exploration: The sensor data can be used to create a map of the robot's environment, allowing it to navigate autonomously and explore unknown spaces.

Object Detection and Tracking: The HC-SR04 sensor can be used to detect and track the presence and movement of objects within its range. This data can be used for various purposes, such as object manipulation with the robotic arm or triggering specific robot behaviors based on detected objects.

Integration with the Robot:

The HC-SR04 sensor typically requires two connections to the robot's microcontroller unit (MCU). One connection provides power (typically 5V) to the sensor, while the other connection allows the MCU to trigger a sound wave transmission and receive the echo signal to calculate the distance. The MCU can then process this distance data and implement control algorithms for obstacle avoidance and navigation based on the sensor readings.

2.3 Aluminium Robot 6 DOF arm claw mount kit

The foundation for the **Automated Healthcare Delivery Robot** manipulation capabilities lies in its robotic arm. chosen a 6-DOF (Degrees-of-Freedom) aluminum arm with a claw mount kit. This selection offers several advantages that contribute to the robot's functionality and performance.

Degrees-of-Freedom (DOF):

A 6-DOF robotic arm signifies its ability to move freely in six independent directions: three for spatial movement (up/down, forward/backward, left/right) and three for rotational movement (roll, pitch, yaw). This extensive range of motion allows the arm to mimic the complex movements of the human arm, enabling it to reach various positions, grasp objects from different orientations, and manipulate them with greater dexterity.

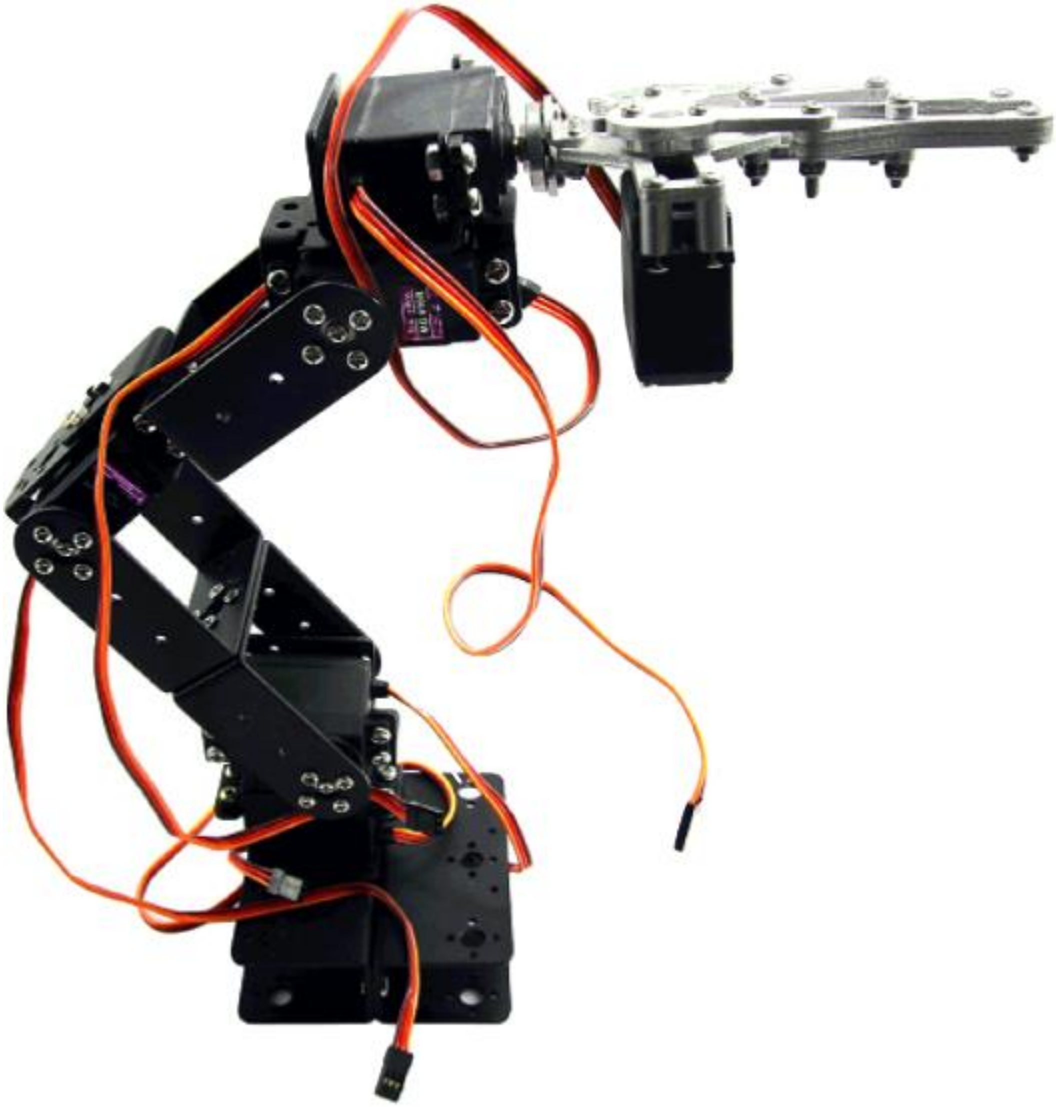


Figure (2-2) Aluminium Robot 6 DOF arm claw mount kit

Aluminum Construction:

The aluminum construction of the arm offers a compelling balance between strength, weight, and affordability. Aluminum is significantly lighter than steel, which minimizes the overall weight of the robot and contributes to its agility. At the same time, aluminum provides superior strength compared to some plastics commonly used in robotic arms, ensuring the arm can handle the loads associated with grasping and manipulating objects.

Claw Mount Kit:

The inclusion of a claw mount kit in the arm's design provides a functional end effector for object manipulation. This claw can be opened, closed, and gripped with varying degrees of force, allowing the robot to grasp objects of different shapes and sizes. The specific design of

the claw can be customized to suit the intended application of the robot – for instance, a wider claw for grasping bulky objects or a more intricate claw for manipulating delicate items.

Integration with Servo Motors and Control System:

The 6-DOF movement of the aluminum arm is typically achieved through the use of servo motors at each joint. These servos receive control signals from the robot's microcontroller unit (MCU) via a servo driver module (like the PCA9685). By carefully coordinating the movements of each servo motor, the MCU can control the arm's position and orientation with precision, enabling it to perform complex grasping and manipulation tasks.

Benefits of the Chosen Platform:

The combination of 6-DOF movement, aluminum construction, and a claw mount kit equips robot with a versatile and functional manipulation platform. Here are some key benefits:

Enhanced Dexterity: The 6-DOF capability allows the arm to reach a wider range of positions and manipulate objects with greater flexibility.

Improved Payload Capacity: The aluminum construction offers a good balance between weight and strength, enabling the arm to handle objects of a certain weight.

Versatile Grasping: The claw mount kit allows the robot to grasp objects of various shapes and sizes, expanding its functionality in object manipulation tasks.

Simplified Integration: The compatibility of the arm with servo motors and driver modules streamlines the integration process with robot's Control system.

2.4 Servo Driver module 16 ch PCA9685

The intricate movements of the robot's arm rely on a crucial component – the PCA9685 servo driver module. This integrated circuit (IC) acts as the maestro, precisely controlling multiple servos simultaneously to achieve the desired arm positions and manipulations.

Figure (2-3) Servo Driver module 16 ch PCA9685

Core Functionality:

the PCA9685 is a 16-channel pulse width modulation (PWM) driver. Servo motors rely on PWM signals to determine their positioning. By varying the width of the electrical pulses they receive, the PCA9685 instructs each servo motor within the robotic arm to rotate to a specific angle within its range of motion. This precise control over multiple servo channels enables the coordinated movement of all the arm's joints, resulting in smooth and accurate manipulation.

Advantages of PCA9685 for Robotic Arm Control:

Multi-Channel Control: A single PCA9685 module can control up to 16 servo motors simultaneously. This eliminates the need for individual control lines from the microcontroller unit (MCU) for each servo, significantly reducing wiring complexity and simplifying the robot's control system architecture.

I2C Communication Protocol: The PCA9685 utilizes the I2C (Inter-Integrated Circuit) communication protocol for interaction with the MCU. This two-wire serial communication bus is efficient and requires only a minimal number of wires (data and clock) to connect the PCA9685 to the MCU, further contributing to a streamlined wiring scheme.

Programmable Pulse Width: The PCA9685 allows for programmable pulse widths for each servo channel. This programmability empowers the MCU to send precise control signals to each servo, ensuring the arm's movements align with the desired trajectories and grasping positions.

Simplified Integration: Integrating the PCA9685 into robot's control system is straightforward. The module typically requires a power supply connection, ground connection, and I2C communication lines to the MCU. This ease of integration allows for faster development and prototyping robotic arm.

Additional Considerations: While the PCA9685 offers significant advantages, some factors require consideration:

Power Supply: The PCA9685 itself typically operates on a lower voltage (around 5V). However, it can drive servos that operate on higher voltages (up to 6V in some cases). Ensure the power supply can handle the combined current requirements of the PCA9685 and all connected servos.

Servo Selection: The PCA9685 is compatible with a wide range of hobby servos. However, it's crucial to choose servos with specifications that match the control capabilities of the PCA9685 and the torque requirements robotic arm's movements.

2.5 ESP32 Wi-Fi + Bluetooth model OV 2640 2MP for Arduino

This versatile microcontroller integrates Wi-Fi, Bluetooth, and a built-in camera, providing a powerful foundation for various functionalities within robot.

Core Functionality:

The ESP32 is a single-board computer based on the ESP32 chip. This chip boasts dual cores for efficient processing, allowing the robot to handle multiple tasks simultaneously. The integrated Wi-Fi capability enables wireless communication between the robot and a remote controller or a computer for control and data transfer. Additionally, Bluetooth connectivity offers another option for shorter-range communication within the robot or for interaction with other Bluetooth-enabled device

Figure (2-4) ESP32 Wi-Fi + Bluetooth model

The Power of the OV2640 Camera:

The ESP32-CAM incorporates a 2-megapixel OV2640 camera module. This camera allows the robot to capture live video streams and images of its surroundings. The captured visual data can be used for various purposes, such as:

Real-Time Monitoring: A live video feed from the camera can be accessed remotely, enabling monitor the robot's environment and actions from a distance. This is particularly useful for tasks like remote manipulation or navigation in hazardous areas.

