

Autonomous Customer-Following Smart Cart with IOT Based Billing System

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Abstract :- The Autonomous Customer-Following Smart Cart with IoT-Based Billing System is designed to simplify shopping by automating cart movement and billing. The system uses STM32 and ATmega328P controllers to manage sensors and operations. An ultrasonic sensor allows the cart to follow the customer while avoiding obstacles. Products are scanned automatically using an RFID reader and RFID tags, and billing information is sent to a server through a WiFi module. The motor driver and servo motor control cart movement and direction. LED indicators and buttons provide user interaction and system status information. The system operates using a rechargeable battery for portable use. Testing results show accurate tracking and automatic bill generation, reducing checkout time and improving shopping efficiency. The project demonstrates the practical use of IoT and embedded systems in smart retail applications. The developed system improves customer convenience by reducing manual effort and waiting time at billing counters. It provides an efficient and smart shopping solution using IoT and automation technology.

Keywords:- Autonomous Smart Cart, IoT-Based Billing, RFID, Ultrasonic Sensor, Embedded System, WiFi Communication, Smart Shopping, Retail Automation.

I. INTRODUCTION

Shopping in supermarkets often takes more time due to long billing queues and manual cart handling. To solve this problem, an Autonomous Customer-Following Smart Cart with an IoT-Based Billing System is developed. The smart cart automatically follows the customer using sensors and avoids obstacles during movement. RFID technology is used to scan products automatically and generate bills without manual work. The product data is sent to a server using a WiFi module for real-time billing. STM32 and ATmega328P controllers manage the overall system operations. The system runs on a rechargeable battery for portable use.

II. LITERATURE REVIEW

With the rapid development of automation and Internet of Things (IoT) technology, many researchers have focused on improving traditional shopping systems by introducing smart shopping carts. In conventional supermarkets, customers spend a significant amount of time waiting in billing queues, and manual barcode scanning increases workload for employees. To overcome these problems, several smart cart systems have been proposed using embedded systems and wireless communication technologies.

Early research mainly concentrated on RFID-based billing systems. In these systems, each product contains an RFID tag that stores product information such as ID and price. When a customer places an item inside the cart, an RFID reader automatically detects the product and updates the bill. This approach reduces human errors and eliminates the need for manual barcode scanning. Researchers found that RFID technology improves billing speed and accuracy compared to traditional checkout systems.

Later studies introduced microcontroller-based smart carts using platforms such as Arduino and ATmega328P. These systems integrated RFID readers, LCD displays, and wireless modules to show product details and total cost directly on the cart. Customers could monitor their expenses while shopping, which improved transparency and user satisfaction. However, these systems still required manual cart handling by customers.

With the advancement of IoT technology, researchers developed IoT-enabled smart carts capable of sending product data to cloud servers through WiFi modules. These systems allowed real-time data storage, remote monitoring, and automatic bill generation.

Some research works focused on improving safety and automation by adding sensors such as ultrasonic sensors and infrared sensors for obstacle detection. These sensors helped prevent collisions and allowed smart navigation inside shopping environments. Sensor-based automation improved system reliability and reduced accidents in crowded areas.

Recent developments in smart retail systems introduced autonomous features where robotic carts could move automatically using motor drivers and control algorithms. These systems aimed to reduce customer effort by assisting in cart movement. However, many existing models lacked proper

integration between autonomous movement and automated billing systems.

The proposed Autonomous Customer-Following Smart Cart combines multiple technologies studied in previous research, including RFID-based billing, IoT communication, sensor-based navigation, and embedded system control. Unlike earlier systems, this project adds customer-following functionality using ultrasonic sensing, allowing the cart to automatically move with the user while maintaining a safe distance.

Furthermore, the integration of STM32 and ATmega328P controllers improves processing efficiency and system performance. The use of WiFi connectivity enables real-time billing updates and reduces dependency on traditional checkout counters. LED indicators and user buttons enhance interaction between the system and the customer.

From the reviewed literature, it is clear that smart cart technology is evolving toward full automation and intelligent retail environments. The combination of IoT, RFID, and autonomous navigation provides a practical solution for reducing billing time, minimizing manual effort, and improving the overall shopping experience.

