IDEAL LAB PROJECT

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Introduction

The demand for autonomous systems has significantly grown due to advancements in embedded electronics and artificial intelligence. Among these systems, human-following robots stand out for their practical applications in service robotics, healthcare, surveillance, and personal assistance. These robots are designed to identify and follow a human target by sensing their position and adjusting movement accordingly.

This project introduces an Autonomous Human-Following Robot designed using an Arduino Uno microcontroller, ultrasonic and IR sensors, and DC motors controlled via a motor shield. The robot utilizes a servo-mounted ultrasonic sensor to scan the environment and detect objects in front of it, simulating human presence by measuring distance. The IR sensors add an additional layer of environmental awareness, detecting side obstacles and enabling real-time adjustments.

The integration of sensors and control logic allows the robot to follow a target autonomously without the need for external inputs like Bluetooth or manual controls.

Objective

The primary objective of this project is to design and develop an autonomous mobile robot capable of following a human or object using a combination of ultrasonic and infrared (IR) sensors. The robot should be able to scan its environment, detect the nearest target, and intelligently navigate toward it without the need for manual control or wireless communication.Specifically, the objectives include:

1. Autonomous Movement:

Enable the robot to move independently without external guidance, using sensor feedback to make real-time navigation decisions.

2. Target Detection and Tracking:

Use a servo-mounted ultrasonic sensor to detect the presence and position of a human or object in front of the robot by scanning a range of angles (typically 60°–120°). The robot should identify the angle with the shortest distance and orient itself toward that direction.

3. Obstacle Detection and Avoidance:

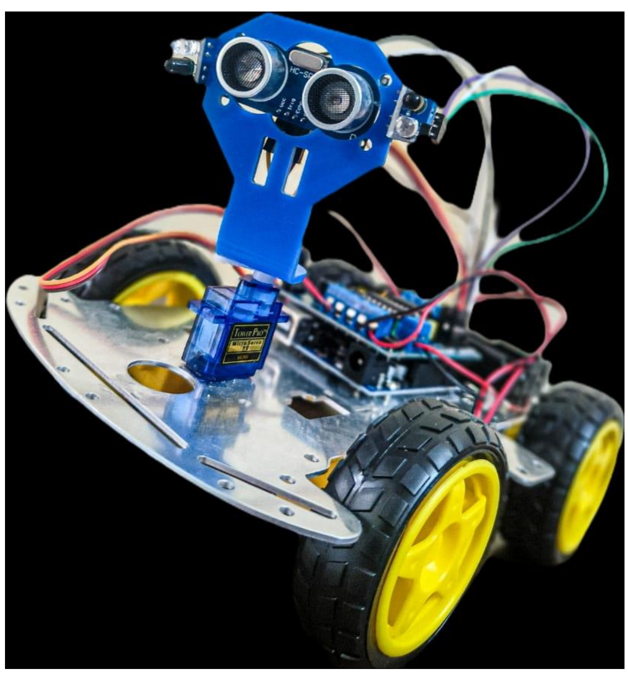
Integrate IR sensors on both sides of the robot to detect nearby obstacles, preventing side collisions during movement and enabling path correction.

4. Smooth Directional Control:

Implement logic that allows the robot to rotate, turn, or stop based on sensor input to ensure smooth and responsive tracking behavior.

5. Modular and Expandable Design:

Build the robot using modular components (Arduino, motor shield, servo, sensors) to allow for future enhancements such as camera-based vision, wireless control, or AI-based tracking algorithms.



Theory & Working Principle

Ultrasonic Sensor (HC-SR04):

Measures distance using sound waves. By calculating the time between emitting a sound pulse and receiving the echo, distance to the object is found.

Servo Motor:

Rotates the ultrasonic sensor between a predefined angular range (e.g., 60° to 120°), allowing area scanning.

IR Sensors:

Detect nearby obstacles using infrared reflection, helping the robot to avoid collisions from the side.

Logic Flow:

Servo rotates and scans the area using ultrasonic sensor.Object distance is measured at different angles.Robot turns to face the closest detected object.IR sensors check for side obstacles before movement.Robot moves forward, turns, or stops based on combined data.

