VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi – 590018, Karnataka

A

MINI PROJECT WORK (**Course code**: **BEC586**)

ON

"4 in 1 Multipurpose Robot"

Carried out

by

Mohammed Taha	:	1KS22EC065
Kiran G	:	1KS22EC050
Lohith Yaadav R	:	1KS22EC055
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Submitted in partial fulfillment for the award of

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

Under the guidance of

Dr. Bharathi Gururaj

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2024-25

K. S. INSTITUTE OF TECHNOLOGY

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CERTIFICATE

This is to certify that the **Mini Project Work** (**Course code: BEC586**) entitled

"4 in 1 Multipurpose Robot"
carried out by

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is a bonafide student of K.S. institute of Technology, Bangalore in partial fulfillmentfor the award of Bachelor of Engineering Degree in Electronics and Communication from Visvesvaraya Technological University, Belagavi during the year 2024-25. It is certified that all corrections and suggestions indicated during internal assessment have been incorporated in the report deposited in the department library. The project report has been approved as it satisfies the academic requirements in respect of Project Work prescribed for Bachelor of Engineering Degree.

Signature of Guide Signature of HOD Signature of Principal

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DECLARATION

We Mohammed Taha USN:1KS22EC065, Kiran G USN:1KS22EC050, Lohith Yaadav R USN:1KS22EC055 and Manojkumar N USN:1KS22EC062 students of 5th semester B.E., Department of Electronics and Communication Engg., K.S. Institute of Technology, Bengaluru declare that the Mini Project entitled "4 in 1 Multipurpose Robot" has been carried out by us and submitted in partial fulfillment of the course requirements for the award of degree in B.E. in Electronics and Communication, Visvesvaraya Technology University, Belagavi during the academic year 2024-25. Further, the matter embodied in the report has not been submitted previously by anybody for the award of any Degree or Diploma to any other University.

Signature of the candidates

Place: Bengaluru
Date: 24/12/2024

ACKNOWLEDGEMENT

The successful project is culmination of efforts of many people who have rendered their unconditional support. We would be dishonest without acknowledging these people.

Dr. Dilip Kumar K, Principal, KSIT, has been a continuous source of inspiration to us. We are indebted to him for his encouragement in making the project a success.

Dr. P.N. Sudha, Head of Department, Electronics and Communication Engg. Department, KSIT, who has continuously encouraged, motivated and provided us with valuable suggestions.

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We are thankful to our project Coordinators **Mrs. Bhargavi Ananth, Assistant Professor and Mrs. Vishalini Divakar, Assistant Professor**, **Department of Electronics and Communication Engineering,** K.S. Institute of Technology, for their coordination and help.

Last but not the least the project would not have been a success without the grace of **God** and support of our **parents** and **friends**.

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INTRODUCTION

With the growing demand for automation in both industrial and home environments, robots that can handle a variety of tasks are becoming increasingly important. The 4-in-1 Multipurpose Robot is created to meet this need, combining four distinct modes of operation: Voice Control, Obstacle Avoidance, Line Following, and Bluetooth Control. Each of these modes serves a unique purpose, allowing the robot to adapt to different environments and tasks.

The Voice Control Mode enables hands-free operation, allowing the robot to respond to voice commands for movement and tasks. In Obstacle Avoidance Mode, ultrasonic sensors help the robot detect and navigate around obstacles in its path, ensuring smooth and efficient movement. The Line Following Mode uses IR sensors to follow a predefined path, making it ideal for precise navigation along lines or tracks. Finally, the Bluetooth Control Mode connects the robot to a mobile app developed with MIT App Inventor, enabling users to manually control the robot, switch between modes, and issue voice commands remotely.

Designed for efficiency, the robot is optimized to consume minimal power while ensuring reliable performance. We’ve kept the components to a minimum to ensure clean, uncluttered connections that help the robot run smoothly. The modular design allows for easy upgrades and additions, making the robot adaptable for future enhancements. This project aims to provide a practical, multi-functional robot that can be used across a variety of fields, including education, industry, and personal applications.

LITERATURE SURVEY

A. Chaudhry, M. Batra, P. Gupta, S. Lamba and S. Gupta, "Arduino Based Voice Controlled Robot," 2019 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS), Greater Noida, India, 2019, pp. 415-417, Doi: 10.1109/ICCCIS48478.2019.8974532. In this research paper, a system is being proposed, which focuses on the concept of how a robot can be controlled by the human voice. Voice control robot is just a practical example of controlling motions of a simple robot by giving daily used voice commands. In this system, an android app is used as a medium for the transmission of human commands to microcontroller. A controller can be interfaced with the Bluetooth module through the UART protocol. The speech is received by the android app and processed by the voice module. Voice is then converted to text. [1] The microcontroller will further process this text, which will take a suitable action to regulate the robot. The objective is to design a robotic car whose basic movements such as moving forward, turning to left or right can be controlled by the human voice. Generally, recognition of human voice using some kind of module cost way too much. This study proposes an easy way to implement voice-controlled mechanism in a robot which is cost effective and has a simpler design.

D. Pal, N. Kaur, R. Motwani, A. D. Mane and P. Pal, "Voice-Controlled Robot using Arduino and Bluetooth," 2023 3rd International Conference on Smart Data Intelligence (ICSMDI), Trichy, India, 2023, pp. 546-549, Doi: 10.1109/ICSMDI57622.2023.00103. This paper proposes a voice-controlled robotic system that uses Bluetooth to follow human commands. The voice commands are given to an android app built using MIT App Inventor. These commands are then sent to the Bluetooth module which then sends them to the controller interfaced with it. This interfacing was done using Universal Asynchronous Receiver-Transmitter (UART) Protocol. After processing the commands, the microcontroller controls the movement of the robot in different directions.[2] An open-source hardware and software is used in the proposed research work. Further, the proposed model can be implemented by almost every student for educational and understanding purposes as it is both economical and easy to use. This study considers the domain of Natural Language Processing (NLP) as well as communication using Bluetooth, both of which have high possibilities in future based on technological advancement.

Bisen, Divyanshu & Makode, Ayushi & Itiwale, Janvi & Warade, Samiksha & Malewar, Prof.Trupti. (2024). Multifunctional Obstacle Avoidance Arduino Robot Car. IJARCCE. 13. 10.17148/IJARCCE.2024.13128.

This study proposes a multipurpose robot car that avoids obstacles, which is built on the Arduino platform. This project's goal is to build an adaptable, autonomous robot that can go through many types of surroundings and instantly avoid obstacles. The robot uses a mix of motor control and sophisticated algorithms to assure obstacle avoidance, and it uses ultrasonic sensors to identify impediments. In addition to ultrasonic sensors for obstacle detection, the robot integrates an ESP32 camera coupled with YOLO (You Only Look Once) object recognition.[3] The incorporation of the ESP32 camera enhances the robot's perception capabilities, allowing it to capture real-time visual data from its surroundings. The YOLO object recognition system further enables the robot to identify and categorize objects swiftly and accurately. The integration of many components for better obstacle detection makes it complicated, incorporates a cluttered design and consumes high voltage which is difficult and expensive to implement.

Khin Khin Saw | Lae Yin Mon "Design and Construction of Line Following Robot using Arduino" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-4, June 2019, pp.939-941. This paper incorporates a line following robot which detects black line to move over the white surface or bright surface. The line following robot is constructed by using Arduino nano microcontroller as a main component and consists of three infrared (IR) sensors, four simple DC motors, four wheels and a PCB frame of robot chassis.[4] The infrared sensors are used to sense the black line on white surface. When the infrared signal falls on the white surface, it gets reflected and it falls on the black surface, it is not reflected. In this system, four simple DC motors attached with four wheels are used to move the robot car's direction that is left, right and forward. The Arduino nano is used as a controller to control the speed of DC motors from the L2953D driver circuit.

A. Sah, A. Muppidwar, A. Raut, J. Nakhate, A. Gavande, and P. Kadam, "Multi-Functional Arduino Robot 'Anima': Review," International Journal for Research in Applied Science and Engineering Technology (IJRASET), vol. 11, no. 3, pp. 230-234, Mar. 2023. DOI: 10.22214/ijraset.2023.56057. In this research paper, a robot with obstacle avoiding and Bluetooth connectivity is built. The obstacle avoiding functionality is integrated with Bluetooth control. This robot incorporates ultrasonic sensor and motion sensors for optimal detection of objects and also a Bluetooth module for wireless connection to a smart device.[5] It also incorporates additional small features like wall following and edge detection and has been programmed with controlled algorithms. The robot can be fully controlled via an application which also allows for mode switching. Overall, this project is cost effective and consumes minimal power for functioning.

