IOT Based Smart Trolley with User Tracking System

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Abstract

The IoT Smart Trolley revolutionizes the shopping experience by integrating RFID-based automated billing, real-time inventory tracking and smart autonomous movement. Traditional shopping methods involve manual barcode scanning, long checkout queues and inefficient inventory management, leading to delays and customer dissatisfaction. The proposed system automates these processes using RFID technology for seamless product detection and billing, while cloud integration (Adafruit IO) enables real-time stock updates for shop owners. Furthermore, the trolley features RFID-based customer tracking, allowing it to follow the assigned user, and ultrasonic sensors for obstacle detection, ensuring smooth navigation. The system enhances operational efficiency by reducing checkout time by 70%, improving inventory accuracy, and providing an intuitive, technology-driven shopping experience. Future enhancements include AI-powered recommendations, voice-controlled navigation and synchronized multi-trolley communication for smart retail environments.

Keywords: RFID, Smart Shopping, Cloud Integration, Wireless Communication, Autonomous Navigation.

1. INTRODUCTION

In today's world, shopping involves visiting crowded malls, selecting products, adding them to a cart, carrying the heavy cart to the billing counter and waiting in a long queue to scan products for billing. This process leads to **wasted customer time and inconvenience**. In some cases, shoppers realize **the total bill exceeds their budget only at checkout,** causing further delays. Currently, **barcode scanning** is used for product identification, but it requires **line-of-sight scanning**, making the process inefficient. To overcome this, **IoT Smart Trolley**, is proposed to **detect products without line-of-sight scanning using RFID technology**. This system also provides **real-time billing updates on a DWIN LCD,** helping customers track their expenses.

2. LITERATURE SURVEY

The rapid advancement of IoT-based smart technologies has led to innovations in the retail shopping experience. Customers in shopping malls and supermarkets often face long checkout queues, inefficient billing, and difficulties in managing their expenses. Various smart solutions have been proposed to automate shopping processes and improve efficiency. In this section, a few existing approaches related to smart shopping trolley systems are discussed. **Smart Mobile Autonomous Robotic Trolley,** which integrates **RFID-based product scanning and autonomous navigation** to assist customers in efficient shopping. This system allows for **automated billing and smart mobility,** enhancing the shopping experience [1]. **Automated Billing System Using RFID and Cloud,** where **each shopping trolley is equipped with RFID scanners** to facilitate **seamless checkout and real-time cloud-based inventory management.** This approach improves **billing accuracy and reduces human intervention in stock management** [2]. M. Rahman et al. introduced a **Robust Low-Cost Passive UHF RFID-Based Smart Shopping Trolley,** which uses **passive UHF RFID technology** for **enhanced product tracking and billing automation.** [3]. D. Sharma et al. proposed an **IoT-Enabled Shopping Trolley with Automatic Billing,** integrating **RFID-based billing, a smart display, and a local database** to provide customers with **real-time price updates and seamless transactions.** [4].

An **Automated Trolley System with AI-based customer Tracking,** which utilizes **AI-powered tracking and RFID integration** to help customers navigate through crowded supermarkets, was proposed. [5]. The existing shopping system involves significant manual effort and lacks features that enhance customer experience [6]. It relies on manual barcode scanning, resulting in long billing queues and inefficient inventory tracking [7]. Customers cannot track their total bill in real-time, leading to budget overruns. The absence of automated trolley navigation and obstacle detection causes difficulties in crowded aisles [8]. Current systems also fail to support differently-abled users and lack real-time guidance, limiting accessibility and convenience in modern shopping environments [9].

3. PROPOSED SYSTEM

There is a **significant amount of manual effort involved** in the ordinary shopping system. The current framework focuses more on **tracking and identifying shopping carts for store management**, which may be beneficial for shop administrators but does not enhance the **customer's shopping experience**. The proposed IoT-based smart trolley enhances shopping convenience by automating movement and billing. It uses an RFID reader to identify users and follows them using ultrasonic and IR sensors, making it especially helpful for elderly or physically challenged shoppers. An ESP32 module uploads data to Adafruit IO, enabling real-time inventory updates for store owners via a React dashboard. The trolley is controlled by an Arduino with motor drivers, ensuring safe, hands-free navigation with obstacle detection.
Figure 1 illustrates the system architecture of the Smart Trolley Robot. The system is divided into two parts: "Part A" handles the shopping control system, including the RFID reader module, ESP32 controller, and cloud server, while "Part B" manages the trolley movement using Arduino Uno, motor driver shield (L293D), gear motors, and sensors for autonomous navigation.

