CartMate: An Automated Shopping Companion

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***Abstract*— This exciting plan aims to transform old-fashioned store visits by combining Embedded technologies. This technology upgrade is targeted at enhancing effectiveness and user-friendliness in the retail field, thus enabling a simpler and more interesting shopping ordeal. The implementation of clever shopping wagons, a crucial part of this novelty, decreases checkout times and provides live data, resulting in a more effective shopping procedure. They are equipped with an automated human-following mechanism, which allows the cart to autonomously follow the shopper, thereby reducing the physical effort required during shopping. In addition, the system incorporates an automatic bill generation feature, which calculates and displays the total cost of the items in the cart in real-time. This feature provides customers with a transparent view of their expenditure, enhancing their shopping experience. By integrating these advanced technologies, the project sets a new benchmark in the retail industry, demonstrating the transformative potential of technological advancements in traditional sectors.**

Keywords- Automated Checkout Systems, Human Following Technology, Retail Automation, RFID Scanning, Driver Units.

I. INTRODUCTION

CartMate, our cutting-edge automated shopping companion, redefines the traditional shopping experience by seamlessly integrating innovative technologies designed to enhance convenience and efficiency. CartMate effortlessly follows shoppers, eliminating the need for manual cart navigation. Additionally, CartMate streamlines the checkout process through automated billing capabilities, allowing customers to bypass long queues and enjoy a swift transaction. Safety and adaptability are prioritized with CartMate's obstacle detection system, ensuring smooth navigation through crowded aisles and busy store environments. Furthermore. Together, these features culminate in an unparalleled shopping companion that prioritizes convenience, efficiency, and customer satisfaction, setting a new standard in shopping automation.

II. PROBLEM STATEMENT

Shopping becomes tedious and tiring when we have to take the purchased items by using a cart as we have to pull it ourselves, it becomes more difficult with increase in items as it increases the weight, So we propose CartMate, a smart cart that can follow the customer automatically.

III. OBJECTIVES

- To create user friendly shopping environment
- To automate the shopping cart to reduce the shopping time as well as the check-out time.
- To reduce the burden of carrying the cart.

IV. LITERATURE SURVEY

Gupta et al. (2019) compared smart shopping cart technologies, analyzing their features, pros, and cons. They evaluated usability, cost-efficiency, and integration potential to identify optimal solutions for various retail settings [1].

Patel M .et .al (2020) designed an IOT-integrated shopping cart system specifically for supermarkets. The system incorporated features like real-time inventory management and personalized suggestions. Its performance was assessed on parameters such as efficiency, accuracy, and user satisfaction, demonstrating its potential to streamline supermarket operations [2].

Sharma N. et al. (2020) developed an RFID and sensor-based smart shopping cart with automated billing and personalized recommendations. The system's effectiveness and usability were validated, showing its potential to improve the shopping experience [3].

Park H. & Jung S. (2020) proposed design guidelines for smart shopping cart interfaces, derived from user research and usability testing. Their recommendations focus on layout, navigation, and visual design to enhance user experience and interaction [4].

Smith J & Johnson A (2020) investigated enhancing smart shopping carts using AI and IOT. They integrated these technologies for personalization, optimized recommendations, and improved navigation, assessing their impact on user satisfaction and engagement [5].

Lee S. & Kim H. (2020) analyzed smart shopping cart security, identifying potential vulnerabilities and evaluating current measures. They proposed enhancements through encryption, authentication, and intrusion detection systems [6].

Wang L, & Zhang Q (2021) developed a smart shopping cart navigation system leveraging machine learning techniques. The system uses algorithms to analyze various factors and optimize navigation routes, aiming to enhance shopping efficiency, reduce congestion, and improve customer experience [7].

Chen X, & Liu Y (2021) investigated energy efficiency optimization in smart shopping carts through edge computing. They developed techniques to offload tasks to edge devices, aiming to reduce power consumption, prolong battery life, and enhance system sustainability [8].

Kim D, & Park S (2022) developed a smart shopping cart localization system utilizing computer vision techniques. They implemented algorithms to analyze visual data for precise localization, aiming to enhance cart positioning, facilitate navigation, and improve shopping efficiency [9].

