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Design And Development Of E-Retail Cart Using Iot And Robotic Technology For Supermarket

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Abstract: The rise of innovative retail solutions has created a need for more efficient and inclusive shopping systems, particularly for individuals with disabilities who often face challenges in traditional supermarkets. This project introduces an automated smart shopping cart designed to simplify the shopping experience, reduce checkout delays, and improve accessibility for every user.

The system features a self-guided cart that assists shoppers in navigating the store and selecting products. Products are automatically scanned and identified, displaying essential details such as name and expiry date on a screen. The cart supports cashless payments through a secure digital link, eliminating the need for manual billing. Additionally, voice command functionality ensures ease of use for individuals with mobility or visual impairments.

This e-retail cart improves convenience and reduces wait times by integrating automation with an easy-to-use design, fostering a more inclusive shopping experience. Its practical and scalable approach makes it a promising solution for modern retail spaces aiming to improve customer experience while embracing technological advancements.

Keywords: **Accessibility, Automated Checkout, Digital Payments, Inclusive Design, Retail Innovation.**

I. INTRODUCTION

The shopping experience in traditional supermarkets often presents significant challenges, particularly for individuals with disabilities. Long queues, physical strain, and difficulties in product selection and payment processing can make shopping frustrating and inaccessible. As retail technology advances, there is a growing opportunity to create solutions that address these pain points while benefiting all shoppers. This project introduces an innovative automated shopping cart designed to revolutionize the supermarket experience by making it more efficient, convenient, and inclusive.

II. MOTIVATION

This project stems from the need to create equal opportunities for everyone in everyday activities like grocery shopping. Elderly shoppers and people with disabilities frequently face barriers in conventional retail environments, from navigating crowded aisles to completing transactions independently. Additionally, the time-consuming nature of traditional checkout processes affects all customers, leading to frustration and inefficiency. This project focuses on creating a smart, automated shopping cart to address these challenges, making shopping a smooth and enjoyable experience for all individuals, regardless of their physical abilities.

III. OBJECTIVES

This initiative focuses on creating a smart shopping cart that improves independence for individuals with disabilities by incorporating voice-assisted controls. It aims to minimize checkout durations through automated scanning and cashless payment options. By offering real-time product details and an intuitive interface, the system is designed to foster an inclusive shopping experience that enhances convenience and efficiency for all customers.

IV. LITERATURE SURVEY

[1] "Automated Smart Cart for Physically Challenged" Sowmyashree M S; Saritha I G; Naveen I G
2024 IEEE International Conference on Recent Innovation in Smart and Sustainable Technology (ICRISST)
This paper proposes an automated tram carrier system with RFID-based billing and navigation to assist elderly, disabled, and blind individuals in malls and large stores, enabling easy product identification, automatic invoicing, and obstacle detection.

[2] "RFID-Powered Intelligent Shopping Cart: Streamlined Checkout and Automated Billing" M. Ramya Krishna;
Mohammad Alifa Firdhos Farheen; Himakiran Killamsetti
2024 IEEE International Conference for Women in Innovation, Technology & Entrepreneurship (ICWITE)
This paper proposes a smart trolley system using RFID technology for automatic billing, enabling real-time item tracking, accurate cost calculation, and seamless checkout, thereby enhancing shopping convenience and efficiency.

[3] "IoT Device Control with Offline Automatic Speech Recognition on Edge Device" Panji Setiawan; Rahadian Yusuf
2022 IEEE 12th International Conference on System Engineering and Technology (ICSET)
This paper proposes speech recognition on edge devices like Raspberry Pi. It can accurately recognize simple voice commands, making it suitable for integrating voice-controlled features in smart shopping carts for automatic human following.

[4] "Smart Shopping Trolley Using IOT" Jaishree.M, Lakshmi Prabha. K.R, Jeyaprabha.S, Mohan. K
2021 7th IEEE International Conference on Advanced Computing & Communication Systems (ICACCS)
This paper proposes an automatic shopping trolley using Raspberry Pi, a barcode scanner, and an LCD, allowing customers to self-scan products and generate bills, reducing queue times and improving shopping efficiency during peak hours.

[5] "IoT-based smart Billing and Direction Controlled trolley" Naveenprabhu T, Mahalakshmi B, Nagaraj T
2020 6th IEEE International Conference on Advanced Computing and Communication Systems (ICACCS)
This paper proposes using a web browser, RFID for automatic billing, and Io T for data transfer to streamline shopping by following user commands, avoiding obstacles, and eliminating manual billing and trolley handling.

