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IoT-Enabled Autonomous Customer-Following Smart Carts: Design and Evaluation

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Abstract

In modern metropolitan areas, shopping malls often experience heavy customer traffic, especially during weekends and festive seasons, leading to long queues at billing counters. Traditional checkout systems rely on manual barcode scanning, which increases waiting time and reduces shopping efficiency. This project introduces an autonomous smart cart integrated with IoT-based technology to enable seamless, real-time billing inside the trolley itself. Each product in the store is equipped with an RFID tag, while every cart contains an RFID reader, a microcontroller, and an LCD interface. When a customer places an item inside the cart, the RFID reader identifies it automatically, and the item details along with its price are displayed and added to the total bill. If an item is removed, the amount is instantly adjusted. The billing data is synchronized with a central server through Wi-Fi, enabling instant checkout and eliminating the need for manual billing. This system significantly reduces customer waiting time, enhances shopping convenience, and provides a step forward toward smart retail automation.

Introduction

In today's urban lifestyle, shopping has become a regular activity for people living in cities. Supermarkets and hypermarkets provide a wide range of products under one roof, making shopping more convenient than ever. However, as these stores grow bigger and more popular, especially during weekends, holidays, and festive seasons, they also attract large crowds of shoppers. This creates common problems such as long waiting lines at billing counters, overcrowded aisles, and delays in completing purchases. Traditional billing systems rely on barcode scanning by cashiers, which is time-consuming and requires significant manpower. Even with multiple billing counters, customers often spend a lot of time waiting to pay, leading to frustration and decreased satisfaction.

To address these challenges, technological advancements such as the Internet of Things (IoT), embedded systems, and smart sensors have opened new possibilities for improving shopping experiences. IoT allows devices to communicate in real time, providing efficient management of both products and customer interactions. Embedded systems, combined with sensors and communication modules, can automate tasks that were traditionally manual. By using these technologies, we can create a smarter, faster, and more convenient shopping system that benefits both customers and retailers.

This project proposes an autonomous customer-following smart cart with IoT-based billing

system. The smart cart is designed to automatically follow the shopper inside the store while handling billing simultaneously. Each product in the store is equipped with an RFID tag that contains information such as product ID, name, and price. The cart contains an RFID reader, a microcontroller, and an LCD display. When a shopper places a product in the cart, the RFID reader detects the tag, displays the product details on the LCD, and adds the price to the total bill automatically. If a product is removed, the total amount is updated instantly. This automated process saves time, eliminates the need for manual scanning, and ensures accurate billing.

The smart cart system also communicates with a central server through a Wi-Fi or wireless module. This enables real-time updates to the store's inventory and billing records. Retailers can monitor product movement, track sales trends, and manage stock levels more effectively.

By combining autonomous movement, real-time billing, and cloud connectivity, the smart cart provides a seamless experience that benefits both shoppers and store owners.

Another advantage of the system is that it helps customers manage their budget. The cart displays the total bill as products are added, allowing shoppers to monitor their spending and avoid exceeding their intended budget. In cases where products need to be removed or replaced, the system automatically adjusts the bill. This feature ensures that billing errors are minimized and customers can shop confidently.

For staff while improving the shopping experience for customers. This shopping trolley assists the customer in cutting down on their shopping time and avoiding the lengthy line at the billing part.

Literature Survey

Shopping in modern cities has changed drastically with the growth of supermarkets and hypermarkets. Traditional shopping involves selecting products, waiting in queues at billing counters, and paying manually, which is time-consuming and often frustrating for customers. Many researchers and engineers have explored ways to automate parts of this process using technology. The integration of IoT, RFID, sensors, and embedded systems has created opportunities to improve both the customer experience and store efficiency

Early attempts in smart shopping focused on automated billing using RFID tags. RFID technology allows items to be identified wirelessly without manual scanning.

Researchers have implemented systems where products are tagged, and checkout counters read the items automatically. These approaches significantly reduced billing time and human error. However, most of these systems still required customers to push the trolley manually to the billing area, which did not fully solve the problem of physical effort and long queues during peak hours.

To overcome this, researchers started working on autonomous shopping carts capable of following customers automatically. These carts use sensors such as ultrasonic sensors, infrared sensors, and cameras to detect obstacles and follow the shopper's movement. By combining obstacle detection and path tracking, these systems reduce the need for manual handling.cart has an RFID reader, microcontroller, and display to show the total bill. Billing data can be transmitted to a central server through Wi-Fi for inventory management and sales analysis. These systems help reduce staff requirements, improve efficiency, and enhance customer satisfaction. Still, challenges remain in ensuring accurate customer tracking in crowded environments and integrating multiple technologies seamlessly.

Many researchers also focused on customer budget management. Some smart cart systems allow users to monitor their total spending in real time. This feature is helpful for budget-overspending. Additionally adjust the bill when items are removed from the cart, reducing billing errors and increasing convenience. Such features demonstrate how technology can improve not only efficiency but also the shopping experience itself.

Proposed Methodology

The proposed system focuses on developing an autonomous customer-following smart cart with IoT-based billing to simplify shopping and reduce waiting time. Each shopping cart is equipped with a microcontroller (such as Raspberry Pi or Arduino), RFID reader, LCD display, sensors for obstacle detection, and a wireless communication module. Every product in the store has an RFID tag containing details like product ID, name, and price and cumulative bill. If the customer removes a product, the system updates the total instantly. The cart also follows the customer autonomously using sensors and obstacle.

