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A MULTI MODE SMART ROBOT FOR ASSISTANCE AND AUTOMATION

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Abstract - *This project of ours presents the development of a Multi-Mode Smart Robot for Assistance and Automation capable of operating four different major modes Voice Control, Bluetooth Remote Control, Human Following and Obstacle Avoidance. The goal of the system is to integrate powerful sensors and autonomous decision making within a compact 4-wheel robot. The robot uses an ESP32 microcontroller as the central processing unit, an offline voice-recognition module for command-based operations, ultrasonic and IR sensors for obstacle detection and an L298N motor driver for motion control. The proposed system user assistance through smart control, allowing hands-free operation, remote command operation, person tracking, and safe obstacle handling. The design aims to support applications in household automation, personal assistance, indoor mobility, warehouse logistics and security patrolling. Experimental results indicate that the robot efficiently works between modes and reliably executes commands, ensuring intelligent and adaptive behavior suitable for real world environments.*

Key Words: **Smart Robot, Voice Control, Human Following, Obstacle Avoidance, ESP32, Automation, Multi-Mode Robot**

1. INTRODUCTION

A smart robot is defined as robotic system capable of sensing, understanding and interacting with its surroundings to perform tasks automatic or semi-automatic. The concept of assistance refers to supporting human activities such as motion, object carrying, navigation and monitoring. Automation refers to enabling machines to perform tasks automatically with minimal human intervention. This project integrates all three concepts into a single robot that can be operated through multiple intelligent modes. The robot is designed to act as versatile assistant capable of responding to voice commands, following a human user, navigating indoors safely and operating under manual Bluetooth control. These features make the robot suitable for real life applications such as home automation, supporting elderly or disabled people, warehouse navigation, indoor delivery and security inspection.

1.1 Relevance of the Study

This project is relevant in today's technology where automation and intelligent robot assistants are increasingly used in homes, industries, healthcare and service sectors. Many existing robots depend on expensive components, cloud-based voice control, or high-complexity systems. This project provides a low-cost, offline, real-time smart robot that can perform multiple tasks without internet and external servers. The relevance also extends to educational, research and practical robotic development since it integrates multimode control and sensing.

1.2 Feasibility Study

1. **Technical Feasibility:** The system uses easily available hardware components ESP32, IR sensors, ultrasonic sensor, servo motor, motor driver which makes it ideal for implementation. Offline voice recognition reduces dependency on internet connection.

2. **Economic Feasibility:** All components used are low cost and easily available. The project can be built within a small budget, making it feasible for academic, hobby, and prototype applications.

3. **Operational Feasibility:** The robot can operate indoors on flat surfaces and can shift between modes without requiring reprogramming. The offline voice module ensures stable performance even in any environments without network connection.

2. LITERATURE SURVEY

1. **Paper title: Voice Controlled Robot with Obstacle Detection**

Author: Sanjana R, Shivani R. Shankar and M. V. Sreenivas Rao.

Abstract and relevance: This work uses Android-based voice recognition to control a robot and ultrasonic sensors for obstacle detection. The system requires internet connectivity and offers limited autonomy. Our project improves this by

using an offline voice module, enabling faster, more reliable command execution without internet support.

2. **Paper title: Human Following Robot Based on Motion Sensing Technology**

Author: V. Buragohain and P. Das

Abstract and relevance: The authors designed a human-following robot using simple motion sensors. It demonstrates that low-cost sensors can maintain human tracking with acceptable accuracy. Supports our IR and Ultrasonic hybrid human-following logic, giving a foundation for distance detection and following.

3. **Paper title: Bluetooth Based and GPS Based Follow Me Robot**

Author: Gujar, Ashutosh, and Kalyanee Jadhav

Abstract and relevance: This study operates Bluetooth controlled movement and GPS-based outdoor tracking. Confirms the reliability of Bluetooth manual control, which our robot uses as one of the main operational modes.

4. **Paper title: A person-following robotic cart controlled via a smartphone application: design and evaluation**

Author: Rawashdeh, Nathir A., Ramez M. Haddad, Omar A. Jadallah, and Abdelhadi E.