[6] "SMART-Smart Mobile Autonomous Robotic Trolley" Mayur Sanap, Priya Chimurkar, Narendra Bhagat,
IEEE Proceedings of the International Conference on Intelligent Computing and Control Systems (ICICCS 2020)
This paper proposes a smart trolley prototype that integrates RFID for item detection, wi-fi for wireless billing communication, and autonomous movement with obstacle avoidance to simplify the shopping process, reduce checkout time, and ease customer effort.

[7] "Human-friendly smart trolley with automatic billing system" T Hanooja, CG Raji, M Sreelekha, Jemsheer Koniyath,
VK Muhammed Ameen, M Mohammed Noufal
2020 4th International Conference on Electronics, Communication and Aerospace Technology (ICECA), 1614-1619, 2020
This paper proposes features for an automated customer-following trolley using RFID and a Raspberry Pi, which tracks items and calculates the bill, reducing physical effort and eliminating the need to wait in billing queues, thereby enhancing the shopping experience.

[8] "Smart Shopping Cart" Viswanadha V.; Pavan Kumar P.; Chiranjeevi Reddy S
2018 IEEE International Conference on Circuits and Systems in Digital Enterprise Technology (ICCSDET)

This paper proposes a smart shopping cart with a barcode scanner and touchscreen display for self-billing and online payment like Paytm, and phone pay, aiming to reduce checkout time, minimize human effort, and enhance the overall shopping experience.

V. METHODOLOGY

5.1 **Research and Analysis:** Analyze the market to identify customer needs, current solutions, and challenges people experience during shopping.
5.2 **Feature Identification:** Recognizing key features like automated tracking, inventory management, and payment solutions based on research insights and customer requirements.
5.3 **Technology Selection:** Selecting appropriate technologies such as sensors, RFID, and payment processing systems to implement identified features.

VI. BLOCK DIAGRAM

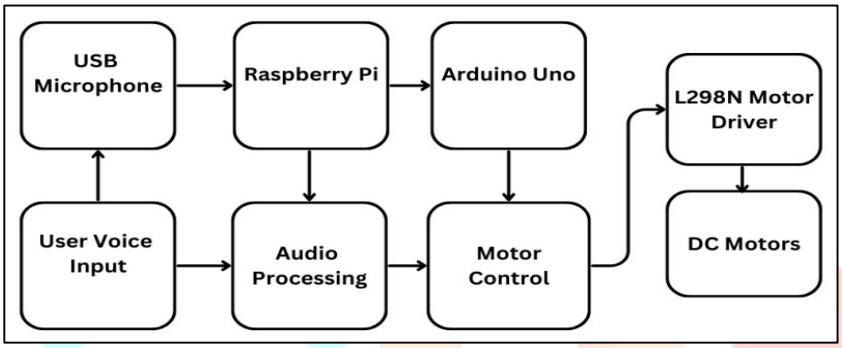


Figure 1: Robotic part of the Shopping cart

The block diagram represents a system designed for voice-controlled motor operation, using a mixture of hardware and software components. The process begins with voice input from the user, captured through a USB microphone. This input is then transmitted to the Raspberry Pi for audio processing, where the voice commands are analyzed and interpreted. The Arduino Uno communicates with an L298N motor driver, assigned to producing the required signals to control the connected DC motors. Based on the user's voice commands, the DC motors perform specific actions, showcasing an innovative integration of voice recognition technology with motor control mechanisms.

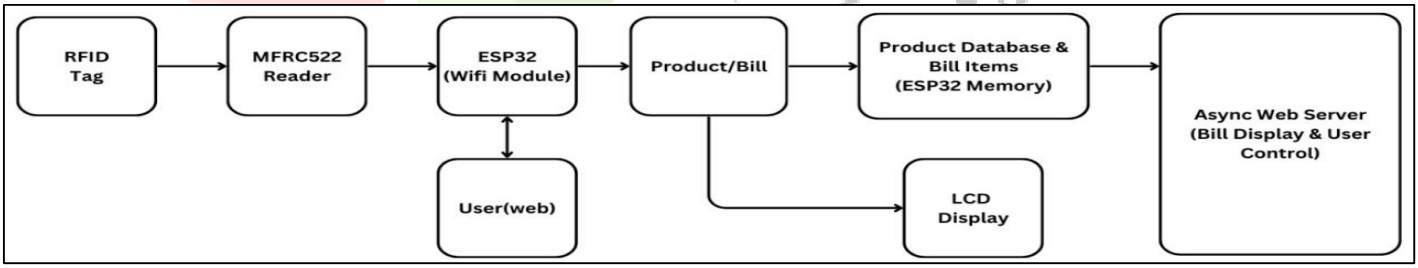


Figure 2: Billing part of the Shopping cart

This block diagram outlines the architecture of a product billing system based on RFID technology and the ESP32 WiFi module. At the heart of the system is an RFID tag, which contains information about the product. The MFRC522 Reader scans the tag and sends the extracted data to the ESP32 module. The ESP32 functioned as the processing unit, storing product information and billing items in its memory. The processed information is displayed on an LCD screen for the user's convenience, ensuring real-time visibility of billing details. Further, the ESP32 module is connected to an asynchronous web server, enabling user interaction through a web interface. This allows customers to view their bills and control system functions remotely. The combination of RFID, WiFi technology, and web server integration ensures efficient and user-friendly operation, making it an ideal solution for modern retail environments.