Components Used

1. Arduino Uno :- Main controller

2. Adafruit Motor Shield (L293D):- Controls 4 DC motors and Battery

3. DC Motors :- 4 × Drives wheels

4. Servo Motor :- Rotates ultrasonic sensor

5. Ultrasonic Sensor (HC-SR04) :- Front object detection

6. IR Sensor :- 2 Side obstacle detection

7. Battery Pack :- Powers the system

8. Lithium Ion Battery :- Acts as a Power House of the System Basically Supply Energy to the System

Hardware Design

The robot is designed on a compact four-wheeled chassis with a stable center of gravity and adequate space to mount sensors, control boards, and a battery pack. Here's a detailed layout of the hardware components:

Chassis and Drive System-

The base is equipped with 4 DC motors, each connected to a wheel to ensure smooth and balanced movement.

Motors are connected to the Adafruit Motor Shield, which handles bidirectional control and PWM speed adjustment.

Sensor Placement-

A Servo motor is mounted at the front center of the robot. The ultrasonic sensor (HC-SR04) is affixed on top of the servo bracket, allowing it to rotate horizontally from 60° to 120°. This setup gives the robot a "field of view" to scan and determine object positions.

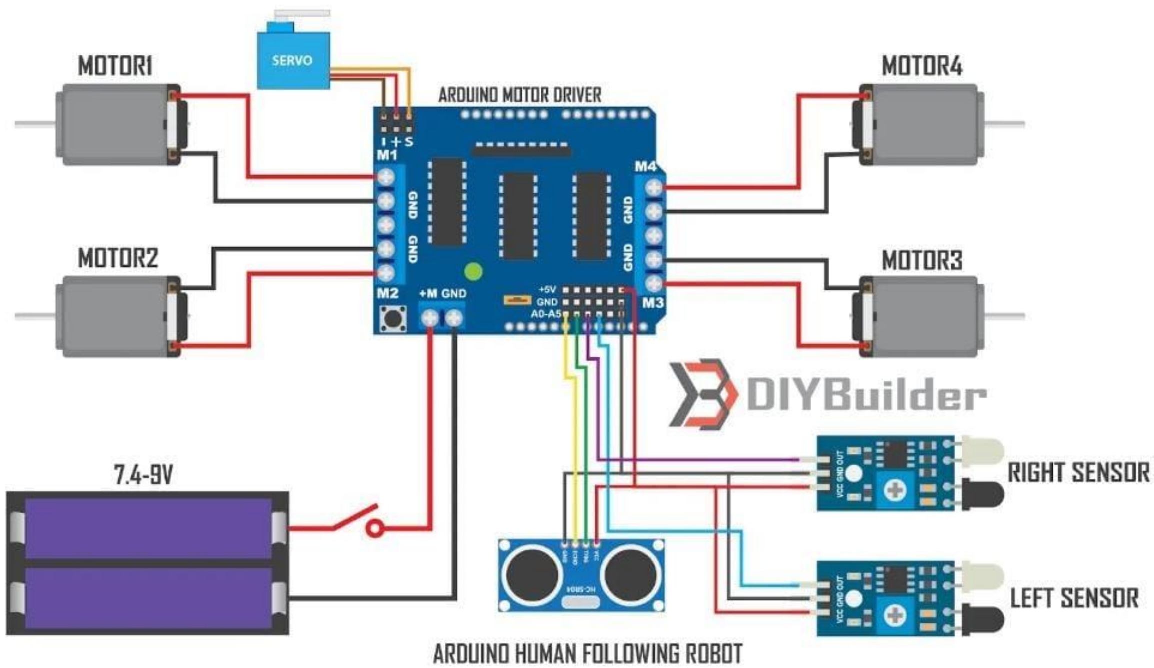
IR sensors are mounted on the left and right sides of the chassis, slightly angled outward to detect nearby obstacles from both sides.

Controller and Power-

The Arduino Uno serves as the central processor. It receives input data from sensors and sends output commands to the motor shield and servo.

