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Robotic Trolley with Integrated Line-Following and Human-Following Functionality

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ABSTRACT—

The Smart Shopping Trolley project integrates advanced technologies to revolutionize the shopping experience in retail environments. This innovative trolley utilizes an Arduino-based system with dual IR sensors for line-following capabilities, allowing it to autonomously navigate predefined paths within stores. To ensure safe interaction with customers, the trolley employs additional IR sensors for obstacle detection, enabling it to avoid collisions and maintain a distance of five feet from the customer. A key feature of the trolley is its RFID billing system, where each product is equipped with an RFID tag containing essential information, such as expiry dates, manufacturing dates, and pricing. When products are added to or removed from the trolley, the system updates in real time, facilitating a seamless checkout experience. Wireless communication allows the trolley to send product details to a central billing PC, streamlining the transaction process and minimizing wait times at checkout. This system not only enhances the efficiency of the shopping process but also improves inventory management and customer engagement. By leveraging automation and RFID technology, the Smart Shopping Trolley aims to create a user-friendly shopping experience, encouraging customer satisfaction and loyalty. This project highlights the potential for integrating IoT solutions in retail settings, paving the way for smarter, more efficient shopping environments.

Keywords- IR Sensor, Ultrasonic Sensor, RFID , Relay, Arduino UNO, Bluetooth Module, LCD Display,

I. INTRODUCTION

A. Introduction to Autonomous Human Following Trolley

In The "Smart Shopping Trolley with Autonomous Navigation and RFID Billing System" is set to transform the conventional retail shopping experience into a seamless and technologically advanced process. This innovative project harnesses the power of several advanced technologies to create a shopping trolley that is capable of autonomous navigation and real-time RFID billing.The autonomous navigation feature allows the trolley to move independently within the store,

guiding customers to the items on their shopping list. This is achieved through a combination of sensors and intelligent algorithms that map the store layout and track the trolley's position, ensuring accurate and efficient navigation. Customers can simply input their shopping list, and the trolley will lead the way, making shopping more convenient and time-efficient.

The trolley also has RFID readers that read items automatically when they go inside besides navigation. No manual scanning is needed at the checkout counter. As items are scanned, the trolley reads the items' RFID tags and adds the data to a live billing interface. As a result, solidifying this system not only accelerates the checkout process but also diminishes mistakes and enhances the shopping experience. The smart trolley also uses IoT connectivity to match data with store inventory and customer management systems. As mentioned previously, this connectivity ensures real-time inventory tracking, and up-to-date stock levels. Furthermore, the system may also track purchasing behaviors and suggest products to customers according to their shopping history and preferences, adding on to the shopping experience.

Using these technologies to revolutionize the customer experience, the Smart Shopping Trolley is designed to provide increased convenience for customers, drastically minimize time spent at checkouts, and improve efficiency in-store. It is a step towards a more futuristic, engaging, and efficient shopping experience, and is likely to become the benchmark in future of retail. Moreover, as it simplifies the process of shopping for the customers, it also provides valuable information to the store management, which can lead to smarter retail stores in the future.

B. Exploring about the Autonomous Trolley

Here's how it would be:Smart Shopping Trolley: A Smart shopping Cart to Enhance the Shopping Experience by Using Autonomous Navigation, RFID and Obstacle Detection. Based on Arduino platform with IR sensors, this trolley has the ability to follow customers and avoid obstacles. As a result, the redistributed system must have created wireless products transmitted to a centralBenefits of the Proposed System.The Smart Shopping Trolley's enjoyment consists of advanced technologies such as autonomous navigation, RFID tracking, and obstacle detection, which enhance the shopping experience. The trolley can autonomously follow customers while reducing physical strain or stress using an Arduino platform with integrated IR sensors, making shopping more pleasant. Positional information which is usually obtained from GPS and visual features for navigation, where the robot finds its path and corrects its navigation also by detecting obstacles. The trolley uses RFID to track products in real-time as well as in clusters for up-to-date data about what is in the trolley (price and expiry date, etc). By wirelessly transmitting product details to a central billing PC, this system also simplifies the checkout process and shortens wait times considerably. The trolley also provides personalized recommendations and promotions based on items the user has selected, boosting customer engagement. This real-time information helps retailers track product movement and enables more efficient stock management, minimizing overstock and stockout scenarios. Its intuitive interface enables customers to keep track of their selections, making their shopping experience much easier, more user-friendly. One of the features of the trolley is that it keeps a safe distance from customers and also avoids obstacles on its own. More importantly, its automation also enables people who have trouble moving to use the store easily, making it inclusive. Additionally, it gathers information about shopping trends and individual preferences, giving retailers critical insights into improving their services and offerings. It transforms retail now and in the future by making shopping easier, fun, and a seamless experience.