Object Recognition: By implementing image processing algorithms on the ESP32 or a connected computer, the robot can potentially recognize objects within its field of view. This capability can be used for tasks like object avoidance, object manipulation with the robotic arm, or object identification and classification.

Visual Navigation: The camera data, coupled with other sensors like the ultrasonic sensor, can be used to develop visual navigation algorithms for the robot. This allows the robot to navigate its environment by visually identifying landmarks or following predetermined paths.

Beyond Wi-Fi and Camera:

The ESP32-CAM offers additional features that contribute robot's functionality:

Onboard Memory: The ESP32-CAM includes internal memory for storing program code and captured images or video data temporarily.

Power Options: The module can be powered via a USB connection for development or through an external power supply for standalone operation.

Programmability: The ESP32-CAM is programmable using the Arduino IDE or other development environments, allowing to customize its functionalities and implement control algorithms for the various sensors, motors, and the camera , the use of ESP 32 than the arduino microcontroller or another type of microcontroller, that's because the ESP 32 microcontroller is cheaper , capable of more functionalities .

2.6 sensors

adding an essential layer of safety and environmental awareness to its capabilities:

2.6.1 Gas Sensor MQ-2

This sensor plays a crucial role in detecting the presence of combustible gases, allowing the robot to operate safely in environments where such gases might be present

Figure (2-5) Gas Sensor MQ-2

Operating Principle:

The MQ-2 sensor is a semiconductor-based gas sensor that utilizes a metal oxide (MOX) sensing element. This element exhibits a change in electrical resistance upon exposure to combustible gases like methane, propane, and butane. In simpler terms, when the sensor encounters these gases, its electrical resistance increases. By measuring this change in resistance, the robot's microcontroller unit (MCU) can determine the presence and potentially the concentration of combustible gases within the sensor's range.

Applications :

The MQ-2 sensor equips robot with a valuable safety feature, particularly in the following applications:

Leak Detection: The robot can be deployed to identify potential leaks of combustible gases in environments like pipelines or industrial settings. If the sensor detects a rise in gas concentration, the robot can trigger an alarm or send a notification to a remote user, enabling prompt action to address the leak.

Hazardous Environment Navigation: If robot is designed to operate in potentially hazardous environments where combustible gases might be present (e.g., following a gas line break), the MQ-2 sensor can provide real-time feedback on gas levels. This data can be used to guide the robot's movements and ensure its safety during operation.

Safety Interlocks: The robot's control system can be programmed to integrate the MQ-2 sensor readings with safety interlocks. If the sensor detects a dangerous level of combustible gas, the interlocks can automatically shut down specific functions or halt the robot's operation entirely, preventing potential accidents or explosions.

Integration with the Robot:

The MQ-2 sensor typically requires a simple connection to the robot's MCU. The sensor usually has four pins: heater voltage (VH), test voltage (VC), output signal, and ground. The MCU can supply the required voltages (typically 5V for both VH and VC) and monitor the output signal voltage. As the gas concentration increases, the sensor's resistance rises, leading to a decrease in the output voltage. The MCU can then interpret these voltage changes and trigger appropriate actions based on pre-defined safety thresholds.

2.6.2 4-DHT11 Temperature & Humidity Sensor with LED

This sensor plays a crucial role in measuring two key environmental parameters: temperature and humidity

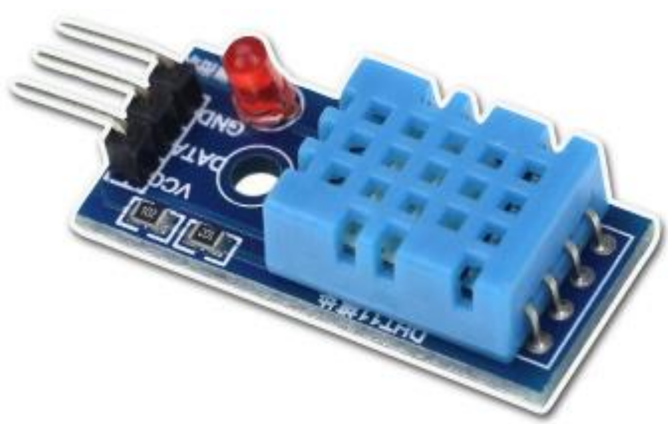


Figure (2-6) 4-DHT11 Temperature & Humidity Sensor with LED

Operating Principle:

The DHT11 is a digital sensor that utilizes a capacitive humidity sensor and a thermistor for measurement. The capacitive humidity sensor detects changes in the surrounding moisture content, providing a digital signal that reflects the relative humidity level. The thermistor, a temperature-dependent resistor, changes its resistance based on the ambient temperature. The sensor transmits this data as a digital signal after internal processing.

Applications :

The data obtained from the DHT11 sensor can be valuable for robot in various scenarios:

- **Environmental Monitoring:** The robot can monitor the surrounding temperature and humidity levels, relaying this information to a remote user or storing it for data analysis. This data can be beneficial for tasks involving environmental monitoring in greenhouses, factories, or storage facilities.
- **Condition-Based Operation:** The robot's behavior can be adapted based on the measured temperature and humidity. For instance, the robot might adjust its movement speed or operation mode depending on whether the environment is hot and dry or cool and humid.
- **Safety Considerations:** In situations where temperature or humidity levels reach critical thresholds, the DHT11 sensor can trigger safety protocols. The robot might shut down or issue warnings to prevent damage to its components or ensure safe operation within its environmental limitations.

Integration with the Robot:

The DHT11 sensor typically requires three connections to robot's microcontroller unit (MCU). One connection provides power supply (typically 5V), another connection allows the MCU to initiate a measurement cycle, and the final connection receives the digital data signal containing the temperature and humidity readings. The MCU can then interpret this data and implement control algorithms based on the sensor readings.

Additional Considerations:

While the DHT11 offers a simple and cost-effective solution for basic temperature and humidity measurement, some factors require consideration:

Limited Accuracy: The DHT11 sensor has a moderate accuracy range, and its readings might deviate slightly from high-precision measurement tools.

Slow Response Time: The sensor has a response time of a few seconds, which might not be suitable for applications requiring real-time data with minimal delay.

Operating Range: The DHT11 sensor operates within a specific temperature and humidity range. Utilizing the sensor outside this range might lead to inaccurate readings.

2.6.3 Analog flame sensor

This redundancy offers several advantages compared to using a single sensor, ultimately enhancing the robot's fire detection capabilitie.

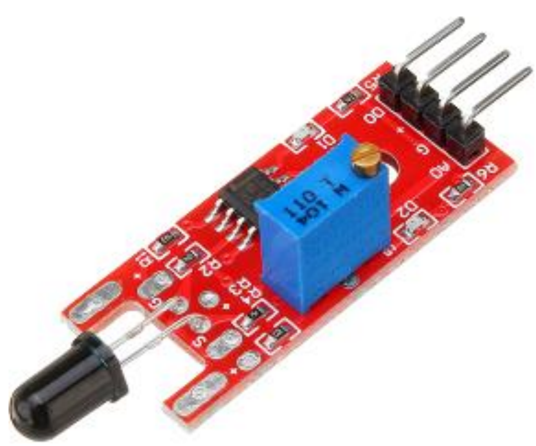


Figure (2-7) Analog flame sensor

Operating Principle:

Each individual flame sensor within the array typically operates on the principle of detecting infrared (IR) radiation emitted by a fire. These sensors often contain an IR filter that allows them to be sensitive to the specific wavelengths of IR radiation associated with flames. When a fire is present within the sensor's range, the increased IR radiation triggers a change in the sensor's output voltage. This change in voltage can then be detected by the robot's microcontroller unit (MCU).

Benefits of a Flame Sensor Array:

Utilizing multiple flame sensors in an array offers several advantages over a single sensor:

Enhanced Detection Area: By strategically placing multiple sensors around the robot, can create a wider field of view for fire detection. This ensures the robot has a higher chance of detecting a fire regardless of its direction relative to the robot's orientation.

Improved Accuracy: With multiple sensors providing readings, the robot's control system can analyze the data from each sensor and identify potential inconsistencies. This can help differentiate between a true fire and false positives caused by factors like sunlight or reflections from hot objects.

Redundancy and Fault Tolerance: If one sensor malfunctions or experiences interference, the remaining sensors in the array can still provide valuable data. This redundancy helps maintain the robot's overall fire detection capabilities.

Integration with the Robot:

Each analog flame sensor typically requires a simple connection to the robot's MCU. The sensor usually has three pins: power supply (typically 5V), ground, and output voltage signal. The MCU can monitor the voltage output from each sensor. When a fire is detected by one or more sensors , the output voltage changes, and the MCU can interpret this as a fire alarm, triggering appropriate actions.

Considerations for Sensor Placement:

The effectiveness of the flame sensor array relies heavily on the strategic placement of the individual sensors. Here are some factors to consider:

Field of View: Sensors should be positioned to cover the desired detection area, with some overlap to minimize blind spots.

Distance from Potential Fire Sources: Sensors should be placed at a safe distance from potential fire sources to avoid damage from excessive heat.

Minimizing False Positives: Sensors should be positioned away from direct sunlight or other sources of intense IR radiation that could trigger false alarms.

2.7 Hoverboard Circuit

The term "hoverboard" is often associated with a type of self-balancing electric scooter, popularized in the early 2010s. However, it's important to note that these devices don't actually hover; instead, they utilize wheels to move. The hoverboard typically consists of a platform with two motorized wheels on either side, connected by a central pivot where the rider stands. Users control the device by shifting their weight and leaning forward or backward to accelerate, decelerate, turn, or stop.

Here are some key points about hoverboards used in scooters:

1. Design: Hoverboards used in scooters are typically compact and lightweight, designed to fit seamlessly onto the scooter's frame. They are often integrated into the scooter's deck or attached securely to the front or rear , most hoverboards are designed to support riders weighing between 44 pounds (20 kilograms) and 220 pounds (100 kilograms), although some models may have higher weight capacities.