Zaw & Aye (2020). Design and Implementation of Universal Motor Control Using IR Remote and Arduino. International Research Journal of Computer Science, Volume VII, 144-150. The main objective of this paper is used to control DC motors for speed control and load characteristics. This system involves interfacing stepper, servo and DC motors on a single platform. IR remote and IR receiver module is used to control all motors. The IR remote communicates digital pulse signals with the Arduino. The remote or the transmitter produces light in the IR spectrum instead of visible spectrum. The IR receiver converts the IR light into electrical signal.[6] The electrical signal in turn is converted to the IR light signal. Finally, the IR light signal is converted to binary form and passed onto the Arduino for processing. This study gives a clear and complete working of IR remote and receiver module. Each time a button is pressed on the remote unique hexadecimal codes are generated. Hence the hexadecimal generated for each key is recorded which is essential for coding.

S. Mandal, S. K. Saw, S. Maji, V. Das, S. K. Ramakuri and S. Kumar, "Low-cost Arduino WIFI Bluetooth integrated path following robotic vehicle with wireless GUI remote control," 2016 International Conference on Information Communication and (ICICES), Chennai, India, 2016, pp. 1-5, doi: 10.1109/ICICES.2016.7518916. This research paper presents path following two wheeled compact portable robots with Arduino nano as central driving functional unit with novel features of wireless control using WIFI and Bluetooth module with collision detection, avoidance and control features which provides the unique ability of danger avoidance, falling from a height with improved stability and precision control. The extremely sophisticated design provides very good controlled movement on horizontal ground terrain surfaces with data collecting and processing capabilities.[7] The design is integrated with infrared sensors, Bluetooth module, WIFI module control with dc gear motors which controls the speed of the vehicle of the robotic vehicle. It has the unique ability of running in maze with path following abilities controlled from any remote location using WIFI for long range control and Bluetooth for short range control. In this research article an entire system is designed and implemented in which movement is stably controlled based on feedback from infrared transmitter receiver module.

D. Arulselvam, C. Nayanatara, P. Sharmila and M. Priyadharshini, "IoT Based Robot for Domestic Surveillance Using ESP-NodeMCU," 2023 Intelligent Computing and Control for Engineering and Business Systems (ICCEBS), Chennai, India, 2023, pp. 1-5, doi: 10.1109/ICCEBS58601.2023.10448871. This paper presents an overview of an IoT-based robot designed for domestic surveillance, leveraging the ESP-Node MCU platform. The proposed system combines the capabilities of a mobile robot with the flexibility of the ESP-Node MCU microcontroller, creating an efficient and cost-effective solution for monitoring and securing residential spaces. The key components of this system include a robot chassis, wheels, motors, a camera module, ultrasonic sensors, and the ESP-Node MCU microcontroller.[8] To enhance the robot's navigational capabilities, ultrasonic sensors are integrated into the system. These sensors enable obstacle detection and avoidance, ensuring that the robot can move autonomously through the home environment without colliding with objects or obstacles. This system is a more advanced and complex as the camera used can be programmed for both obstacle detection and surveillance.

A. Azhiimah, K. Alfiantin, K. Khotimah, M. Sumbawati, and A. Santosa, "Automatic control based on voice commands and Arduino," in Advances in Engineering Research, 2020. doi: 10.2991/aer.k.201124.006. This paper presents automation control based on voice commands and an Arduino for processing. Voice commands are of two types voice recognition and speech recognition. Voice recognition is specific to a particular person’s voice. It works by analyzing the individual’s tone, style and speech accent.[9] A voice recognition module V3 is used for voice recognition which is expensive and difficult to implement. On the other hand, speech recognition involves converting the voice commands to text and sending it to Arduino for processing. The use of such technology can be found on Google voice, Microsoft dictation and so on. Voice control does not require much power consumption and requires a speaker to capture the voice command.

A. Vijayaraj, A. Deepika, A. K, G. V, G. A and I. H, "Obstacle Detection and Avoidance Robot with Multi-Control System Using IoT," 2023 International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE), Chennai, India, 2023, pp. 1-7, doi: 10.1109/RMKMATE59243.2023.10369630. This project aims to develop an obstacle detection and avoidance robot using the IoT (Internet of Things) with multiple control systems, including voice, terminal, and Bluetooth mode. The proposed robot is designed to navigate through its environment autonomously and avoid obstacles in its path using an ultrasonic sensor. It also includes a servo motor for steering and a gear motor for driving the wheels. The robot can be controlled using various modes, including voice mode, terminal mode, and Bluetooth mode.[10] The voice mode allows the user to communicate with the robot using voice commands, while the terminal mode enables the user to send commands to the robot through a terminal window. The Bluetooth mode allows the user to control the robot wirelessly using a smartphone or a tablet. The IoT capabilities are implemented using a Wi-Fi module, which enables the robot to connect to the internet and be controlled remotely from anywhere in the world.

PROBLEM IDENTIFICATION

There is a growing need for versatile robotic systems capable of handling multiple functions within a single platform. Such systems can offer significant advantages in terms of adaptability, cost-effectiveness, and ease of use.

- **Voice Control:** Hands-free operation is essential in scenarios where manual control is inconvenient or unsafe. Voice control allows the robot to respond to spoken commands, providing accessibility for users with physical limitations and enhancing usability in real-world applications such as home automation or industrial settings.

- **Bluetooth Control:** The demand for wireless communication in robotics is increasing due to its convenience and flexibility. Bluetooth control enables users to operate the robot remotely via a smartphone or similar device, making it suitable for applications requiring long-distance control or where physical presence near the robot is not feasible.

- **Obstacle Avoidance:** Autonomous navigation is critical for the safe operation of robots in dynamic or unknown environments. The obstacle avoidance feature allows the robot to detect and circumvent objects in its path, ensuring safety and efficiency, particularly in tasks such as delivery, exploration, or rescue missions.

- **Line Following:** Many applications require precise movement along predefined paths, such as in warehouse management, assembly lines, or educational projects. The line-following functionality provides a reliable solution for guided movement, ensuring the robot adheres to specific routes with accuracy

The integration of these functionalities into a single robotic platform not only demonstrates technological innovation but also provides a cost-efficient and practical solution to the challenges faced by single-function robots. This multi-functional robot has potential applications in automation, research, education, and daily life, bridging the gap between single-purpose designs and the need for versatile robotic systems.

OBJECTIVES

- **To implement voice control functionality:**

  Develop a system that enables the robot to recognize and respond to voice commands for hands-free and accessible operation.

- **To enable Bluetooth control:**

  Incorporate a wireless control mechanism using Bluetooth technology, allowing users to operate the robot remotely through a smartphone or other Bluetooth-enabled devices.

- **To integrate obstacle avoidance capability:**

  Equip the robot with sensors to detect and avoid obstacles autonomously, ensuring safe navigation in dynamic or unknown environments.

- **To incorporate line-following functionality:**

  Develop an algorithm for guiding the robot along a predefined path, suitable for applications such as automated transportation and material handling.

- **To design a cost-effective and compact robotic platform:**

  Create a system that integrates all four functionalities without compromising on affordability, efficiency, or ease of use.

- **To enhance the versatility and adaptability of the robot:**

  Ensure the robot can switch seamlessly between the four modes of operation to cater to diverse applications in automation, education, and research.

