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IOT BASED ROBOT FOR MILITARY APPLICATIONS

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ABSTRACT

Terrorism and insurgency are two of the world's most pressing issues today. Governments and scientists from all around the world are working around the clock to address these issues. Nations spend billions of dollars on research into new defensive technologies capable of protecting civilians from terrorist attacks. In modern military operations, environmental conditions play a crucial role in ensuring the safety and efficiency of both personnel and equipment. Monitoring temperature and humidity levels in various operational environments is essential for optimizing performance and safeguarding assets. This paper presents the design and implementation of a specialized military robot equipped with sensors for real-time monitoring of temperature and humidity in diverse settings. In today's world, robotics is fastest growing and very interesting field. ROBOT has various input and output to sense the environment and take appropriate action. With the development and research of technology, scientist has come up with invention of military robots. This makes soldier's life more secure on war field. Military robots are used to perform various risky tasks like monitoring the temperature and humidity of the environment and these can view through IOT App.

INTRODUCTION

The Internet of Things (IOT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifier and the ability to transfer data over a network without requiring human- to-human or human to-computer interaction. The IOT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. The need for self con-trolled robots is due to the terrorism and insurgency problems faced by the people and soldiers. Huge investments are made by nations for the research of new defence systems which are capable of safeguarding citizens from terrorist threats.

Unmanned ground vehicles are divided into two categories:

1. Tele-operated

2. Autonomous.

TELE – OPERATED

A Tele-operated UGV is a robot that is controlled by a communications link by a human operator at a remote location. The operator can perform task by taking the output of the sensor which is coming from the robot and by the help of live video streaming the can operate easily.

Toy remote control automobile is a simple demonstration of Tele-operation concepts. Each vehicle is unmanned and controlled remotely via a link, with the user providing full control based on the vehicle's observed performance. Tele-operated UGVs are currently in use in a wide range of applications. These vehicles are mostly employed to replace humans in dangerous situations. Explosives and bomb-disabling vehicles are two examples.

AUTONOMOUS

An autonomous UGV is similar to an autonomous robot, however it is a vehicle that operates on the ground surface. In the actual world, a fully autonomous robot can: • Gather information about its surroundings.

• It can work a large time without intercession.

• It can repair itself without help from others.

• Detect objects of interest such as people and automobiles.

• A robot may also be capable of self-learning.

Autonomous learning entails the ability to:

• Learn or acquire new skills without the assistance of others.

• Adapt strategies to the circumstances.

• Adapt to new situations without help from others.

• Robots with autonomy

OBJECTIVE

Create a smart robot that can gather information about the surroundings and effectively transmit it to an operator. To display transferred real-time environmental information through IoT. Provide full remote control of the unmanned ground vehicle's movements to the operator. To design and develop an IoT-based robotic system capable of performing a variety of tasks to support military operations, thereby enhancing operational efficiency, reducing human risk. Implement IoT frameworks for collecting, processing, and analyzing environmental and situational data in real-time. To develop an IoT-based robotic system for military applications that enhances operational efficiency, improves situational awareness, reduces human risk, and enables real-time data collection and analysis.

INTRODUCTION OF EMBEDDED C

An embedded system is an integrated system that combines computer hardware and software to perform a specific function. Unlike traditional general-purpose computers, embedded systems are designed for dedicated purposes and often work independently or as part of a larger system. These systems can operate with minimal human intervention and are found in various domains, from home appliances to industrial machinery.

Key Characteristics of Embedded Systems:

- **Performs Specific Tasks:** Embedded systems are tailored to perform specific functions or tasks.
- **Low Cost:** They are cost-effective compared to general-purpose computers.
- **Time-Specific**: Tasks are executed within predefined time frames.
- **Low Power:** Embedded systems operate efficiently with minimal power requirements.
- **High Efficiency**: These systems are optimized for performance.
- **Minimal User Interface**: They require minimal user interaction.
- **Less Human Intervention**: Embedded systems work autonomously or with minimal human involvement.
- **Highly Stable**: Stability is crucial; these systems don't change frequently.
- **High Reliability**: They consistently perform tasks reliably.
- **Use Microprocessors or Microcontrollers**: Embedded systems utilize microprocessors or microcontrollers with limited memory.
- **Manufacturable**: Most embedded systems are compact and affordable to manufacture.