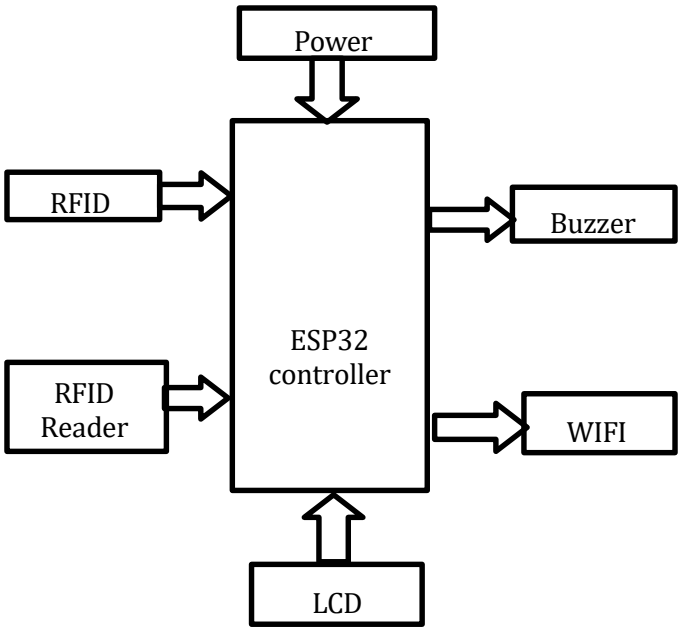

Fig 1: Block Diagram

Future Scope

The proposed autonomous customer-following smart cart with IoT-based billing has a modular and expandable design, which allows for numerous future improvements in both hardware and software. One promising direction is the development of a smartphone application that can replace the RFID scanner and enable seamless payment directly through the app.

This would make the system more cost-effective, widely accessible, and convenient for a larger number of users.

Customers would simply enter the name of the product they are looking for into a mobile device, and the cart could autonomously navigate to the exact product location.

Future research can also focus on increasing the scalability of the system to accommodate larger stores with a greater variety of products. This could include optimizing hardware components and software algorithms to ensure smooth, uninterrupted operation during peak shopping hours. Improvements to the user interface can make the system more intuitive for people of all ages and technical expertise. Incorporating user feedback directly into interface design can enhance the overall shopping experience and make it more customer friendly.

Applications

1. Supermarkets & Hypermarkets
2. Departmental & Grocery Stores
3. Retail Chains & Malls
4. Airports & Duty-Free Shops
5. Smart City / Future Retail Solutions
6. Healthcare & Pharmacy Stores
7. Campus & Institutional Stores

Conclusions

The proposed autonomous customer-following smart cart with IoT-based billing demonstrates a practical and efficient solution for modern retail challenges. By integrating RFID technology, sensors, and wireless communication, the system automates both the movement of the cart and the billing process, significantly reducing waiting time at checkout counters. Customers can track their total spending in real time, add or remove products easily, and complete payments directly from the cart, enhancing convenience and satisfaction. For retailers, the system reduces manpower requirements, improves inventory management, and provides real-time data on product sales. The modular design allows for future upgrades such as smartphone applications, GPS navigation, predictive analytics, and advanced user interfaces, making the system scalable and adaptable to larger stores. Overall, this smart cart framework represents a step forward in automating retail operations, improving customer experience, and shaping the future of smart shopping environments.

References

Apeksha Jagatap, Rohit Pagar, Gopika Nair, ”Smart Shopping Trolly With Automated Billing” 2023 International Research Journal of Modernization in Engineering Technology (IRJMET),2023.

Shubas S R, Dhanyatha R P, Keerthana S P, Vinay B M, Dhanush H S "Smart Shopping Trolly With Automated Billing System" 2025 International Journal of Scientific Research in Engineering and Management [IJSREM], 2025

Kumar, A. Gupta, S. Balamurugan, S. Balaji and R. Marimuthu, "Smart Shopping Cart," 2017 International conference on Microelectronic
Devices, Circuits and Systems (ICMDCS), 2017, pp. 1-4, doi: 10.1109/ICMDCS.2017.8211723.

V. V., P. K. P. and C. R. S., "Smart Shopping Cart," 2018 International Conference on Circuits and Systems in Digital Enterprise Technology (ICCSDET), 2018, pp. 1-4, doi: 10.1109/ICCSDET.2018.8821103.

T. K. Das, A. K. Tripathy and K. Srinivasan, "A Smart Trolley for Smart Shopping," 2020 International Conference on System, Computation, Automation and Networking (ICSCAN), 2020, pp. 1-5, doi: 10.1109/ICSCAN49426.2020.9262350.

S. Kowshika, S. S. Madhu mitha, G. Madhu Varshini, V. Megha and K. Lakshmi, "IoT based Smart Shopping Trolley with Mobile Cart Application," 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), 2021, pp. 1186-
1189, doi: 10.1109/ICACCS51430.2021.9441866.

M. Jaishree., K. R. Lakshmi prabha., S. Jeyaprabha. and
K. Mohan., "Smart Shopping Trolley Using IOT," 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), 2021, pp.793- 796 doi:10.1109/ICACCS51430.2021.9441786.

Belibov and D. S. Tudose, "Smart Shopping Cart," 2019 18th RoEduNet Conference: Networking in Education and Research (RoEduNet), 2019, pp. 1-6, doi:10.1109/ROEDUNET.2019.8909680

M. Shahroz, M. F. Mushtaq, M. Ahmad, S. Ullah, A. Mehmood and G. S. Choi, "IoT-Based Smart Shopping Cart Using Radio Frequency Identification," in IEEE Access, vol. 8, pp. 68426-68438,
2020,doi:10.1109/ACCESS.2020.2986681.

Atar Nasrin, Awatade Vidya, Hegadkar Rani, Bansude Vijaysinh, "Fingerprint Based Security System for Banks," *International Research Journal of Engineering and Technology (IRJET)*, Vol. 03, Issue 04, April 2016