VII. HARDWARE AND SOFTWARE COMPONENTS

7.1 **Raspberry Pi3b+:** We are using a third-generation Raspberry Pi. This is a strongly built credit card-sized single-board computer which can be used for various implementations. The Raspberry Pi3b+ possesses wireless LAN and Bluetooth connectivity. This operates with a 5.1V micro USB supply. The maximum power supply Raspberry Pi can use is 2.5Amp.

Figure 3: Raspberry Pi3b+

7.2 **MCRF522 Reader:** Radio Frequency Identification is the wireless non-contact use of radio frequency waves that were
used to transfer data. An RFID reader is called the brain of the RFID system and any system needs to function. RFID readers use radio waves to communicate with RFID tags.

Figure 4: MCRF522 Reader

7.3 Arduino Uno: Arduino Uno is a Microcontroller board based on an ATmega328P chip. It contains 14 digital input /output pins,6 analog input pins, USB connectivity for programming, and a power jack. Arduino UNO is the central processing unit that is programmed to control the operation of other modules.

Figure 5 : Arduino Uno

7.4 L298N Motor Driver: It is a motor driver IC placed in PCB to prevent the back emf produced by the two gear motors and to avoid a shortage of pi. It is a 16-pin integrated circuit that manages the voltage and provides a regulated output.

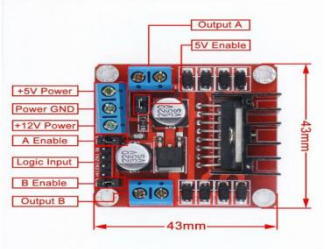


Figure 6: L298N Motor driver

7.5 ESP32 Microcontroller: The ESP32 microcontroller is a small, low-cost computer chip made by Express if Systems. It has built-in Wi-Fi and Bluetooth, it can connect to the internet and other devices. It is often used in smart gadgets, home automation, and IoT (Internet of Things) projects. The ESP32 is powerful, easy to use, and works with popular programming platforms like Arduino and Micro Python.

Figure 7: ESP32 Microcontroller

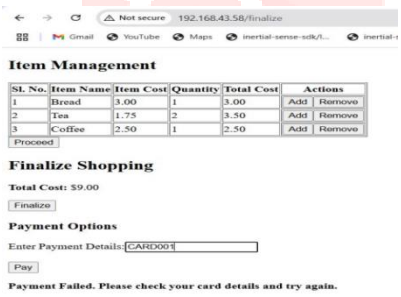
7.6 D C Motor: A DC motor converts direct current (DC) electrical energy into mechanical energy. It works by using magnetism and electric current to spin.

Figure 8: DC Motor

VIII. APPLICATIONS

- Airport: It makes travel easier by helping with shopping, offering personal tips, checking baggage rules, and improving safety and service to passengers and airport staff.
- Hospitals: It helps deliver medicines, supplies, and equipment more accurately and safely using technologies like RFID scanning, which improves patient care and makes hospital work more efficient.
- Malls: They make shopping easier by helping customers scan items, get personal offers, and enjoy faster checkout, while also helping mall owners improve service and enhance operational management.