Application Areas of Embedded Systems:

- **Home Appliances:** Examples include washing machines, digital watches, and televisions.
- **Transportation:** Embedded systems are prevalent in automobiles, trains, and aircraft.
- **Healthcare:** Medical equipment often relies on embedded systems.
- **Business Sector & Offices:** Security systems, printers, and office equipment.
- **Defence Sector:** Military applications such as drones and communication devices.
- **Aerospace:** Aircraft avionics and navigation systems.
- **Agricultural Sector:** Precision farming and automated machinery

APPLICATION OF EMBEDDED C

Embedded C is a variant of the C programming language specifically tailored for embedded systems. These systems combine both hardware and software to perform specific tasks. Let's delve into the fundamentals of Embedded C programming.

What is an Embedded System?

- An embedded system is a combination of hardware and software designed to perform a specific task. Examples include washing machines, cars, and industrial machinery. Washing machines, for instance, take user inputs (wash cycle, type of clothes, etc.), execute instructions, and complete the washing process.
- Cars consist of multiple embedded systems (e.g., Anti-lock Braking System, Temperature Monitoring, etc.) working together for a smooth and safe journey.

Programming for Embedded Systems:

- Embedded systems use processors like microcontrollers, DSPs, or FPGAs as their main hardware modules.
- Embedded C extends the standard C programming language with features optimized for resource-constrained environments.

Key considerations for embedded programming:

- **Memory constraints:** Efficient memory usage is crucial.
- **Real-time operation:** Responsiveness to external events.
- **Low-level hardware interactions:** Direct manipulation of hardware registers.

SEGMENTS OF EMBEDDED C

Certainly! Let's explore the memory layout of Embedded C programs. When writing code for embedded systems, understanding the memory organization is crucial. Here are the key segments of memory in an embedded C program:

Code Segment (Text Segment): The code segment (also known as the text segment) stores the executable program code—the machine instructions that make up your program's logic.It contains functions, statements, and instructions.Typically, the code segment is read-only and shared among multiple instances of the same program.For frequently executed programs (e.g., text editors, compilers, shells), only a single copy needs to be in memory.To prevent accidental modification, the text segment is often marked as read-only.

Initialized data segment:

- The initialized data segment (also called the data segment) holds global variables and static variables that are initialized by the programmer. Unlike the text segment, the data segment is not read-only because variable values can change at runtime.

This segment can be further classified into:

- **Initialized read-only area:** Contains data that cannot be altered at runtime (e.g., global strings).
- **Initialized read-write area:** Stores data that can be modified during program execution.
- **Uninitialized Data Segment (BSS Segment):** The uninitialized data segment, often called the BSS segment, contains global and static variables that are:
- **Initialized to zero:** Not explicitly initialized in the source code. The kernel initializes these variables to zero before program execution star.

Heap:

The heap is a segment of system memory (RAM) used for dynamic memory allocation. Programs allocate memory on the heap during runtime (e.g., using malloc or new).For more information, check out my article on The Concept of Heap and Its Usage in Embedded Systems.

Stack:

The stack area is a temporary storage for data. It follows a Last-In-First-Out (LIFO) structure.Traditionally, the stack adjoined the heap and grew in the opposite direction.Modern techniques allow placing the stack almost anywhere in memory.For more details, see my article on The Concept of Stack and Its Usage in Microprocessors.

ROLE OF EMBEDDED C

Embedded C is a programming language used in the development of embedded systems. These systems are specialized and designed to perform specific tasks within larger mechanical or electrical systems.