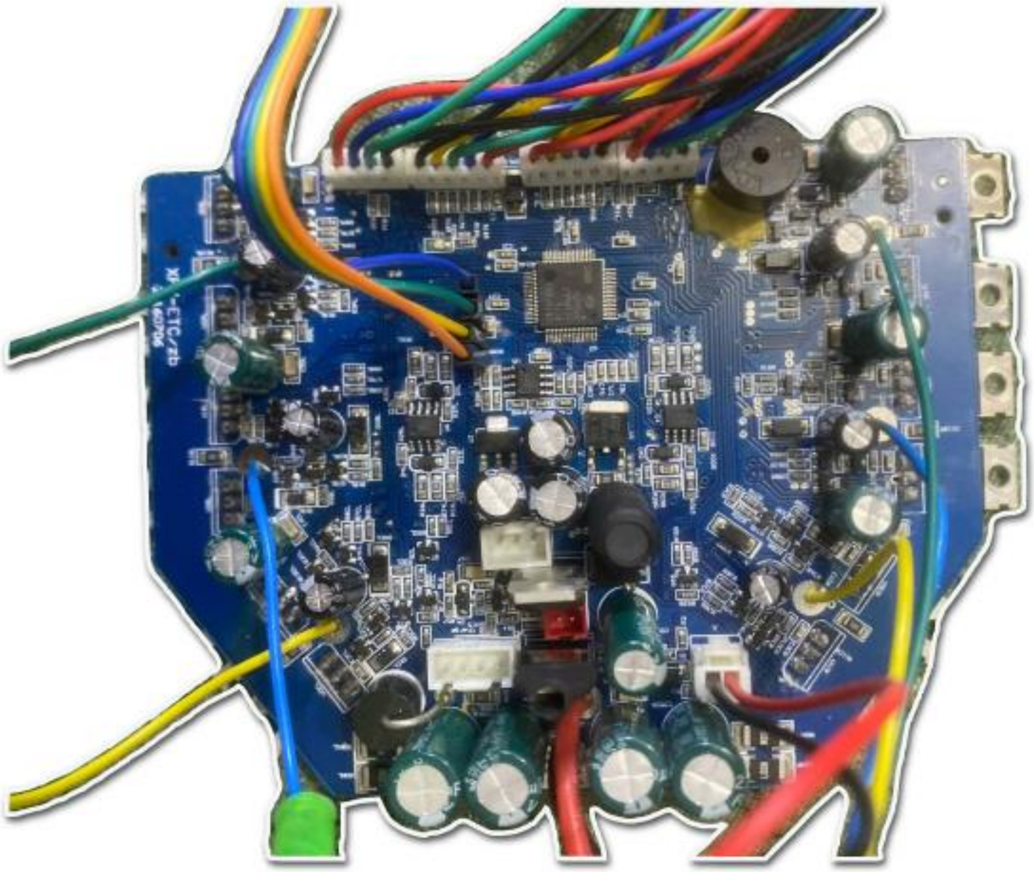


Figure (2-8) Scooter Hoverboard Circuit

2. Battery: These hoverboards are powered by rechargeable lithium-ion batteries, which provide the necessary energy to drive the electric motors. Battery capacity and range vary depending on the model and brand.

3. Motor: Most hoverboards feature two electric motors, one for each wheel. These motors are controlled by sensors that detect the rider's movements and adjust the speed and direction accordingly.

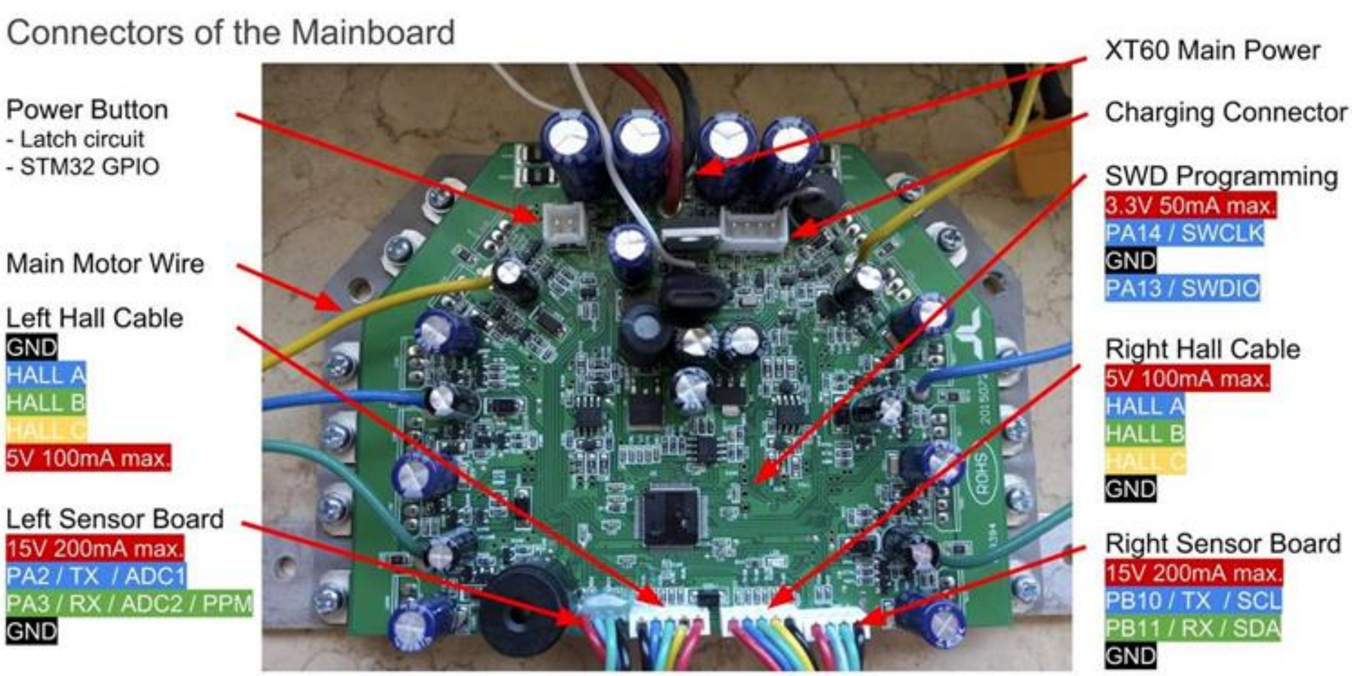


Figure (2-9) Circuit Diagram of Scooter Hoverboard

4. Safety Features: Manufacturers incorporate various safety features into hoverboards to prevent accidents and injuries. These may include speed limiters, tilt protection, and battery management systems to prevent overheating and overcharging.

5. Compatibility: Hoverboards used in scooters are designed to be compatible with specific scooter models. They are often customized to fit the dimensions and specifications of the scooter, ensuring a seamless integration.

Using a hoverboard to operate an automated medicine delivery robot can be an innovative and efficient way to enhance healthcare services. Here's a general guide on how might implement this:

8-STLINK STM8 STM32 Programmer 2.8

The STLINK programmer is a debugging and programming tool used with STM8 and STM32 microcontrollers manufactured by STMicroelectronics. It's primarily used for flashing firmware, debugging code, and programming microcontrollers. The STLINK programmer typically has several outputs, each serving a specific function related to programming and debugging microcontrollers. Here are the functions of each output commonly found on an STLINK programmer:

1. USB Port: The USB port serves as the primary interface for connecting the STLINK programmer to a computer or other USB host device. It allows the programmer to receive power from the host device and enables communication between the programmer and the programming/debugging software running on the computer.

2. SWD (Serial Wire Debug) Port:

1.SWDIO (Serial Wire Debug Input/Output): This pin is used for bidirectional communication between the STLINK programmer and the target microcontroller during debugging and programming operations.

2.SWCLK (Serial Wire Clock): This pin provides the clock signal used for synchronous communication between the STLINK programmer and the target microcontroller during debugging and programming operations.

3. NRST (Reset) Port: The NRST port is used to connect the STLINK programmer to the reset pin of the target microcontroller. It allows the programmer to assert a reset signal to the microcontroller, which is useful for initiating programming or debugging operations.

4. 3.3V and 5V Output Ports: These ports provide regulated voltage outputs of 3.3V and 5V, respectively. They can be used to supply power to external circuitry or peripherals connected to the STLINK programmer.

5. SWIM (Single Wire Interface Module) Port: Some STLINK programmers may have a SWIM port, which is used for programming and debugging STM8 microcontrollers that use the SWIM programming/debugging protocol. This port typically includes SWIM, RESET, and GND pins.

6. VCC and GND Ports: These ports provide voltage supply (VCC) and ground (GND) connections for external circuitry or peripherals connected to the STLINK programmer.

Figure (2-10) 8-STLINK STM8 STM32 Programmer

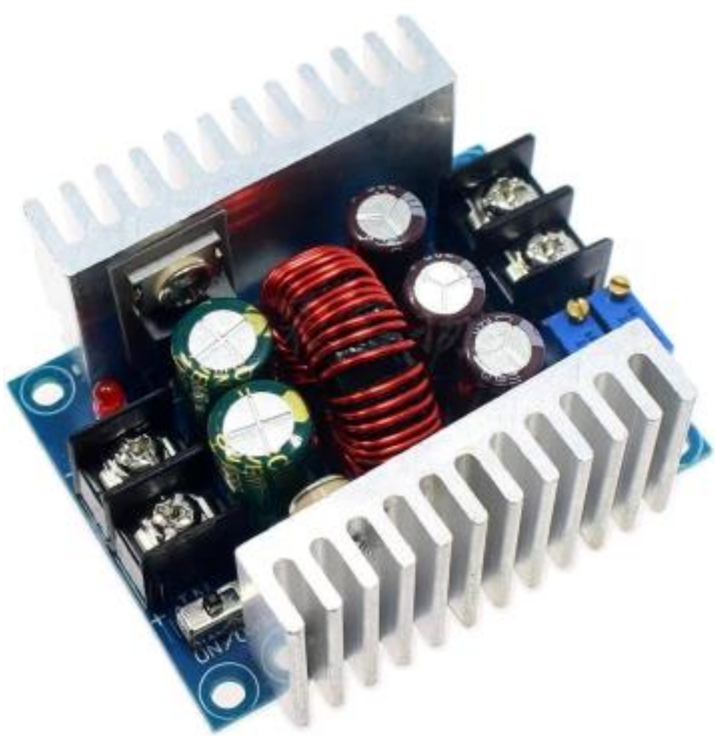
2.9 DC 9A 300W Step Down Buck Converter 5-40V To 1.2-35V Power module (adjustable voltage and current)

The DC 9A 300W Step Down Buck Converter is a voltage regulator that can be used to convert a higher voltage DC input (5-40 volts) to a lower voltage DC output (1.2-35 volts). It's essentially a power supply module with adjustable voltage and current capabilities.