The Adafruit Motor Shield is stacked directly on the Arduino board and is responsible for controlling the direction and speed of the DC motors.

A battery pack (4x 1.5V AA or 9V battery) powers the entire system. An optional capacitor or voltage regulator can be used to prevent power drops during motor load.



Software & Code Structure

The robot's behavior is governed by code written in the Arduino IDE, utilizing a combination of libraries and custom logic to manage sensor readings and motor control.

Key Libraries:

AFMotor.h: Controls DC motors via the Adafruit Motor Shield.

NewPing.h: Simplifies the ultrasonic sensor interface, offering stable and fast distance measurements.

Servo.h: Allows precise angle control of the servo motor.

Main Functional Blocks:

1. Initialization (setup function):

Set servo to center position.

Initialize serial communication (for debugging).

Define motor and sensor pin modes.

Perform a quick startup scan.

2. Servo Scanning:

scanArea() rotates the ultrasonic sensor from 60° to 120°, measuring distance at each step.

The function stores the closest detected object angle and returns it for action.

3. Decision Making:

If a valid object is detected within a certain threshold (e.g., < 40 cm), the robot turns toward that angle and moves forward.

If IR sensors detect a side obstacle, the robot turns away from that side.

If no object is found, the robot performs a slow rotation to re-scan the environment.

4. Motor Control:

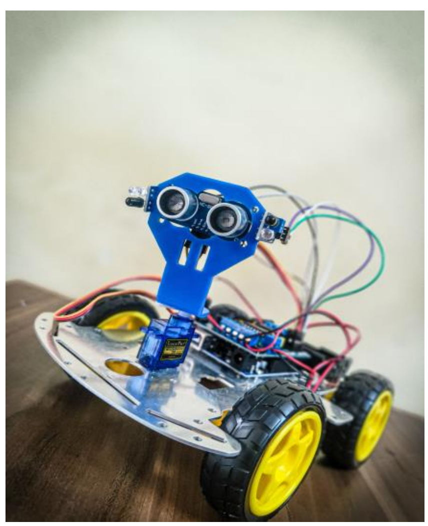
moveForward(): Activates both motors forward.

turnLeft() and turnRight(): Activate motors in opposite directions for turning.

stopMotors(): Stops all motor activity.

Code Link:

https://github.com/GlavinAmbler/Human-Following-Robot-Code/tree/e074f2d3d1c089c4ba7e240eb385d5cb49a5be7d



Advantages

1. Autonomous operation
2. Accurate detection via rotating ultrasonic sensor
3. Basic obstacle avoidance
4. Modular and upgradable
5. Cost-effective and educational

Applications

1. Assistance in healthcare (e.g., for elderly)
2. Patrol/security robots
3. Service sector (retail guides)
4. Educational and STEM-based learning

Future Enhancements

1. Integration with ESP32-CAM for face detection
2. Mobile app/Web interface for manual override
3. LED/Buzzer alerts for status indication
4. Smoother motion using PID algorithms
5. Indoor mapping using SLAM

Demonstration

The Photos and Videos of the above Project is uploaded here.

Click on the below Link:

https://drive.google.com/drive/folders/1JuLhc5kUkSJt2B_Zg7PlZ4alHg-RubTH

Conclusion

The development of this Autonomous Human-Following Robot project successfully demonstrates how basic sensors and embedded systems can be integrated to achieve intelligent behavior. Through the use of ultrasonic distance sensing, servo-based scanning, and IR obstacle detection, the robot can detect and track a moving object in its field of view and adjust its direction accordingly.

The project highlights several key learning outcomes:

- Understanding of sensor integration and data handling in embedded systems.
- Implementation of servo and motor coordination for real-time motion control.
- Practical application of logic programming to solve navigation problems.

Furthermore, the robot is modular, allowing easy hardware upgrades and code improvements. With the integration of computer vision (e.g., ESP32-CAM) or wireless control (Bluetooth/Wi-Fi), this robot can evolve into a more advanced system capable of facial recognition, path planning, or multi-target tracking.

This project serves as a foundation for more complex autonomous systems and offers valuable insights for anyone interested in robotics, automation, and embedded design.