Human-Following Shopping Trolley Using RFID and Sensor Integration

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Abstract: The integration of robotics and automation has led to innovations like the human-following shopping trolley, designed to revolutionize the shopping experience. Unlike traditional trolleys, this smart system autonomously tracks and follows a user, offering a hands-free solution. It uses RFID technology for user identification and ultrasonic and infrared sensors for navigation and obstacle detection, ensuring smooth operation in crowded environments like supermarkets.

Beyond retail, this technology improves accessibility for individuals with mobility challenges and enhances efficiency in warehouses. While challenges such as precise tracking and obstacle avoidance remain, advancements in sensors and algorithms continue to address these issues.

Human-following shopping trolleys combine convenience, accessibility, and innovation, representing a significant leap toward the future of shopping and showcasing the potential of robotics in everyday life.

I. INTRODUCTION

The motivation for developing a human-following shopping trolley arises from the need to enhance convenience, accessibility, and efficiency in shopping environments. Traditional trolleys require manual effort to push or carry items, which can be particularly burdensome for elderly individuals, those with mobility challenges, or shoppers navigating crowded spaces. This often results in discomfort, inconvenience, and a suboptimal shopping experience.

In today's fast-paced world, there is growing demand for personalized and efficient solutions to simplify daily tasks. The human-following trolley meets this need by providing a hands-free, intelligent system that reduces physical strain and improves ease of use. By integrating smart technologies such as RFID for accurate user identification and ultrasonic sensors for navigation and obstacle detection, this system enhances both functionality and user experience.

Beyond retail, the motivation extends to addressing broader challenges, such as improving accessibility for individuals with disabilities and optimizing logistics in warehouses. The potential for such systems to revolutionize various industries underscores the importance of this innovation.

Furthermore, the project is driven by a desire to showcase how robotics and automation can solve real-world problems, making everyday life more convenient and inclusive. By transforming traditional shopping practices, the human-following trolley demonstrates the power of technology to create smarter, more user-friendly solutions for the modern world.

II. LITERATURE SURVEY

Customer-following trolleys have gained significant attention due to their potential to enhance shopping convenience and efficiency. The integration of technologies such as RFID, IoT, and human-following mechanisms has contributed to the development of smart trolleys with versatile applications. Various studies have explored innovative approaches to improve their functionality and user experience.

Dr. Allirani S., Dr. Balamurugan K., Shobika K., et al. proposed an Advanced Multi-Purpose Smart Trolley designed to assist customers in diverse environments. The study highlighted the use of sensors and navigation systems to enable human-following capabilities, providing a hands-free shopping experience. However, challenges such as obstacle detection and system reliability were identified, requiring further refinement for widespread adoption [1].

Siddiqui, A. Basker, M. Dias, et al. investigated Human Following Carts (HFC) for multipurpose applications. Their research emphasized the implementation of ultrasonic and infrared sensors for precise human detection and navigation. While the system proved effective in controlled environments, its performance in crowded spaces showed limitations, necessitating the need for advanced algorithms to handle dynamic surroundings [2].

Dr. Jeevanandham, Hariharan P., Dhanraj PL S., et al. introduced an RFID and IoT-Based Smart Trolley that integrates RFID technology to streamline the shopping process. This system automatically identifies and tracks items added to the cart, reducing checkout times. The study also explored IoT integration for real-time cart monitoring, but issues such as RFID interference and high implementation costs were noted [3].

Ileni Abhinav Theja, Gudur Chandrakanth, Ravvula Akhil, et al. developed a Human-Guided Following Trolley Mechanism and Integrated Shopping Mechanism Using RFID. Their research combined RFID-based item tracking with human-following technology. While the trolley successfully followed the customer and maintained accurate item tracking, challenges in maintaining consistent tracking in cluttered environments were highlighted [4].

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M. L. N. Vital, V. Hari Vamsi, and T. Purnachandra Rao presented a Smart Human Following Robot utilizing a combination of ultrasonic and IR sensors for efficient navigation. The study demonstrated robust human detection and following capabilities but faced challenges with sudden directional changes and sensor inaccuracies in crowded areas [5].

Komal Ambekar, Vinayak Dhole, Supriya Sharma, Tushar Wadekar, et al. proposed a Human Following Robot leveraging a fusion of sensor technologies for improved accuracy in detecting and following customers. While the model showcased reliable performance in structured environments, issues like battery optimization and scalability for larger spaces were identified as areas for improvement [6].

III. PROPOSED SYSTEM

The human-following shopping trolley is an intelligent system designed to transform the shopping experience by integrating advanced technologies for autonomous operation. It provides a hands-free, efficient solution to traditional shopping challenges, specifically addressing the needs of everyday consumers and individuals with mobility limitations.

The proposed system employs **RFID-based user identification** to ensure the trolley accurately follows a designated user. An RFID tag carried by the user is paired with an RFID reader on the trolley, establishing a reliable tracking mechanism. For navigation and obstacle avoidance, the system utilizes **ultrasonic and infrared sensors**, enabling the trolley to detect and avoid barriers in real time. These sensors continuously scan the surroundings, allowing the trolley to make dynamic decisions in crowded and complex environments like supermarkets or malls.

A **motorized base** drives the trolley's autonomous movement, while a **microcontroller** processes real-time data from the sensors. Intelligent algorithms govern user tracking, obstacle avoidance, and path correction, ensuring smooth and responsive operation. For example, the trolley calculates distances using ultrasonic sensors and adjusts its direction to maintain an optimal and safe distance from the user.

