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AI-Powered Smart Shopping Trolley

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Abstract
Trolleys are widely used in various places like shopping malls, hospitals, and colleges, but in supermarkets or malls, long queues during peak shopping hours often result in time loss for both shoppers and staff. This paper aims to design and develop an AI-Powered Smart Shopping Trolley to transform the conventional shopping experience by leveraging advanced technologies to enhance efficiency and customer satisfaction. The key objectives include automating checkout processes to save time, utilizing barcode scanners for accurate product tracking, and implementing real-time inventory management to prevent stock shortages and overstocking. The system also provides a personalized shopping experience by offering product recommendations based on customer preferences. Each item has a barcode linked to its price, and the trolley is equipped with indicators and alerts to assist with budgeting: a red light and buzzer activate when spending exceeds the preset budget, while a green light blinks when spending remains within limits. If an item is removed, the system recalculates the total, and the change is indicated via a buzzer and the embedded LCD screen. This allows customers to monitor their expenses and pay the total directly at the counter, eliminating traditional product scanning and reducing waiting time. By automating the billing process, the system minimizes human errors and helps shoppers prioritize essential purchases, ultimately saving time and money. Additional features, such as the ability to delete scanned products, further optimize the shopping experience. The hardware prototype is developed using an Arduino platform and comprises components such as an AI-integrated barcode scanner, LCD, push buttons, visual indicators, a Wi-Fi module, and a PIC microcontroller.
Keywords: *Flex sensor, HC-05Bluetooth Module, Aurdino Nano, Voltage Divider, LCD*

1. Introduction
Shopping marts have become a vital part of daily life, particularly in urban areas of India, where they are a regular part of the lifestyle. However, in rural regions, shopping centers remain an unattainable dream. It is essential to develop intelligent systems that not only improve access to goods in rural areas but also empower these regions by introducing them to advanced automation and technology. Traditional methods of manually placing and storing goods have become increasingly inefficient and burdensome, necessitating innovative solutions to simplify and improve the process [1]. The Smart Trolley concept, powered by Artificial Intelligence (AI), is designed to transform the shopping experience for customers while optimizing operational efficiency for retailers. AI algorithms enable automation of the checkout process by using sensors and cameras to identify and track items as customers place them in the trolley. AI-powered image recognition software can accurately detect products, calculate their prices, and add them to a virtual shopping cart. By analyzing a customer's past purchase history and current selections, AI can offer personalized recommendations, displayed on the trolley's user interface, suggesting complementary products or promotions based on individual preferences and shopping habits. Additionally, AI can revolutionize inventory management by providing real-time monitoring of

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stock levels. As items are scanned and purchased, the system updates inventory records, notifies store managers of low stock, and automates reordering processes. AI-driven dynamic pricing algorithms can adjust product prices in real-time, based on factors such as demand, time of day, or competitor pricing, to maximize sales and profitability while offering customers competitive prices. AI also enhances the reliability of the Smart Trolley by monitoring its hardware components, predicting maintenance needs through sensor data analysis, and scheduling proactive repairs to minimize downtime and ensure seamless customer experiences. Data analytics powered by AI provide valuable insights into customer preferences and trends, enabling retailers to refine their marketing strategies, create targeted promotions, and enhance overall customer satisfaction. Moreover, the Smart Trolley can integrate natural language processing (NLP) capabilities, allowing customers to interact with it via voice commands or text inputs. Shoppers can inquire about products, seek assistance, or provide feedback, improving the accessibility and usability of the system.[2] By incorporating AI into the Smart Trolley, retailers can deliver a more efficient, personalized, and engaging shopping experience while optimizing business operations and boosting revenue. The proposed Smart Trolley system aims to be reliable, simpler, faster, and more effective. This initiative prioritizes customer satisfaction and offers significant potential for improvement in urban shopping malls and stores. As technology continues to advance, new innovations can be integrated into this system, addressing real-world challenges and making everyday tasks more manageable [3].