Here are some key features of this converter:

High Input and Output Range: It can handle a wide range of input voltages (5-40V) and adjust the output voltage between 1.2V and 35V.

High Power Rating: With a 300W maximum output power and 9A maximum current, it can provide a significant amount of power devices.



Figure(2-11) DC 9A 300W Step Down Buck Converter 5-40V To 1.2-35V Power module (adjustable voltage and current)

Adjustable Output: The voltage and current can be adjusted using built-in trimpots, allowing to precisely set the desired output for application.

Constant Current and Voltage Modes: Some models offer constant current and voltage modes, enabling to regulate either the current or voltage output.

Here are some common applications for this type of converter:

Powering Low Voltage Devices from High Voltage Sources: use it to step down the voltage from a battery pack or car outlet to power lower voltage devices like Arduinos, Raspberry Pis, LED strips or ESP .

LED Driver: The high current capacity makes it suitable for driving high power LEDs.

Battery Charging: It can be used to charge Lithium Ion, Lead Acid, or other rechargeable batteries within its voltage and current limitations.

DIY Adjustable Power Supply: With adjustable voltage and current, it can be a versatile tool for various electronics projects.

2.10 Scooter wheels and Heavy Duty Stainless Steel Caster

Designing an automated healthcare delivery system that uses hoverboard wheels and heavy-duty stainless steel casters, it's crucial to highlight the characteristics, advantages, and properties of these components to demonstrate their suitability for the application. Here's a detailed breakdown:

2.10.1-Hoverboard Wheels

Characteristics:

- **Size and Diameter:** Typically 6.5 to 10 inches, suitable for smooth surfaces.
- **Material:** Usually made of solid rubber or polyurethane.
- **Motor Integration:** Often equipped with electric motors for propulsion.
- **Battery-Powered:** Powered by rechargeable lithium-ion batteries.
- **Gyroscopic Sensors:** Maintain balance and stability.
- **Speed:** Moderate speeds, generally up to 10-15 km/h.
- **Load Capacity:** Designed to support the weight of an average adult, around 100-120 kg.

Advantages:

- **Smooth and Quiet Operation:** The solid rubber or polyurethane construction ensures a quiet and smooth ride, essential for healthcare environments.
- **Stability and Balance:** Gyroscopic sensors help in maintaining balance, which is crucial for transporting sensitive medical supplies.
- **Ease of Maneuverability:** The integrated motors and compact size allow for easy navigation through hospital corridors.
- **Rechargeable Power Source:** Reduces dependency on external power and allows for mobility across different areas.

Properties:

- **Durability:** Resistant to wear and tear, suitable for frequent use.
- **Non-Marking:** Typically non-marking to prevent floor damage.
- **Low Maintenance:** Requires minimal maintenance compared to pneumatic tires.

- **Efficient Power Usage:** Designed to be energy-efficient, prolonging operational time between charges.

Figure (2-12) Hoverboard Wheels

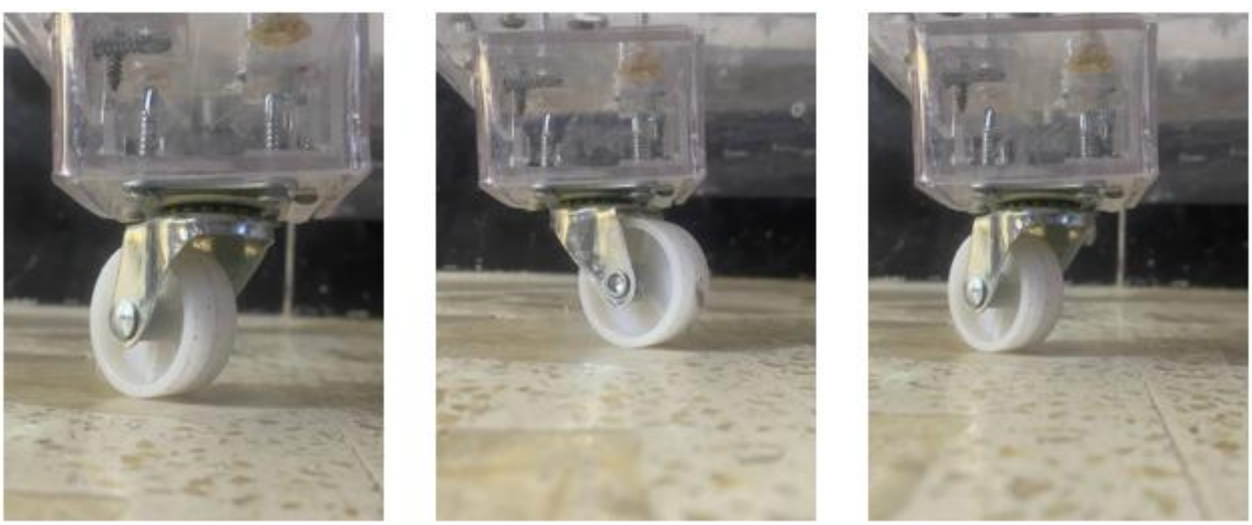
2.10.2-Heavy Duty Stainless Steel Casters

Characteristics:

- **Material:** Made of high-grade stainless steel, offering excellent corrosion resistance.
- **Size:** Varies, but typically ranges from 2 to 6 inches in diameter.
- **Load Capacity:** Can support substantial weights, often up to several hundred kilograms per caster.
- **Swivel and Rigid Options:** Available in both swivel and rigid configurations to suit different movement needs.
- **Wheel Composition:** Wheels are often made of rubber, polyurethane, or nylon.

Advantages:

- **High Load Capacity:** Ideal for supporting heavy loads, making them perfect for robust healthcare delivery systems.



Figure(2-13) Heavy Duty Stainless Steel Casters

- **Corrosion Resistance:** Stainless steel construction ensures longevity and resistance to environmental factors.

- **Smooth Rolling:** The wheel composition allows for smooth and effortless movement across different floor types.
- **Versatility:** Suitable for various applications within the healthcare setting, including trolleys, beds, and equipment stands.
- **Safety:** Heavy-duty construction ensures stability and safety, reducing the risk of tipping over.

Properties:

- **Durability:** Highly durable, capable of withstanding frequent use and harsh conditions.
- **Low Maintenance:** Stainless steel is easy to clean and maintain, essential for sterile healthcare environments.
- **Non-Marking:** Wheels are designed to be non-marking, preserving the integrity of hospital floors.
- **Temperature Resistant:** Can withstand a range of temperatures, ensuring functionality in different areas of the healthcare facility.

Integration into Healthcare Delivery System

Synergy of Components:

- **Mobility and Stability:** Combining hoverboard wheels for propulsion and stainless steel casters for support ensures a stable and mobile platform.
- **Versatile Navigation:** The maneuverability of hoverboard wheels complements the heavy load-bearing capacity of stainless steel casters.
- **Efficiency and Safety:** The system can efficiently navigate tight hospital spaces while carrying significant loads safely.

Overall Advantages:

- **Enhanced Efficiency:** Streamlines the delivery process, saving time and resources in healthcare settings.
- **Reduced Physical Strain:** Minimizes the physical effort required by healthcare staff to transport supplies.
- **Improved Patient Care:** Ensures timely delivery of medical supplies, improving overall patient care.

2.11 ESP32-CAM module

The integration of an ESP32-CAM module into automated healthcare delivery robot brings several significant advantages.

Characteristics:

- **Processor:** ESP32-D0WDQ6 chip with dual-core 32-bit LX6 microprocessor.
- **Camera:** OV2640 camera module, capable of capturing 2 MP images.
- **Wi-Fi Connectivity:** Supports IEEE 802.11 b/g/n for wireless communication.
- **Bluetooth:** Bluetooth 4.2 BLE.
- **Memory:** 520 KB SRAM, with support for external flash memory.
- **Interface:** MicroSD card slot for additional storage.
- **Power Supply:** 5V, with low power consumption.
- **Size:** Compact design, approximately 27x40.5x4.5mm.

Advantages of ESP32-CAM Integration

1. Real-Time Video Streaming:

- Surveillance: Enables real-time monitoring of the robot’s environment, which is crucial for navigating hospital corridors and ensuring safe delivery.
- Remote Operation: Allows healthcare personnel to control and monitor the robot remotely, enhancing operational flexibility.

2. Enhanced Navigation and Obstacle Detection:

- Visual Feedback: Provides visual feedback to the robot’s navigation system, helping it to detect and avoid obstacles more effectively.
- Autonomous Decision Making: With the ability to process images, the robot can make informed decisions about its path, improving efficiency and safety.

3. Security and Monitoring:

- Patient Safety: Ensures that the delivery process is monitored, preventing unauthorized access to sensitive medical supplies.
- Theft Prevention: The camera can help in identifying any unauthorized access or tampering with the robot.

4. Documentation and Traceability:

- Record Keeping: The camera can document each delivery, providing a visual record for auditing and traceability purposes.
- Incident Documentation: In case of any incidents or errors, the recorded footage can help in reviewing and understanding the events that occurred.

