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Table of Contents

List of Symbols

IR: Infrared

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Abstract:
This project focuses on the development of an Object-Following Robot designed to autonomously track and follow a specified target in various environments. The robot utilizes advanced technologies in computer vision, sensor integration, and machine learning to accurately detect and follow objects in real-time. Equipped with ultrasonic sensors, and infrared sensors, the robot can effectively identify and maintain a consistent distance from the target, even in dynamic and cluttered settings. Our approach involves the implementation of sensors for object detection and tracking, which are integrated with the robot's motion control system to ensure smooth and adaptive movement. Through extensive testing and iteration, the Object-Following Robot demonstrates reliable performance in both indoor and outdoor scenarios, showcasing its potential for applications in logistics, retail, and personal assistance. By enhancing the robot's ability to autonomously follow objects, this project aims to pave the way for more intelligent and interactive robotic solutions in various industries. Future work will focus on integrating AI for predictive analytics and further system optimization.

Introduction:

Background

In recent years, robotics has advanced significantly, transforming tasks that once seemed impossible into automated processes. Among these innovations, human-following robots have emerged as a promising technology designed to detect and follow humans or objects within a specific range. Known as "Smart Human Following Robot,"[2] these machines have the potential to enhance daily life in various sectors.

Problem Statement

In various environments, such as hospitals, warehouses, and homes, there is a need for robots capable of autonomously following humans while carrying out specific tasks. Current solutions often rely on pre-defined paths, manual control, or require extensive sensor setups, limiting their adaptability, reliability, and ease of use in dynamic and unstructured environments. Human following robots can be used in shopping centers, hospitals, and homes, offering practical assistance by carrying items, delivering medicine, or supporting people without the need for remote control. For instance, in hospitals, these robots can function as trolleys for transporting medical supplies or medicines, providing a fast and accurate solution. In commercial settings, such as malls or restaurants, they can carry packages or groceries, reducing human effort and improving efficiency [1][2].The potential of this technology goes beyond day-to-day tasks—it could be utilized in defense, where robots could carry weapons or supplies for soldiers, navigating challenging terrains with ease[4].As people increasingly integrate robots into their lives, human-following robots are seen as valuable companions that can co-exist with humans and assist in a wide variety of tasks with precision and speed[2]. Future advancements could further enhance these robots by incorporating more sophisticated components like cameras, tracking systems, and improved designs, making them even more functional and aesthetically appealing[1]. These robots are poised to play a vital role in shaping our future, blending seamlessly into daily life and industry alike.

Objectives:

The primary objective is to design and implement a human-following robot using Arduino and ultrasonic sensors. The project will aim to:

- To develop a prototype that can autonomously detect and follow a human using ultrasonic sensors,ensuring real-time responsiveness.
- To develop an efficient control system that enables the robot to follow the human while avoiding obstacles in real-time
- To integrate Arduino as the central processing unit for controlling sensor data and motor functions, ensuring smooth and accurate movements.
- To evaluate the robot's ability to perform in various environments such as hospitals, shopping centers, and military settings, enhancing its adaptability.

Literature Review:

Research has shown that integrating computer vision and Internet of Things (IoT) can significantly improve the capabilities and efficiency of robot assistants in diverse applications, including healthcare, logistics, and personal assistance [3]. The prioritization of emergency responses while maintaining human safety has been an ongoing debate, particularly in scenarios where robots must balance following tasks with collision avoidance [5]. Recent studies have demonstrated the successful integration of microcontrollers, such as Arduino or Raspberry Pi, with sensor-based object detection systems for autonomous navigation and human-following robots [6][7]..

Materials and Methods:

Materials:

- Arduino Uno
- Motor Driver Shield
- Wheels (4x)
- TT Gear Motor (4x)
- Servo Motor
- Ultrasonic Sensor
- Infrared Sensor (2x)
- 18650 Li-on Battery (2x)
- 18650 Battery Holder
- Male and Female Jumper wire
- Cock Sheet
- DC Power Switch

<u>Components of Arduino Uno R3:</u>

Microcontroller (ATmega328P):

- [10] The heart of the board, responsible for executing instructions and managing I/O.
- Digital I/O Pins: 14 (6 of which support PWM output).
- Analog Input Pins: 6.
- Flash Memory: 32 KB, SRAM: 2 KB, EEPROM: 1 KB1.

Digital Pins:

- Used for general-purpose input/output.
- Serial communication pins (RX and TX).
- External interrupt pins (2 and 3).
- PWM pins (3, 5, 6, 9, 10, and 11).

Analog Input Pins:

- Used for reading analog sensor values (0-5 or 0-8, depending on the version).
- Connect to analog sensors like temperature sensors or light sensors.

USB Connector:

- Used for uploading sketches (programs) to the board.
- Also facilitates serial communication with the computer.

Power Port:

- Accepts an external power supply (9-12V DC).
- Can be powered via USB as well.

Reset Button (S1):

- Resets the microcontroller, restarting the program execution.

In-Circuit Serial Programmer (ICSP):

- Used for programming the microcontroller directly.

16 MHz Ceramic Resonator:

- Provides the clock signal for the microcontroller.

Power and Ground Pins:

- Power pins (orange) and ground pins (light orange) for connecting external components.

External Power Supply In (X1):

- Accepts an external power source (9-12V DC).
- Toggle between external and USB power using jumper pins (SV1).