This system’s design focuses on providing convenience, accessibility, and efficiency, making shopping easier for all users. By leveraging cutting-edge technologies, the human-following trolley exemplifies the potential of robotics to enhance daily life and redefine conventional practices.

IV. ARCHITECTURE

The architecture of the system is designed around an Arduino Uno as the central control unit, with various sensors and actuators interfaced to it. Here's a simplified architecture:

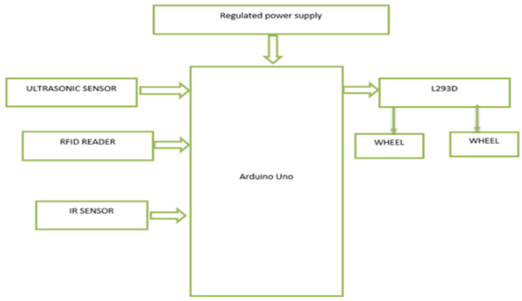

Figure: Architecture of Smart trolley

The human-following shopping trolley integrates several key components to ensure seamless functionality. At its core is the Arduino Uno, which serves as the central controller, processing inputs from all sensors and controlling the trolley's movement. An ultrasonic sensor is used to measure the distance between the trolley and the user, maintaining a fixed following distance while avoiding obstacles. The RFID reader identifies and locks onto a specific user, ensuring the trolley follows only the intended individual. IR sensors detect the user's directional movement, with the left and right sensors guiding the trolley to turn accordingly. The L293D motor driver controls the speed and direction of the DC motors, which facilitate the trolley's forward, backward, and turning motions.The wheels enable the physical movement of the trolley, while a regulated power supply provides stable DC power to the Arduino, sensors, and motor driver, ensuring reliable operation. Together, these components create an intelligent and autonomous system that enhances the shopping experience.

V. METHODOLOGY

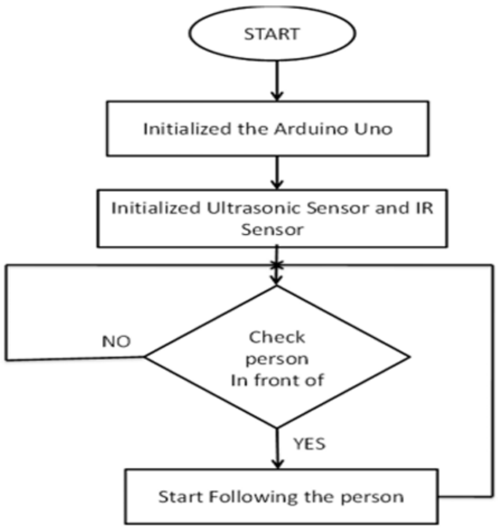

Figure: Methodology of Smart Trolley

The operation of the human-following shopping trolley begins by initializing the Arduino UNO and activating the Ultrasonic and IR sensors. The system continuously scans for a user in front of the trolley. Once a person is detected, the trolley starts following them, maintaining a consistent distance of 30 cm. If the user turns left or right, the trolley adjusts its direction accordingly using IR sensor inputs. The trolley stops if the user halts or moves beyond the 100 cm detection range. The system then resumes scanning for the user's presence, repeating the process to ensure continuous tracking and navigation.

VI. MODULES

The human-following shopping trolley comprises several key modules working together for seamless operation.

The **User Interaction Module** activates the trolley and initiates user tracking via an RFID tag, with a stop/pause option for manual control. The **User Tracking Module** uses RFID signals to continuously follow the user while maintaining a safe distance.The **Obstacle Detection and Avoidance Module** relies on ultrasonic and infrared sensors to detect and navigate around obstacles, ensuring safe movement. The **Navigation Module** controls the trolley's direction and speed based on user tracking and obstacle data, enabling smooth movement.The **Motor Control Module** executes navigation commands to operate the motors, while the **Sensor Data Processing Module** analyzes sensor inputs to calculate distances and avoid obstacles. Together, these modules provide an intelligent, hands-free, and user-friendly shopping solution.

VII. CONCLUSION

The development of a human-following shopping trolley represents a significant step forward in the integration of robotics into everyday life. By leveraging RFID technology for user identification and ultrasonic and infrared sensors for obstacle detection, this intelligent trolley enhances the shopping experience, offering hands-free convenience and improved accessibility. The system's ability to navigate dynamic and crowded environments like supermarkets and malls demonstrates its practicality and adaptability. Although challenges such as precise user tracking and background-foreground separation remain, advancements in sensor technology and real-time data processing are addressing these hurdles effectively. As this technology continues to evolve, human-following shopping trolleys have the potential to revolutionize the retail sector, making shopping more efficient, inclusive, and enjoyable. Furthermore, they highlight the growing role of robotics in enhancing daily activities, paving the way for more innovative and user-centric solutions in the future.

VIII. FUTURE SCOPE

The human-following shopping trolley holds immense potential for future advancements and broader applications. Integrating voice recognition and command systems can enhance user interaction, making the trolley more intuitive and user-friendly. Connecting the trolley to smartphones or wearable devices via dedicated mobile applications can enable seamless user identification, navigation, and shopping list management. Advanced AI and machine learning algorithms can further refine obstacle detection and navigation, ensuring smooth operation in crowded environments. The addition of AI-driven personalized shopping assistance could provide real-time product recommendations based on user preferences, creating a tailored experience.

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