Gupta R, & Singh M (2022) conducted a case study on smart shopping cart interaction design. They investigated user behaviors and preferences to design user-friendly interfaces, aiming to enhance interaction experiences, streamline navigation, and improve usability [10].

Kim J, Park Y (2022) developed a smart shopping cart gesture recognition system using machine learning. Their algorithms interpret shopper gestures into commands for the carts, aiming to improve user experience, enable hands-free operation, and enhance retail accessibility [11].

Chang W & Lee H (2023) conducted a lifecycle sustainability assessment of smart shopping carts. They analyzed their environmental impact from production to disposal, focusing on energy consumption and material usage, to identify sustainability improvement opportunities [12].

Zhang Y & Wang C (2023) conducted data analytics on smart shopping cart data for consumer behavior analysis. They used data mining on purchase history, product interactions, and navigation patterns to identify trends and preferences that can inform marketing strategies [13].

Yang L & Chen S (2023) proposed a blockchain-based approach for privacy protection in smart shopping carts. They used blockchain to secure and anonymize sensitive data, aiming to enhance privacy, data security, and ensure user information remains confidential and tamper-proof [14].

Li Q & Wu J (2023) investigated inventory management in smart shopping carts using RFID technology. They implemented RFID tags and readers for real-time tracking, aiming to optimize inventory, reduce stockouts, and enhance supply chain efficiency [15].

V. METHODOLOGY

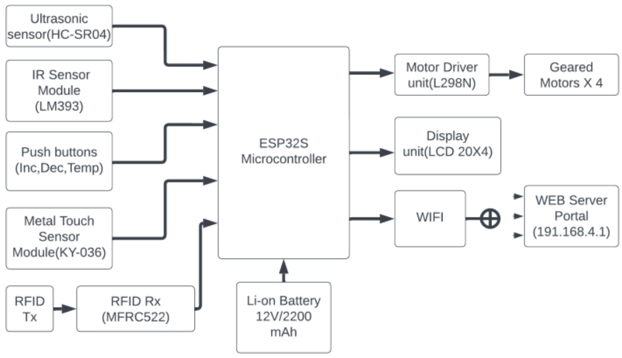


Fig. 1. Block diagram of proposed system architecture.

WORKING:

Fig. 1 depicts the Block diagram of the proposed System. This diagram illustrates the proposed system architecture, In developing "CartMate - An automated shopping companion," we employed a comprehensive methodology to integrate various sensors and components for efficient functionality.

The ESP32 Microcontroller is the central processing unit, coordinating the gathered information. The system relies on inputs from ultrasonic sensors, IR sensors, weight sensors, touch sensors, voltage sensors, RFID cards, and their respective readers. The system outputs are managed through geared motors, providing mobility to CartMate, a display screen for user interaction, and a push button for manual control.

This methodology ensures seamless communication between sensors, the ESP-32 controller, and the diverse output components, creating an intelligent and user-friendly automated shopping companion.

SYSTEM OVERVIEW:

Fig. 2 illustrates the flowchart detailing the methodology of the proposed work, which conveys the process of identifying and following the human utilizing various sensors.

Step 1: The CartMate is initialized using the switches on its dashboard. The customer should connect to the CartMate's Wi-Fi.

Step 2: Once the system is initialized, the ultrasonic sensor continuously checks for any intervention using sound waves. If the distance is equal to the default distance (the distance set for the CartMate to follow the individual), then the CartMate will follow the customer.

Step 3: The customer scans the item to be purchased using the RFID scanner available on the dashboard. They can increment or decrement the number of items.

Step 4: The list of items purchased is updated on the website in real time through the customer's mobile phone. The customer can initiate payment using the payment gateway available on the website.

Step 5: Upon successful payment, the customer can leave the shopping area hassle-free.

