Mini Project Report

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Branch: MCA(AI/ML) **Section: 24MAM-1B**
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Subject Name: Internet of Things **Subject Code: 24CAH-723**

Title: Arduino Obstacle Avoiding Robot with Voice Control and Bluetooth Control

Objectives:

1. **Autonomous Obstacle Detection and Avoidance:** Enable real-time obstacle detection using HC-SR04 ultrasonic sensor and autonomous navigation with automatic direction changes.
2. **Multi-Mode Control System Implementation:** Provide dual-control capability through autonomous mode (ultrasonic-based) and manual mode (Bluetooth smartphone control).
3. **Voice Command Recognition and Execution:** Integrate voice control functionality allowing users to command robot movement via speech-to-text through smartphone application.
4. **Motor Control and Movement Coordination:** Optimize L293D motor driver control of four DC gear motors for precise multi-directional movement (forward, backward, left/right turns).
5. **Real-Time System Integration and Optimization:** Achieve seamless integration of all hardware components with optimized firmware for responsive and reliable operation.

Components Required:

S.No.	Name of Component	Qty.
1.	Arduino UNO	1
2.	Gear Motor	4
3.	Robot wheels	4
4.	Motor Driver (L293D)	1
5.	Servo Motor	1
6.	Ultrasonic sensor	1
7.	Bluetooth Module	1
8.	Li-ion battery	2
9.	Li-ion battery holder	1
10.	Jumper Wires	15-25
11.	Cardboard	1
12.	Switch	1

Details of Components:

1. Arduino UNO

The Arduino UNO is a microcontroller development board based on the ATmega328P 8-bit microcontroller that serves as the brain of your robot. It features 14 digital input/output pins (6 with PWM support), 6 analog inputs, 32 KB flash memory, and operates at 5V with a 16 MHz clock speed. The board can accept input voltages between 7-12V and includes built-in voltage regulation, USB communication, and a reset button. It controls all robot movements, processes sensor data, and communicates with the motor driver and Bluetooth module.

2. Gear Motor (DC Gear Motor)

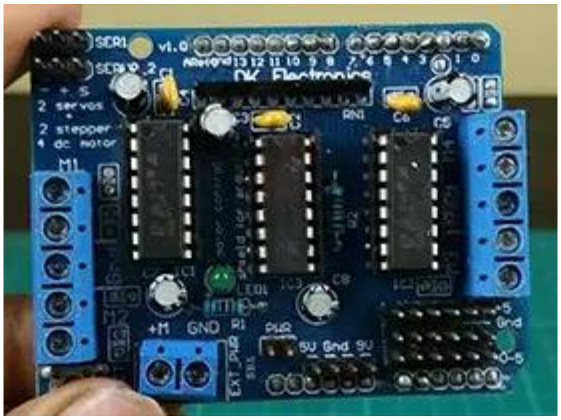
Gear motors are DC motors equipped with a gear reduction system that increases torque while reducing speed. Typical specifications include 3-12V operating voltage, 100-430 RPM rotation speed, and 50 g.cm torque. These compact, lightweight motors are ideal for mobile robots as they deliver consistent power at reduced speeds with silent operation. The dual-shaft design enables easy wheel mounting and provides the controlled movement necessary for obstacle avoidance navigation.

3. Robot Wheels

Robot wheels convert motor rotation into controlled robot movement and are typically made from rubber or TPU material. Standard sizes range from 50-100mm diameter, with wheel size directly affecting distance traveled per motor revolution. Four standard wheels provide stable forward/backward and turning motion with predictable handling. They mount easily on motor shafts and provide good traction on various surfaces for reliable robot locomotion.

