

Design and Implementation of Smart Shopping Trolley with Automated Billing System Using RFID

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Abstract—*The increasing adoption of automation and intelligent technologies has transformed modern retail environments, creating a need for quicker, smarter, and more convenient shopping solutions. Conventional shopping systems often require customers to wait in long checkout lines, depend on manual barcode scanning, and involve greater human effort, which may cause delays and billing mistakes. To address these issues, this project focuses on the design and implementation of an IoT-enabled Smart Shopping Trolley integrated with RFID technology for automatic billing and wireless operation. The developed system uses an RFID reader to detect products attached with RFID tags, allowing fast and contactless item identification without traditional barcode scanning. An Arduino UNO microcontroller manages the scanned product data and updates the total amount instantly, which is shown on an LCD display in real time. This helps customers track their spending during shopping and improves convenience as well as billing transparency. Furthermore, the trolley includes an ESP8266 Wi-Fi module that provides IoT-based control through a mobile application. Customers can move the trolley using simple commands, making the system highly useful for senior citizens and physically disabled users. Trolley movement is achieved using DC motors controlled through an L298 motor driver, ensuring reliable and smooth performance.*

Keywords: *Smart Shopping Trolley, RFID System, Arduino UNO, Internet of Things, ESP8266, Automatic Billing, Embedded Technology, Wireless Navigation, Retail Innovation, LCD Module*

I. INTRODUCTION

In recent years, the combination of embedded systems, automation, and the Internet of Things (IoT) has brought major changes to many industries, especially the retail sector. Traditional shopping methods mainly depend on manual billing processes and barcode scanning, which often create long queues, increase customer waiting time, and may result in human errors during checkout. These drawbacks reduce store efficiency and lower customer satisfaction [1].

An advanced solution to this problem is the Smart Shopping Trolley, designed to make shopping easier and faster by integrating RFID (Radio Frequency Identification) technology with microcontroller-based systems. RFID allows products to be identified quickly without physical contact or direct line-of-sight, making it more effective than traditional barcode systems [2][3].

The Smart Shopping Trolley uses an Arduino UNO microcontroller as the main control unit to handle signals from the RFID reader and other user inputs. Whenever a product with an RFID tag is scanned, the system automatically reads the product details and updates the total bill instantly. The updated amount is then shown on an LCD display in real time. This process removes the need for separate billing counters and greatly reduces checkout delays [4][5].

In addition, the use of IoT technology increases the capabilities of the trolley by providing wireless communication and remote access. With the help of the ESP8266 Wi-Fi module, the trolley can connect to mobile applications such as Blynk, allowing users to control its movement through a smartphone. This feature is highly beneficial for elderly people and physically disabled users, making shopping more comfortable and accessible [6][7].

The movement of the trolley is controlled through DC motors operated by an L298 motor driver, which receives commands from the microcontroller. This setup shows the practical implementation of embedded hardware in everyday applications [8]. The system also gives instant feedback through an LCD display and buzzer, which improves user interaction and helps prevent mistakes during operation [9].

Although the system offers many benefits, certain challenges still exist, such as RFID signal disturbances, higher installation costs, and security

risks related to data communication. However, continuous improvements in technology and affordable hardware components are making such smart systems more practical for large retail stores in the future [10].

II. PROBLEM STATEMENT

In today's retail stores, the shopping process still depends largely on conventional billing systems that use manual barcode scanning and centralized payment counters. This often creates long queues at checkout sections, especially during busy hours, causing delays, wasting customer time, and reducing satisfaction. The involvement of human operators also increases the possibility of billing mistakes such as missed product scans or wrong price entries, affecting both customers and store owners.

Another important problem is that customers cannot monitor their total shopping cost in real time while selecting products. They usually know the final bill only at the payment counter, which may create budget issues and inconvenience. In addition, moving heavy shopping trolleys across large supermarkets can be difficult for senior citizens and physically challenged people, making shopping less comfortable and less accessible.