Thus, the proposed system builds upon existing research and contributes to the development of smart retail automation by providing an efficient, user-friendly, and contactless shopping solution.

III. SYSTEM ARCHITECTURE

The system architecture of the Autonomous Customer-Following Smart Cart includes sensors, controllers, communication modules, and a cloud server working together. STM32 and ATmega328P controllers manage system operations and process sensor data. The ultrasonic sensor enables customer following and obstacle detection. An RFID reader scans product tags for automatic billing, while the WiFi module sends billing data to the server for real-time updates. Motor drivers and a servo motor control cart movement and direction. LED indicators and buttons provide user interaction and system status. The system is powered by a rechargeable battery for portable operation.

The system works by continuously collecting data from sensors and processing it through the microcontrollers to perform automatic operations. When a customer moves, the ultrasonic sensor detects the distance and the cart follows accordingly. Products added to the cart are identified using RFID technology, and the billing information is updated automatically through IoT communication. The motor driver controls wheel movement for smooth navigation, while the server stores and manages billing data. This integration of hardware and software creates a smart, efficient, and user-friendly shopping system.

A. Dispensing Mechanisms

The dispensing mechanism controls detection and confirmation of products added to the smart cart. When a product is placed inside, the RFID reader scans the tag and sends data to the controller. The controller verifies the item and updates billing through the IoT server. LED indicators confirm successful scanning, while buttons allow item reset or removal if required. A servo motor assists in guiding product handling, ensuring accurate detection and automatic billing without manual scanning.

IV. SOFTWARE & HARDWARE IMPLEMENTATION

The software implementation of the Autonomous Customer-Following Smart Cart is developed using embedded programming to control sensors, motors, and communication modules.

- The software is developed using Arduino IDE and Embedded C programming language.
- STM32 and ATmega328P controllers are programmed to control all system operations.
- The ultrasonic sensor program enables customer-following and obstacle detection.
- RFID reader software scans product tags and identifies product information.
- Billing data is processed automatically after product detection.
- The WiFi module sends product details to the cloud server for real-time billing updates.
- Motor control algorithms manage cart movement and direction.
- Servo motor control is implemented for steering or positioning functions.
- LED indicators are programmed to show system status and scan confirmation.
- Push buttons are used for reset and user control operations.
- The software integrates all modules to ensure smooth and automatic system performance.

V. RESULTS AND DISCUSSION

The Autonomous Customer-Following Smart Cart with IoT-Based Billing System was successfully designed and tested under different working conditions. The system was able to follow the customer automatically using the ultrasonic sensor while maintaining a safe distance. Obstacle detection worked properly, and the cart stopped or changed movement when an object was detected in its path.

The RFID reader successfully scanned product tags placed inside the cart and transmitted product information to the controller. The billing data was updated automatically and sent to the server through the WiFi module. Real-time bill generation was achieved without manual scanning at the billing counter. The motor driver controlled wheel movement smoothly, and the servo motor provided proper directional control.

During testing, the system showed accurate product detection and reliable communication with the server. LED indicators correctly displayed system status and scanning confirmation. The overall system reduced billing time and minimized human effort during shopping.

The results demonstrate that the proposed smart cart improves shopping efficiency, reduces waiting time, and provides a convenient and contactless shopping experience. The integration of IoT, RFID, and embedded systems proved effective for smart retail automation.

The system performance was evaluated by testing different shopping conditions and product quantities. The smart cart maintained stable communication between hardware components and the cloud server throughout operation. Customer-following functionality worked efficiently within the sensing range, providing smooth and comfortable cart movement. Automatic billing reduced checkout time significantly compared to traditional billing methods. The system showed high accuracy in product detection and billing calculation during multiple trials. Power consumption remained stable, allowing continuous operation using the rechargeable battery. Minor delays were observed only when network connectivity was weak, but overall system performance remained reliable. The integration of sensors, controllers, and IoT communication created a synchronized and efficient smart shopping solution suitable for modern retail environments.

The overall system demonstrated reliable and stable performance during continuous testing. The cart responded quickly to sensor inputs and maintained smooth movement while following the customer. The RFID system minimized billing errors and ensured accurate product identification. Real-time data transmission through the WiFi module allowed instant bill updates on the server. User interaction through buttons and LED indicators made the system easy to operate and understand. The developed prototype successfully reduced manual effort and improved shopping efficiency.