Abstract and relevance: They combined smartphone-based Bluetooth commands with autonomous following, proving that multi-mode switching is practical and stable. Relevance: Directly supports our system's dual-mode and multi-mode integration.

5. **Paper title: Design and development of human following robot.**

Author: Hassan, Muhammad Sarmad, Mafaz Wali Khan, and Ali Fahim Khan.

Abstract and relevance: This research focuses on ultrasonic based distance tracking and microcontroller-based motion control. Provides strong technical backing for our ultrasonic distance measurement, servo scanning and navigation adjustments.

3. Existing and Proposed system

3.1 Existing System

Existing robots generally operate in a single mode such as only voice control, only follow-me or only Bluetooth operation. Most depend on Google API's voice recognition or high-cost hardware, making them unsuitable for local and offline use.

3.1.1 Disadvantages of Existing System

- Single-function capability
- Dependency on internet or smartphone
- Limited sensing capability
- Poor obstacle handling
- Lack of autonomous behaviour

3.2 Proposed System

The proposed multi-mode smart robot integrates voice control, Bluetooth control, and autonomous follow mode and obstacle avoidance using multiple sensors, making intelligent, flexible and adaptive operation.

4. OBJECTIVES AND METHODOLOGY

4.1 Objectives

The objective is to design a multi-mode robot integrating voice, Bluetooth, human-following and obstacle avoidance. To make fully offline operation using ESP32 and Gravity voice module, reduce hardware cost while maintaining smart functionalities. Also to create a stable, safe and user-friendly robotic assistant.

4.2 Methodology

The System planning is considered first with hardware selection including Circuit and chassis design. Next the development for each mode starting with training the voice module followed by making the Bluetooth control system. Then comes obstacles avoidance with integration of IR sensor and ultrasonic sensor supported to servo for rotation control. Later all modes testing and performance validation.

5. DESIGN CONSIDERATION

The Design and developing a 4-wheel differential drive mechanism for robot movement. Considering the Servo- mounted ultrasonic sensor for scanning left, right and front. IR sensors placed forward tilted towards left and right both side each. Ensuring emergency stop during sudden obstacle.

For controlling the whole robot, the ESP32 microcontroller is chosen which has in build Bluetooth and Wi-Fi connectivity helps handling the bigger logic system and future enhancements IOT systems. Also considering smooth transitions between control modes

All the major considerations are designed and implantation are verified with references. The Proposed system has a unique design and working structure.

6. MATERIAL IDENTIFICATION AND SPECIFICATIONS

Table -1: Components and Specifications

Component	Specification	Purpose
ESP32 DevKit V1	Dual-core 32-bit MCU and Bluetooth	Main controller
Voice Recognition Module	Gravity Offline Voice Recognition, supports 17 commands	Manual voice control
Ultrasonic Sensor	2–200 cm range	Obstacle detection and follow.
IR Sensor	2–5 cm range	Emergency Stop
L298N Motor Driver	Operates 5–35V, 2A	Motor control
DC Gear Motor	200–255 RPM	Robot motion
Battery Pack	9–12V Li-ion	Power supply

7. WORKING PRINCIPLE

The working of multi-mode robot operates Voice mode control as major mode and all the other modes is switched from voice mode. When the voice commands are given, it operates based on the predefined function for all commands. To switch between mode, give command as "Bluetooth mode" it switches to Bluetooth mode and it can be connected to phone app which sends commands like, F-Forward, B-Backward, L-Turns Left, R-Turns Right, S-Stop robot.

The Obstacles Avoidance mode is switched when command "Obstacle Avoidance mode" is given which basically moves forward and divert its direction when an obstacle is detected from ultrasonic sensor. For human Following mode switching the command to be used is "Follow mode" the robot follows the person in front of robot about 30cm to 70cm maintaining the safe distance of 30cm.

