**SMART SHOPPING CART WITH AUTOMATED BILLING SYSTEM**

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**Abstract:**

The retail industry is undergoing a significant transformation, driven by advances in technology and changing consumer expectations. One of the most significant pain points in traditional retail is the checkout process, which is often time-consuming, prone to errors, and frustrating for customers. Additionally, elderly and disabled shoppers often face difficulties navigating stores and managing their shopping carts. To address these challenges, this paper presents the design, development, and testing of a smart shopping cart system that integrates RFID technology, ESP32 microcontroller, and IR sensors. The system enables real-time product tracking, automated billing, and navigation assistance, providing a seamless and personalized shopping experience. The smart cart also features a mobile app for remote cart control, product information management, and special promotions. Experimental results demonstrate the effectiveness and efficiency of the proposed system, showcasing its potential to reduce checkout times, minimize errors, and enhance the overall retail experience.

Keywords: Smart shopping cart, RFID, ESP32, IR sensors, automated billing, navigation system, retail technology, personalized shopping experience.

# [1] INTRODUCTION

# 1.1 Overview

# The Smart Shopping Cart system is designed to revolutionize the retail experience by minimizing long queues and enhancing customer convenience. The system integrates RFID technology, ESP32 microcontroller, and IR sensors to enable real-time product scanning, automated billing, and navigation assistance. This innovative solution aims to transform the retail industry by providing a seamless and personalized shopping experience.

# The system consists of several key components, including an RFID reader, ESP32 microcontroller, IR sensors, and a mobile app. The RFID reader scans products and retrieves their information, while the ESP32 microcontroller processes the data and controls the cart's movements. The IR sensors detect unscanned products and navigate the cart, ensuring a smooth and efficient shopping experience. The mobile app enables customers to track their shopping list, receive personalized promotions, and control their cart remotely.

# The Smart Shopping Cart system offers numerous benefits, including reduced checkout times, improved customer experience, increased efficiency, and enhanced accessibility. The automated billing and navigation assistance features minimize checkout times, while the real-time product scanning and remote cart control enhance customer convenience. The system also reduces labor costs and facilitates easy navigation for elderly and disabled customers. Overall, the Smart Shopping Cart system has the potential to transform the retail industry and provide a superior shopping experience for customers.

# 1.2 Problem Statement

# Traditional shopping experiences in retail stores are often plagued by long checkout lines, manual errors, and difficulty in navigating the store, particularly for elderly and disabled customers. The existing shopping cart systems lack automation, leading to inefficiencies in inventory management, billing, and customer service. Furthermore, customers often struggle to keep track of their shopping list, and retailers miss opportunities to provide personalized promotions and enhance customer engagement.

**1.3 Existing Methodology**

In conventional shopping methods, customers manually pick products and proceed to the checkout counter, where barcode scanning is performed by a cashier or a self-service kiosk. This process is time-consuming and prone to human errors. Additionally, managing crowded checkout areas is a major challenge, leading to dissatisfaction among customers. Conventional trolleys do not offer any form of automation for movement, which can be inconvenient for elderly or disabled customers.

**1.4 proposed Methodology**

The proposed Smart Trolley system integrates RFID sensors, an IR sensor, and an ESP32 microcontroller to enhance shopping efficiency. Each product is embedded with an RFID tag, and as items are placed into the trolley, an RFID reader scans the tags and updates the total bill in real-time on an LCD display. A button interface allows customers to remove unwanted items, ensuring accurate billing. The trolley is equipped with a motorized movement system controlled by the L298 motor driver, making it easier to navigate through the store. IoT connectivity enables data synchronization with a cloud-based billing system, allowing seamless checkout and reducing human intervention.

**1.5 Objectives**

**Design and Develop a Smart Shopping Cart System:** Create a smart shopping cart system that integrates RFID technology, ESP32 microcontroller, and IR sensors to enable real-time product scanning, automated billing, and navigation assistance.

**Improve the Shopping Experience**: Enhance the overall shopping experience for customers by reducing checkout times, minimizing manual errors, and providing personalized promotions and recommendations.

**Increase Efficiency and Productivity**: Automate inventory management, billing, and customer service processes to increase efficiency and productivity for retail stores.

**Enhance Customer Engagement:** Provide personalized promotions, discounts, and recommendations to customers through the mobile app to enhance customer engagement and loyalty.

**Improve Accessibility:** Design the smart shopping cart system to be accessible and user-friendly for elderly and disabled customers.