A. Control and Navigation Accuracy

The control and navigation of the smart cart are managed by STM32 and ATmega328P controllers, which process data from all sensors. The ultrasonic sensor detects customer distance and helps the cart follow the user automatically. The L298N motor driver controls wheel motors for movement and stopping during obstacle detection. A servo motor assists in direction control and smooth navigation of the cart. LED indicators, buttons, and the WiFi module support user control, system status display, and communication with the server.

B. Real-time Responsiveness

The smart cart system responds quickly to sensor inputs for smooth and automatic operation. The ultrasonic sensor continuously updates distance data, allowing real-time customer following and obstacle detection. RFID scanning instantly updates product information and billing through IoT communication. Fast processing by STM32 and ATmega328P controllers ensures stable and responsive system performance.

C. Operational Efficiency

The smart cart system improves operational efficiency by automating customer following and billing processes. RFID technology reduces manual scanning time and minimizes billing errors. IoT communication enables real-time data updates and faster checkout operations. The integrated controllers and sensors ensure smooth performance with reduced human effort and improved shopping efficiency.

Parameter	Operation	Result
Customer following	Ultrasonic sensing	Smooth movement
Product Billing	RFID + IoT	Fast billing
System Response	Controller processing	Quick response

TABEL1 . PERFORMANCE

D. Power Consumption

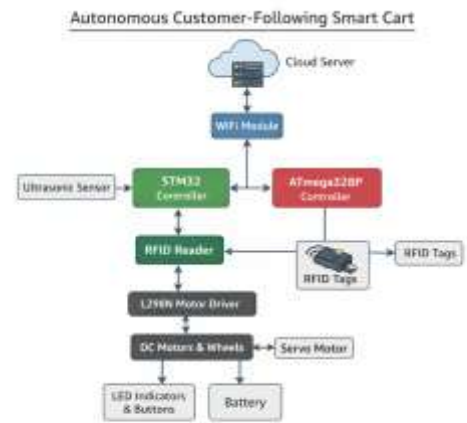
The smart cart system is designed for low power consumption using efficient controllers, sensors, and communication modules. A rechargeable battery powers the system, while motors consume power mainly during movement, ensuring energy-efficient operation.

VI. HARDWARE SUBSYSTEM INTERACTION

The hardware subsystem integration combines all electronic components to work as a single smart cart system. The STM32 and ATmega328P controllers act as the main control units connecting sensors, motors, and communication modules. The ultrasonic sensor provides distance data for customer-following navigation, while the RFID reader detects product tags for automatic billing. The WiFi module enables communication between the cart and the cloud server. Motor drivers control DC motors and wheels for movement, and the servo motor assists in direction control. LED indicators and buttons provide user interaction and system feedback. All components are powered by a rechargeable battery, ensuring stable and portable system operation.

Following the hardware integration, proper synchronization between all subsystems ensures reliable and real-time operation of the smart cart. The controllers continuously process sensor inputs and execute control algorithms to maintain accurate customer tracking and smooth navigation. Data acquired from the ultrasonic sensor and RFID reader is validated before processing to minimize errors during movement and billing operations. The WiFi communication module securely transmits billing information to the cloud database, enabling real-time monitoring and automated invoice generation. Power management circuitry regulates voltage levels to protect sensitive components and improve battery efficiency. The integrated hardware architecture enhances system stability, reduces response delay, and enables

seamless coordination between navigation, billing, and communication functions, resulting in an efficient autonomous shopping experience.



VII. CONCLUSION

The Autonomous Customer-Following Smart Cart with IoT- Based Billing System successfully integrates hardware and communication technologies to improve the shopping experience. The system enables automatic customer tracking, efficient navigation, and seamless product billing using sensors, controllers, and IoT connectivity. By combining real-time data processing with automated billing, the smart cart reduces manual effort and waiting time at checkout counters. The integrated hardware and software architecture ensures reliable performance, portability, and user-friendly operation. Overall, the proposed system demonstrates an innovative and practical solution for modern smart retail environments. This project represents a step toward smart retail automation and future intelligent shopping solutions. The proposed smart cart system demonstrates how automation and IoT technologies can transform traditional shopping into a faster and smarter experience.

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