An embedded system combines hardware and software, with the software (often called firmware) embedded into the system hardware. Embedded C is specifically tailored for microcontrollers and microprocessors. It requires fewer resources compared to high-level languages like assembly. It includes additional data types and keywords, such as sbit and sfr, used for addressing special function registers in memory. Embedded C allows interaction with hardware devices like sensors and input-output peripherals.

Key Characteristics of Embedded C:

- **Efficiency:** Embedded C enables efficient code optimization for the limited resources available in embedded systems.
- **Hardware Dependency:** Unlike standard C, Embedded C is hardware-dependent, closely tied to the underlying microcontroller architecture.
- **Advanced Techniques:** It supports techniques specific to embedded systems development.

Programming for steps:

- **Embedded C:** Block Diagram Description: Understand the system architecture and constraints.
- **Setting up the Development Environment:** Use tools like Keil IDE for embedded systems programming.
- **Writing Your First Embedded C Program**: Start with a simple program, like a "Hello, World!" example.

Applications of Embedded C: Embedded C is used in various applications, including:

- Robots
- Vehicle tracking systems
- Smart monitoring systems
- Devices like air conditioners, printers, and mobile phones.

Table 1 COMPARISON TABLE

S.No.	Title	Author Name	Merits	Demerits
1	Energy comparison of controllers used for a differential drive wheeled mobile robot.	Alexanderstefex	Path length Trade-off	Ground plan sensitivity
2	locomotion strategies for amphibious robots-a review	Mohd asyrafrazib	Safety and feasibility, open research areas	Slower speed, complex design
3	Exploiting bands for military communication.	James	Increased connectivity, Faster data rates	Limited range due to obstacles
4	A robust autonomous following method for mobile robots in dynamic environment	Dapingjin	Safety, Scalability	Speed, Inaccuracy, Inefficiency
5	Past, present and future of path-planning algorithms for mobile robot navigation in dynamic environments	Hewawasam	multi-agent coordination, safety-centric design	Computational complexity, computational overhead

OVERVIEW OF PROJECT

The IoT-based military robot application is a cutting-edge project aimed at enhancing military operations through the integration of Internet of Things (IoT) technology into robotic systems. Here's an overview of the project.

The IoT-based military robot application is a cutting-edge project aimed at enhancing military operations through the integration of Internet of Things (IoT) technology into robotic systems. Here's an overview of the project. The robot can be remotely operated by military personnel from a safe distance using a secure wireless connection. The robot is equipped with a variety of sensors such as cameras, LiDAR, GPS, and thermal

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imaging, providing real-time data on its surroundings. Utilizing IoT technologies, the robot is capable of autonomous navigation, obstacle avoidance, and path planning, allowing it to navigate complex terrains and environments. The collected sensor data is transmitted in real-time to a central command station or military base, providing commanders with up-to-date information for decision-making. The robot is equipped with onboard processing capabilities for edge computing, enabling it to perform local data analysis and decision-making without relying solely on external commands. Robust encryption and authentication mechanisms are implemented to ensure the security and integrity of communications between the robot and command station, protecting sensitive military data from unauthorized access. The design of the robot is scalable and modular, allowing for easy customization and integration of additional sensors or functionalities based on specific mission requirements. The robot can be deployed for reconnaissance missions, gathering intelligence on enemy positions, terrain features, and potential threats without putting human lives. Integration of AI algorithms for advanced decision-making, object recognition, and behavior analysis.

