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IoT-Based Smart Shopping Trolley with Automated Billing System Using RFID

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Abstract: *The rapid growth of automation and smart technologies has significantly influenced modern retail systems, creating a demand for faster, more efficient, and user-friendly shopping experiences. Traditional shopping methods often involve long billing queues, manual scanning, and increased dependency on human effort, which can lead to delays and errors. To overcome these challenges, this project presents the design and development of an IoT-based Smart Shopping Trolley integrated with RFID technology for automated billing and wireless control.*

The proposed system utilizes an RFID reader to identify products equipped with RFID tags, enabling instant and contactless scanning without the need for barcode systems. An Arduino UNO microcontroller processes the scanned data and continuously updates the total bill, which is displayed on an LCD screen in real time. This allows customers to monitor their expenses while shopping, enhancing transparency and convenience.

In addition, the system incorporates an ESP8266 Wi-Fi module to enable IoT-based control of the trolley through a mobile application. Users can navigate the trolley using simple commands, making it especially beneficial for elderly or physically challenged individuals. The movement is controlled using DC motors driven by an L298 motor driver, ensuring smooth and efficient operation.

Keywords: Smart Shopping Trolley, RFID Technology, Arduino UNO, IoT, ESP8266, Automated Billing, Embedded Systems, Wireless Control, Retail Automation, LCD Display

I. INTRODUCTION

In recent years, the integration of embedded systems, automation, and the Internet of Things (IoT) has significantly transformed various industries, particularly the retail sector. Traditional shopping methods, which rely heavily on manual billing and barcode scanning, often lead to long queues, increased waiting time, and human errors during checkout. These limitations reduce operational efficiency and negatively affect the overall customer experience [1].

One such innovation is the Smart Shopping Trolley, which aims to simplify the shopping process by integrating RFID (Radio Frequency Identification) technology with microcontroller-based systems. RFID enables fast and contactless identification of products without requiring direct line-of-sight, making it more efficient than conventional barcode systems [2][3].

The Smart Shopping Trolley system uses an Arduino UNO microcontroller as the central processing unit to manage inputs from RFID modules and user controls. When a product equipped with an RFID tag is scanned, the system automatically retrieves product information and updates the bill in real time, which is displayed on an LCD screen. This eliminates the need for separate billing counters and reduces checkout time significantly [4][5].

Furthermore, the incorporation of IoT technology enhances the functionality of the system by enabling wireless communication and remote control. The ESP8266 Wi-Fi module allows the trolley to connect with mobile applications such as Blynk, through which users can control the movement of the trolley. This feature improves accessibility, especially for elderly and physically challenged users, making shopping more convenient and inclusive [6][7].

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Motorized movement of the trolley is achieved using DC motors controlled by an L298 motor driver, which receives signals from the microcontroller. This integration of hardware components demonstrates the practical application of embedded systems in real-world scenarios [8]. Additionally, the system provides immediate feedback through a display and buzzer, ensuring user-friendly interaction and minimizing operational errors [9].

Despite its advantages, the system also faces challenges such as RFID signal interference, system cost, and data security concerns. However, ongoing advancements in technology and cost-effective components are continuously improving the feasibility of such systems in large-scale retail environments [10].

II. PROBLEM STATEMENT

In modern retail environments, the shopping process still relies heavily on traditional billing systems that require manual barcode scanning and centralized checkout counters. This often results in long waiting queues, especially during peak hours, leading to customer dissatisfaction and inefficient use of time. Additionally, the dependence on human operators increases the chances of billing errors, such as missed scans or incorrect pricing, which affects both customers and store management.

Another major issue is the lack of real-time cost awareness for customers while shopping. Shoppers are unable to track their total expenditure until they reach the billing counter, which can lead to budget mismanagement. Furthermore, physically pushing heavy trolleys throughout large supermarkets can be challenging for elderly or differently-abled individuals, reducing accessibility and comfort.