Retail businesses also face challenges such as high manpower requirements for billing counters, poor crowd management, and slower checkout operations. Many existing shopping systems do not effectively use advanced technologies like IoT and RFID for automation and better management.

Therefore, there is a strong need for a smart and automated shopping trolley system that reduces manual work, shortens billing time, improves billing accuracy, provides live cost updates, and increases customer convenience. The system should also include wireless control and intelligent features to make shopping easier, faster, and more 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) developed an RFID-based Smart Shopping Cart system that used RFID tags and readers to automate the billing process in retail stores. Customers could scan products directly into the trolley, removing the need for traditional checkout counters. This method reduced billing time and increased accuracy. However, the requirement of RFID tags for all products increased setup cost and created difficulties for large-scale implementation.

2) Sharma and Patel (2019) designed a smart trolley system based on the Arduino UNO microcontroller for automated shopping applications. Their system combined RFID modules, an LCD display, and push buttons to provide real-time billing and user interaction. It improved customer convenience and minimized manual work. However, the absence of wireless connectivity limited remote monitoring and future scalability.

3) Lee and Park (2020) proposed an IoT-based smart trolley system using the ESP8266 Wi-Fi module for retail automation. Their system enabled real-time communication between the trolley and mobile applications, allowing remote control and monitoring. This provided a more advanced and flexible shopping experience. However, the system depended on a reliable internet connection, and poor network signals could reduce performance.

4) Nguyen et al. (2017) introduced a smartphone-controlled motorized trolley for assistive shopping applications. The system used DC motors and motor drivers for movement control, making it helpful for elderly and differently-abled users. Although it improved mobility and convenience, it did not include an automatic billing feature, requiring additional technologies for complete retail automation.

5) Gupta and Kumar (2021) studied the use of cloud computing and IoT in smart retail systems. Their work focused on storing shopping data on cloud platforms for customer analysis and inventory management. This improved store operations and provided useful business insights. However, issues such as data privacy, security risks, and increased system complexity were considered major challenges.

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

IV. WORKING OF SYSTEM

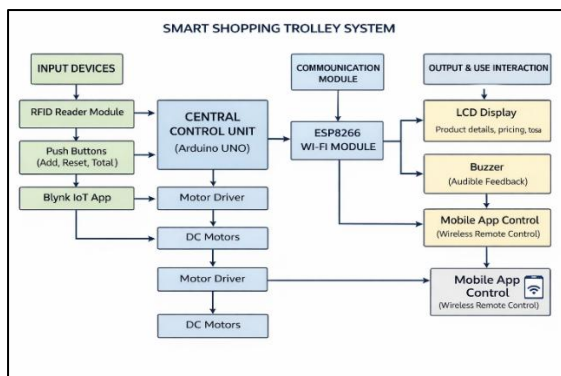


Fig 1: Design of the system

The block diagram illustrates the complete structure of the Smart Shopping Trolley System, showing the connection between input devices, processing unit, communication module, and output components. The system is developed to automate product billing and provide wireless trolley control using IoT technology.

1. Input Devices Section

The input section contains devices that send data and commands to the system. The RFID Reader Module is used to scan RFID tags attached to products, where each tag stores unique details such as product identification number and price. Push Buttons such as Add, Reset, and Total are provided for user

interaction to add products, clear billing data, or display the final amount. The Blynk IoT Application works as a wireless input platform, allowing users to control trolley movement through a smartphone. All these inputs are transferred to the controller for processing.

2. Central Control Unit

The Arduino UNO acts as the main controller of the system. It receives signals from the RFID reader, push buttons, and Wi-Fi module. The controller processes scanned product information, calculates the total bill, updates the display, and manages all connected devices. It also sends control commands to the motor driver for trolley movement.

3. Communication Module

The ESP8266 Wi-Fi Module provides wireless communication between the Arduino UNO and the Blynk mobile application. It enables real-time transfer of commands and data through the internet. This module makes the trolley IoT-enabled and supports remote monitoring and operation.