MODULES

- Remote operation module
- Sensor integration module
- Autonomous navigation module
- Data transmission module
- Security module

REMOTE OPERATION MODULE

Enables remote control of the robot by military personnel. Utilizes secure wirelesscommunication protocols for command transmission. Provides user interfaces for controlling movement, sensors, and other functionalities remotely.1. The module features a user-friendly interface accessible via computers, tablets, or specialized control stations. This interface provides intuitive controls for commanding the robot's movements, activating sensors, and executing mission-specific tasks. Leveraging secure wireless communication protocols such as Wi-Fi, Bluetooth, or radio frequency (RF), the module establishes a reliable and low-latency connection between the remote operator and the robot. This allows for real-time transmission of commands and feedback between the two endpoints. Military personnel can issue a variety of control commands to the robot, including directional movement (forward, backward, left, right), rotation, speed adjustments, and stop commands. Advanced control modes may also be available, such as waypoint navigation or predefined patrol routes. The module enables remote activation and control of the robot's onboard sensors, including cameras, LiDAR, thermal imaging, and environmental sensors. Operators can switch between different sensor views, adjust parameters, and capture images or video footage for analysis. Real-time feedback mechanisms provide operators with visual and auditory cues to monitor the robot's status, environment, and operational conditions. This includes live video feeds from onboard cameras, sensor data readouts, battery status indicators, and system health diagnostics. The module incorporates safety protocols and fail-safe mechanisms to prevent unauthorized access, mitigate potential risks, and ensure the secure operation of the robot.

SENSOR INTEGRATION MODULE

The module involves careful selection and integration of various sensors tailored to the specific requirements of military operations. This may include cameras (RGB, infrared, or thermal), LiDAR (Light Detection and Ranging), GPS (Global Positioning System), proximity sensors, microphones, and environmental sensors (temperature, humidity, gas). Integrated sensors continuously gather real-time data from the robot's environment, capturing information about terrain features, obstacles, targets, and potential threats. This data is essential for generating a comprehensive situational picture and informing decision-making processes. The module incorporates algorithms for fusing and processing sensor data to extract meaningful insights and actionable intelligence. Techniques such as sensor fusion, filtering, and feature extraction are employed to enhance the accuracy and reliability of the information collected. Advanced image processing algorithms analyze visual sensor data to detect and recognize objects of interest, including vehicles, personnel, and equipment. This enables the robot to identify potential threats, track targets, and differentiate between friend and foe.

AUTONOMOUS NAVIGATION MODULE

The module utilizes data from various sensors, including cameras, LiDAR, GPS, and inertial sensors, to perceive its surroundings accurately. Sensor fusion techniques integrate and process this data to generate a comprehensive understanding of the environment, including terrain features, obstacles, and navigable paths. Using Simultaneous Localization and Mapping (SLAM) algorithms, the robot constructs and maintains a map of its surroundings in real-time. This map serves as a reference for localization, enabling the robot to determine its precise position and orientation relative to its environment. Based on the acquired map and mission objectives, the module generates optimal paths for navigation while considering factors such as terrain roughness, obstacles, and mission constraints. Path planning algorithms, such as A* or D* algorithms, determine the most efficient route to reach the designated destination while avoiding collisions and hazards.

DATA TRANSMISSION MODULE

The module employs secure communication protocols such as Wi-Fi, cellular, satellite, or military-grade radio frequencies to establish reliable data links between the robot and command centres. These protocols are selected based on factors such as range, bandwidth, security requirements, and environmental conditions. Sensor data collected by the robot, including images, video feeds, environmental parameters, and operational status, is transmitted in real-time to command centres or military bases. This ensures that decision-makers have access to up-to-date information for situational awareness and mission planning. To safeguard sensitive military data from interception or tampering, the module implements robust encryption and authentication mechanisms. Data encryption techniques such as AES (Advanced Encryption Standard) or RSA (Rivest-Shamir-Adleman) ensure that transmitted data remains confidential and secure. Authentication protocols such as TLS (Transport Layer Security) or VPN (Virtual Private Network) verify the identity of communication endpoints and prevent unauthorized access.

SECURITY MODULE

The Security Module employs advanced encryption algorithms such as AES (Advanced Encryption Standard) or RSA (Rivest-Shamir-Adleman) to encrypt sensitive data transmitted between the robot and command canters. Encryption ensures that even if intercepted, data remains unintelligible to unauthorized entities, maintaining confidentiality. To verify the identities of communication endpoints and prevent unauthorized access, the module implements authentication protocols such as TLS (Transport Layer Security) or VPN (Virtual Private Network). Authentication mechanisms validate the legitimacy of users, devices, or systems before granting access to sensitive resources.