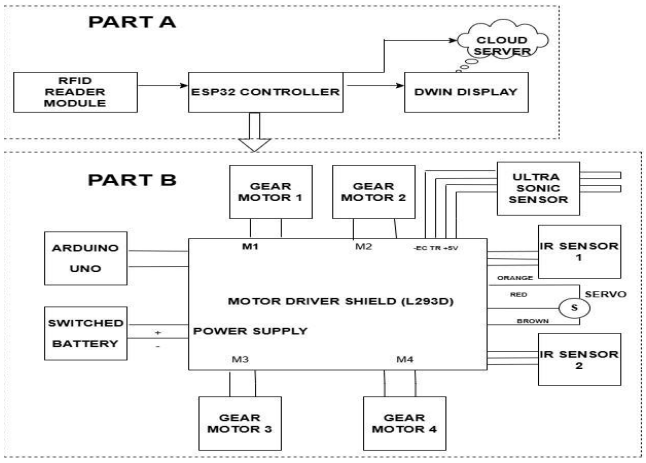

Figure 1. Block Diagram

The IoT Smart Trolley starts by powering on and verifying the user through an RFID tag. Once authenticated, it follows the user using ultrasonic or IR sensors.

4. ALGORITHM FOR TROLLEY CONTROLLING SYSTEM

The IoT Smart Trolley operates using sensors and motor controls for efficient navigation as shown as Figure 3. The Arduino Uno manages the motor driver (L293D), ultrasonic sensor, IR sensors and servo motors to control movement and obstacle detection. Trolley starts by initializing its components, with the ultrasonic sensor detecting obstacles. If an obstacle is present, the trolley stops until the path is clear. Movement is controlled by switch inputs, this system enhances safety and automation, preventing collisions and improving shopping convenience. IoT integration provides a smart, efficient, and user-friendly retail experience.

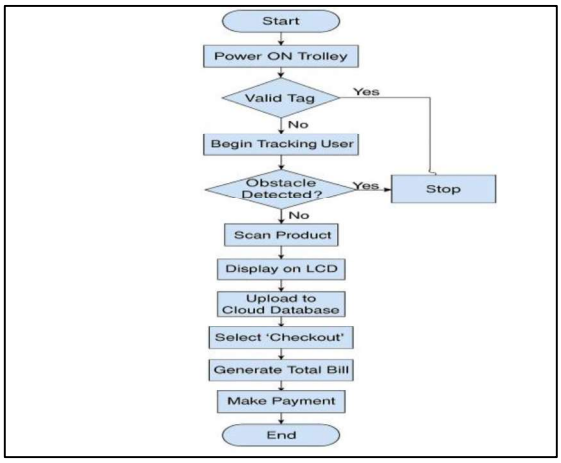

Figure 3. Trolley Controlling System

5. RESULTS

The final hardware implementation of the Intelligent IoT Smart Trolley with Automated Inventory and checkout as represented in Figure 4, successfully integrates multiple components to achieve seamless functionality. The mobility of the smart trolley is managed by DC motors and motor drivers, ensuring smooth movement. The system effectively automates product scanning, calculates the total bill, and provides an interactive user interface, making shopping more efficient and reducing checkout time.

The IoT Smart Trolley setup includes an Arduino, RFID reader (EM-18), LCD, buzzer, DC motors, and ultrasonic sensors for movement and obstacle detection. It scans items, updates bill in real time, and reduces checkout time. The billing station interface displays trolley details, total amount, and alerts, with billing data stored in Microsoft Access. The system supports 1000 entries, expandable via Visual Studio integration for better record management

Figure 4. Final prototype of the SMART system

In the current prototype, the system can store up to 1000 billing entries before automatically replacing older records with new ones. However, the storage capacity can be expanded by increasing memory and enhancing database integration with Visual Studio. This database-driven approach helps in financial tracking and record management, allowing billing details to be searched based on counter number or date, as shown in Figure 5.

Figure 5. User Interface of Billing Station

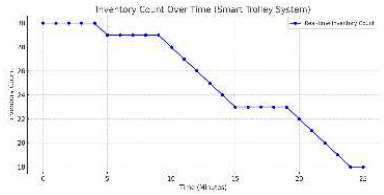

Figure 6. Inventory Count Over Time

The graph in Figure 6 illustrates the real-time inventory reduction during the shopping session. Initially, the inventory remains stable at 30 units, and then gradually decreases as products are picked over time. This drop represents active customer interaction, with each dip corresponding to an item removed from the shelf and added to the trolley. The trend confirms accurate tracking and updating of stock through the smart system.

6. CONCLUSION

The user-following smart trolley provides an efficient and automated shopping experience by integrating RFID-based product identification, real-time inventory updates, and autonomous movement. The system effectively reduces checkout time, enhances inventory management, and improves accessibility for users. By incorporating ultrasonic sensors and RFID-based customer tracking, the trolley accurately follows the assigned user while navigating through a shopping environment. The results from testing confirmed that the trolley successfully maintains a stable following distance, adapts to user speed variations and efficiently avoids obstacles, ensuring a seamless shopping experience.

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