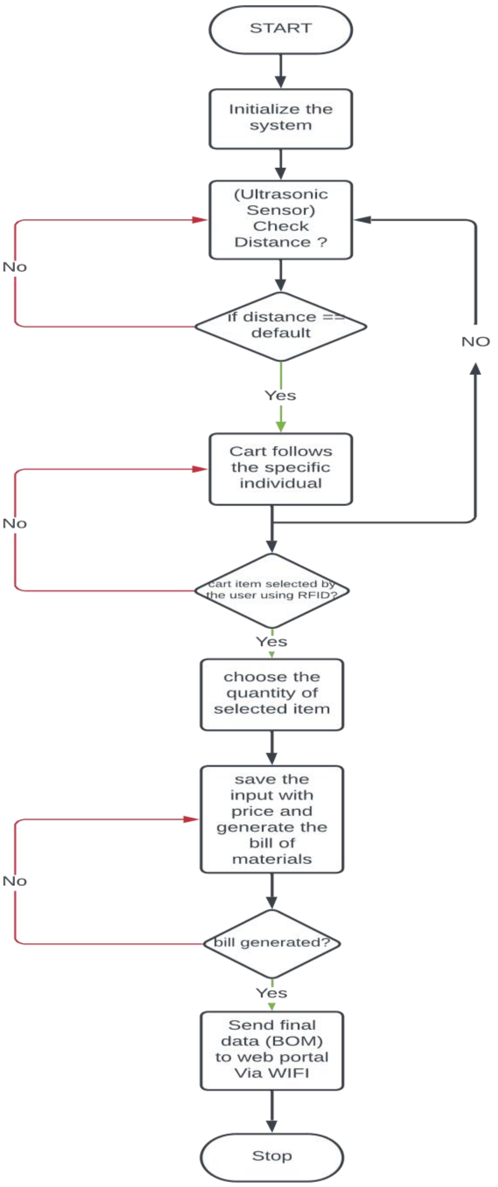


Fig. 2. Flowchart of proposed model.

VI. HARDWARE & SOFTWARE REQUIREMENTS

A. HARDWARE REQUIRED

1. ESP-32 MICROCONTROLLER

The ESP-32 microcontroller is a powerful development platform which has gained popularity in embedded systems and Internet of Things (IOT) applications. It is based on the ESP32 system-on-a-chip (SOC) designed by Espressif Systems, a leading semiconductor company. The ESP32 board combines a dual-core processor, wireless connectivity options, and a rich set of peripherals, making it a suitable choice for a wide range of projects. It features two 32-bit Xtensa LX6 microprocessor cores, which can be clocked up to 240 MHz, offering substantial computational power for demanding tasks.

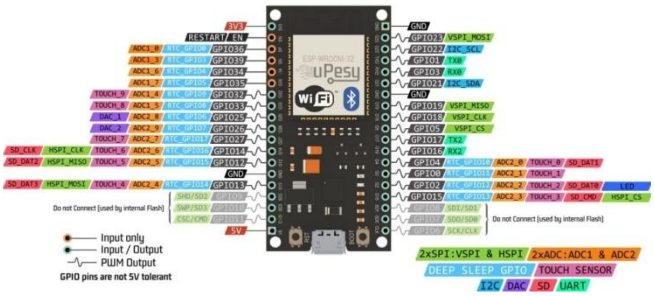


Fig. 3. ESP-32 MICROCONTROLLER

Fig. 3 depicts the pin configuration of ESP32 Microcontroller. One of the standout features of the ESP32 is its comprehensive wireless capabilities. It supports Wi-Fi, both 2.4 GHz and 5 GHz bands, allowing seamless connectivity to local networks or the internet. Additionally, it includes Bluetooth Low Energy (BLE) support, enabling communication with other devices and peripherals in energy-efficient ways. The ESP32 board also offers a multitude of interfaces and peripheral options, including GPIO (General Purpose I/O) pins, I2C, SPI, UART, ADC, DAC, and more. These interfaces enable easy integration with various sensors, actuators, displays, and other components, facilitating the development of complex and interactive projects.