II. RELATED WORKS

A. *Customer-Following Shopping Trolley*

This project relies on an Atmega 328 Controller, IR Sensors, Ultrasonic Sensors, motor drivers, and DC motors.The IR Sensors detect the customer's location and the Ultrasonic Sensors help maintain a safe distance. The motor drivers and DC motors facilitate the smooth movement of the trolley. By following the customer, this trolley reduces the need for manual pushing and enhances the shopping experience, particularly for elderly or differently-abled customers.

B. *Human-Following Shopping Trolley*

Similar to the customer-following trolley, it uses IR Sensors and an Atmega 328 Microcontroller, along with motor drivers and DC motors. The IR Sensors detect the presence and movement of the customer, while the microcontroller processes this information to navigate the trolley through the store.This project aims to provide a more personalized shopping experience by autonomously following the customer, making the shopping process more convenient.

C. Automated Billing Shopping Trolley

This project integrates an RFID reader controlled by an Arduino microcontroller, along with RFID tags on each product.

As products are added or removed from the trolley, the RFID reader scans the tags and updates the bill in real-time. This information is sent to a central billing PC to streamline the checkout process. This system reduces wait times at checkout and improves inventory management by keeping track of products in real time.

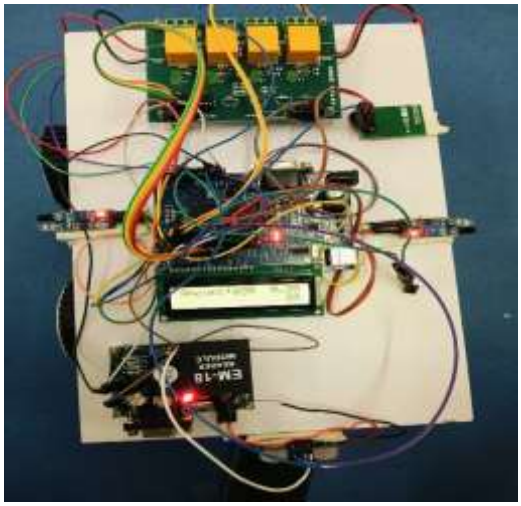

Fig. 1. Autonomous Shopping Trolley

D. The technological innovations of our project

The trolley uses infrared (IR) sensors to follow designated paths within the store, ensuring a hands-free shopping experience. Side- mounted IR sensors detect obstacles, allowing the trolley to navigate around barriers and maintain a safe distance from shoppers. Each product is tagged with an RFID card

containing crucial information, such as cost, manufacturing date, and expiry date. As customers add or remove items from the trolley, updates are sent wirelessly to a central billing PC, simplifying checkout and inventory management. The trolley sends updates to a central billing PC using wireless communication technology. The central billing PC receives updates from the trolley, generating invoices and managing centralized records. 1. The trolley features an LCD display that provides real-time feedback to customers about selected items, total cost, and other relevant details. The system features a single-switch operation to simplify interactions .The trolley uses an Arduino-based design to create a smart and interactive system .The trolley's functionality is coded in Embedded C++, ensuring efficient processing of sensor data and control signals.

E. *Objective of this Trolley*

Design a shopping trolley that can autonomously follow customers using IR sensors for line detection and obstacle avoidance. Ensure the trolley maintains a safe distance of five feet from the customer to enhance comfort and safety during shopping. Implement an RFID system that tracks products, including their expiry dates, manufacturing dates, and costs, for efficient billing. Develop a mechanism for real-time updates of the product list when items are added or removed from the trolley. Enable seamless data transmission to a central billing PC for quick and accurate transaction processing. Ensure the trolley can detect and navigate around obstacles using side-mounted IR sensors for improved navigation. Provide a hands-free shopping experience that increases customer satisfaction and engagement.

III. EXPERIMENTAL SETUP

The Smart Shopping Trolley with Autonomous Navigation and RFID Billing System demonstrates a seamless integration of multiple cutting-edge technologies to address inefficiencies in traditional shopping environments.

Arduino Uno: Acts as the core microcontroller, managing all input/output signals from the sensors, motors, and other peripherals. IR Sensors: Two front-facing sensors enable line-following functionality by detecting path markers on the store floor. Side-mounted sensors are used for obstacle detection and avoidance, ensuring smooth navigation in crowded areas. Ultrasonic Sensors: Enhance obstacle detection by measuring the distance to objects, allowing the trolley to maintain a safe five-foot distance from the customer. RFID Readers: Scan RFID tags on products to retrieve data such as pricing, manufacturing details, and expiry dates, enabling real-time inventory tracking. DC Motors and Relays: Control the movement of the trolley, providing smooth, autonomous navigation .LCD Display: Provides real-time feedback to customers about selected items, total cost, and other relevant details.