Retail stores also face operational challenges, including high labor costs for billing staff, inefficient crowd management, and delays in the checkout process. Existing systems do not fully utilize modern technologies such as IoT and RFID to automate and streamline shopping operations.

Therefore, there is a need to develop an intelligent and automated shopping solution that minimizes manual intervention, reduces billing time, improves accuracy, provides real-time cost updates, and enhances overall customer convenience. The system should also incorporate wireless control and smart features to make shopping more efficient, accessible, and user-friendly.

III . OBJECTIVES

- To develop an automated smart shopping trolley for efficient billing.
- To implement RFID technology for quick and contactless product identification.
- To provide real-time billing information to users through a display system.
- To enable wireless control of the trolley using IoT technology.
- To reduce checkout time and improve overall shopping experience.

IV. LITERATURE SURVEY

1. Karmakar et al. (2018) presented an innovative system in their work on “RFID-Based Smart Shopping Cart,” where they utilized RFID tags and readers to automate the billing process in retail stores. Their system enabled customers to scan items directly into the cart, eliminating the need for traditional checkout counters. This approach significantly reduced billing time and improved accuracy. However, the system required all products to be equipped with RFID tags, which increased implementation cost and posed challenges in large-scale deployment.

2. Sharma and Patel (2019) proposed a microcontroller-based smart trolley system using Arduino UNO in their study on automated retail solutions. The system integrated RFID modules, LCD display, and push buttons to allow real-time billing and user interaction. Their design improved user convenience and reduced manual effort. However, the system lacked wireless connectivity, limiting its scalability and remote control capabilities in modern smart retail environments.

3. Lee and Park (2020) introduced an IoT-enabled smart trolley system using the ESP8266 Wi-Fi module in their research on “Smart Retail Automation using IoT.” Their approach allowed real-time data communication between the

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trolley and mobile applications, enabling remote monitoring and control. The system enhanced flexibility and provided a modern shopping experience. However, it depended heavily on stable internet connectivity, and performance could degrade in areas with poor network coverage.

4. Nguyen et al. (2017) developed a motorized smart trolley controlled via smartphone in their study on assistive shopping systems. The system used DC motors and motor drivers to enable movement control, making it particularly useful for elderly and physically challenged users. While the system improved accessibility and ease of use, it did not include an automated billing mechanism, requiring integration with additional technologies for a complete solution.

5. Gupta and Kumar (2021) explored the integration of cloud computing and IoT in smart retail systems. Their work focused on storing shopping data in cloud platforms for analysis and inventory management. This approach provided valuable insights into customer behavior and improved store management efficiency. However, concerns related to data security, privacy, and system complexity were identified as major limitations.

6. Zhang et al. (2018) investigated the challenges associated with RFID technology in retail applications, particularly focusing on signal interference and tag collision issues. Their research proposed the use of anti-collision algorithms and optimized reader placement to improve system performance. Although these solutions enhanced reliability, the complexity and cost of implementation remained a concern for widespread adoption.

Comparison Table

Author & Year	Method Used	Advantages	Limitations
Karmakar et al. (2018)	RFID-based Smart Trolley	Fast billing, reduces checkout time	High cost of RFID tags
Sharma & Patel (2019)	Arduino-based Billing System	Simple design, easy implementation	No IoT or remote control
Lee & Park (2020)	IoT-enabled Trolley (ESP8266)	Remote control, real-time monitoring	Depends on internet connectivity
Nguyen et al. (2017)	Motorized Smart Trolley	Improves accessibility and mobility	No automated billing system
Gupta & Kumar (2021)	IoT with Cloud Integration	Data analysis, inventory management	Security and privacy concerns
Zhang et al. (2018)	RFID Optimization Techniques	Improves accuracy and reliability	Complex and costly implementation