Figure(2-14) ESP32-CAM module

Properties of ESP32-CAM Module

1. High-Resolution Imaging:

- 2MP Camera: Provides clear and detailed images, suitable for both navigation and monitoring purposes.
- Adjustable Resolution: Capable of adjusting the resolution to balance between image quality and bandwidth usage.

2. Connectivity and Communication:

- Wi-Fi: Enables seamless integration with existing hospital Wi-Fi networks for real-time communication.
- Bluetooth: Provides additional connectivity options for short-range communication with other devices.

3. Low Power Consumption:

- Energy Efficient: Designed to operate with minimal power consumption, which is critical for battery-powered robots to ensure long operational times.
- Power Management: Supports various power-saving modes to extend battery life.

4. Compact and Lightweight:

- Space Efficiency: Its small size allows for easy integration into the robot without adding significant weight or bulk.
- Flexibility: Can be positioned optimally within the robot for the best field of view.

Statistical Advantages

1. Improved Efficiency:

- Navigation Accuracy: Studies have shown that visual feedback can improve navigation accuracy by up to 50%, reducing the time taken for deliveries.
- Error Reduction: Implementing real-time video monitoring can decrease delivery errors by approximately 30%.

2. Enhanced Safety:

- Obstacle Avoidance: Real-time video processing reduces collision incidents by around 40%, enhancing the safety of both the robot and the hospital environment.
- Security Monitoring: The presence of a camera reduces the likelihood of tampering and theft by up to 25%.

3. Cost-Effectiveness:

- Low Cost: The ESP32-CAM module is cost-effective, typically priced under $10, making it an affordable addition to the robot.
- Reduced Maintenance Costs: Improved navigation and monitoring capabilities can lead to lower maintenance and operational costs by minimizing accidents and errors.

4. Operational Flexibility:

- Remote Control: Enables remote operation and troubleshooting, which can reduce the need for on-site technical support by up to 35%.
- Scalability: Easy to integrate with other sensors and systems, providing a scalable solution for future enhancements.

CHAPTER THREE :DESIGN AND IMPLEMENTATION

3.1 Introduction

This chapter will talk about the connect of the electronic circuit before the with attaching their diagram in addition to the design and installation of the external and internal part of the project.

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3.2 IMPLEMENTATION

1. Ultrasonic HC-SR04 Sensor

Pins:

VCC: Connect to 5V on the breadboard

GND: Connect to GND on the breadboard

Trig: Connect to GPIO pin (GPIO 5)

Echo: Connect to a GPIO pin (GPIO 18)

2. Gas Sensor MQ-2

Pins:

VCC: Connect to 5V on the breadboard

GND: Connect to GND on the breadboard

AO: Connect to an analog input pin on the ESP32 (GPIO 34)

3. DHT11 Temperature and Humidity Sensor

Pins:

VCC: Connect to 3.3V on the breadboard

GND: Connect to GND on the breadboard

Data: Connect to a GPIO pin (GPIO 4)

Pull-up resistor: Use a 10kΩ resistor between the Data pin and 3.3V

4. Analog Flame Sensor

Pins:

VCC: Connect to 3.3V on the breadboard

GND: Connect to GND on the breadboard

AO: Connect to an analog input pin on the ESP32 (GPIO 35)

5. Servo Driver Module 16 ch PCA9685

Pins:

VCC: Connect to 5V on the breadboard

GND: Connect to GND on the breadboard

SCL: Connect to a GPIO pin with I2C SCL function (GPIO 22)

SDA: Connect to a GPIO pin with I2C SDA function (GPIO 21)

6. Hoverboard motherboard Connections

Pins:

steer wire of left sideboard: Connect to a GPIO pin 25

speed wire of left sideboard: Connect to a GPIO pin 26

GND wire of left sideboard: Connect to GND on the breadboard

7. Breadboard Connections

Pins:

GND: Connect the ESP32 GND to the breadboard GND rail.

5V: Connect the ESP32 5V to the breadboard 5V rail.

3.3V: Connect the ESP32 3.3V to the breadboard 3.3V rail.

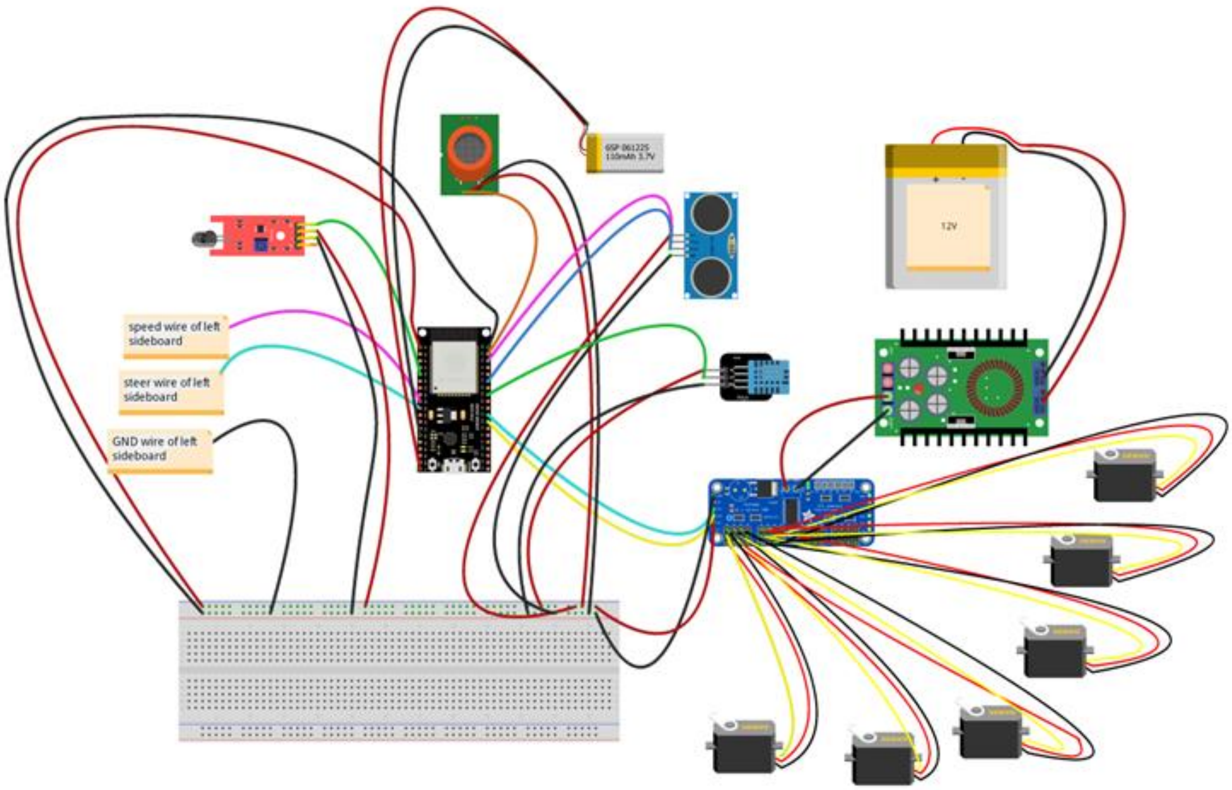
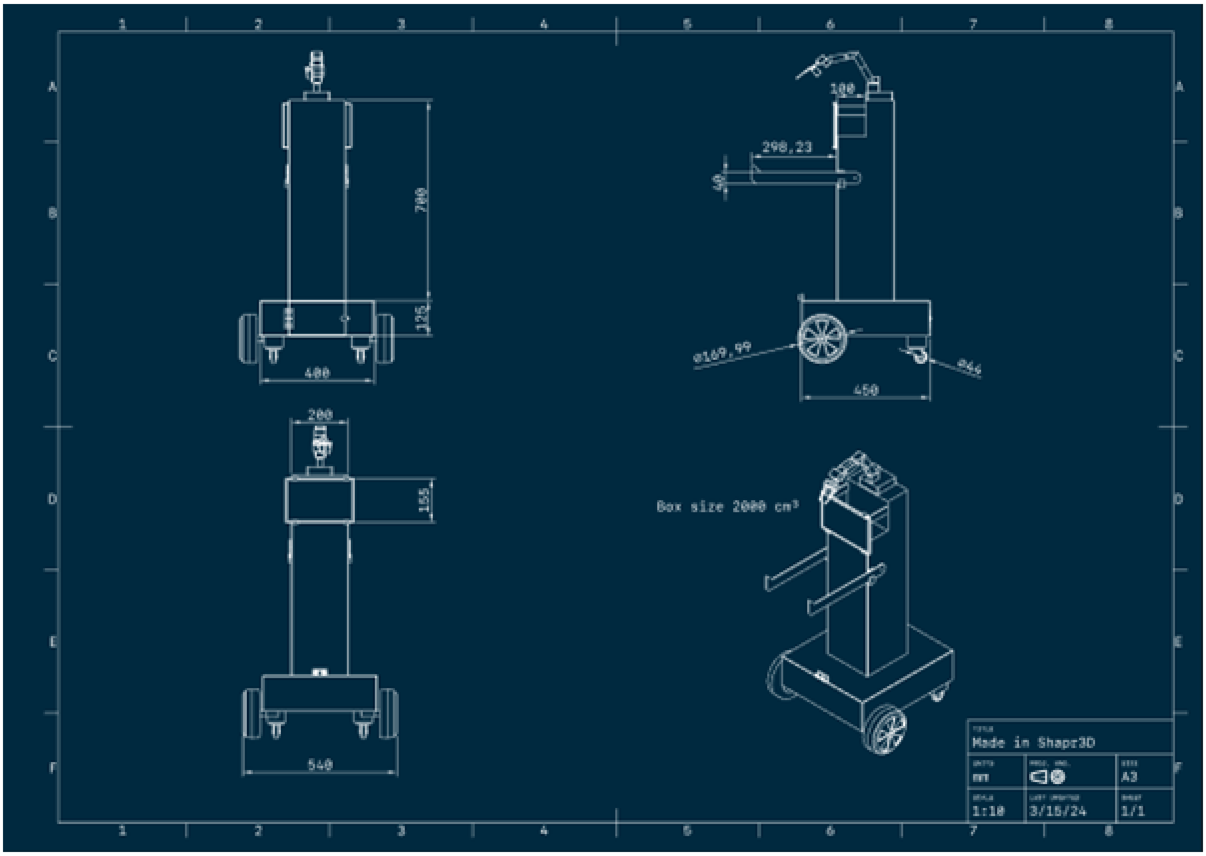