BLOCK DIAGRAM

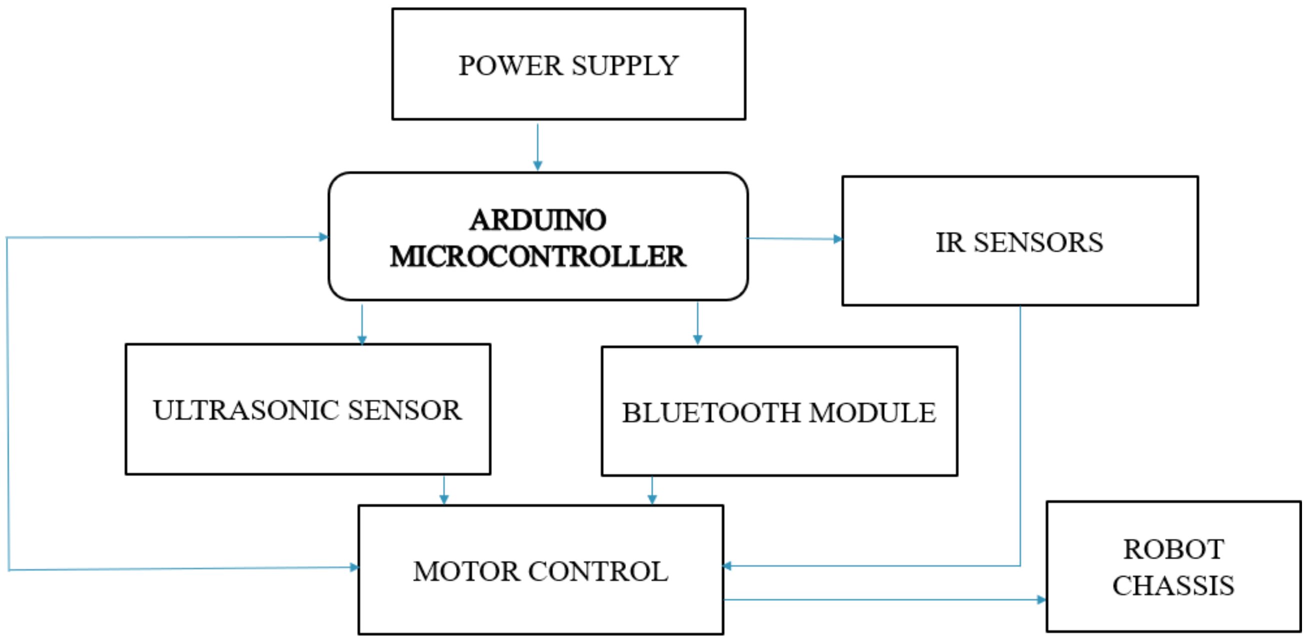
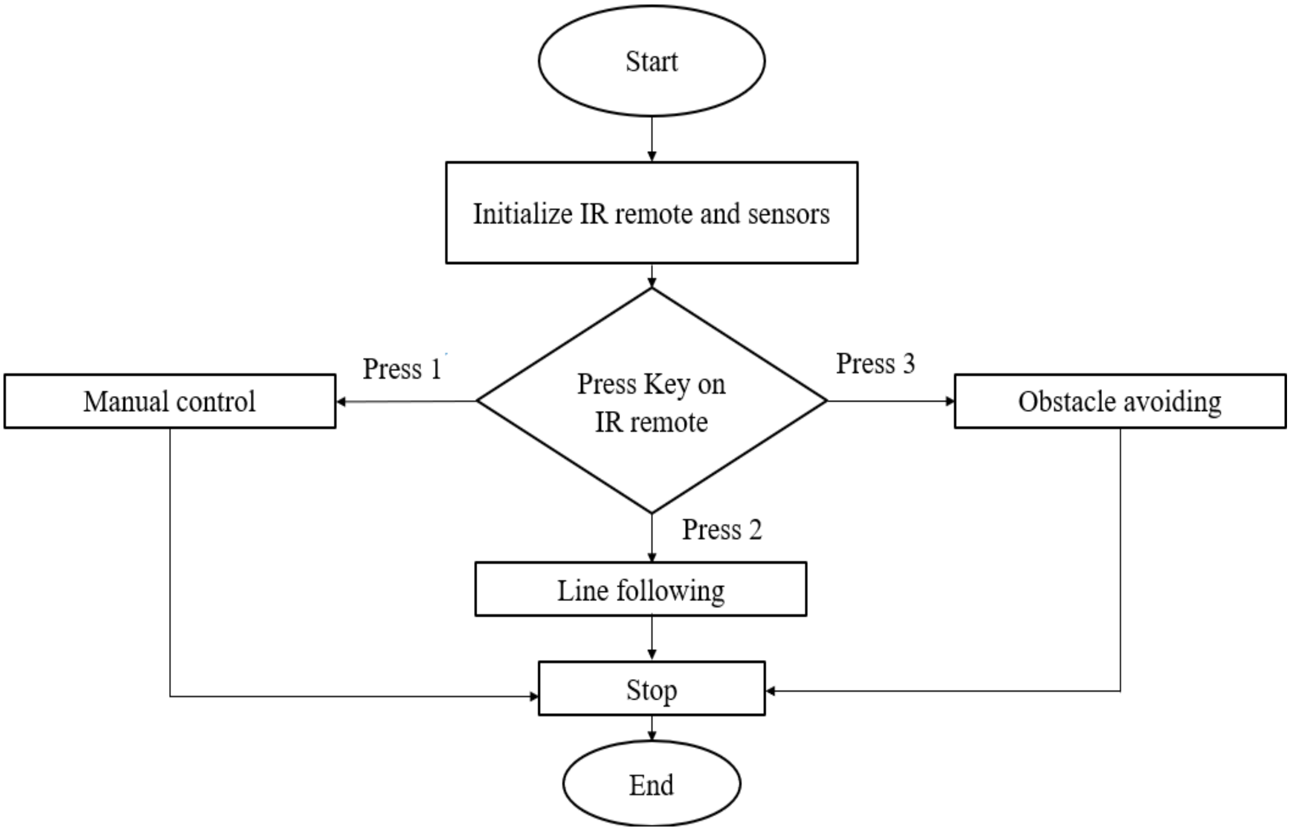


Fig 1: Block Diagram of 4 in 1 Multipurpose Robot

FLOW CHART


Start
Initialize IR remote and sensors
Press Key on
IR remote
Press 1
Press 2
Press 3
Manual control
Line following
Obstacle avoiding
Stop
End

METHODOLOGY

Hardware setup: An analysis was conducted where hardware requirements for each mode- Bluetooth control, Obstacle avoidance and Line following were identified. All the required set of components were mounted on the robot chassis and the connections were made as per the circuit diagram shown in Figure 2. The ultrasonic sensor was placed facing front on top of the servo motor for detecting objects efficiently. The two IR sensors were placed at the front of the robot facing the ground, a minimum space of 6cm was given between the two IR sensors, this depends on the width of the line being followed and may vary for different cases. The sensors were calibrated in a way such that it detected the white surface and generated output 1(HIGH) and for the black line the sensors generated output 0(LOW). The logic was the robot moved only when it detected the white surface and would stop movement if it detected the black line. Hence, the IR sensors had to be placed in a way where they did not face the black line directly. The black line had to be exactly in the middle of the two IR sensors for its proper functioning. The Bluetooth control required the usage of Bluetooth module which is paired to the mobile phone.

All components here receive 5V directly from the Arduino. The voltage connections for every component are made on the bread board due to shortage of voltage pins on the Arduino UNO, the same goes for the ground connections. Moreover, analog pins of the Arduino UNO are used in connection for ultrasonic sensor, IR sensors, servo motor and IR receiver module. The digital pins are used for L298N motor driver and Bluetooth module. In this way we make sure that every component is connected and receives the right amount of voltage for proper operation. Two 18650 Li-ion batteries are used to power up the system which are held in a 2-cell battery holder with positive and negative connections directly connected to the Arduino UNO.

Software setup: Once the hardware connections were made, each mode was programmed separately using the Arduino IDE. Voice controlled and response, Obstacle avoidance with ultrasonic sensors, Line following with IR sensors and Manual control via Bluetooth module. After programming and testing each function separately we integrated all of it into one. The code written mostly contained hexadecimal codes because of the use of IR remote and receiver module which is known for generating hexadecimal codes each time we press a button on the remote.

```
long IRremote_data(){
if (results.value==0xFF02FD) {IR_data=1;}
else if (results.value==0xFF9867) {IR_data=2;}
else if (results.value==0xFFE01F) {IR_data=3;}
```

```
else if (results.value==0xFF906F) {IR_data=4;}
else if (results.value==0xFF629D || results.value==0xFFA857) {IR_data=5;}
else if (results.value==0xFF30CF) {IR_data=8;}
else if (results.value==0xFF18E7) {IR_data=9;}
else if (results.value==0xFF7A85) {IR_data=10;}
return IR_data;
}
```

The above function is a part of the code where recorded hexadecimal values are used. This function maps specific hexadecimal IR codes to numerical values (IR_data). These numerical values are easier to work with in the main program and can correspond to different robot functionalities such as:

1: forward movement

2: backward movement

3: left movement

4: right movement

5: stop

8, 9, 10: Manual control, line following and obstacle avoiding respectively.

Suppose we press 1 on the IR remote, 1 is sent on the Bluetooth module which communicates with the Arduino and robot moves forward as 1 is defined for forward movement in the code, same stands for all other buttons. By using this function, the program can easily interpret which button was pressed on the remote and perform the corresponding action. The robot can be controlled using the IR remote or the Mobile app.

Mobile app development: A mobile application with user friendly interface was developed using MIT app inventor. Figure 14 shows the app interface, the app has two buttons at the top- connect and disconnect which enables or disables Bluetooth connection with the HC-05 Bluetooth module. If connect option is clicked a Bluetooth pair list opens which gets the device connected. Below this, there is a speech recognition mic-like icon which when pressed calls a speech recognizer function to capture voice commands and converts them into text for voice control function. There are also up, down, right and left arrows surrounding the mic icon which are used for manual control, this function is enabled when the manual option is selected. Below this, there are three buttons reading LF (line following), manual and OA (obstacle avoiding), these can be used to switch between modes. At the bottom there is a slider which is used to control the speed of the robot from 0 to 255 duty cycle. Only for line following function the maximum speed set is 130 duty cycle which is defined in the code as the robot requires to be a bit slow moving to ensure optimum performance for line following especially while making turns along the line.

