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Smart Human Following Trolley

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Abstract -*This paper presents the design and implementation of a Smart Human Following Trolley based on autonomous robotic technology for efficient and hands-free material transportation. Traditional trolleys require continuous manual effort for carrying loads, which can lead to physical fatigue and reduced productivity.*

The proposed system addresses this issue by developing an intelligent trolley capable of automatically following a human target while maintaining a safe distance. The system is built using the ATmega2560 microcontroller as the main processing unit, along with ultrasonic sensors and infrared (IR) sensors for human tracking and obstacle detection.

The L298N motor driver controls DC gear motors to achieve smooth and accurate movement of the trolley. Real-time sensor feedback enables dynamic tracking, obstacle avoidance, and automatic stopping during unsafe conditions. The system operates autonomously without requiring manual pushing, making it suitable for smart transportation applications.

The proposed trolley is designed to be low-cost, energy-efficient, reliable, and scalable for real-world deployment. Experimental analysis demonstrates effective human-following capability, safe obstacle detection, and stable motor control performance. The system can be applied in hospitals, airports, warehouses, shopping centers, and industrial environments to reduce human effort and improve operational efficiency. Future enhancements may include artificial intelligence-based vision tracking, IoT connectivity, and multi-trolley communication systems for advanced autonomous transportation applications.

Introduction-

Transportation of heavy materials using traditional trolleys requires continuous manual effort, which causes physical fatigue and reduces efficiency.

To overcome this problem, a Smart Human Following Trolley is proposed that can automatically follow a user without manual pushing.

The system uses an ATmega2560 microcontroller, ultrasonic sensors, IR sensors, and DC motors for human tracking and obstacle detection. The trolley maintains a safe distance from the user and stops automatically when obstacles are detected. The proposed system is low-cost, reliable, and suitable for applications in hospitals, airports, warehouses, and industrial environments.

System Architecture

The overall system architecture of the Smart Human Following Trolley is divided into hardware architecture and software architecture.

A. Hardware Architecture

The hardware components used in the proposed system include:

1) ATmega2560 Microcontroller

The ATmega2560 acts as the central processing unit of the system. It processes sensor data, controls motor movement, and manages the overall tracking mechanism. Its multiple input/output pins make it suitable for handling various sensors and motor control operations simultaneously.

2) Ultrasonic Sensors (HC-SR04)

The ultrasonic sensors are used to measure the distance between the trolley and the user. These sensors continuously transmit and receive ultrasonic waves to calculate real-time distance for human-following operation.

3) Infrared (IR) Sensors

IR sensors are used for obstacle detection and short-range sensing. They help the system detect nearby objects and prevent collisions during movement.

4) L298N Motor Driver

The L298N motor driver module acts as an interface between the microcontroller and DC motors. It receives control signals from the ATmega2560 and drives the motors accordingly.

5) DC Gear Motors

DC gear motors provide the mechanical movement required for the trolley.The motors control forward movement, stopping, and turning operations based on sensor feedback.

6) Power Supply Unit

The system is powered using a rechargeable Li-ion battery pack with a Battery Management System (BMS) for safe and stable power delivery.

B. Software Architecture

The software is developed using the Arduino IDE with Embedded C/C++ programming.

1) Sensor Processing

The microcontroller continuously reads data from ultrasonic and IR sensors to determine user position and obstacle presence.

2) Motion Control

Based on sensor inputs, the microcontroller generates PWM control signals for the motor driver to regulate motor speed and direction.

3) Human Following Mechanism

The trolley maintains a predefined safe distance from the user and dynamically adjusts its movement according to the user's motion.

4) Obstacle Detection and Safety Control

If an obstacle is detected within the unsafe range, the system immediately stops the motors to prevent collision and ensure user safety.

IV. Working Principle

The Smart Human Following Trolley operates by continuously tracking the user and maintaining a safe following distance using real-time sensor feedback. The system works in the following steps:

1) User Detection

The ultrasonic sensors continuously measure the distance between the trolley and the user. The system identifies the target user within the predefined tracking range.

2) Distance Monitoring

The ATmega2560 microcontroller processes the sensor data and calculates the distance between the trolley and the user in real time.