IV. WORKING OF SYSTEM

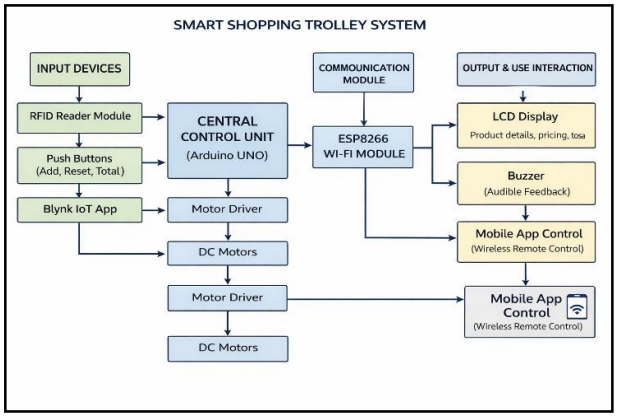

Fig 1: Design of the system

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The block diagram represents the overall architecture of the Smart Shopping Trolley System, showing the interaction between input devices, control unit, communication module, and output components. The system is designed to automate product billing and enable wireless control of the trolley using IoT technology.

1. Input Devices Section

The input section consists of components that provide data and commands to the system:

RFID Reader Module is used to scan RFID tags attached to products. Each tag contains unique information such as product ID and price.

Push Buttons (Add, Reset, Total) allow the user to interact with the system for adding items, clearing the cart, or displaying the final bill.

Blynk IoT Application acts as a wireless input interface, enabling users to send movement commands to the trolley via a smartphone.

These inputs are sent to the central control unit for processing.

2. Central Control Unit

The **Arduino UNO** acts as the brain of the system.

It receives data from the RFID reader and user inputs.

It processes product information, updates the total bill, and controls other components.

It also generates control signals for the motor driver based on commands received from the IoT module.

3. Communication Module

The ESP8266 Wi-Fi Module enables communication between the Arduino and the Blynk mobile application.

It allows real-time wireless control of the trolley and data exchange over the internet.

This module makes the system IoT-enabled and supports remote operation.

4. Motor Control Section

The Motor Driver (L298N) receives signals from the Arduino and controls the direction and speed of the motors.

DC Motors are used to move the trolley forward, backward, left, and right based on user commands.

This section enables smooth and controlled movement of the trolley.

5. Output and User Interaction Section

LCD Display shows product details, individual prices, and total bill in real time, providing transparency to the user.

Buzzer gives audio feedback for actions such as successful item scanning or errors.

Mobile App Control allows the user to remotely control trolley movement through wireless commands.

V. SYSTEM DESIGN

5.1. System Overview:

The proposed Smart Shopping Trolley System is designed to automate the shopping and billing process using embedded systems and IoT technology. It enables customers to scan products, view real-time billing information, and control trolley movement wirelessly through a mobile application. The system integrates RFID technology for product identification, a microcontroller for processing, and a Wi-Fi module for communication.

5.2. Components Description:

1. Arduino UNO (Central Control Unit)

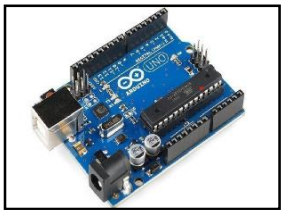

Fig.2.Arduino UNO

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Arduino UNO acts as the main controller of the system. It processes input data from the RFID reader, push buttons, and Wi-Fi module. It performs operations such as product identification, bill calculation, and sending control signals to output devices like the LCD and motor driver.

2. RFID Module (RC522)

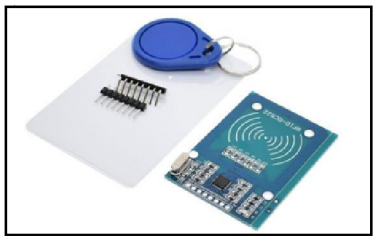

Fig.3.RFID Module

The RFID module is used to scan RFID tags attached to products. Each tag contains a unique identification number.