4. Motor Control Section

The L298N Motor Driver receives control signals from the Arduino and regulates the direction and speed of the motors. The DC Motors are responsible for moving the trolley in forward, backward, left, and right directions according to user commands. This section ensures smooth and controlled trolley navigation.

5. Output and User Interaction Section

The LCD Display shows product names, item prices, and the total bill instantly, helping users monitor expenses while shopping. The Buzzer provides sound indications for successful scanning, button operations, or errors. The Mobile App Control feature allows users to operate the trolley wirelessly, improving convenience and accessibility.

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)

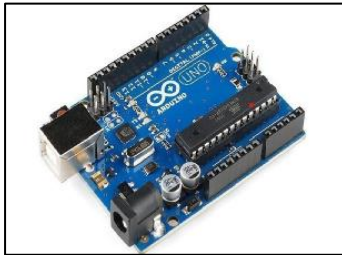


Fig.2.Arduino UNO

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.

5. L298 Motor Driver

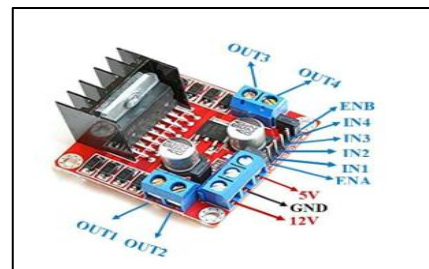


Fig.6.L298 Motor Driver

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 designed, implemented, and tested under real-time shopping conditions to evaluate its overall performance. The system showed accurate

and quick product identification through the RFID module, where items were scanned instantly without requiring manual barcode reading. The Arduino-based billing unit efficiently processed the scanned product data and continuously updated the total bill, which was clearly displayed on the LCD screen. This real-time billing feature allowed users to monitor their expenses while shopping and reduced dependency on traditional billing counters.

The IoT-based trolley control using the ESP8266 Wi-Fi module and Blynk mobile application operated effectively, providing smooth and responsive movement in multiple directions. The motor driver and DC motors ensured stable navigation and easy handling of the trolley. This feature proved especially useful for elderly users and physically challenged individuals by improving convenience and accessibility. The buzzer feedback system also worked properly by giving audio indications for successful product scans and other system operations, enhancing user interaction.

Overall, the system successfully reduced checkout time, minimized billing errors, and improved the shopping experience. The combination of RFID and IoT technologies created an efficient, reliable, and user-friendly solution for modern retail stores, proving the practicality of automated smart shopping trolley systems.

VII. CONCLUSION

The Smart Shopping Trolley System presents a successful combination of RFID technology, embedded systems, and IoT to improve the traditional shopping experience. The system effectively automates product detection and billing, removing the need for manual scanning and reducing long queues at checkout counters. The real-time display of product details and total bill increases transparency and helps customers manage their shopping budget more efficiently.

The addition of wireless control through the ESP8266 Wi-Fi module further enhances convenience by allowing users to move the trolley using a mobile application. The system operated reliably with accurate RFID scanning, smooth motor movement, and quick user response. By reducing manual effort, decreasing billing mistakes, and saving valuable time, the proposed system offers a practical and

efficient solution for modern retail stores. It also demonstrates the wide potential of IoT and embedded technologies in improving everyday applications.

VIII. FUTURE SCOPE

The Smart Shopping Trolley System can be improved further by adding advanced technologies and smart features. Integration with digital payment methods such as UPI, debit cards, or mobile wallets can allow customers to complete billing and payment directly from the trolley, removing the need for separate checkout processes.

The system can also be linked with a centralized cloud database for real-time inventory monitoring, sales tracking, and customer behavior analysis. This would help store management improve stock control and business decisions. Additional components such as weight sensors and cameras can be included to increase product detection accuracy and prevent misuse or item mismatch.

Future enhancements may also include voice command control and upgraded mobile applications to make the trolley more user-friendly for elderly and differently-abled people. Artificial intelligence can be used for personalized product suggestions, route guidance inside supermarkets, and smart shopping assistance. With these developments, the system can become a fully automated shopping solution and support the growth of smart retail and smart city environments.

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