SYSTEM TESTING

Usability Evaluation Three heuristic evaluations have been performed, one on the existing systems in the retail store, and two on the produced system:

Heuristic Evaluation 1: Test performed on existing systems in the retail market. The system uses manual identification of the fruit.

Heuristic Evaluation 2: Test performed on progressing system to discover flaws during the development

Heuristic Evaluation 3: Test performed on finished system.

The tests has been performed on five test persons since the method only requires 3-5 persons to find 70% of the usability flaws. The heuristic evaluation has following steps to be completed: 1. Recording of the procedure starts 2. The individual is asked to identify a fruit 3. The recorded material is analyzed. The usability tests are performed without any information given to the user. The user is simply requested to identify a fruit or vegetable with the goal of printing a label. No information is given which could lead to any clues or guidance. The result has been analyzed by following the interactions between the individual and the computer to find any possible flaws. Furthermore, another kind of usability test of the system has been performed with the help of fifteen individuals. The individuals are of different age, gender and background to get as many insights as possible. The test was created by the project members and is called the ”Prelaunch Test”. The test was performed when the project members felt the graphical user interface was finished. Since the project members is the creators of the system, the procedure of identifying a product is clearly perceived, hence there is no experienced usability flaws according to the creators. To find possible flaws not detected by the creators and to get inputs from the users, the Prelaunch Test was performed.

EXISTING SYSTEM

The existing system has a drawback that is it has less range and we cannot determine the exact location of robot so with this we cannot know where it is going and location of the robot if we have a robot location when it detects the human beings, we can plan attack on them wisely. As well as existing systems which track or detects the land mines by manually holding device with human so it may have some tracking problems. and it is less range communication. It will not give security to the soldiers to avoid the problem we have invented a robot with more range and exact location of the robot with global positioning system.

DEMERITS

- Some existing military robots may have sensors with limited range or coverage, which can result in incomplete data collection.
- This limitation can lead to blind spots in environmental monitoring, reducing the accuracy and reliability of the data obtained.

PROPOSED SYSTEM

The proposed military robot integrates state-of-the-art sensor technologies for precise measurement of environmental parameters. Utilizing advanced sensor arrays, the robot is capable of gathering accurate data on temperature and humidity levels with high reliability and efficiency. The collected data is transmitted in real-time to a central command center, enabling rapid decision-making and proactive response to environmental changes. Key features of the military robot include rugged construction, mobility over various terrains, and autonomous operation capabilities. Designed to withstand harsh conditions prevalent in military environments, the robot is equipped with robust components and protective enclosures to ensure resilience against environmental hazards and physical damage.

BLOCK DIAGRAM

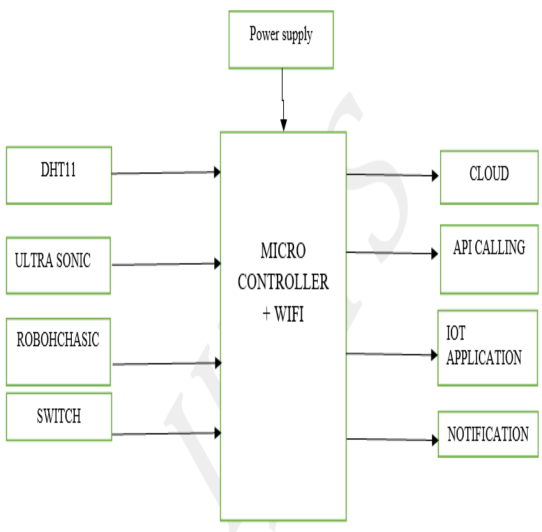


Figure 1 block diagram of proposed system

ADVANTAGES

- The proposed system integrates advanced sensor technologies capable of providing accurate and precise measurements of temperature and humidity levels in real-time.
- Unlike some existing systems, the proposed military robot is designed to be highly adaptable to diverse operational environments, including different terrains, climates, and conditions.
- Its robust construction and versatile navigation system enable it to operate effectively in dynamic and unpredictable settings, ensuring reliable data collection across a wide