IR sensors are used to detect sudden obstacle from either side of robot to make direct the robot to safer motion. The safety is active in all modes the sensor always checks for obstacle before any movement is operated to make safe movement without any harm to environment.

The Servo helps in scanning the environment which is mounted with ultrasonic sensor. All modes work on voice commands and switches accordingly when needed.

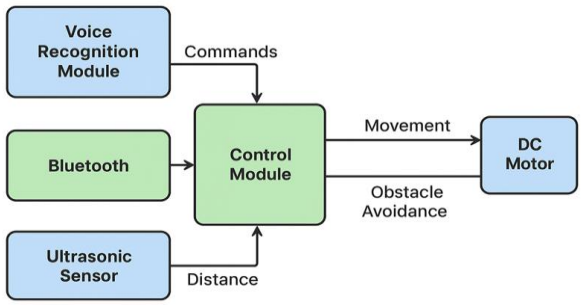

Fig -1: Block diagram

8. RESULTS & DISCUSSION

The multi-mode smart robot successfully responds to all voice commands with smooth Bluetooth operation also stable follow mode at 30–70 cm and Reliable obstacle detection up to 100 cm. The Mode switching accurate and fast.

Supported Commands

- "Hello Robot"
- "Forward"
- "Backward"
- "Stop"
- "Follow mode"
- "Turn left"
- "Turn Right"
- "Bluetooth mode"
- "Obstacle avoidance mode"

9. CONCLUSION

The multi-mode robot provides an efficient solution for assistance and indoor automation tasks. It performs voice control, Bluetooth operation, human following and obstacle avoidance effectively. The Deigning and developing the robot matches with the objective.

10. FUTURE ENHANCEMENT

- Integration of Machine Learning-Based Human Detection with camera vision.
- GPS and Outdoor Navigation
- Upgraded Voice Recognition Module
- Integration of IoT Features
- Battery Management and Solar Charging
- Advanced Obstacle Avoidance Using AI
- Multi-Sensor Fusion System

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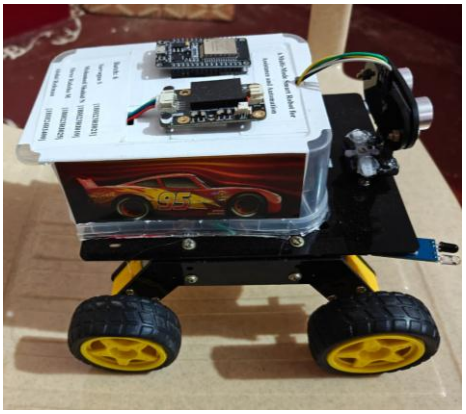
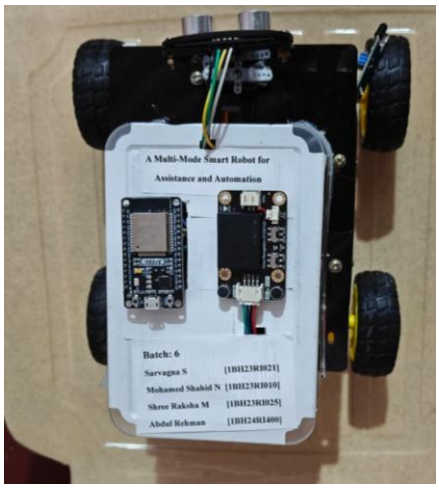
Appendix- Photographs of Prototype





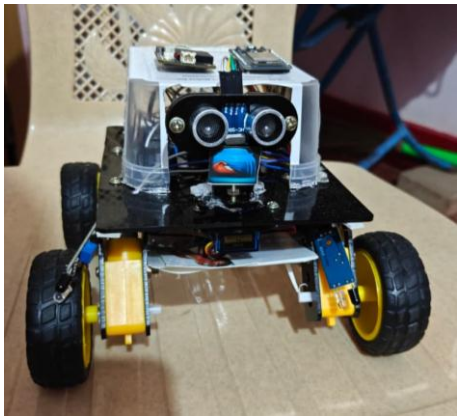


Fig -2: Prototype