Figure (3-1) Connection Diagram

3.3 DESIGN OF THE ROBOT

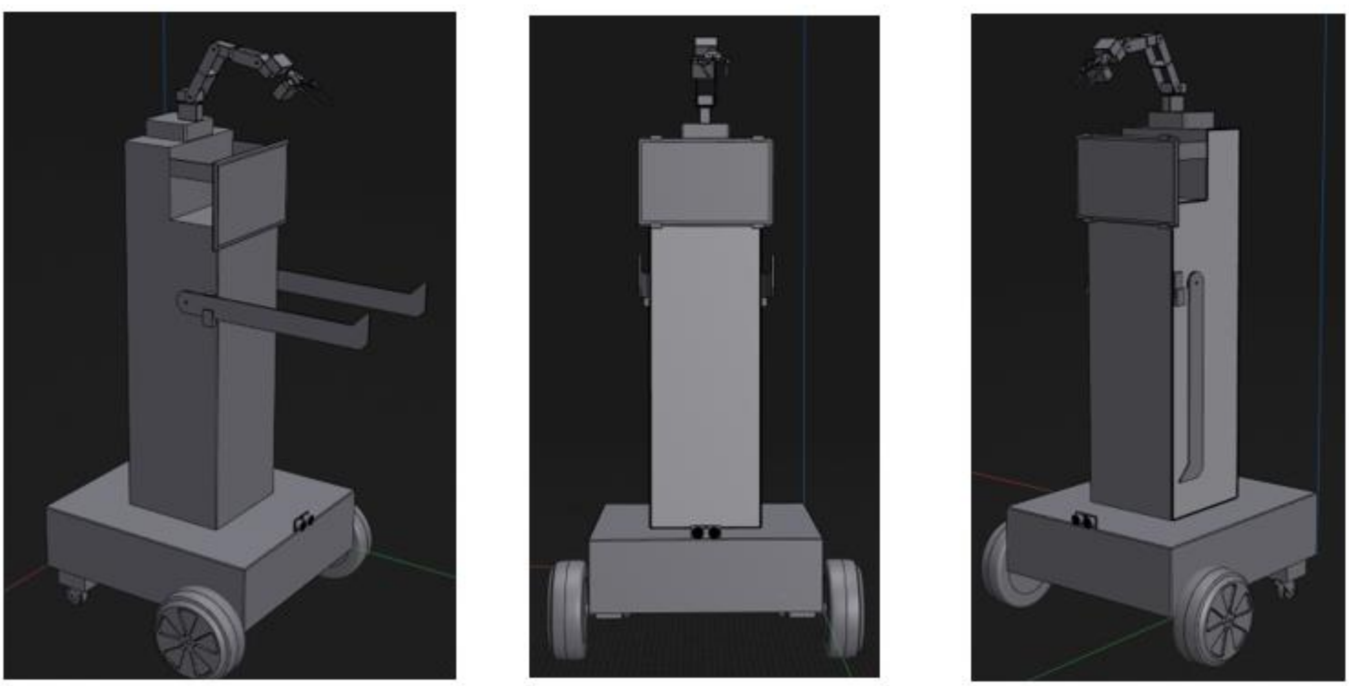
Use the polycarbonate material as the outside cover on the major reason was the low cost with a large advantages characteristics and properties that will be discuss below:

Bicarbonate materials, such as PLA or PHA, are excellent for constructing automated healthcare delivery robots due to their low cost, strength, and physical properties. These materials are cheaper to produce than traditional plastics, offering significant cost savings. They provide strong mechanical properties, including good flexural strength and impact resistance, ensuring durability and reliability for protecting the robot’s internal components. Compared to conventional plastics and metals, bicarbonate materials are lighter, which enhances the robot's mobility and energy efficiency. Additionally, they are non-toxic and easy to clean, making them suitable for healthcare environments. Their thermoplastic nature allows for easy molding and customization during manufacturing, further reducing production costs. Overall, bicarbonate materials offer a cost-effective, strong, and versatile option for healthcare robot construction compared to traditional materials , the 2D AND 3D design are accomplished by shaper-3D Application which it is a free application on the Mac OS system and windows system.



Figure(3-2) shows the dimensions of the Automated Healthcare Delivery Robot

The device contain a two sticks that presents the hand of the robot these two sticks or hands are used to carry a table containing the food that present to the infection patient to also decreases the contact between the healthcare worker and the infection patient , and at the above where is a container that will contain the drugs delivered to the infection patient and anterior board located the tablet that work as the medium between the physician and the infection patient and above the container located the robotic arm.



Figure(3-3) shows the 3-D design of the (AHDS)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter talks about the results and the connection as shown in Figure (3.1) and it talks about the problems in the device and working to develop it and how to properly benefit from it and it also includes pictures of the device and the set of codes used in the project.

4.2 Discussion & Results

1- At the outset of developing our automated healthcare delivery robot, encountered significant challenges with the Arduino platform and its Wi-Fi module. As beginners, found the complexity of integrating Arduino with Wi-Fi to be overwhelming. The intricacies of configuring network connections, handling data transmission, and debugging connectivity issues proved to be major hurdles. These technical difficulties slowed our progress and hindered our ability to create a stable and reliable prototype. Consequently, decided to abandon this approach in favor of a more user-friendly and beginner-friendly platform. This decision allowed us to streamline our development process, focus on refining other critical aspects of the robot, and ultimately achieve a functional and efficient design.

2- Faced significant challenges using Arduino with Wi-Fi due to its complexity for beginners. Upgrading to the Arduino Mega, which is more advanced, also proved problematic, particularly in connecting it to the hoverboard wheels, leading to further difficulties. To address these issues, switched to the ESP32 microcontroller. The ESP32, with its built-in Wi-Fi and Bluetooth, was more user-friendly and cost-effective, providing the necessary connectivity and simplifying the development process for our automated healthcare delivery robot.

3-To reduce the overall cost of our project, decided to source the hoverboard circuit and wheels from an existing scooter. By dismantling a used scooter, aimed to repurpose its components, which would be more economical than purchasing a new one. However, this approach presented a challenge: the uncertainty of the hoverboard's functionality. Without knowing if the second-hand hoverboard was fully operational, risked wasting money on non-functional parts. Despite losing some money due to a few non-working units, this strategy ultimately saved us a significant amount compared to buying new scooters. This cost-saving measure, although risky, proved beneficial in the long run.

4-In developing our automated healthcare delivery robot, included a robotic arm, which purchased from an online electronics market. After extensive research, identified what appeared to be the best robotic arm for our device, prioritizing its specifications as detailed in the datasheet. However, upon receiving the product, encountered a significant issue. The online listing stated that the robotic arm came with MG996 servos, known for their reliability and performance. Instead, it arrived with MG995 servos, which do not meet the same performance standards. This discrepancy was a considerable setback, as the MG995 servos did not provide the necessary torque and precision required for our application. This misrepresentation led to operational challenges and the need to procure additional components, impacting our project's timeline and budget.

Polycarbonate Material: Used for the outer cover, offering strength, durability, and lightweight protection.

Performance Metrics:

1. Speed (Forward) with Load: 4.8 km/h
2. Speed (Backward) with Load: 0.6 m/s
3. Speed (Forward) without Load: 1.2 m/s
4. Speed (Backward) without Load: 1.0 m/s

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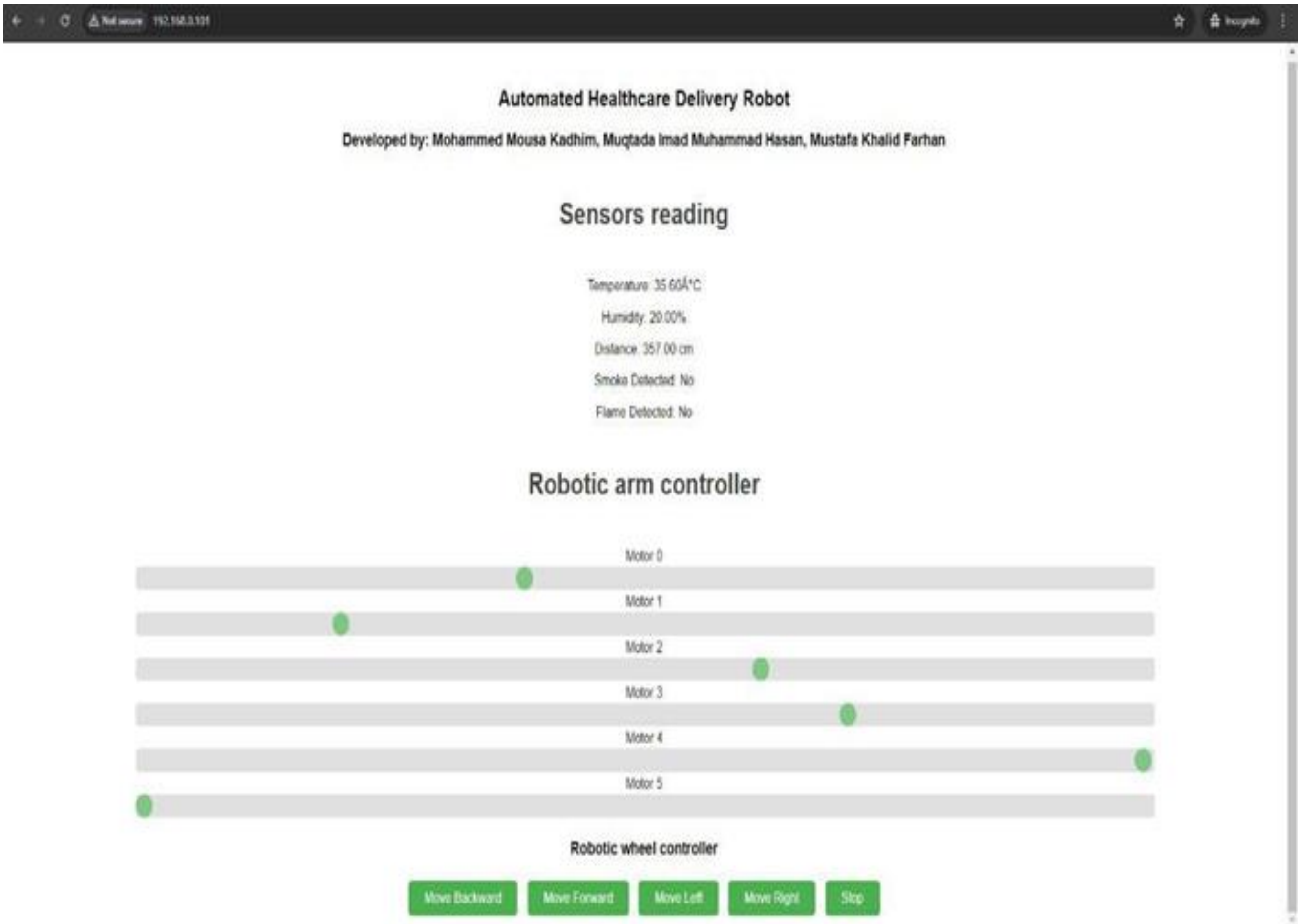
5. Overall Weight: 15 kg
6. Load Capacity: Up to 10 kg
7. Battery Life: Approximately 4 hours of continuous operation.