USB Port:

- Used for both programming and powering the board. [10]

components of IR sensors:

- [11]IR LED/IR Tx: Emitts IR rays
- Photodiode/IR Rx: Detects IR
- LM393 comparator IC: to detect objects or measure proximity
- signal LED: Indicates signal detection
- power LED: Indicates power
- Trimpot: To adjust the distance range of detection, the preset knob needs to be rotated and the efficient operation range is from 2 to 10 cm. If the preset knob is turned in a clockwise direction, then the range of detection will be enhanced. Similarly, if it is turned in a counter-clockwise direction, then the range of detection will be reduced.
- Pins
    - VCC: a +5V power supply pin
    - GND: ground pin
    - Output: digital output pin

Components of Motor Driver Shield:

- [8][9]**L293D motor drivers**
    - Controlls DC or Stepper motors
- **74HC595 shift register**
    - extends the Arduino's four digital pins to the eight direction control pins of two L293D chips.
- **Power Supply Selection Jumper**
    - To choose whether the supplied power is to be shared with the Arduino or used separately.
- **Motor Power Supply Terminal**
    - Supports a motor voltage range of 4.5 to 25 volts
- **Motor Connections**
    - Consists of two 5-pin screw terminals labeled M1, M2, M3, M4
    - Connects four DC motors or 2 Stepper motors
- **Servo Motor Connections**
    - 16-bit PWM output lines to two 3-pin headres
    - connect two servo motors
- **Pull Down Resistor Array**
    - to keep motors off during power-up
- **Power LED**
    - Indicates power supply
- **Reset Switch**
    - Arduino's reset button
- **Analog Pins with Power and gnd rails**
    - Can be used to connect other sensors
- **Software: AFMotor Library**
    - To communicate with the shield and control DC, stepper, and servo motors with simple commands.

Methods:

- **System Design**

  Focus on the structural design of the robot, particularly on sensor placement and integration with the Arduino microcontroller. Ultrasonic sensors will be strategically positioned to detect the user and measure the distance between the robot and the target human.

- **Sensor Integration**
  Implement ultrasonic and Infrared sensors for accurate human tracking. These sensors will relay real-time data to the Arduino, which will process the input to control the motors, ensuring responsive adjustments to the robot's movement.
- **Objestacle Detectation**
  Uses IR sensor for obstacle detectation to avoid them.
- **Human Following Mechanism**
  Servo motors along with wheels operate to make the robot mobile.

Discussion:

System Performance: The Smart Huma Following Robot has the ability to reliably track humans using sensors like IR, ultrasonic sensors. Quick processing and execution of movement commands results in a quickly responsive robot. Smooth control of motor functions to follow humans effectively while avoiding obstacles. Optimal power usage by motors and sensors for extended operation. Performance improves with better calibration, robust algorithms, and precise sensor integration.

Advantages:

The key advantages of the Smart Human Following Robot include:

1. Assistance in Daily Tasks: Useful for carrying items in warehouses, homes, or shopping malls.

2. Elderly and Disabled Support: Helps individuals with mobility challenges by transporting essentials.

3. Improved Safety: Can follow users in hazardous environments, reducing human exposure to danger.

4. Autonomous Operation: Reduces the need for constant human supervision.

5. Efficiency in Workspaces: Optimizes operations in industrial or commercial settings by automating item transport.

6. Customizable Applications: Can be tailored for specific needs such as healthcare or personal assistance.

7. Cost-Effectiveness: Using Arduino and other readily available components makes the system affordable and easy to implement.

Limitations:

Despite its advantages, the Smart Human Following Robot has several limitations:

1. Sensor Reliability: The system's performance heavily relies on the accuracy and reliability of PIR motion sensors, which can be affected by environmental factors such as weather conditions.

2. Maintenance Requirements: Regular maintenance is necessary to ensure the proper functioning of sensors and mechanical components like servo motors.

Results:

Introducing sensor-based smart human following robot produced impact results in giving human a personal alibi. The system's resilience to varying environmental conditions was evident, ensuring reliable operation under diverse circumstances.

Field Test Results

The field tests were conducted in diverse urban settings to evaluate the efficacy of the smart human following robot. Here are the key findings:

1. Accuracy of Human Tracking

- Sensors Used: The ultrasonic sensor can accurately keep the robot within proximity while the IR sensor detects obstacles to avoid..
- Reliability: the robot can consistently identify and track human without deviation or losing the target.
- Range: Within the determined range, the robot can effectively detect and follow the human.
- Latency: The robot is quite responsive to changes in human movement or path.

2. Navigation and Movement Performance

- Obstacle Avoidance: the robot is able to avoid static and dynamic obstacles while following the human using IR sensor.
- Path Smoothness: the robot follows a natural and smooth trajectory without unnecessary detours or abrupt changes.

3. Adaptability in Varied Environments

- Lighting Conditions: The can perform under various lighting.

4. User Interaction

- Ease of Use: users can easily initiate and control.
- Safety: Ensured the robot maintains a safe distance and reacts appropriately to sudden changes in user behavior.

Conclusions:

The field tests of the human-following robot show it effectively tracks and follows a human in various environments, with strong performance in obstacle avoidance and ease of use. However, challenges remain in crowded areas, low-light conditions, and battery life.

Future improvements focuses on enhancing tracking accuracy, extending battery life, and adapting to diverse environments. Also, integrating AI models to distinguish human from other objects. Overall, the robot shows great potential but requires refinement for broader applications.

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