CIRCUIT DIAGRAM

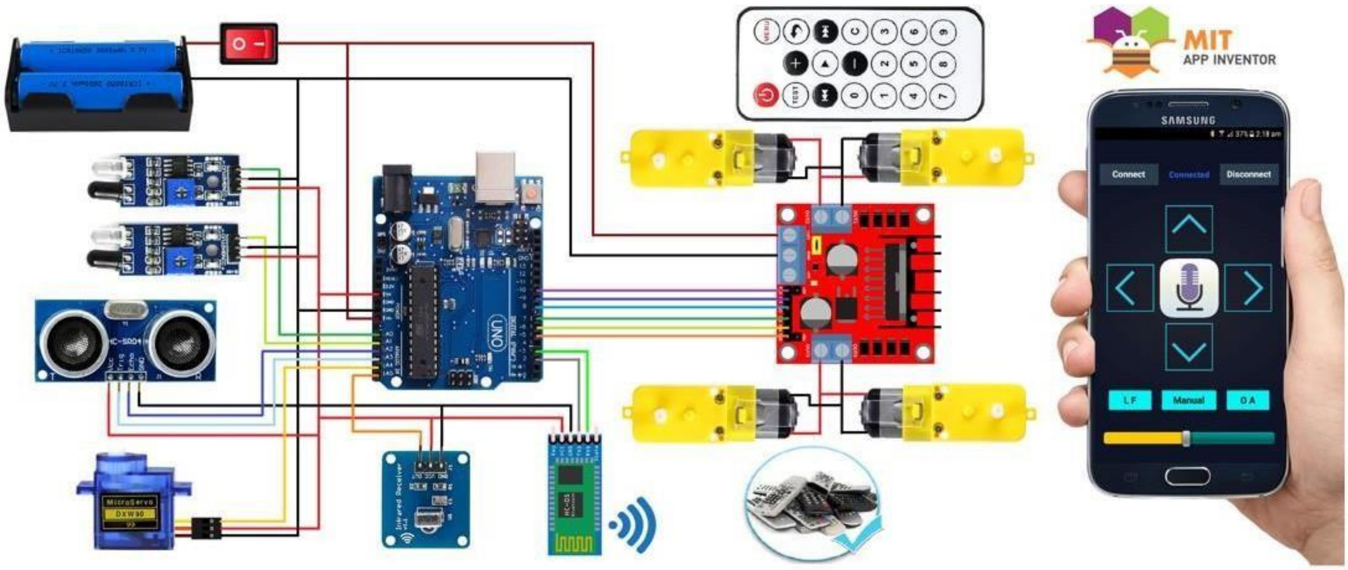


Fig 2: Circuit Diagram

HARDWARE USED

- **Arduino UNO:** Figure 3 illustrates an Arduino UNO a microcontroller board based on the ATmega328P. It has 14 digital input/output pins. It allows users a simple pathway to creating interactive objects that can take input from switches and sensors, and control physical outputs like lights, motors.

Fig 3. Arduino Uno

- **IR sensor:** Figure 4 illustrates an IR (Infrared) sensor a type of sensor that uses infrared radiation to detect objects, measure distances, or recognize specific environmental conditions. It works by emitting or receiving infrared light, which is invisible to the human eye. IR sensors are commonly used in various applications due to their simplicity, reliability, and cost-effectiveness.

Fig 4. IR sensor

- **HC-SR04 Ultrasonic sensor:** Figure 5 shows an ultrasonic sensor a device that uses ultrasonic waves to measure the distance to an object or detect its presence. It works similarly to radar or sonar, emitting sound waves at a frequency higher than humans can hear (usually above 20 kHz) and measuring the time it takes for the sound to reflect off an object and return to the sensor. By calculating the time delay, the sensor determines the distance between itself and the object.

Fig 5. HC-SR04 ultrasonic sensor

- **SG 90 Servo motor:** Figure 6 illustrates a servo motor which is a rotary or linear actuator designed for precise control of angular or linear position, speed, and acceleration. It consists of a motor, a feedback sensor (usually a potentiometer), and control circuitry. Servo motors are widely used in robotics, CNC machinery, and automated systems for tasks requiring precise movement. They are controlled by pulse-width modulation (PWM) signals, where the pulse duration determines the motor's angle or position. Typically compact, they are energy-efficient and offer high torque in small sizes, making them ideal for applications like robotic arms and drones.

Fig 6. SG 90 Servo motor

- **HC-05 Bluetooth module:** Figure 7 is a HC-05 Bluetooth module which is a popular, easy-to-use module for wireless communication in embedded systems. It operates using Bluetooth 2.0 technology and supports both master and slave modes. Commonly used in robotics and IoT projects, it allows devices like microcontrollers to communicate wirelessly with smartphones or computers. The module operates at 3.3V to 5V, with a communication range of up to 10 meters. It uses serial communication (UART) to transmit and receive data, making it ideal for Arduino and other microcontroller projects.

Fig 7. HC-05 Bluetooth module

- **Li-ion battery (18650):** Figure 8 illustrates a Lithium-ion (Li-ion) batteries which are rechargeable power sources commonly used in electronics and electric vehicles. They consist of a cathode (positive electrode), an anode (negative electrode), and an electrolyte that allows ion movement. Li-ion batteries are lightweight, have high energy density, and offer a long cycle life. They store energy by moving lithium ions between the anode and cathode during charging and discharging. Common cathode materials include lithium cobalt oxide and lithium iron phosphate. Li-ion batteries are prone to degradation over time, losing capacity with repeated use.

Fig 8. Li-ion battery (18650)

- **2-Cell battery holder:** Figure 9 shows a cell battery holder which is a device used to securely hold a battery or multiple batteries in place for easy connection to an electrical circuit. It ensures proper alignment and contact between the battery terminals and the circuit. Commonly made from plastic or metal, these holders can accommodate different battery types, such as AA, AAA, or coin cells. They often include a spring or clip mechanism to maintain pressure on the battery. Battery holders are designed for convenience, allowing easy battery replacement and preventing short circuits. They are widely used in electronic devices, toys, and DIY projects.

Fig 9. 2-Cell battery holder

- **DC gear motor:** Figure 10 illustrates a DC gear motor an electric motor combined with a gear system that reduces speed while increasing torque. It operates on direct current (DC) power and is commonly used in applications that require precise control of speed and movement. The gear mechanism adjusts the motor's output to achieve desired rotational force. These motors are widely used in robotics, automotive, and home appliances. DC gear motors are compact, efficient, and suitable for various low-speed.

Fig 10. DC gear motor

- **Breadboard:** Figure 11 illustrates a breadboard which is a tool used for prototyping electronic circuits without soldering. It consists of a grid of holes, allowing components like resistors, capacitors, and ICs to be inserted and connected with jumper wires. The internal connections of the breadboard are arranged in rows and columns to establish electrical connections. Breadboards are reusable and ideal for testing circuit designs before final assembly. They are widely used in educational, DIY, and development environments for creating temporary circuits.

Fig 11. Bread board

- **L298N Motor driver:** Figure 12 represents an L298N motor driver which is an electronic device that controls the operation of a motor by regulating its speed, direction, and torque. It acts as an interface between a low-power control signal (like from a microcontroller) and the higher power needed to run the motor. Motor drivers can handle DC, stepper, and AC motors, depending on their design. They typically include components like transistors, H-bridge circuits, or relays to control the motor’s behavior. Motor drivers are commonly used in robotics, automation.

Fig 12. L298N Motor driver

- **REES52 IR remote control module:** Figure 13 is an infrared (IR) remote control module used to wirelessly control electronic devices by transmitting signals via infrared light. It consists of an IR LED for transmitting data and an IR receiver to decode the signals. The module typically communicates with a microcontroller, sending data in a modulated pattern. IR remotes are commonly used in TVs, appliances, and electronics for short-range communication.

Fig 13. REES52 IR remote control module

SOFTWARE USED

- **Arduino IDE:** The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension. ino.