4. Motor Driver (L293D)

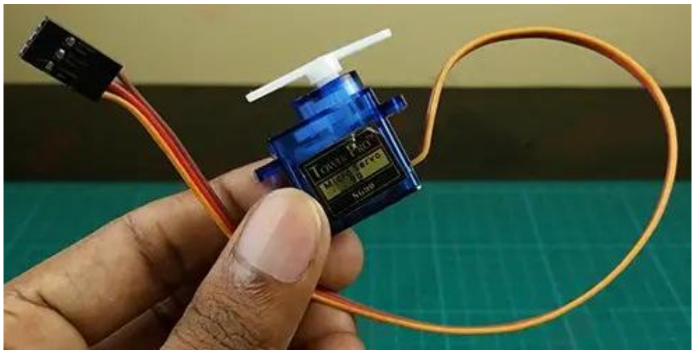
The L293D is a dual H-bridge motor driver IC that controls two DC motors simultaneously in both directions. Key specifications include 4.5-36V motor supply voltage, 5V logic voltage, 600 mA continuous current per channel, and 1.2A peak current. The IC features four control pins (IN1-IN4) for direction control and two enable pins for PWM speed adjustment. Built-in protection includes ESD protection and thermal shutdown to prevent overheating and damage.



5. Servo Motor

A servo motor is a specialized motor with closed-loop feedback control for precise positional accuracy. It operates on 4.8-6V DC, accepts PWM control signals at 50 Hz, and can be positioned to specific angles (typically 0° to 180°). Servo motors contain internal potentiometers and control circuitry that maintain position.

They consume 10 mA idle and 100-250 mA during movement, making them efficient for selective control tasks like sensor mount positioning.



6. Ultrasonic Sensor (HC-SR04)

The HC-SR04 operates on SONAR principles to measure distances using 40 kHz ultrasonic sound waves. It features a 2-400 cm detection range with ±3 mm accuracy and 15-degree measurement angle. Operating at 5V DC with 15 mA current, it transmits ultrasonic bursts that reflect off obstacles. The Echo pin output duration is proportional to distance, enabling real-time obstacle detection for autonomous navigation.

7. Bluetooth Module (HC-05)

The HC-05 implements Bluetooth v2.0 + EDR protocol for wireless communication between robot and smartphone. It operates on 4-6V, has a 100-meter communication range, and uses 9600 bps UART serial interface (configurable up to 460800 bps). The module operates in slave mode by default, making it ideal for receiving commands from smartphone applications for manual Bluetooth control and voice command integration.

8. Li-ion Battery (18650)

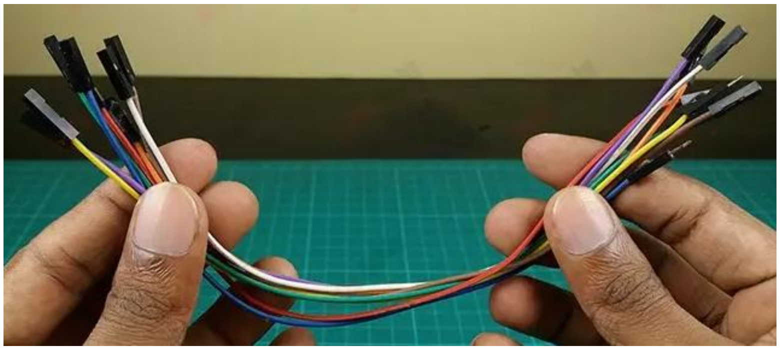
Lithium-ion 18650 batteries are rechargeable cylindrical cells with 3.7V nominal voltage, 2000-3600 mAh capacity, and 18 mm × 65 mm dimensions. They feature 4000 mA maximum discharge current and weigh approximately 45 grams each. These batteries offer high energy density, making them ideal for powering robot motors and electronics. Two batteries in series provide 7.4V output for adequate power delivery to the motor driver and Arduino.

9. Li-ion Battery Holder

A Li-ion battery holder is a plastic housing for securely holding 18650 cells and connecting them safely. Single-cell holders hold one battery (~3.7V) while dual-cell holders (series configuration) provide 7.4V output. Features include high-quality plastic construction, soldered wire leads for easy integration, and open-frame design for convenient battery installation and removal.