3) Human Following Operation

If the user moves forward, the microcontroller sends control signals to the L298N motor driver, which drives the DC motors to move the trolley in the same direction while maintaining a safe distance.

4) Direction and Speed Control

The trolley dynamically adjusts motor speed and direction according to the movement of the user. Differential motor control is used for smooth turning and stable movement.

5) Obstacle Detection

IR sensors continuously monitor the surroundings for obstacles. If any object is detected in the path, the system immediately stops the motors to prevent collision.

6) Safety Mechanism

In case of sensor failure or unstable readings, the system automatically enters a safe stop condition to avoid accidental movement.

The complete process operates continuously in a loop, enabling autonomous, safe, and hands-free transportation of materials.

V. Applications

The proposed Smart Human Following Trolley can be used in various real-world environments, including:

- Hospitals and Healthcare Centers – For transporting medicines, medical equipment, and oxygen cylinders without manual effort.
- Airports and Railway Stations – Assisting passengers in carrying luggage automatically.
- Warehouses and Industries – For material handling and transportation of heavy tools or goods.
- Shopping Malls and Supermarkets – Helping customers carry purchased items conveniently.
- Smart Offices and Campuses – For automated document and equipment transportation.
- Assistive Transportation Systems – Supporting elderly and physically challenged individuals in carrying loads safely and easily.

VI. Advantages of the Proposed System

- Reduces physical effort in carrying heavy loads
- Provides hands-free and autonomous operation
- Real-time human tracking and obstacle detection
- Low-cost and energy-efficient design
- Improves safety and transportation efficiency
- Easy to use and scalable for future upgrades

VII. Experimental Results and Discussion

The Smart Human Following Trolley was tested in different conditions to check its performance. The trolley successfully followed the user while maintaining a safe distance. The ultrasonic sensors accurately detected the user, and the IR sensors helped in obstacle detection. The motors provided smooth movement and stopped automatically when obstacles were detected. The system worked reliably with low response time and showed effective performance for real-world transportation applications.

VIII. Conclusion

The proposed Smart Human Following Trolley successfully reduces the manual effort required for carrying heavy loads. The system uses ultrasonic sensors, IR sensors, and an ATmega2560 microcontroller to achieve autonomous human following and obstacle detection. The trolley operates safely, efficiently, and reliably in real-time conditions. The low-cost and scalable design makes it suitable for applications in hospitals, warehouses, airports, and industrial environments. The project demonstrates the effective use of embedded systems and robotics for smart transportation solutions.

IX. Future Scope

The proposed Smart Human Following Trolley can be further improved by integrating advanced technologies and intelligent automation features. Some possible future enhancements are described below:

1) AI-Based Human Tracking

The current system uses ultrasonic and IR sensors for tracking the user. In future, camera-based artificial intelligence (AI) and computer vision techniques can be added for more accurate human detection and tracking. This will improve performance in crowded and complex environments.

2) IoT Integration

Internet of Things (IoT) technology can be integrated into the system for remote monitoring and control. Users will be able to monitor trolley location, battery status, and movement using a mobile application or cloud platform.

3) GPS Navigation System

GPS technology can be added for outdoor navigation and location tracking. This feature will help the trolley move intelligently in large areas such as airports, industries, and warehouses.

4) Mobile Application Control

A dedicated mobile application can be developed to control the trolley, adjust tracking distance, monitor battery level, and activate emergency stop functions remotely.

5) Voice Command System

Voice recognition technology can be integrated to allow users to control the trolley using voice commands. This will improve accessibility and provide hands-free operation for elderly and physically challenged users.

6) Increased Load Carrying Capacity

The system can be upgraded with high-power motors and improved chassis design to carry heavier industrial and commercial loads more efficiently.

7) Multi-Trolley Communication

Future systems can support communication between multiple trolleys using wireless technology. This will enable coordinated movement and smart transportation in warehouses and industrial environments.

8) Solar Power Integration

Solar charging systems can be added to improve battery backup and reduce power consumption, making the trolley more energy efficient and environmentally friendly.

9) Autonomous Path Planning

Advanced algorithms can be implemented for automatic path planning and intelligent navigation, allowing the trolley to move independently without continuous user tracking.

10) Smart Safety Features

Additional safety features such as automatic emergency braking, fire detection, and accident alerts can be integrated to improve system reliability and user safety.

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