Fig 14. Arduino IDE Tool

RESULTS

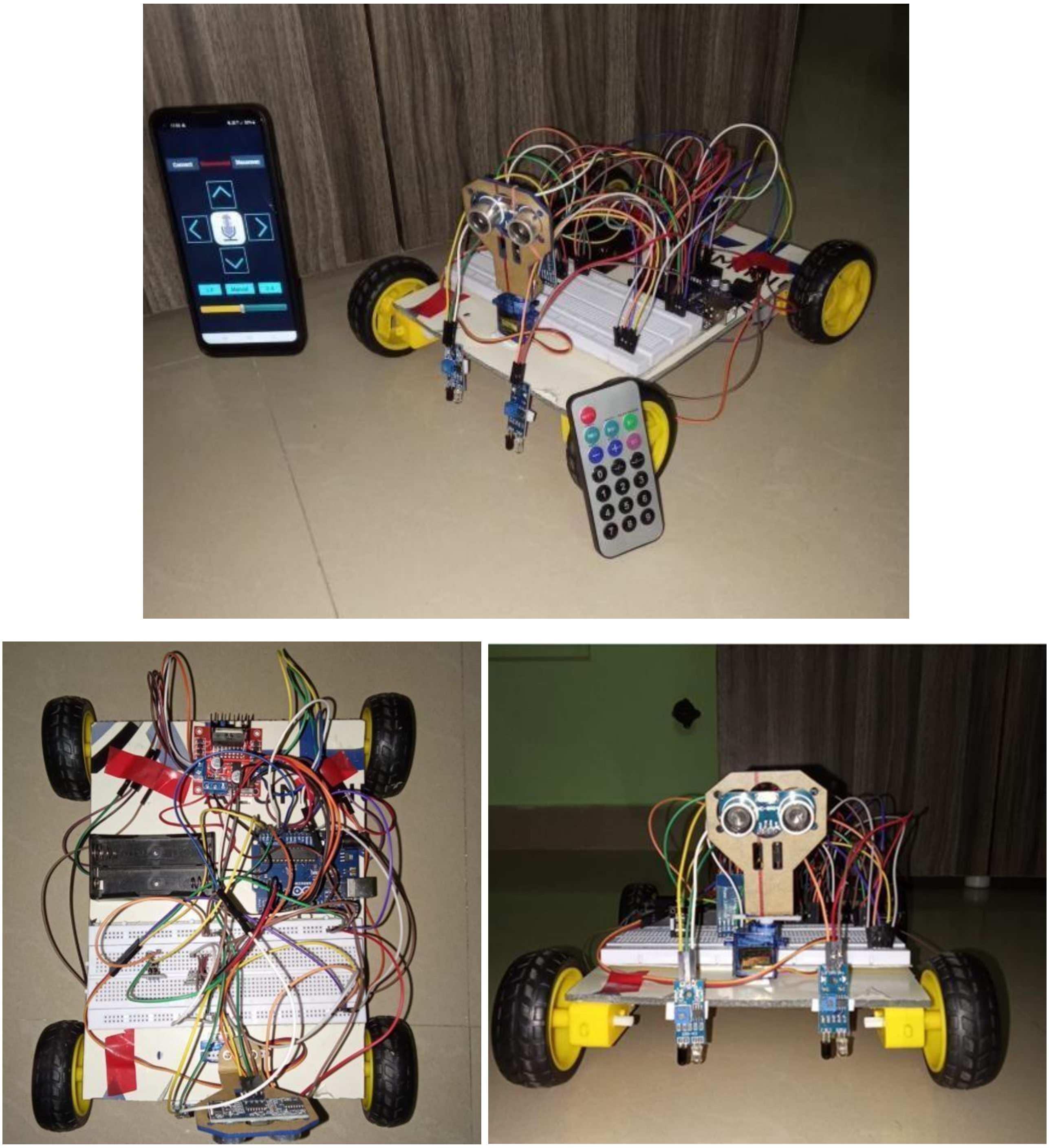


Fig 15. Overall Results

APPLICATIONS

- **Home Automation**: The robot can assist in automating household tasks such as controlling appliances, cleaning, or security monitoring through voice and remote control.
- **Assistive Technology**: It can provide support to individuals with physical disabilities by responding to voice commands for basic tasks or navigation assistance.
- **Industrial Operations**: The robot can enhance efficiency in industrial environments by automating repetitive tasks, monitoring operations, or moving materials.
- **Autonomous Vehicles**: Line-following and obstacle-avoidance capabilities make it suitable for creating prototypes of autonomous delivery or transport systems.
- **Search and Rescue**: Equipped with obstacle avoidance, the robot can navigate disaster zones, helping locate survivors or deliver supplies in inaccessible areas.
- **Warehouse Robotics**: Line-following functionality can be utilized to automate goods transport and inventory management in warehouses.
- **Automated Delivery Systems**: The robot can deliver items within controlled environments, like campuses or industrial sites, by following paths and avoiding obstacles.
- **Production Line Monitoring**: It can assist in monitoring and managing production lines by transporting tools or parts along a predetermined route.
- **Indoor Navigation**: The robot can be used as a guide in indoor environments like museums, hospitals, or offices to lead visitors or staff to their destinations.
- **Remote-Controlled Toys**: Its Bluetooth control and multi-functional abilities can make it a versatile and educational toy for children and hobbyists.
- **Custom Robotics Projects**: The modular design allows it to be adapted for various experimental or research purposes in robotics and automation.
- **Industrial Equipment Management**: The robot can assist in monitoring, inspecting, or transporting equipment in industrial setups, ensuring safe and efficient operations.

CONCLUSION & FUTURE ENHANCEMENT OF WORK

- The 4-in-1 robot is a versatile, adaptable, flexible, and scalable system that incorporates multiple modes integrated into a single platform. By integrating voice control, Bluetooth control, obstacle avoidance, and line-following functionalities, the project addresses the limitations of single-function robots while offering a cost-effective and compact solution. Additionally, the robot is designed to consume minimal power, prioritizing energy efficiency, and features a simple, clean, and uncluttered design for ease of use and maintenance.

- This robot has the potential to be used in diverse applications, including home automation, industrial operations, assistive technology, and search and rescue missions. Moreover, additional features can be added to the 4 in 1 robot for upgradation like an ESP32 camera which can make the robot more efficient in obstacle avoiding even in tight and complex areas. Also, the camera integrated with the ultrasonic sensor can be used as a surveillance camera, adding a new feature. A WIFI Module can also be added to increase the control range of the robot as Bluetooth module provides control only within limited range of distance.

PROJECT PLAN

WEEK 1	Generate and finalize project idea.
WEEK 2	Conduct a comprehensive literature survey and gather relevant research papers.
WEEK 3	Identify and list all required components for the project.
WEEK 4	Purchase all necessary components.
WEEK 5	Receive and organize purchased components.
WEEK 6	Begin testing the functionality of individual components.
WEEK 7	Continue testing component functionality, resolving any issues.
WEEK 8	Continue writing and refining code, integrating additional features.
WEEK 9	Complete code development and test overall system integration.
WEEK 10	Performthorough testing and debugging of the entire system.
WEEK 11	Prepare for final project presentation and demonstration.
WEEK 12	Conduct a full project demonstration, showcasing all functionalities.

PROJECT COST

COMPONENTS	QUANTITY	ESTIMATED COST(Rs)	ACTUAL COST(Rs)
ARDUINO UNO	1	400	500
L298N MOTOR DRIVER	1	200	160
IR SENSOR	2	120	160
ULTRASONIC SENSOR	1	80	100
SERVO MOTOR	1	60	60
HC-05 BLUETOOTH MODULE	1	120	200
18650 Li-ION BATTERY (3.7V)	2	80	100
2-CELL BATTERY HOLDER	1	60	25
DC GEAR MOTOR	4	180	220
IR REMOTE CONTROL MODULE	1	120	180
BREAD BOARD	1	80	60
JUMPER WIRES	3 strips	150	105
TOTAL	-	1650	1870

DEMONSTRATION PLAN

- **Voice Control Demonstration (2-3 minutes):**
  - Activate the voice control feature.
  - Issue voice commands such as "move forward," "turn left," or "stop," and showcase the robot's response.

- **Bluetooth Control Demonstration (2-3 minutes):**
  - Pair the robot with a smartphone via Bluetooth.
  - Control its movements using a mobile application, showing precise responses to commands.

- **Obstacle Avoidance Demonstration (2-3 minutes):**
  - Place obstacles in the robot's path and demonstrate its ability to detect and navigate around them without collision.

- **Line Following Demonstration (2-3 minutes):**
  - Place the robot on the pre-designed track and show how it follows the line accurately, even during curves or intersections.

INDIVIDUAL AND TEAM CONTRIBUTION

NAME	CONTRIBUTON
MOHAMMED TAHA	WORKED ON EXECUTION AND IMPLENTATION OF PROJECT AND PAPER WORKS
KIRAN G	WORKED ON IMPLEMENTATION OF PROJECT, PPT AND REPORT WORKS
LOHITH YAADAV R	WORKED ON DEMONSTRATION OF PROJECT, PAPER WORKS
MANOJKUMAR N	WORKED ON DEMONSTRATON OF PROJECT, PPTAND REPORT WORKS

IMPLEMENTATION PAPER

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4 IN 1 MULTIPURPOSE ROBOT

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Abstract: This paper presents the design and development of a 4 in 1 Multipurpose Robot, engineered to perform a variety of tasks. The robot integrates four distinct operating modes: Voice Control, Obstacle Avoidance, Line Following, and Bluetooth Control. The Voice Control Mode allows users to operate the robot through voice commands, providing hands-free functionality. The Obstacle Avoidance Mode uses ultrasonic sensors to navigate around obstacles, ensuring smooth movement. In Line Following Mode, the robot follows a predefined path using IR sensors for precise movement along the line. The Bluetooth Control Mode enables wireless communication with the robot via a mobile application developed using the MIT app inventor, providing manual control and mode switching. Powered by an Arduino Uno, the robot uses key components including DC motors, an L298N motor driver, ultrasonic sensor, servo motor, HC-05 Bluetooth module, and REES52 IR remote and receiver module. The robot operates with minimal power consumption and the connections designed are designed to be clean and uncluttered, using fewer components to simplify the setup. The robot's design ensures flexibility and scalability for future enhancements or additional features.