10. Jumper Wires

Jumper wires are flexible conductors used for temporary electrical connections on breadboards and between modules. Available types include male-to-male, male-to-female, and female-to-female configurations. Wires come in 20-29 AWG gauge, multiple color-coded options (red, black, green, blue) for circuit tracing, and various lengths (100-300 mm). They enable quick prototyping without soldering, allowing flexible circuit modifications during development.

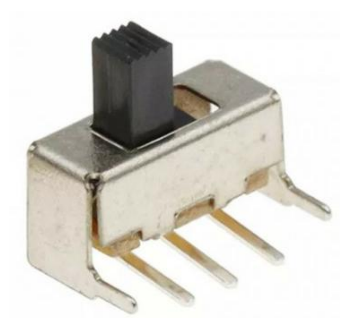


11. Cardboard

Cardboard is an economical and lightweight material commonly used as the chassis or structural frame for robot construction. Corrugated cardboard consists of multiple layers with an internal wavy "flute" structure that provides good strength-to-weight ratio at minimal cost. It has moisture sensitivity (optimal humidity 6-9%) which can reduce structural rigidity. It's ideal for rapid prototyping of robot chassis before transitioning to more durable materials for final designs.

12. Power Switch

A power switch controls electrical current flow to the robot's power system for safe ON/OFF operation. Common types include SPST toggle switches that stay in position after switching. The switch connects in series with the positive battery terminal, typically handling 1-2 amp current and requiring 20-50 millisecond debounce time to eliminate electrical noise. It allows safe power management without disconnecting battery leads directly.

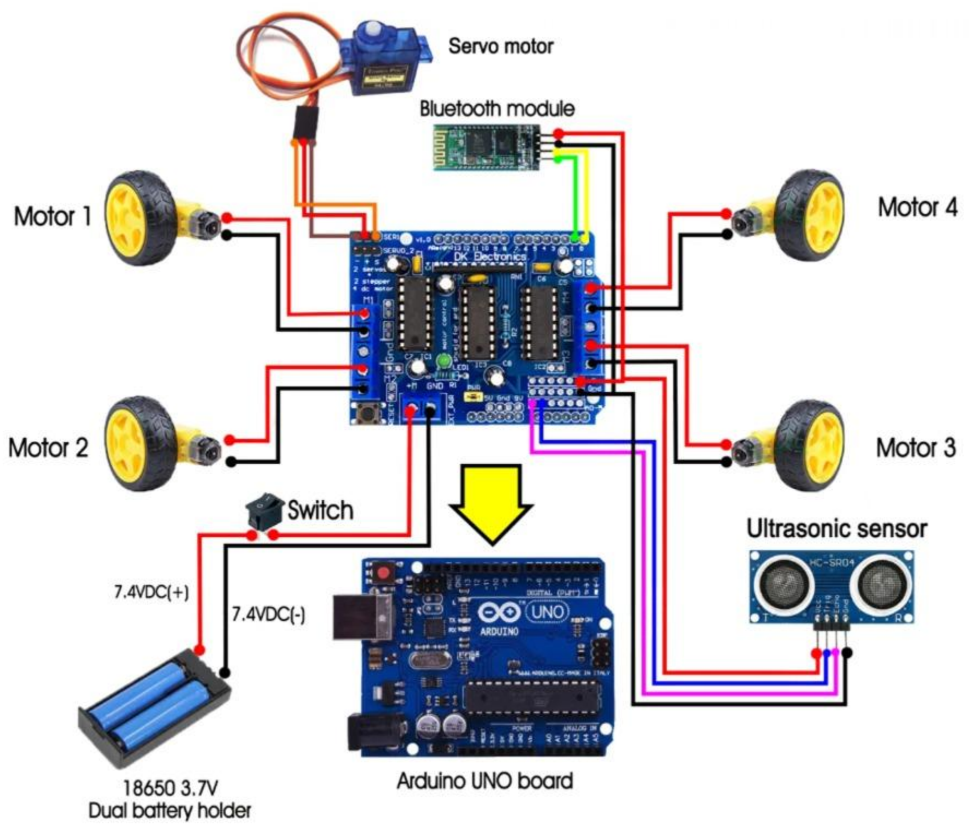


Circuit Diagram of Designed Model:

The circuit uses a 7.4V Li-ion dual battery holder as the power source, controlled by a mechanical switch, with the positive terminal connecting to the L293D motor driver and negative terminal as common ground for all components. The Arduino UNO serves as the central microcontroller, receiving signals from the HC-SR04 ultrasonic sensor (connected to pins 9 and 10) and the HC-05 Bluetooth module (connected to serial pins 2 and

3 with a voltage divider on the RXD line to convert 5V to 3.3V). The L293D motor driver receives 7.4V power supply and 5V logic from the Arduino, with input pins (IN1-IN4) controlling motor direction and enable pins receiving PWM signals for speed adjustment. Four DC gear motors connect to the driver's output terminals in pairs (Motors 1&2 on left channel, Motors 3&4 on right channel) for coordinated movement.

In autonmous mode, the ultrasonic sensor continuously measures distances by transmitting 40 kHz sound waves, and when obstacles are detected within 15-20 cm, the Arduino commands the motor driver to change the robot's direction. In manual Bluetooth mode, the smartphone application sends commands through the HC-05 module to control motor direction and speed independently for forward, backward, and turning movements. The servo motor (if used) connects to a PWM-capable pin for sensor turret positioning, receiving control pulses of 1-2 milliseconds at 50 Hz frequency. All components share a common ground reference through the battery's negative terminal, ensuring proper circuit operation and voltage level compatibility across all subsystems.



Working of Designed Model:

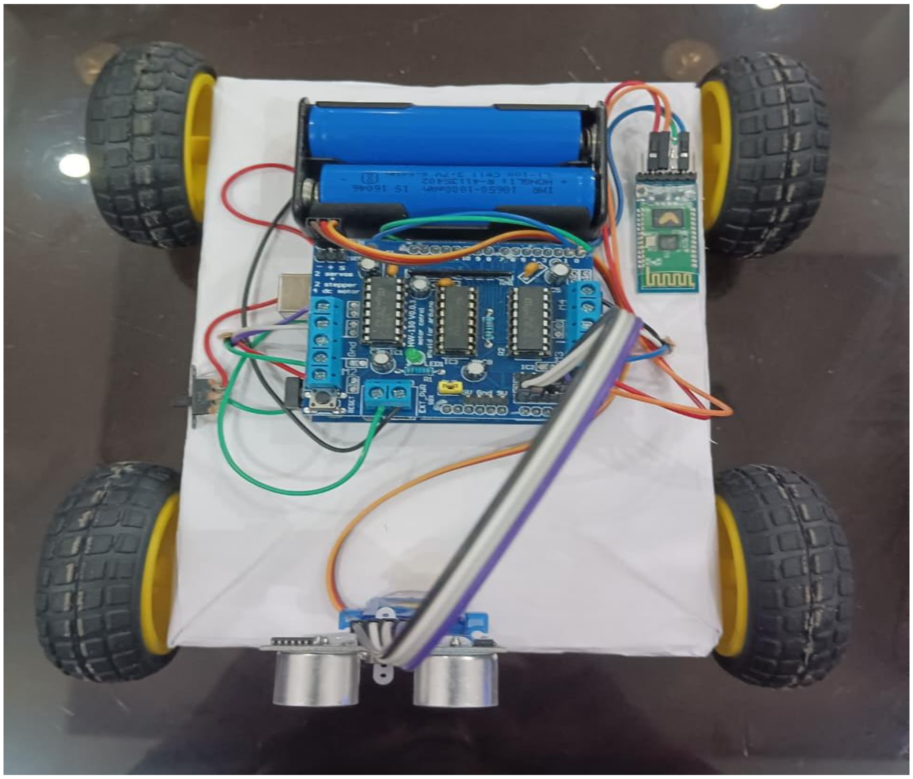
- The robot begins operation when powered on, and both gear motors run continuously to move the robot forward. During this movement, the HC-SR04 ultrasonic sensor continuously emits 40 kHz ultrasonic sound waves every 300 milliseconds, which reflect off surrounding obstacles. The Arduino calculates the distance to obstacles using the time-of-flight method: Distance = (Echo Duration × Speed of Sound) / 2, where the speed of sound is approximately 340 m/s. This real-time distance measurement occurs constantly as the robot navigates, providing the microcontroller with continuous environmental awareness. If no obstacles are detected within the predefined threshold distance (typically 15-20 cm), the robot continues moving forward unimpeded. Some systems use alternative protocols like Zigbee, Z-Wave, or Bluetooth for connectivity, depending on the device and its requirements. Smart home devices, including lights, thermostats, cameras, locks, and appliances, are equipped with sensors and connected to the home's WiFi network, allowing them to communicate with each other and be controlled remotely.