Software and Programming:

Arduino IDE: The trolley's functionality is coded in Embedded C++, ensuring efficient processing of sensor data and control signals. Visual Basic: Powers the billing system by receiving wireless data from the trolley, generating invoices, and managing centralized records. Wireless Communication Module:

Facilitates seamless, real-time transmission of product data to the central billing system using LoRa technology.

Autonomous Navigation:

Line Following: The IR sensors enable the trolley to follow specific routes marked on the floor of the store. This allows for hands-free passage of the trolley, minimizing physical strain on customers. Obstacle Avoidance: The trolley detects and avoids obstacles in real time using ultrasonic and side-mounted IR sensors. Integration of RFID: RFID cards tag products that have clear data including: Cost Expiry date Manufacturing date. When a product is added to or removed from the trolley, the RFID reader immediately updates the inventory and informs the central billing system about those changes. Centralized Billing: Real-time trolley product tracking system forwards the data to a central billing PC: Rapid invoice generation.

A continuously optimized checkout process with virtually no waiting.

Easy-to-Use Interface: The system uses a single-switch actuator to facilitate interaction. The LCD interface gives wholesome, real-time feedback on product details and cart totals.

Advanced Functionalities:

Obstacle Avoidance and Safety: A fixed distance can keep customers safe as it navigates around barriers. Optimized Inventory Management: Retailers gain real-time visibility into product movement and inventory levels, allowing for efficient restocking and minimizing the risk of stockouts. Automated Shopping Patterns Understanding A trolley collects progress data throughout its trips to understand shopping trends, so retailers can better understand customers and adjust their services accordingly. What It is: The setup allows for various store layouts and can accommodate customers who may have mobility limitations.

This truly helps elderly or disabled customers especially as they can use the automated navigation systems. This experimental system brings hardware and software together as one coherent system, making the shopping experience convenient, efficient, and inclusive. It has designed a fusion of ever-present data and intelligent environments with user comfort and safety in mind, to create a new theorem for the shape of the retail store.

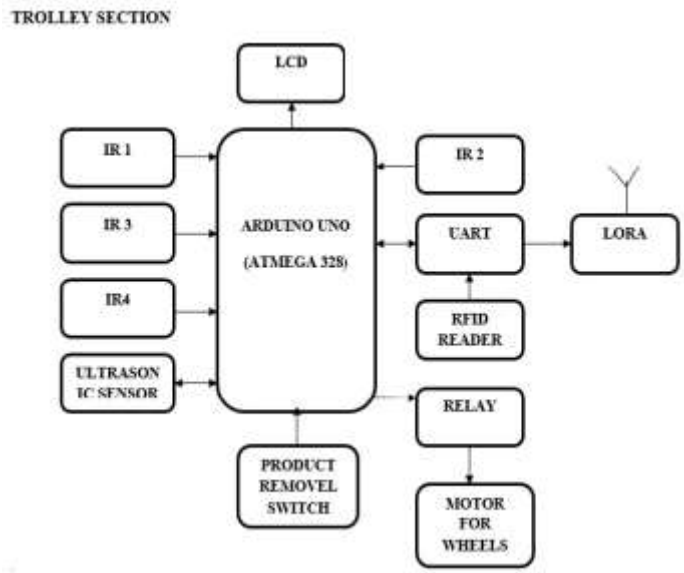

Fig 2:Block Diagram

IV.RESULT AND ANALYSIS

Commencing this project smart shopping trolley combines the advanced technology to change the process of shopping along with the retail. With dual IR sensors, the Arduino-based trolley can follow a predetermined path in stores and stream videos as it makes its way around the store. Now, to make use of IR sensors during its interactions with customers, the trolley also employs extra IR sensors that are used for obstacle detection, allowing it to not bump into obstacles or customers and maintain a distance of at least five feet away. One of the main aspects of the trolley is an RFID billing system in which each product is fitted with an RFID tag, which contains important details such as expiry dates, manufacturing dates, and prices. The real-time updates enable seamless checkouts as products are added to or removed from the trolley. This wireless communication enables the trolley to transmit product information to a central billing PC located at the checkout counter, making the transaction a lot easier and significantly reducing the queue at the cash counter. 3) Such a system not only improves the overall shopping experience and makes it more efficient but also makes inventory more efficient and customer self-engagement.