Keywords **– 4 in 1 Multipurpose robot, Arduino Uno, Voice control, Bluetooth control, Obstacle avoidance, Line following, HC-05 Bluetooth module, REES52 IR remote and receiver module, minimal power consumption.**

I. Introduction

With the growing demand for automation in both industrial and home environments, robots that can handle a variety of tasks are becoming increasingly important. The 4-in-1 Multipurpose Robot is created to meet this need, combining four distinct modes of operation: Voice Control, Obstacle Avoidance, Line Following, and Bluetooth Control. Each of these modes serves a unique purpose, allowing the robot to adapt to different environments and tasks.

The Voice Control Mode enables hands-free operation, allowing the robot to respond to voice commands for movement and tasks. In Obstacle Avoidance Mode, ultrasonic sensors help the robot detect and navigate around obstacles in its path, ensuring smooth and efficient movement. The Line Following Mode uses IR sensors to follow a predefined path, making it ideal for precise navigation along lines or tracks. Finally, the Bluetooth Control Mode connects the robot to a mobile app developed with MIT App Inventor, enabling users to manually control the robot, switch between modes, and issue voice commands remotely.

Designed for efficiency, the robot is optimized to consume minimal power while ensuring reliable performance. We've kept the components to a minimum to ensure clean, uncluttered connections that help the robot run smoothly. The modular design allows for easy upgrades and additions, making the robot adaptable for future enhancements. This project aims to provide a practical, multi-functional robot that can be used across a variety of fields, including education, industry, and personal applications.

II. Literature Survey

A. Chaudhry, M. Batra, P. Gupta, S. Lamba and S. Gupta, "Arduino Based Voice Controlled Robot," 2019 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS), Greater Noida, India, 2019, pp. 415-417, Doi: 10.1109/ICCCIS48478.2019.8974532. In this research paper, a system is being proposed, which focuses on the concept of how a robot can be controlled by the human voice. Voice control robot is just a practical example of controlling motions of a simple robot by giving daily used voice commands. In this system, an android app is used as a medium for the transmission of human commands to microcontroller. A controller can be interfaced with the Bluetooth module through the UART protocol. The speech is received by the android app and processed by the voice module. Voice is then converted to text. [1] The microcontroller will further process this text, which will take a suitable action to regulate the robot. The objective is to design a robotic car whose basic movements such as moving forward, turning to left or right can be controlled by the human voice. Generally, recognition of human voice using some kind of module cost way too much. This study proposes an easy way to implement voice-controlled mechanism in a robot which is cost effective and has a simpler design.

D. Pal, N. Kaur, R. Motwani, A. D. Mane and P. Pal, "Voice-Controlled Robot using Arduino and Bluetooth," 2023 3rd International Conference on Smart Data Intelligence (ICSMDI), Trichy, India, 2023, pp. 546-549, Doi: 10.1109/ICSMDI57622.2023.00103. This paper proposes a voice-controlled robotic system that uses Bluetooth to follow human commands. The voice commands are given to an android app built using MIT App Inventor. These commands are then sent to the Bluetooth module which then sends them to the controller interfaced with it. This interfacing was done using Universal Asynchronous Receiver-Transmitter (UART) Protocol. After processing the commands, the microcontroller controls the movement of the robot in different directions.[2] An open-source hardware and software is used in the proposed research work. Further, the proposed model can be implemented by almost every student for educational and understanding purposes as it is both economical and easy-to-use. This study considers the domain of Natural Language Processing (NLP) as well as communication using Bluetooth, both of which have high possibilities in future based on the technological advancement.

Bisen, Divyanshu & Makode, Ayushi & Itiwale, Janvi & Warade, Samiksha & Malewar, Prof.Trupti. (2024). Multi-functional Obstacle Avoidance Arduino Robot Car. IJARCCE. 13. 10.17148/IJARCCE.2024.13128. This study proposes a multipurpose robot car that avoids obstacles, which is built on the Arduino platform. This project's goal is to build an adaptable, autonomous robot that can go through many types of surroundings and instantly avoid obstacles. The robot uses a mix of motor control and sophisticated algorithms to assure obstacle avoidance, and it uses ultrasonic sensors to identify impediments. In addition to ultrasonic sensors for obstacle detection, the robot integrates an ESP32 camera coupled with YOLO (You Only Look Once) object recognition.[3] The incorporation of the ESP32 camera enhances the robot's perception capabilities, allowing it to capture real-time visual data from its surroundings. The YOLO object recognition system further enables the robot to identify and categorize objects swiftly and accurately. The integration of many components for better obstacle detection makes it complicated, incorporates a cluttered design and consumes high voltage which is difficult and expensive to implement.

Khin Khin Saw | Lae Yin Mon "Design and Construction of Line Following Robot using Arduino" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-4, June 2019, pp.939-941. This paper incorporates a line following robot which detects black line to move over the white surface or bright surface. The line following robot is constructed by using Arduino nano microcontroller as a main component and consists of three infrared (IR) sensors, four simple DC motors, four wheels and a PCB frame of robot chassis.[4] The infrared sensors are used to sense the black line on white surface. When the infrared signal falls on the white surface, it gets reflected and it falls on the black surface, it is not reflected. In this system, four simple DC motors attached with four wheels are used to move the robot car's direction that is left, right and forward. The Arduino nano is used as a controller to control the speed of DC motors from the L2953D driver circuit.

A. Sah, A. Muppidwar, A. Raut, J. Nakhate, A. Gavande, and P. Kadam, "Multi-Functional Arduino Robot 'Anima': Review," International Journal for Research in Applied Science and Engineering Technology (IJRASET), vol. 11, no. 3, pp. 230-234, Mar. 2023. DOI: 10.22214/ijraset.2023.56057. In this research paper, a robot with obstacle avoiding and Bluetooth connectivity is built. The obstacle avoiding functionality is integrated with Bluetooth control. This robot incorporates ultrasonic sensor and motion sensors for optimal detection of objects and also a Bluetooth module for wireless connection to a smart device.[5] It also incorporates additional small features like wall following and edge detection and has been programmed with controlled algorithms. The robot can be fully controlled via an application which also allows for mode switching. Overall, this project is cost effective and consumes minimal power for functioning.

Zaw & Aye (2020). Design and Implementation of Universal Motor Control Using IR Remote and Arduino. International Research Journal of Computer Science, Volume VII, 144-150. The main objective of this paper is used to control DC motors for speed control and load characteristics. This system involves interfacing stepper, servo and DC motors on a single platform. IR remote and IR receiver module is used to control all motors. The IR remote communicates digital pulse signals with the Arduino. The remote or the transmitter produces light in the IR spectrum instead of visible spectrum. The IR receiver converts the IR light into electrical signal.[6] The electrical signal in turn is converted to the IR light signal. Finally, the IR light signal is converted to binary form and passed onto the Arduino for processing. This study gives a clear and complete working of IR remote and receiver module. Each time a button is pressed on the remote unique hexadecimal codes are generated. Hence the hexadecimal generated for each key is recorded which is essential for coding.

S. Mandal, S. K. Saw, S. Maji, V. Das, S. K. Ramakuri and S. Kumar, "Low-cost Arduino WIFI Bluetooth integrated path following robotic vehicle with wireless GUI remote control," 2016 International Conference on Information Communication and (ICICES), Chennai, India, 2016, pp. 1-5, doi: 10.1109/ICICES.2016.7518916. This research paper presents path following two wheeled compact portable robots with Arduino nano as central driving functional unit with novel features of wireless control using WIFI and Bluetooth module with collision detection, avoidance and control features which provides the unique ability of danger avoidance, falling from a height with improved stability and precision control. The extremely sophisticated design provides very good controlled movement on horizontal ground terrain surfaces with data collecting and processing capabilities.[7] The design is integrated with infrared sensors, Bluetooth module, WIFI module control with dc gear motors which controls the speed of the vehicle of the robotic vehicle. It has the unique ability of running in maze with path following abilities controlled from any remote location using WIFI for long range control and Bluetooth for short range control. In this research article an entire system is designed and implemented in which movement is stably controlled based on feedback from infrared transmitter receiver module.