- When the ultrasonic sensor detects an obstacle within the threshold distance, the Arduino microcontroller processes this sensor data and initiates an automated decision-making algorithm. The robot automatically stops forward motion and scans left and right directions by measuring distances on both sides to determine the path with the largest clearance. Based on these measurements, the Arduino sends command signals to the L293D motor driver, which adjusts the motor speeds and directions accordingly—either turning left or right to navigate around the obstacle. This decision-making process happens in real-time, enabling the robot to respond immediately to changing obstacles without human intervention.

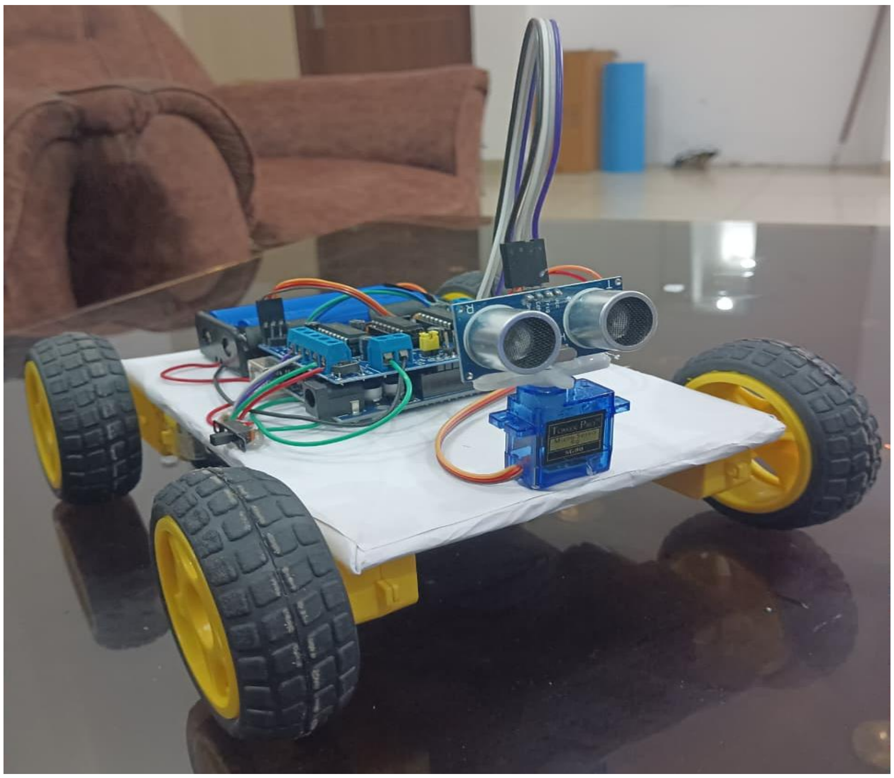
- In manual mode, the HC-05 Bluetooth module receives commands transmitted from a smartphone application with voice recognition capabilities. When the user sends voice commands like "move forward," "move backward," "turn left," "turn right," or "stop," the smartphone application converts these voice inputs into serial data packets and transmits them via Bluetooth to the robot. The Arduino receives these Bluetooth commands, decodes them, and sends appropriate PWM (Pulse Width Modulation) signals to the motor driver to control motor direction and speed independently. This dual-mode operation allows the robot to function both autonomously with obstacle avoidance or under complete manual control via wireless commands, providing maximum flexibility for different operational scenarios.