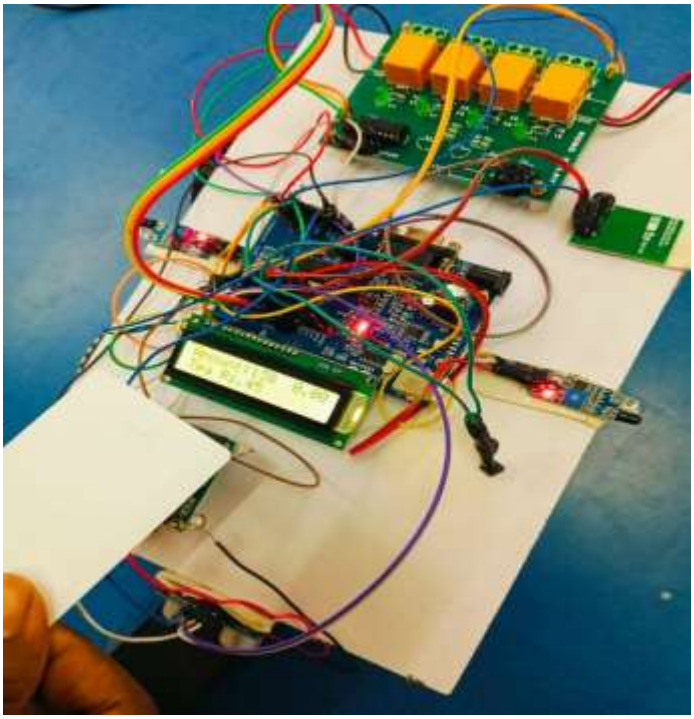

Fig 3: To Add an item

By leveraging automation and RFID technology, the Smart Shopping Trolley aims to create a user-friendly shopping experience, encouraging customer satisfaction and loyalty. This project highlights the potential for integrating IoT solutions in retail settings, paving the way for smarter, more efficient shopping environments.

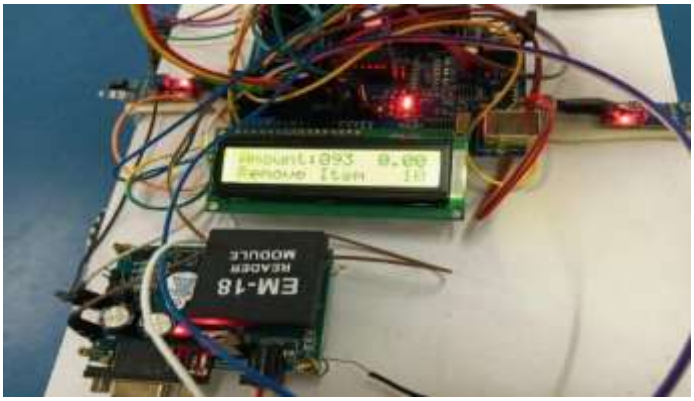

Fig 4: To Remove an item

Comparison	Arduino UNO	Raspberry Pi Zero 2W
Definition	A microcontroller based development board	A single-board computer
Application	Embedded projects	IoT projects, Standalone PC
Processor	ATmega328p Microcontroller	Broadcom BCM2710A1, quad-core 64-bit SoC
Clock Speed	16MHz	1GHz
Architecture	8-bit	64-bit
RAM	2kb	512MB
GPIO	20	40
Max. I/O Current	40 mA	5-10 mA
Power	175mW	700mW
Programming Language	C++ (Usually)	Python (Usually)
WiFi Connectivity	No built-in WiFi	Built-in WiFi and Bluetooth

Fig 4:Comparison

V. CONCLUSION

The Smart Shopping Trolley with Autonomous Navigation and RFID Billing System is a transformative innovation aimed at enhancing the efficiency and convenience of shopping experiences. By integrating autonomous navigation and RFID technology, the system eliminates

the need for manual barcode scanning, reduces checkout times, and minimizes human effort. It offers a seamless shopping experience with real-time billing, automated navigation, and enhanced security features like theft prevention through load sensors. This solution is particularly beneficial in high-traffic environments such as supermarkets and hypermarkets, where it addresses common challenges like long queues and inventory mismanagement. Despite potential challenges, such as the high initial implementation cost and technical complexities, the long-term advantages in operational efficiency, customer satisfaction, and reduced manpower reliance outweigh the limitations. The Smart Shopping Trolley not only simplifies shopping but also paves the way for the future of retail automation, offering a glimpse into how technology can revolutionize everyday tasks.

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