2. Literature Survey

The research article [3] presents an IoT-integrated system designed to improve the shopping experience by incorporating a smart trolley that autonomously follows customers. Utilizing IoT technology and a dedicated mobile application, the system enhances convenience and streamlines the shopping process, making it more efficient and user-friendly. Author [4] presents an overview of a hands-free smart shopping trolley that autonomously follows customers within a store. It discusses the integration of technologies such as autonomous navigation, RFID, sensor networks, and cloud computing to enhance the shopping experience. Another study focuses on the development of a human-following trolley using a Raspberry Pi and pi-camera to capture and follow a specific individual. The system aims to reduce the physical effort required in pushing trolleys, enhancing user convenience [5]. Author explores the use of RFID technology in smart shopping carts to identify product details, aiming to reduce waiting times during the billing process [6]. This paper [7] explores various implementations of smart trolleys using AI through different methods and technologies. It addresses common issues in shopping systems, such as long billing times, and proposes AI and RFID-based solutions to enhance efficiency. The research article [8] discusses the design of an automated human-following trolley that utilizes image and video processing techniques. The system employs background subtraction algorithms for human recognition and detection, enabling the trolley to follow a user under various conditions. An IoT-based trolley that autonomously follows customers, scans products using RFID for real-time billing, and includes obstacle detection for navigation [9]. It enhances shopping convenience and streamlines checkout while providing retailers with consumer insights. This study presents the design and fabrication of a human-following smart trolley equipped with a Kinect sensor. The trolley is capable of autonomously following a user, reducing the physical effort required during shopping. The research article [11] examines various smart trolley systems designed to enhance the shopping experience. It discusses the integration of technologies such as RFID, IoT, and AI to automate product scanning and billing processes, thereby reducing wait times and improving efficiency. Study discusses the development of a smart trolley equipped with human-following capabilities. The system utilizes ultrasonic sensors to detect obstacles and follows the user, aiming to improve convenience and efficiency in shopping environments [12]. Implementation of a smart shopping cart using ZigBee networks, focusing on a reliable and cost-efficient system design that ensures detection of

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deception [13]. Authors propose an automated shopping cart system that optimizes the shopping process by enabling customers to handle the checkout process, thereby reducing long queues at billing counters [14]. The study proposes an interactive kiosk-based cart designed with RFID technology to identify product details, aiming to reduce waiting times and improve the shopping experience [15]. The paper introduces a new technique for smart shopping carts that simplifies the billing process and enhances security using MIFARE technology [16]. Design a smart shopping cart based on RFID technology, discussing various implementations and their effectiveness in automating the billing process [17].

3. Methodology

The Figure below shows a block diagram comprises a total of eight components, six of which are embedded and directly attached to the shopping cart. At the core of the system is the Arduino UNO (ATmega328) microcontroller, which interfaces with multiple modules to ensure seamless operation. These modules include:

- RFID Reader (RC522 SPI) – Scans RFID tags for product identification.
- LCD Panel (20x4) – Displays relevant product and billing information.
- Buzzer – Provides audio alerts for various system notifications.
- 9V Battery – Powers the entire system.
- RFID Card – Used for item detection and authentication.
- GSM Module (SIM 900) – Facilitates communication by sending SMS alerts.
- Additionally, a mobile phone is required to receive SMS notifications related to the shopping process. [18-20]

As illustrated in the block diagram, the Arduino microcontroller is connected to all other components. When powered by a 9V battery, the microcontroller initializes with its default settings, preparing the system for operation. At this point, an RFID card or tag can be scanned. Once the RFID reader scans a card or tag, it retrieves the stored details. If the scanning process is successful, the product information is stored in the microcontroller's memory and then displayed on the LCD screen. The RFID module utilizes the SPI communication protocol to exchange data with the RFID card or tag. After shopping is completed, the total bill details are displayed on the LCD. Each RFID card or tag corresponds to a product, with product details preloaded onto the card. Once the payment is completed, the GSM module (SIM900) sends a confirmation SMS with the shopping details to the customer's registered mobile number. The entire system is programmed using the Arduino IDE, while Proteus simulation software is used for testing and validating the design before implementing it in hardware. (Figure 1)

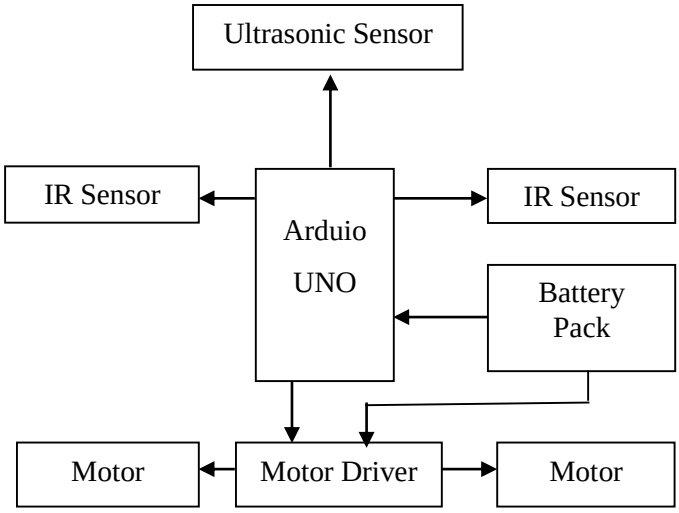

Figure 1 Block Diagram

4. System Flow Diagram

- Start
- Power up the system and display initial information.
- Scan the RFID membership card.
- If the membership card is successfully scanned, fetch and display the customer's
- details on the LCD. Otherwise, repeat the scanning process until successful.
- Start product scanning. If a product tag is detected, display its details on the LCD; otherwise, keep scanning until successful. This step is repeated for each product.
- If a product is scanned again, it will be removed from the microcontroller's memory and deducted from the ongoing bill.