3. ESP8266 Wi-Fi Module

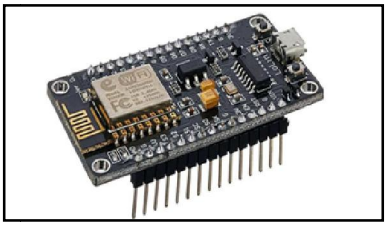

Fig.4. ESP8266 Wi-Fi Module

This module provides wireless connectivity to the system. It connects the trolley to a mobile application (Blynk), allowing users to control the movement of the trolley remotely. It also enables real-time communication between the system and the user.

4. LCD Display (16x2)

Fig.5.LCD Display

The LCD display is used to show product information such as item name, price, and total bill. It provides real-time feedback to the user, helping them keep track of their expenses during shopping.

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5. L298 Motor Driver

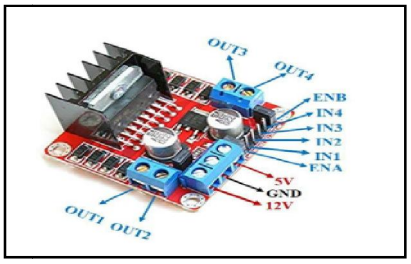

Fig.6.L298 Motor Driver

The motor driver controls the speed and direction of the DC motors. It receives signals from the Arduino and drives the motors accordingly, enabling the trolley to move in different directions.

9. 12V Battery Pack

The battery pack supplies power to all components of the system. It ensures continuous operation of the trolley without the need for external power sources.

VI. RESULTS

The developed Smart Shopping Trolley System was successfully implemented and tested to evaluate its performance in real-time shopping scenarios. The system demonstrated accurate and fast product detection using the RFID module, where items were scanned instantly without the need for manual barcode reading. The Arduino-based billing system efficiently processed the product data and continuously updated the total amount, which was clearly displayed on the LCD screen. This real-time billing feature helped users keep track of their expenses and eliminated the need for traditional checkout counters.

The IoT-based control using the ESP8266 Wi-Fi module and Blynk application worked reliably, allowing smooth and responsive movement of the trolley in different directions. The motor driver and DC motors provided stable and controlled navigation, ensuring ease of use, especially for elderly and physically challenged users. The buzzer feedback system effectively indicated successful scans and system actions, improving user interaction.

Overall, the system significantly reduced billing time, minimized human errors, and improved shopping convenience. The integration of RFID and IoT technologies resulted in an efficient, user-friendly, and practical solution for modern retail environments, demonstrating the feasibility of automated smart shopping systems

VII. CONCLUSION

The Smart Shopping Trolley System demonstrates an effective integration of RFID technology, embedded systems, and IoT to modernize the conventional shopping process. The system successfully automates product identification and billing, eliminating the need for manual scanning and reducing long checkout queues. Real-time display of product details and total cost enhances transparency and helps customers manage their expenses efficiently.

The inclusion of wireless control through the ESP8266 module further improves user convenience by allowing easy navigation of the trolley using a mobile application. The overall system performs reliably, with accurate product

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detection, smooth motor control, and responsive user interaction. By reducing human effort, minimizing billing errors, and saving time, the proposed system provides a practical and efficient solution for smart retail environments. It also highlights the potential of combining IoT and embedded systems to improve everyday applications.

VIII. FUTURE SCOPE

The Smart Shopping Trolley System can be further enhanced by incorporating advanced technologies and additional features. Integration with digital payment systems such as UPI or mobile wallets can enable automatic billing and payment directly from the trolley, eliminating the need for separate transactions.

The system can also be connected to a centralized cloud database for real-time inventory management and data analysis, helping store owners track product demand and customer behavior. Adding sensors such as weight sensors or cameras can improve accuracy in product detection and prevent misuse.

Further improvements may include voice control and mobile app enhancements to make the system more accessible for elderly and differently-abled users. The use of artificial intelligence can enable personalized recommendations and smart navigation within stores. With these advancements, the system can evolve into a fully autonomous shopping solution, contributing to the development of smart retail and smart city ecosystems.

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