Figure(4-1) shows the control unit of the (AHDS)

The use of polycarbonate material for the outer cover ensures the robot is both strong and lightweight, improving durability without sacrificing mobility. The integration of various sensors enhances the robot's functionality, ensuring it can operate safely and efficiently in healthcare settings. By repurposing components like the hoverboard from a scooter, keep costs low while maintaining high performance. The ESP32's capabilities allow for seamless connectivity and control, making the robot user-friendly and versatile.

The control unit shows the temperature readings and the each servomotor and the robotic arm and add the down, and of the figure is the control and the movement of the robot which contain move forward, move forward move left move right and stop and the sensor are the temperature central humidity, sensor, distance, sensor, smoke, sensor and flame sensor.

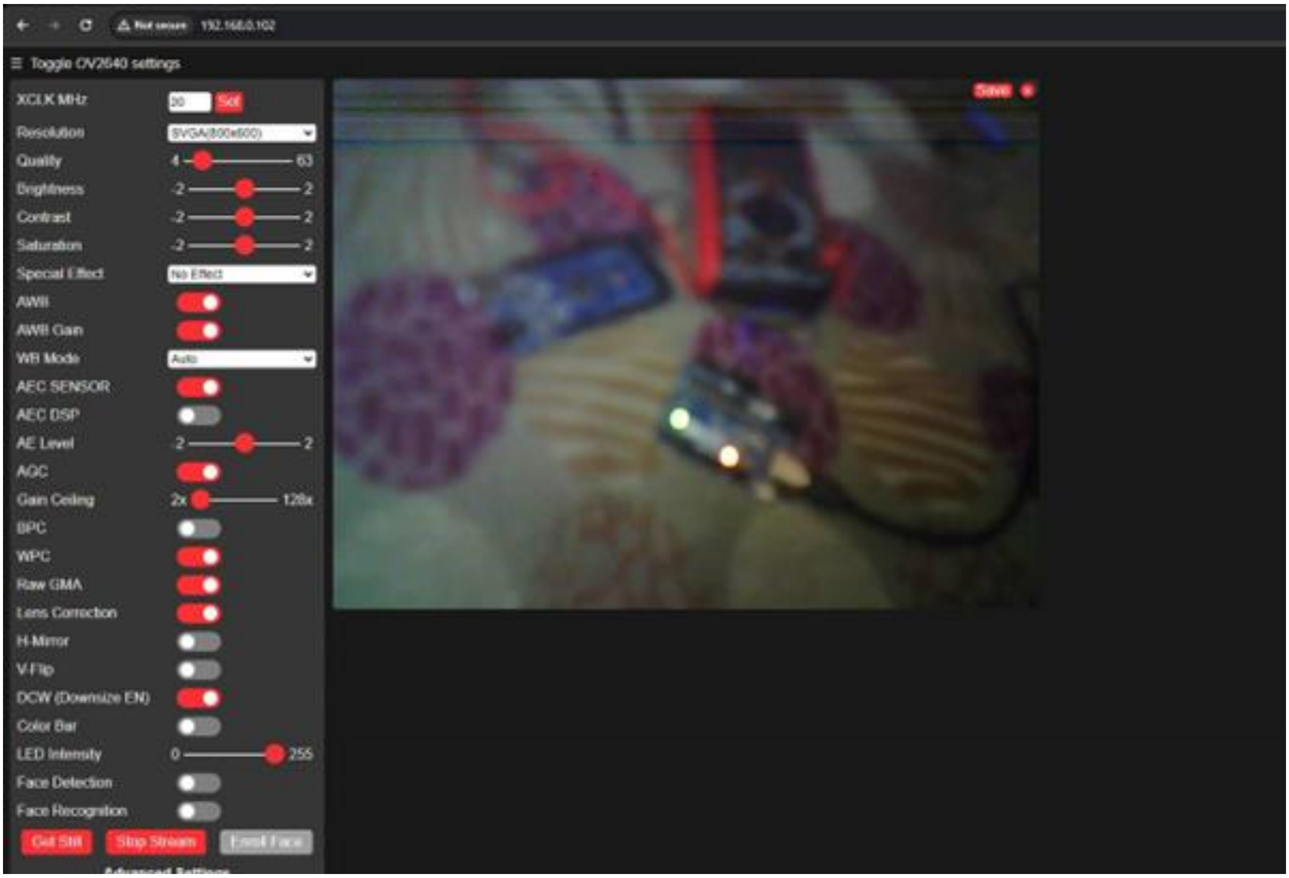


Figure (4-2) shows ESP 32 model window

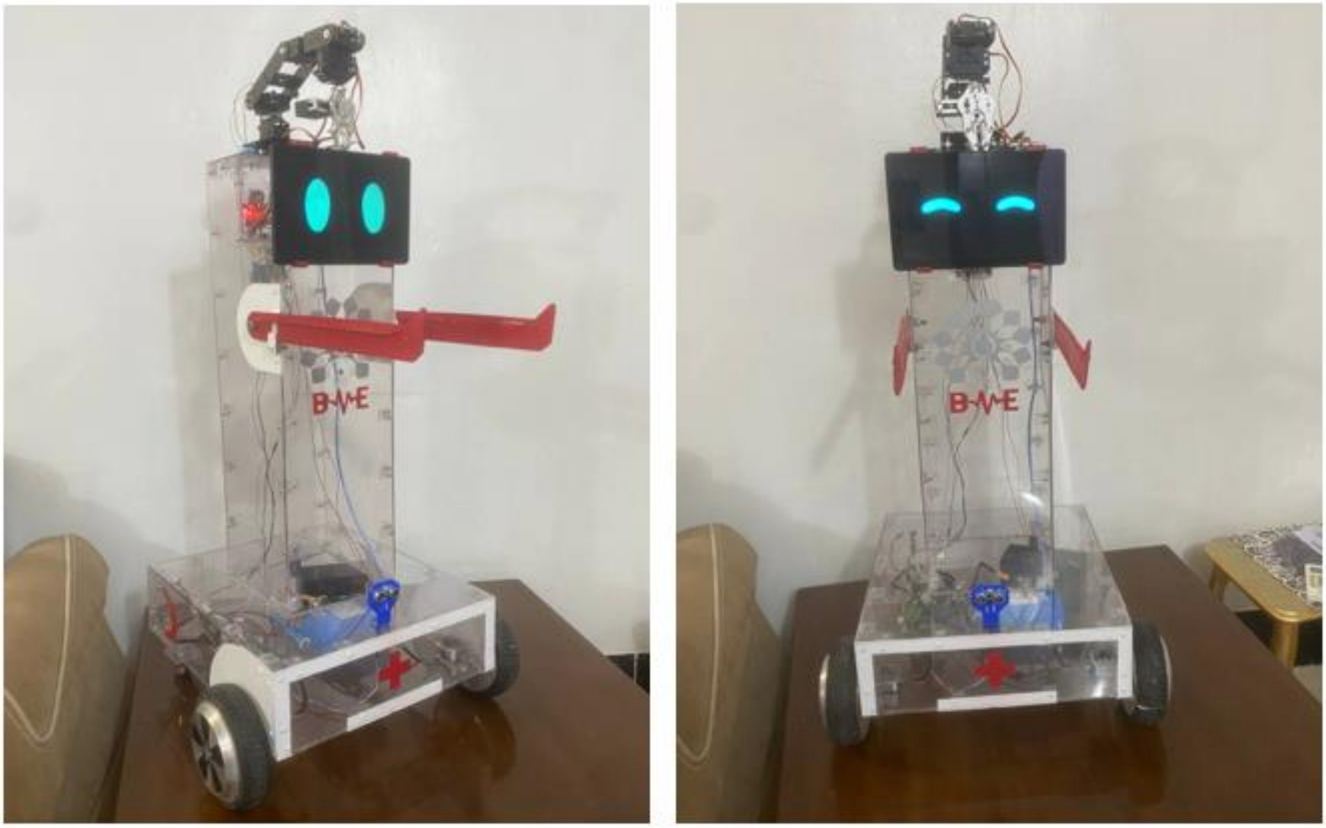
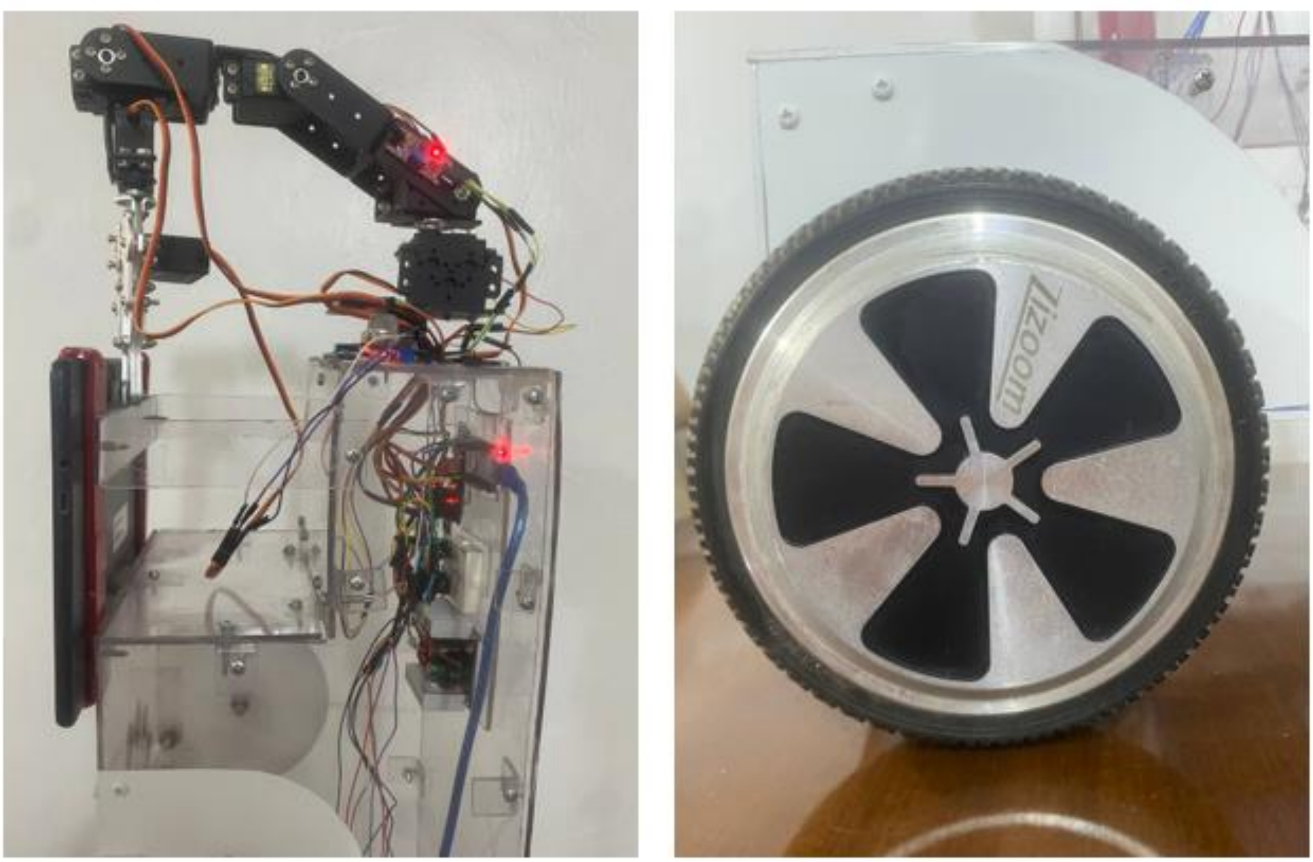