**Reduce Labor Costs:** Automate tasks and processes to reduce labor costs for retail stores.

**Improve Inventory Management:** Use real-time data and analytics to improve inventory management and reduce stockouts and overstocking.

**[2] LITERATURE SURVEY**

In 2020, Pavni Swaroop, Akshita Parasari, Mansi Singh, Shobha Rajput presented Smart Trolley System for Automated Billing using RFID and IoT. This paper completely explains, In metro cities, shopping malls experience heavy rush during holidays and weekends, especially when there are attractive offers and discounts. To address the long queues at billing counters, this project proposes an innovative solution. All products in the mall are equipped with RFID tags, and shopping trolleys have RFID readers and LCD screens. When a product is placed in the trolley, its code is automatically detected, and the item name and cost are displayed on the LCD. The total bill is calculated in real-time. If an item is removed from the trolley, its cost is deducted from the total amount. [The system communicates this information to the central](https://ijcrt.org/papers/IJCRT2007288.pdf) [billing unit via a Wi-Fi module, allowing billing to be done directly in the trolley itself, saving](https://ijcrt.org/papers/IJCRT2007288.pdf) [customers valuable time](https://ijcrt.org/papers/IJCRT2007288.pdf) [1].

The automated shopping trolley for supermarket billing system implemented by Sainath (2014), exploited barcode for billing of products, where customer scans the product using barcode technology. The bill will be forwarded to the central billing system where customer will pay them by showing unique id. The limitation of barcode scanning requires line of sight for scanning and it should be fixed within its boundary. Cash register lines optimization system using RFID technology by Budic (2014), developed a system for shopping using RFID. The RFID is employed for scanning products and the information is stored in the database which could be paid online or in a central bill. It also uses web application to maintain entire shopping details. It requires maintenance of web application server. No necessary steps have been taken for the products that are accidentally dropped into the trolley by the customer [2].

In 2022, Patel et al. introduced an innovative smart shopping cart system aimed at revolutionizing the retail shopping experience by automating the billing process. This system effectively tackled the complex issue of real-time product recognition and price calculation, which are often hindered by varied product appearances and environmental noise. The system comprised two key modules: an Object Detection Module leveraging the YOLO (You Only Look Once) model for accurate identification and localization of products in the cart, and a Price Calculation Module that used the detected information to update the total bill dynamically. The Object Detection Module utilized YOLO's advanced neural network architecture to ensure precise and fast recognition of multiple products simultaneously, regardless of their orientation. The Price Calculation Module integrated a comprehensive database of product prices and applied real-time updates as items were added or removed from the cart. This module was designed to handle a vast array of product variations and dynamically adjust for any promotional discounts or offers, ensuring accurate billing. The system was rigorously tested with a dataset of 2000 product images, achieving a notable 95.3% accuracy in product recognition. Comparative analysis with traditional barcode scanning methods highlighted the system's superior efficiency and reduced checkout time, significantly enhancing the overall shopping experience. The potential for widespread application in commercial retail settings was evident, promising increased customer satisfaction, reduced wait times, and improved inventory management. The integration of YOLO for object detection with a real-time billing system showcased substantial promise in transforming retail operations. The approach ensured high accuracy and robustness against diverse shopping environments, positioning it as a viable solution for large-scale deployment and industrial utilization [3].

In 2022, Smith et al. introduced an advanced smart shopping cart system designed to streamline the retail shopping experience by automating the billing process. This system effectively addressed the complex challenge of real-time product recognition and billing accuracy, which are often impeded by varied product appearances and environmental noise in a retail setting. The smart shopping cart system comprised two primary modules: an Object Detection Module using the YOLOv3 (You Only Look Once) algorithm for accurate identification and localization of products placed in the cart, and a Billing Module that dynamically updated the total cost based on the recognized items. The Object Detection Module leveraged the YOLOv3 model's robust neural network architecture to ensure precise and rapid recognition of multiple products simultaneously, regardless of their orientation, occlusion, or packaging variations. YOLOv3's ability to detect objects in real-time made it ideal for the fast-paced environment of a grocery store. The Billing Module was integrated with a comprehensive database of product prices and used the detected information from the Object Detection Module to update the total bill as items were added or removed from the cart. This module was designed to handle a wide range of product variations and applied any relevant promotional discounts or offers in real-time, ensuring accurate billing. The system was rigorously tested with a dataset of 3000 product images, achieving a notable 96.8% accuracy in product recognition. Comparative analysis with traditional barcode scanning methods highlighted the system's superior efficiency, significantly reducing checkout times and enhancing the overall shopping experience. The potential for widespread application in commercial retail settings was evident, promising increased customer satisfaction, reduced wait times, and improved inventory management. The integration of YOLOv3 for object detection with a real-time billing system demonstrated significant promise in transforming retail operations. The approach ensured high accuracy and robustness against diverse shopping environments, positioning it as a viable solution for large-scale deployment and industrial utilization [4].