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D. Arulselvam, C. Nayanatara, P. Sharmila and M. Priyadharshini, "IoT Based Robot for Domestic Surveillance Using ESP-NodeMCU," 2023 Intelligent Computing and Control for Engineering and Business Systems (ICCEBS), Chennai, India, 2023, pp. 1-5, doi: 10.1109/ICCEBS58601.2023.10448871. This paper presents an overview of an IoT-based robot designed for domestic surveillance, leveraging the ESP-Node MCU platform. The proposed system combines the capabilities of a mobile robot with the flexibility of the ESP-Node MCU microcontroller, creating an efficient and cost-effective solution for monitoring and securing residential spaces. The key components of this system include a robot chassis, wheels, motors, a camera module, ultrasonic sensors, and the ESP-Node MCU microcontroller.[8] To enhance the robot's navigational capabilities, ultrasonic sensors are integrated into the system. These sensors enable obstacle detection and avoidance, ensuring that the robot can move autonomously through the home environment without colliding with objects or obstacles. This system is a more advanced and complex as the camera used can be programmed for both obstacle detection and surveillance.

A. Azhiimah, K. Alfiantin, K. Khotimah, M. Sumbawati, and A. Santosa, "Automatic control based on voice commands and Arduino," in Advances in Engineering Research, 2020. doi: 10.2991/aer.k.201124.006. This paper presents automation control based on voice commands and an Arduino for processing. Voice commands are of two types voice recognition and speech recognition. Voice recognition is specific to a particular person's voice. It works by analyzing the individual's tone, style and speech accent.[9] A voice recognition module V3 is used for voice recognition which is expensive and difficult to implement. On the other hand, speech recognition involves converting the voice commands to text and sending it to Arduino for processing. The use of such technology can be found on Google voice, Microsoft dictation and so on. Voice control does not require much power consumption and requires a speaker to capture the voice command.

A. Vijayaraj, A. Deepika, A. K, G. V, G. A and I. H, "Obstacle Detection and Avoidance Robot with Multi-Control System Using IoT," 2023 International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE), Chennai, India, 2023, pp. 1-7, doi: 10.1109/RMKMATE59243.2023.10369630. This project aims to develop an obstacle detection and avoidance robot using the IoT (Internet of Things) with multiple control systems, including voice, terminal, and Bluetooth mode. The proposed robot is designed to navigate through its environment autonomously and avoid obstacles in its path using an ultrasonic sensor. It also includes a servo motor for steering and a gear motor for driving the wheels. The robot can be controlled using various modes, including voice mode, terminal mode, and Bluetooth mode.[10] The voice mode allows the user to communicate with the robot using voice commands, while the terminal mode enables the user to send commands to the robot through a terminal window. The Bluetooth mode allows the user to control the robot wirelessly using a smartphone or a tablet. The IoT capabilities are implemented using a Wi-Fi module, which enables the robot to connect to the internet and be controlled remotely from anywhere in the world.

III. System Design and Components

The design consists of components necessary for the four different modes built. The voice-controlled mode incorporates a built-in speech to text conversion technique. Speech recognition type of voice command. The Bluetooth controlled mode uses HC-05 Bluetooth module for wireless connection with the mobile for operation via the developed mobile application. The obstacle avoiding mode uses HC-SR04 ultrasonic sensor for object detection which is mounted on the SG 90 servo motor for wide range of detection. The line following mode uses two IR sensors attached in the front of the robot facing the ground for line detecting and following. The robot is a 4-wheel robot which uses 4 DC gear motors for movement, the speed of which is controlled by the L298N motor driver. It also consists of a bread board to make the connections. Additionally, a REES52 IR remote and receiver module is also used in case there are issues with the Bluetooth connectivity due to which there may arise difficulties which may not allow the user to control the robot via the mobile app. All this is powered by an Arduino UNO and two Li-ion 18650 batteries of 3.7V each. The setup is mounted on the robot chassis. Figure 1 shows the diagrammatic representation of the design and Figure 2 illustrates the connections of the complete setup.

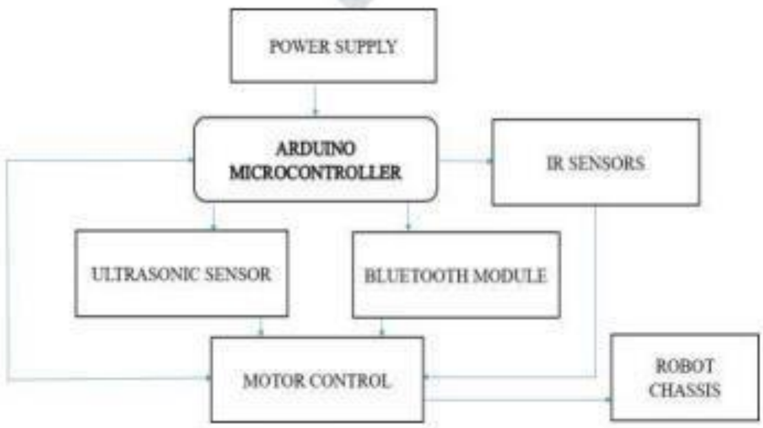

Fig 1. Block diagram

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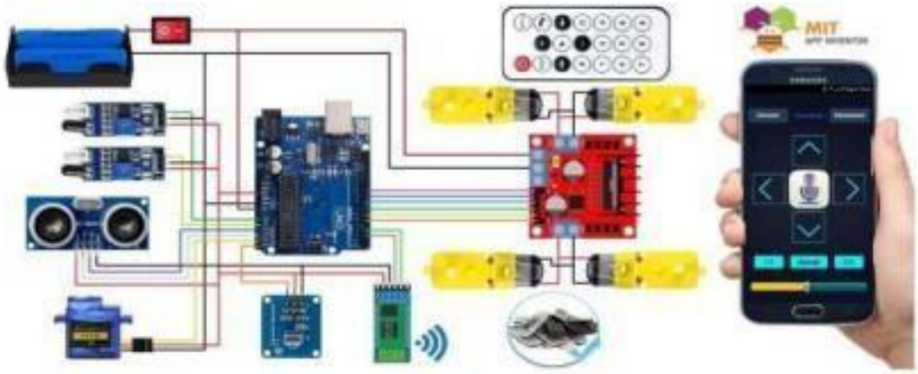

Fig 2. Circuit diagram

Components used:

Arduino UNO: Figure 3 illustrates an Arduino UNO a microcontroller board based on the ATmega328P. It has 14 digital input/output pins. It allows users a simple pathway to creating interactive objects that can take input from switches and sensors, and control physical outputs like lights, motors.

Fig 3. Arduino Uno

IR sensor: Figure 4 illustrates an IR (Infrared) sensor a type of sensor that uses infrared radiation to detect objects, measure distances, or recognize specific environmental conditions. It works by emitting or receiving infrared light, which is invisible to the human eye. IR sensors are commonly used in various applications due to their simplicity, reliability, and cost-effectiveness.

Fig 4. IR sensor

HC-SR04 Ultrasonic sensor: Figure 5 shows an ultrasonic sensor a device that uses ultrasonic waves to measure the distance to an object or detect its presence. It works similarly to radar or sonar, emitting sound waves at a frequency higher than humans can hear (usually above 20 kHz) and measuring the time it takes for the sound to reflect off an object and return to the sensor. By calculating the time delay, the sensor determines the distance between itself and the object.

Fig 5. HC-SR04 ultrasonic sensor

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SG 90 Servo motor: Figure 6 illustrates a servo motor which is a rotary or linear actuator designed for precise control of angular or linear position, speed, and acceleration. It consists of a motor, a feedback sensor (usually a potentiometer), and control circuitry. Servo motors are widely used in robotics, CNC machinery, and automated systems for tasks requiring precise movement. They are controlled by pulse-width modulation (PWM) signals, where the pulse duration determines the motor's angle or position. Typically compact, they are energy-efficient and offer high torque in small sizes, making them ideal for applications like robotic arms and drones.

Fig 6. SG 90 Servo motor

HC-05 Bluetooth module: Figure 7 is a HC-05 Bluetooth module which is a popular, easy-to-use module for wireless communication in embedded systems. It operates using Bluetooth 2.0 technology and supports both master and slave modes. Commonly used in robotics and IoT projects, it allows devices like microcontrollers to communicate wirelessly with smartphones or computers. The module operates at 3.3V to 5V, with a communication range of up to 10 meters. It uses serial communication (UART) to transmit and receive data, making it ideal for Arduino and other microcontroller projects.

Fig 7. HC-05 Bluetooth module

Li-ion battery (18650): Figure 8 illustrates a Lithium-ion (Li-ion) batteries which are rechargeable power sources commonly used in electronics and electric vehicles. They consist of a cathode (positive electrode), an anode (negative electrode), and an electrolyte that allows ion movement. Li-ion batteries are lightweight, have high energy density, and offer a long cycle life. They store energy by moving lithium ions between the anode and cathode during charging and discharging. Common cathode materials include lithium cobalt oxide and lithium iron phosphate. Li-ion batteries are prone to degradation over time, losing capacity with repeated use.

Fig 8. Li-ion battery (18650)

2-Cell battery holder: Figure 9 shows a cell battery holder which is a device used to securely hold a battery or multiple batteries in place for easy connection to an electrical circuit. It ensures proper alignment and contact between the battery terminals and the circuit. Commonly made from plastic or metal, these holders can accommodate different battery types, such as AA, AAA, or coin cells. They often include a spring or clip mechanism to maintain pressure on the battery. Battery holders are designed for convenience, allowing easy battery replacement and preventing short circuits. They are widely used in electronic devices, toys, and DIY projects.