METHODOLOGY

The first step in developing the military robot involves conducting a comprehensive analysis of the requirements and specifications for temperature and humidity monitoring in military environments. This includes identifying the operational scenarios, environmental conditions, and performance criteria that the robot needs to meet. Sensor Selection and Integration: Based on the requirements analysis, suitable temperature and humidity sensors are selected for integration into the robot. These sensors should offer high accuracy, wide range coverage, and resilience to environmental factors. The integration process involves designing the sensor placement and wiring within the robot's chassis to ensure optimal data collection. Robot Design and Construction: The next step involves designing the physical structure and components of the military robot. This includes selecting materials for robustness and durability, designing protective enclosures for the sensors, and integrating mechanical and electronic components such as motors, actuators, and controllers. The robot's design should prioritize ruggedness, mobility, and adaptability to diverse terrains. Develop a high-level system architecture that outlines the components, modules, and interactions within the military robot application. Define the roles and responsibilities of each system component, including sensors, actuators, control systems, communication interfaces, and data processing modules. Choose appropriate sensors based on mission requirements, environmental conditions, and operational constraints. Consider factors such as range, accuracy, resolution, and power consumption when selecting sensors for integration into the robot. Design secure communication protocols for transmitting data between the robot and command centers. Select communication technologies such as Wi-Fi, cellular, satellite, or military-grade radio frequencies based on range, bandwidth, and security considerations. Define the autonomy levels of the military robot, ranging from manual control by operators to semi-autonomous or fully autonomous operation. Determine the decision-making algorithms, navigation strategies, and control mechanisms required to achieve the desired autonomy level. Implement the software components of the military robot application, including firmware for onboard microcontrollers, control algorithms, sensor data processing modules, communication protocols, and user interfaces.

RESULT AND DISCUSSION

- Real-time transmission of battlefield visuals and environmental data, providing comprehensive situational awareness to commanders and decision-makers.
- Autonomous or remote-controlled operations allow for faster and more precise execution of military tasks, reducing delays and improving mission outcomes.
- Reduced detection by the enemy through advanced camouflage, low noise, and minimal heat signature, enhancing the element of surprise and mission success.
- Modular design allows for easy upgrades and the addition of new capabilities, ensuring the robot can adapt to evolving military needs.