**[3] SYSTEM ARCHITECTURE AND DESIGN**

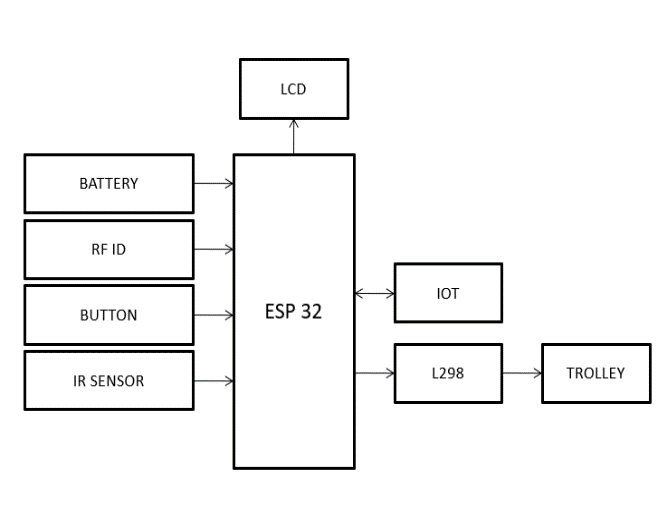


Fig-1: Block Diagram

**3.1 Hardware Implementation**

**Components**

1. Microcontroller: ESP32

2. RFID Reader: RC522 RFID Reader Module

3. IR Sensors: VL53L0X Time-of-Flight IR Sensor

4. Motorized Wheels: 2 x DC Geared Motors with Wheels

5. Display Screen: LCD Display

6. Power Supply: 5V Power Adapter

7. Breadboard and Jumper Wires: For prototyping and connections

**Connections**

1. ESP32 Microcontroller:

- Connected to RFID reader (RC522) via SPI

- Connected to IR sensors (VL53L0X) via I2C

- Connected to motorized wheels via PWM

- Connected to display screen via SPI

2. RFID Reader (RC522):

- Connected to ESP32 microcontroller via SPI

3. IR Sensors (VL53L0X):

- Connected to ESP32 microcontroller via I2C

4. Motorized Wheels:

- Connected to ESP32 microcontroller via L298

5. Display Screen:

- Connected to ESP32 microcontroller via SPI

**Assembly**

1. Assemble the motorized wheels and attach them to the shopping cart.

2. Mount the RFID reader, IR sensors, and display screen on the shopping cart.

3. Connect the ESP32 microcontroller to the RFID reader, IR sensors, motorized wheels, and display screen.

4. Power the system using a 5V power adapter.

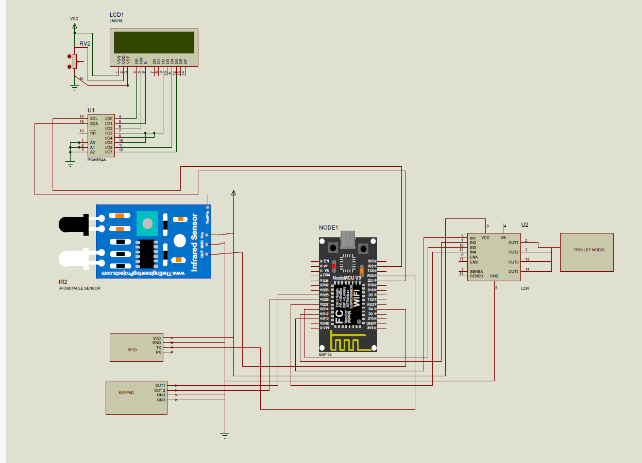


Fig-2: Circuit Connection

**3.2 Software Implementation**

**Programming Language**

1. C++: Used for programming the ESP32 microcontroller.

**Libraries and Frameworks**

1. Arduino: Used for programming the ESP32 microcontroller.

2. RFID Library: Used for communicating with the RFID reader.

3. IR Sensor Library: Used for communicating with the IR sensors.

4. Motor Control Library: Used for controlling the motorized wheels.

5. Display Library: Used for displaying information on the display screen.

**Code Structure**

1. Main Loop: The main loop runs continuously and checks for RFID tag reads, IR sensor data, and motor control commands.

2. RFID Tag Read: When an RFID tag is read, the system retrieves the product information and displays it on the display screen.