Fig 9. 2-Cell battery holder

DC gear motor: Figure 10 illustrates a DC gear motor an electric motor combined with a gear system that reduces speed while increasing torque. It operates on direct current (DC) power and is commonly used in applications that require precise control of speed and movement. The gear mechanism adjusts the motor's output to achieve desired rotational force. These motors are widely used in robotics, automotive, and home appliances. DC gear motors are compact, efficient, and suitable for various low-speed.

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Fig 10. DC gear motor

Bread board: Figure 11 illustrates a breadboard which is a tool used for prototyping electronic circuits without soldering. It consists of a grid of holes, allowing components like resistors, capacitors, and ICs to be inserted and connected with jumper wires. The internal connections of the breadboard are arranged in rows and columns to establish electrical connections. Breadboards are reusable and ideal for testing circuit designs before final assembly. They are widely used in educational, DIY, and development environments for creating temporary circuits.

Fig 11. Bread board

L298N Motor driver: Figure 12 represents a L298N motor driver which is an electronic device that controls the operation of a motor by regulating its speed, direction, and torque. It acts as an interface between a low-power control signal (like from a microcontroller) and the higher power needed to run the motor. Motor drivers can handle DC, stepper, and AC motors, depending on their design. They typically include components like transistors, H-bridge circuits, or relays to control the motor's behavior. Motor drivers are commonly used in robotics, automation.

Fig 12. L298N Motor driver

REES52 IR remote control module: Figure 13 is an infrared (IR) remote control module used to wirelessly control electronic devices by transmitting signals via infrared light. It consists of an IR LED for transmitting data and an IR receiver to decode the signals. The module typically communicates with a microcontroller, sending data in a modulated pattern. IR remotes are commonly used in TVs, appliances, and electronics for short-range communication.

Fig 13. REES52 IR remote control module

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IV. Methodology

Hardware setup:

An analysis was conducted where hardware requirements for each mode- Bluetooth control, Obstacle avoidance and Line following were identified. All the required set of components were mounted on the robot chassis and the connections were made as per the circuit diagram shown in Figure 2. The ultrasonic sensor was placed facing front on top of the servo motor for detecting objects efficiently. The two IR sensors were placed at the front of the robot facing the ground, a minimum space of 6cm was given between the two IR sensors, this depends on the width of the line being followed and may vary for different cases. The sensors were calibrated in a way such that it detected the white surface and generated output 1(HIGH) and for the black line the sensors generated output 0(LOW). The logic was the robot moved only when it detected the white surface and would stop movement if it detected the black line. Hence, the IR sensors had to be placed in a way where they did not face the black line directly. The black line had to be exactly in the middle of the two IR sensors for its proper functioning. The Bluetooth control required the usage of Bluetooth module which is paired to the mobile phone.

All components here receive 5V directly from the Arduino, the voltage connections for every component are made on the bread board due to shortage of voltage pins on the Arduino UNO, the same goes for the ground connections. Moreover, analog pins of the Arduino UNO are used in connection for ultrasonic sensor, IR sensors, servo motor and IR receiver module. The digital pins are used for L298N motor driver and Bluetooth module. In this way we make sure that every component is connected and receives the right amount of voltage for proper operation. Two 18650 Li-ion batteries are used to power up the system which are held in a 2-cell battery holder with positive and negative connections directly connected to the Arduino UNO.

Software setup:

Once the hardware connections were made, each mode was programmed separately using the Arduino IDE. Voice controlled and response, Obstacle avoidance with ultrasonic sensors, Line following with IR sensors and Manual control via Bluetooth module. After programming and testing each function separately we integrated all of it into one. The code written mostly contained hexadecimal codes because of the use of IR remote and receiver module which is known for generating hexadecimal codes each time we press a button on the remote.

```
long IRremote_data(){
    if (results.value==0xFF02FD) {IR_data=1;}
  else if (results.value==0xFF9867) {IR_data=2;}
  else if (results.value==0xFFE01F) {IR_data=3;}
  else if (results.value==0xFF906F) {IR_data=4;}
  else if (results.value==0xFF629D || results.value==0xFFA857) {IR_data=5;}
  else if (results.value==0xFF30CF) {IR_data=8;}
  else if (results.value==0xFF18E7) {IR_data=9;}
  else if (results.value==0xFF7A85) {IR_data=10;}
  return IR_data;
}
```

The above function is a part of the code where recorded hexadecimal values are used. This function maps specific hexadecimal IR codes to numerical values (IR_data). These numerical values are easier to work with in the main program and can correspond to different robot functionalities such as:

1: forward movement
2: backward movement
3: left movement
4: right movement
5: stop
8, 9, 10: Manual control, line following and obstacle avoiding respectively.

Suppose we press 1 on the IR remote, 1 is send on the Bluetooth module which communicates with the Arduino and robot moves forward as 1 is defined for forward movement in the code, same stands for all other buttons.

By using this function, the program can easily interpret which button was pressed on the remote and perform the corresponding action. The robot can be controlled using the IR remote or the Mobile app.

Mobile app development:

A mobile application with user friendly interface was developed using MIT app inventor. Figure 14 shows the app interface, the app has two buttons at the top- connect and disconnect which enables or disables Bluetooth connection with the HC-05 Bluetooth module. If connect option is clicked a Bluetooth pair list opens which gets the device connected. Below this, there is a speech recognition mic-like icon which when pressed calls a speech recognizer function to capture voice commands and converts them into text for voice control function. There are also up, down, right and left arrows surrounding the mic icon which are used for manual control, this function is enabled when the manual option is selected. Below this, there are three buttons reading LF (line following), manual and OA (obstacle avoiding), these can be used to switch between modes. At the bottom there is a slider which is used to control the speed of the robot from 0 to 255 duty cycle. Only for line following function the maximum speed set is 130 duty cycle which is defined in the code as the robot requires to be a bit slow moving to ensure optimum performance for line following especially while making turns along the line.

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Fig 14. App interface

V. Results and Discussions

The robot performed well across all its modes, showcasing a blend of hardware and software integration. The ultrasonic sensor, mounted on the servo motor, accurately detected obstacles and guided the robot to avoid them without any issues. The IR sensors effectively followed the black line on the track, with their placement and calibration proving crucial for smooth navigation, even on sharp curves. The Bluetooth module connected effortlessly to the mobile app, allowing users to switch between modes, control the robot manually, and adjust speed in real-time. The app itself, developed using MIT App Inventor, provided an intuitive interface, making it easy to control the robot through voice commands and buttons. The robot maintained a high success rate of 95% in obstacle avoidance and demonstrated consistent performance in line-following. However, in line-following mode, the robot had to slow down for better accuracy during turns, indicating room for improvement in speed optimization. Figure 15 presents the Front view of the robot and Figure 16 presents the Top view of the robot. Overall, the project successfully combined functionality and user-friendliness, creating a robot that operated efficiently and met the intended objectives.

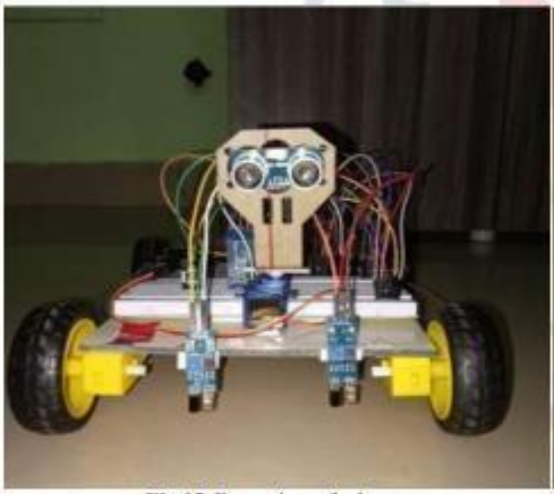

Fig 15. Front view of robot

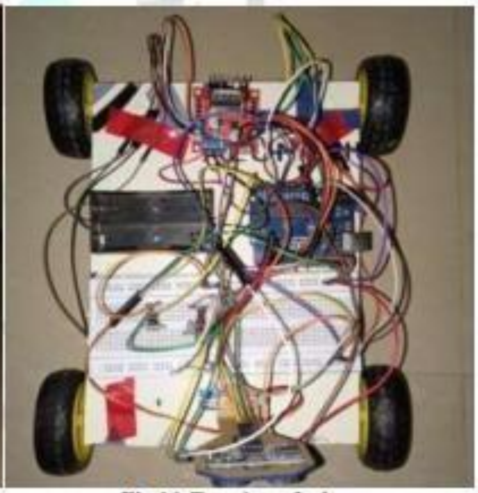

Fig 16. Top view of robot

VI. References

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