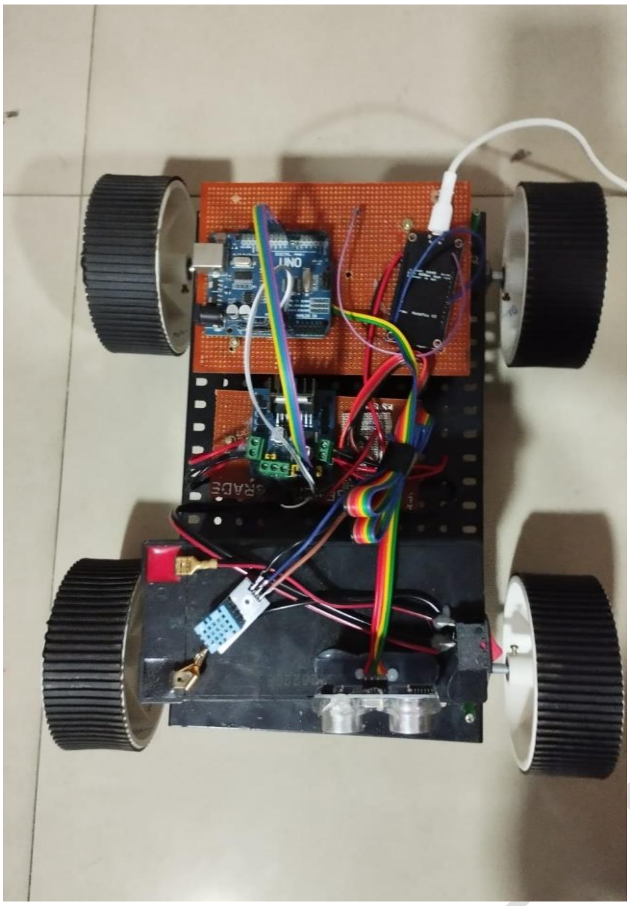


Figure2: Result 1

CONCLUSION AND FUTURE ENHANCEMENT

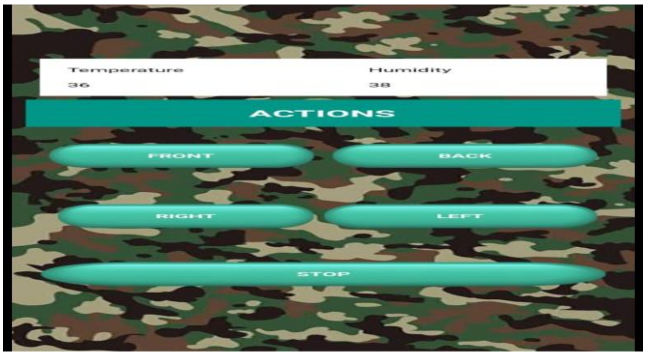
Today we are in the world of robotics. Knowingly or unknowingly, we have been using different types of robots in our daily life. The project is "ESP-32 based Surveillance Robot for Military Applications" is practically proved by using the Camera for live telecasting Motor Shield Driver for the driving the dc motors, dc motor is used for the movement of the robot with the help of the Esp-32 Microcontroller. A lot of factors determined the accuracy of the robot we designed. These factors were the environmental phenomenon in which the robot was tested, the number of obstacles present making the test space crowded or relatively less crowded the type and shape of the obstacle (the robot is designed for a uniform shaped obstacle).

These factors majorly affected the sensors. The accuracy of the robot is dependent on the sensors used. Thus, the nature of the sensor and its accuracy defined the accuracy of my robot. This technique can also be used as a vision belt for blind people by adding a kinetic sensor, which is a type of microwave sensor whose sensing range is very high and the output of this sensor vary in according to the object position changes. This technique enables blind people to navigate obstacles easily by placing three vibratos in left, right and the center of a belt named as Vision Belt. They can be used as services robots, for the low-cost Obstacle Avoidance Robot, purpose of household work and so many other indoor applications. This technique can also be used as a vision belt for blind people by adding a kinetic sensor, which is a type of microwave sensor whose sensing range is very high and the output of this sensor vary in according to the object position changes. This technique enables blind people to navigate obstacles easily by placing three vibratos in left, right and the center of a belt named as Vision Belt.They can be used as services robots, for the low-cost Obstacle Avoidance Robot, purpose of household work and so many other indoor applications.

APPENDIX

STEP 1 :

STEP 2 :



STEP 3 :

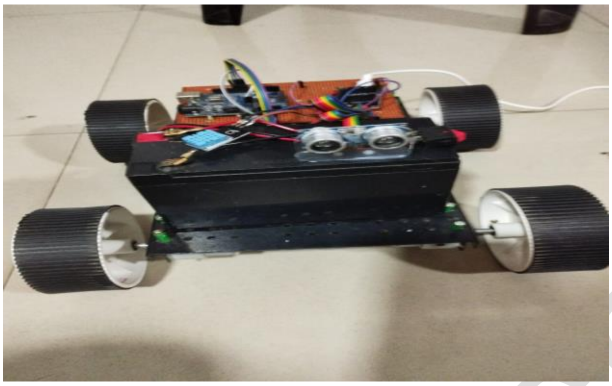


Figure 3Results

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