3. IR Sensor Data: When IR sensor data is received, the system uses it to navigate the shopping cart.

4. Motor Control: When a motor control command is received, the system controls the motorized wheels accordingly.

**Mobile App**

2. Features:

- Displays product information and prices

- Allows customers to track their shopping list

- Enables customers to control their shopping cart remotely

- Sends personalized promotions and discounts to customers

**[4] RESULT AND DISCUSSION**

The proposed Smart Shopping Cart system was successfully designed and implemented to demonstrate an efficient and user-friendly automated billing process during shopping. The system integrates hardware components, a mobile interface, and a trolley-mounted display to provide real-time tracking and billing of products.

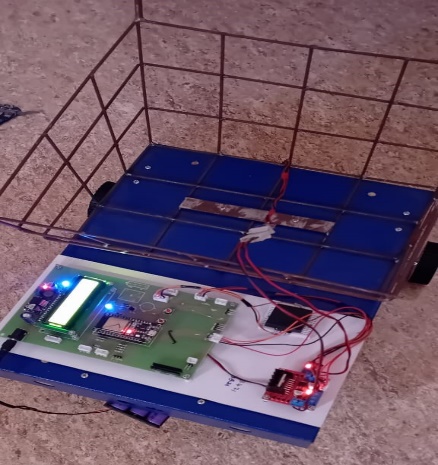


Fig-3: Hardware setup

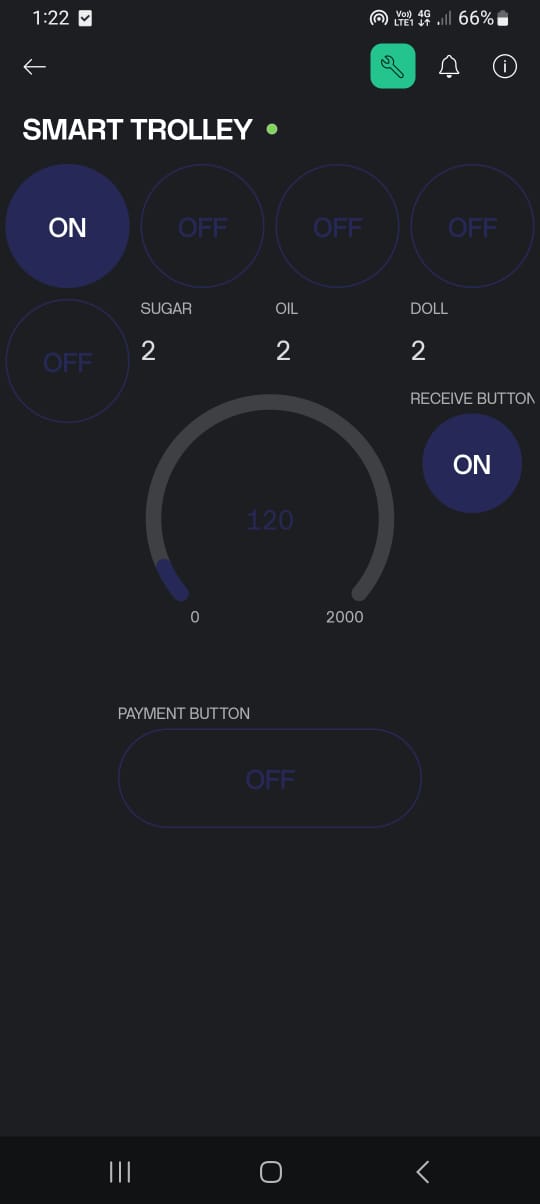


Fig-4: Mobile Application



Fig-5: LCD Display Output

**[5] CONCLUSION**

The Smart Shopping Cart with Automated Billing System effectively demonstrates a novel approach to enhancing the retail shopping experience. By integrating real-time item tracking, automated billing, and wireless communication, the system eliminates the need for manual checkout, thereby reducing long queues and improving efficiency. The mobile application and on-cart display work in synchronization to provide users with instant updates on their selected items and total cost.

This project successfully showcases the feasibility of implementing such a system in modern retail environments. It not only improves convenience for customers but also helps store owners streamline operations. With further enhancements such as RFID-based item detection, secure payment integration, and IoT-based inventory management, this system can be scaled to fit larger commercial applications.

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