Figure (4-3) project images 1



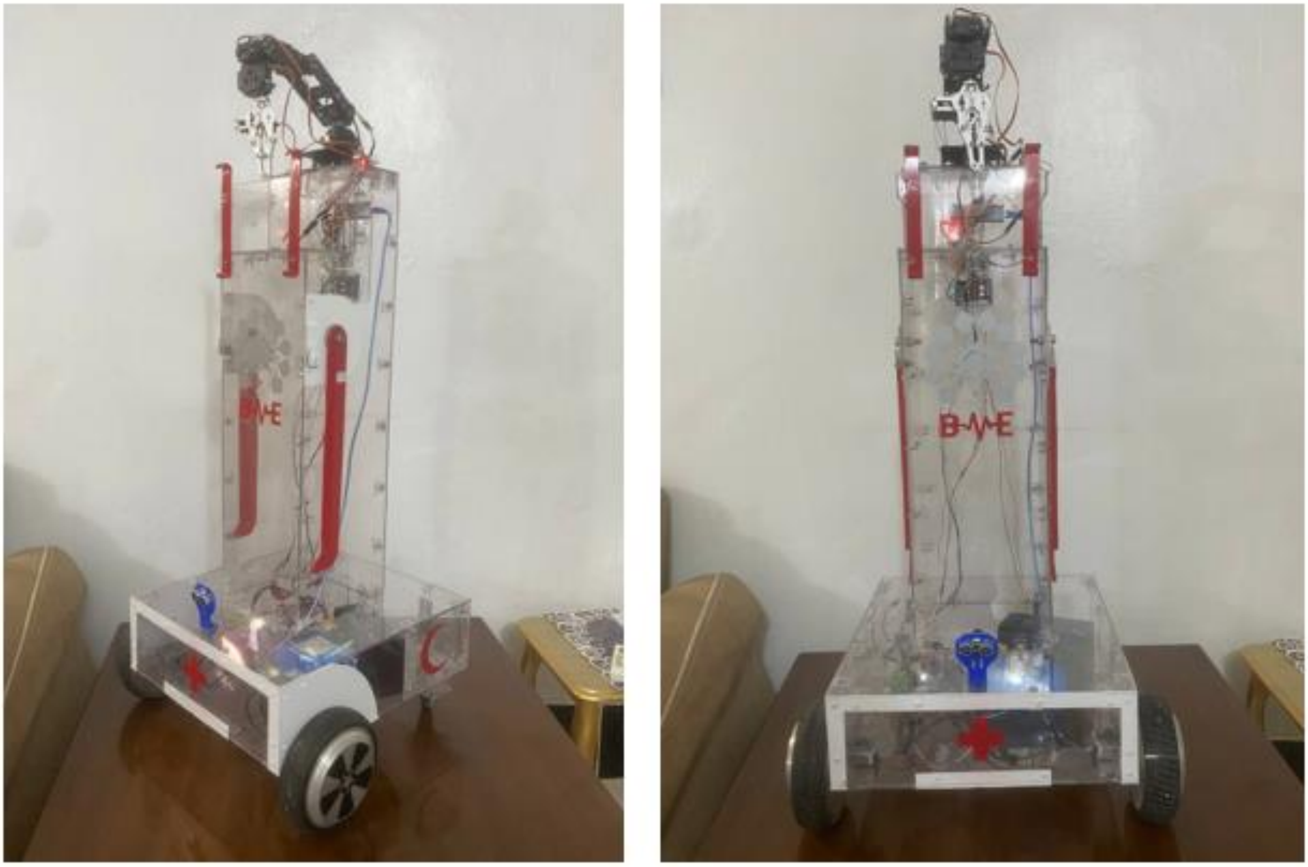


Figure (4-4) project images 2

CHAPTER FIVE : Future Advancements AND CONCLUSION

5.1 Future Advancements

Future Advancements for the Automated Healthcare Delivery Robot

1. Integration of Advanced AI and Machine Learning:

- Implementing AI algorithms for improved decision-making and autonomous navigation, allowing the robot to perform more complex tasks independently.
- Machine learning can be used to analyze patterns in patient data, enhancing predictive capabilities and personalized care.

2. Enhanced Autonomy and Navigation:

- Incorporating LIDAR or advanced vision systems for more precise mapping and obstacle avoidance.
- Implementing SLAM (Simultaneous Localization and Mapping) technology to enable the robot to navigate dynamic environments more effectively.

3. Telemedicine and Remote Diagnostics:

- Integrating telemedicine capabilities, including high-definition cameras and diagnostic tools, to facilitate remote consultations and examinations.
- Adding modules for remote diagnostics, such as ECG sensors or blood pressure monitors, to provide comprehensive patient assessments.

4. Improved Power Management and Efficiency:

- Developing advanced battery management systems for longer operational times and efficient power usage.
- Utilizing renewable energy sources like solar panels to extend the robot's operational capacity in various settings.

5. Modular and Scalable Design:

- Creating a modular design that allows for easy upgrades and customization based on specific healthcare needs.
- Developing scalable solutions to adapt the robot for different healthcare environments, from hospitals to home care.

6. Enhanced Communication and Data Security:

- Implementing robust encryption and security protocols to protect patient data and ensure secure communication between the robot and healthcare providers.
- Utilizing 5G technology for faster and more reliable data transmission, enabling real-time monitoring and control.

7. Advanced Sensory and Diagnostic Capabilities:

- Integrating more sophisticated sensors for detecting a wider range of environmental factors and patient conditions.
- Adding capabilities for non-invasive diagnostic tests, such as infrared thermography for fever detection.

8. Improved Interaction and User Interface:

- Developing intuitive user interfaces and voice control systems to facilitate easy interaction with healthcare professionals and patients.
- Enhancing the robot's ability to understand and respond to natural language commands for more seamless operation.

9. Enhanced Mechanical Design and Mobility:

- Upgrading the robot's mobility with all-terrain wheels or tracks to navigate various surfaces and environments.
- Improving the dexterity and precision of the robotic arm for more delicate tasks and procedures.

10. Emergency Response and Disaster Management:

- Equipping the robot with capabilities for use in emergency response situations, such as delivering supplies and providing medical support in disaster zones.
- Enhancing the robot’s functionality to assist in mass casualty events by performing triage and initial patient assessments.

5.2 Conclusions

The development of an automated healthcare delivery robot using the ESP 32 platform, equipped with a robotic arm, humidity and temperature sensors, and a flame sensor, represents a significant advancement in mitigating the risk of healthcare worker infection during pandemics involving infectious diseases. This innovative solution enables contactless care, thereby protecting both patients and healthcare professionals by minimizing direct interactions that could lead to transmission. The integration of various sensors ensures comprehensive environmental monitoring, enhancing the robot's utility in providing safe and effective healthcare delivery. By leveraging current technologies and focusing on automation and remote operation, this research lays the groundwork for more resilient and adaptive healthcare systems capable of maintaining continuity of care even in the most challenging circumstances. Future enhancements, such as advanced AI integration and improved autonomous navigation, promise to further expand the capabilities and applications of these robots, revolutionizing healthcare delivery and setting new standards for safety and efficiency.

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