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- To finalize the shopping process, the customer must scan the membership card. Once scanned, the total bill amount is displayed on the LCD.
- After the payment is processed, an SMS notification with shopping details is sent to the customer's mobile phone via the GSM module.
- Stop
- If a new membership card is detected, the process repeats for the next customer.

Results and Discussion

Since this device is portable, it can be demonstrated live. The system's functionalities are showcased as follows: The circuit connections are illustrated in the following diagram, where both the cart module and the database system are visible. The diagram clearly highlights the presence of Arduino microcontrollers. The cart module is integrated with an LCD display and an RFID reader. Upon powering the system, a Start purchasing your item appears on the LCD screen, along with the total amount, which initially starts at zero. Once powered on, the system is ready for product scanning. The upcoming figures illustrate the scanning process. Figure 2. presents the product's initialization screen. The cart is equipped with a product deletion feature, allowing customers to remove an item if they change their mind or if a product is accidentally scanned multiple times. To delete an item, the button on the left side of the breadboard must be pressed while rescanning the product. After deleting the total amount will be update. After paying total bill trolley will be reset for new shopping. (Figure 2,3,4,5)

Figure 2 Initialized Shopping

Figure 3 Scanning Product

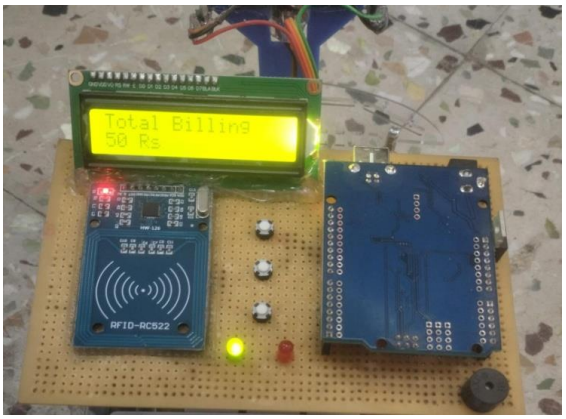

Figure 4 After Scanning Display Total Billing

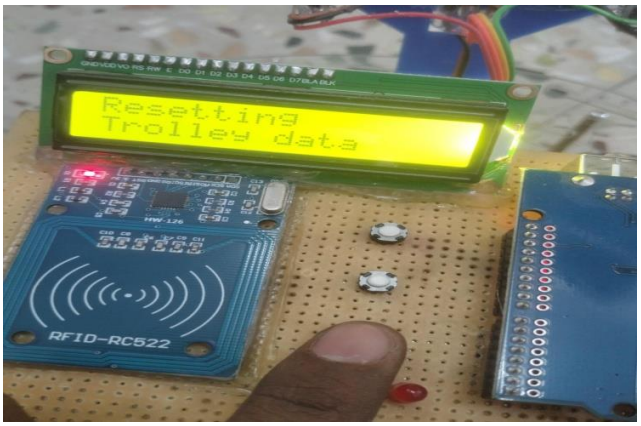

Figure 5 Reset Trolley

Conclusion

This paper explores the development of an intelligent smart mart designed to optimize space and cost, making automated systems more efficient, particularly in rural India. The system streamlines the

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shopping experience, preventing customers from exceeding their budgets while minimizing the need for manual labor in stocking shelves. Enhanced security measures ensure that no item leaves the store without proper billing, increasing reliability. A built-in weighing mechanism within the shopping cart allows customers to weigh items instantly, eliminating the need for separate weighing stations and long queues. Additionally, products are systematically. arranged with designated shelf coordinates, further reducing human intervention. Compared to traditional urban marts, this smart mart is more cost-effective, efficient, and user-friendly, also improving working conditions for staff. A standout feature is the AI-powered barcode scanner integrated into the shopping cart, addressing the common issue of long billing lines. With an LCD display providing real-time price updates and the ability to remove unwanted items with automatic price adjustments, customers enjoy greater control over their purchases. Payments are effortlessly processed through popular digital platforms, ensuring a smooth and hassle-free shopping experience.

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