IX. RESULTS



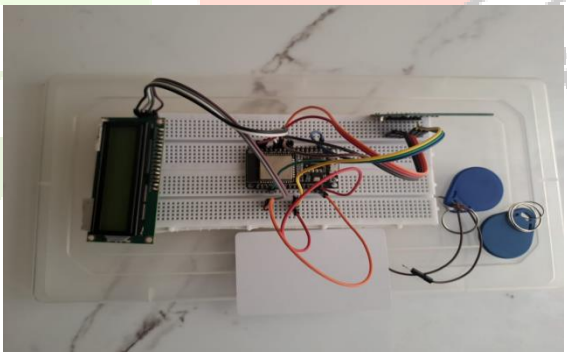


Figure 9: Output getting in web server

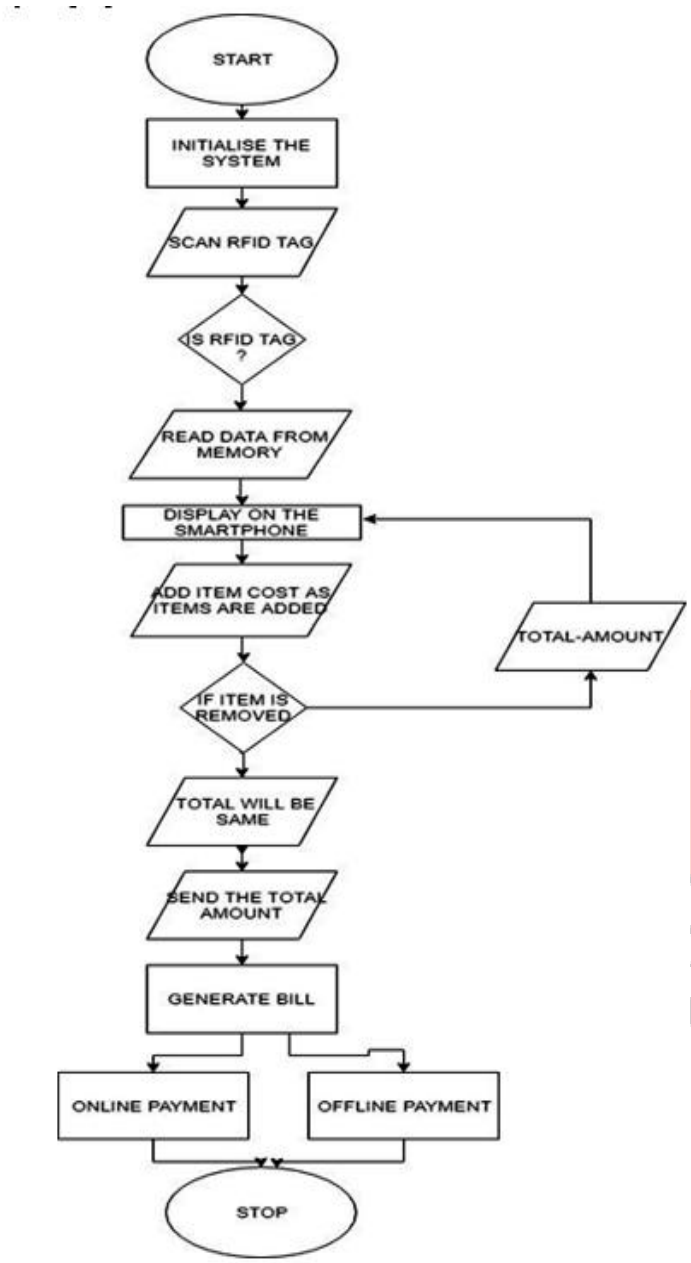
The project showcases a seamless integration of voice-controlled robotics with a billing interface, presenting innovative potential for applications in automation and retail. The robotic system operates on voice commands, allowing hands-free movement and control to enhance operational efficiency. Additionally, a green LCD screen serves as an integral part of the billing process, displaying critical information such as whether the product is found or not.

The system also includes a web-based billing interface, featuring functionalities for managing items, viewing individual and total costs, and selecting payment methods. The "Item Management" interface allows users to add or remove items, review total costs, and proceed to payment options. However, as depicted in the current stage, troubleshooting card input validation may be required to address errors like "Payment Failed. Please check your card details and try again."

The physical setup of the prototype includes essential hardware components such as a breadboard, electronic circuitry, and the LCD screen, which collectively ensure smooth communication between the software and hardware systems. This combination of voice-controlled navigation, billing integration, and

real-time display reflects an innovative approach to merging user interaction with automation, paving the way for practical and efficient real-world applications.

X. SYSTEM IMPLEMENTATION



Flow Chart for the billing system

XI. SYSTEM IMPLEMENTATION

The development of an E-retail cart integrating IoT and robotic technology, along with an automated payment system, provides a seamless and efficient shopping experience for customers. Through RFID-based item detection, real-time billing, voice-controlled navigation, and integrated digital payment, the system revolutionizes conventional supermarket operations. Customers can shop independently, with automated billing ensuring accurate cost calculations, and finalize their purchases through **secure payment gateways** integrated within the system.

By conducting **research and analysis**, we identified key challenges in traditional retail, leading to the **feature identification** of smart product recognition, automated billing, self-navigating carts, and integrated payment

mechanisms. **T**he choice of technology was essential for the seamless operation of the system, incorporating RFID readers, ESP32 modules, robotic mobility solutions, and secure digital payment platforms.

This initiative improves retail automation and also plays a significant role in the development of smart shopping ecosystems. Future enhancements could focus on AI-powered recommendations, biometric payment verification, and personalized shopping assistance, ensuring an even **smarter and more interactive retail experience**. With continued innovation, this solution holds the potential to redefine supermarket operations by **improving efficiency, security, and customer satisfaction**.

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