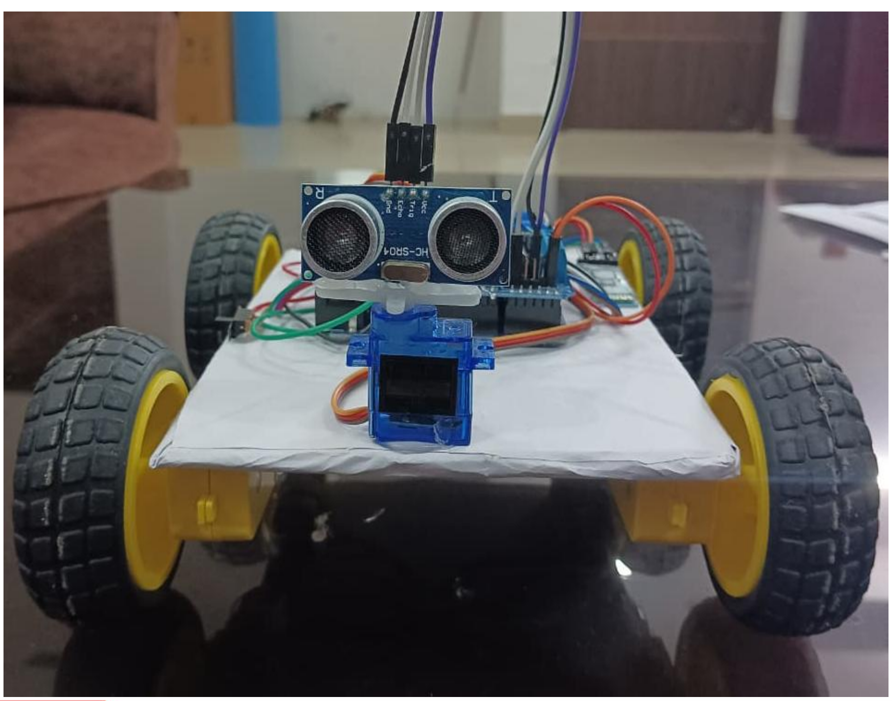
- The L293D motor driver receives control signals from the Arduino to manage the four DC gear motors for coordinated multi-directional movement. By varying the PWM duty cycle on the enable pins (EN1, EN2) and changing the logic states on input pins (IN1, IN2, IN3, IN4), the Arduino can independently control motor pairs: Motors 1 and 2 on the left side, and Motors 3 and 4 on the right side. For forward movement, all motors run at equal speeds; for turning left, right-side motors run faster than left-side motors; for backward movement, all motors reverse direction. This precise motor coordination, combined with real-time sensor feedback and responsive decision-making, enables the robot to smoothly navigate complex environments while avoiding collisions.

Pictures of Prototype:



Output of Designed Model:





Learning Outcomes:

1. **Gained practical knowledge of microcontroller programming** - Learned to write and upload C/C++ code to the Arduino UNO for controlling hardware components and managing sensor inputs/outputs.
2. **Understood sensor interfacing and real-time distance measurement** - Acquired hands-on experience with HC-SR04 ultrasonic sensors and implemented distance calculation algorithms for obstacle detection.
3. **Mastered motor control and direction management** - Developed competency in using H-bridge motor drivers (L293D) to control multiple DC motors with PWM signals for multi-directional movement.
4. **Implemented wireless communication protocols** - Learned to interface HC-05 Bluetooth modules with Arduino for establishing wireless connectivity and receiving commands from mobile applications.
5. **Developed autonomous decision-making algorithms** - Created logic systems that allowed the robot to independently sense obstacles and make navigation decisions without human intervention.
6. **Integrated multiple subsystems into a cohesive platform** - Successfully combined power management, sensors, actuators, and communication modules into a functional robotic system that demonstrated system integration principles.
7. **Applied voice control and command processing** - Implemented speech-to-text conversion and voice command interpretation to enable voice-based control of the robot's movements through natural language commands.