2. Ultrasonic Sensor

Fig. 4. Ultrasonic Sensor (HC-SR04)

Fig. 4 depicts the HC-SR04 Ultrasonic Sensor, a widely used sensor for applications involving distance measurement or object sensing. It operates on a voltage of +5V. The sensor has four pins: Vcc, Trigger, Echo, and Ground. The Vcc pin powers the sensor. The Trigger pin is an input pin that needs to be kept high for 10us to initialize the measurement by sending an ultrasonic wave. The Echo pin is an output pin that goes up for equal time taken for ultrasonic ripple to return back to the detector. The Ground pin is connected to the system ground. This configuration allows the sensor to accurately measure distances and detect objects.

3. RFID Transreceiver

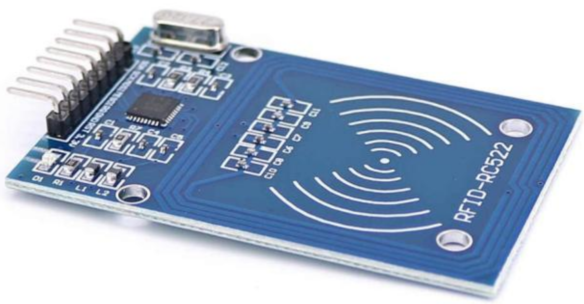


Fig. 5. RFID Transreceiver (MFRC522).

Fig. 5 illustrates the MFRC522 RFID Transceiver which is a highly integrated reader/writer IC for contactless communication at 13.56 MHz. It consists of the MFRC522 IC, a 27.12 MHz Crystal Oscillator, and an Antenna. The module supports I2C, SPI, and UART communication protocols. The operating voltage is typically 3.3V, but the communication pins are tolerant to 5V. The intern transmitter, drives read-writer antenna design for communicate with card and transponders without active circuitry. This module is commonly used in attendance systems and other person/object identification applications.

4. **Motor Driver Unit**

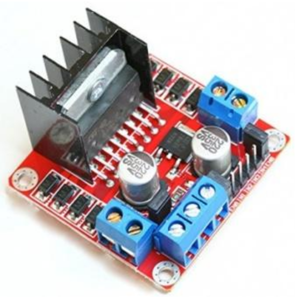


Fig. 6. Motor Driver Unit (L298N).

Fig. 6 depicts the L298N Motor Driver Module, a high-power module designed for driving DC and Stepper Motors. It consists of an L298 motor driver IC and a 78M05 5V regulator. This module can control up to 4 DC motors, or 2 DC motors with directional and speed control. The L298N operates on a driver voltage and requires an external 5V power supply. It supports a maximum motor supply voltage of 46V and a maximum motor supply current of 2A. The logic voltage is 5V, and the driver voltage ranges from 5-35V. The driver current is 2A, and the logical current ranges from 0-36mA. The module also includes a current sense for each motor and a heatsink for better performance. The L298N module is commonly used in autonomous robots and RC cars. The L298N motor driver is based on the H-bridge configuration, which is useful in controlling the direction of rotation of a DC motor.

B. SOFTWARE REQUIRED

1. **Arduino IDE 2.1.1 Software**

Fig. 7. Arduino IDE 2.1.1 Software.

Fig.7 illustrates the Arduino IDE software which is an open-source Integrated Development Environment that is extensively used for programming various microcontrollers, including the ESP32. Moreover, the Arduino IDE comes with a library manager that allows you to easily manage and install libraries needed for projects. This feature is particularly useful when programming the ESP32, as it often requires various libraries for its different functionalities. This feature is particularly useful when programming the ESP32, as it often requires various libraries for its different functionalities.

VII. RESULTS AND DISCUSSIONS

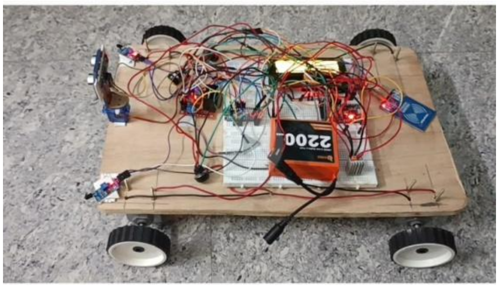


Fig. 8. The CartMate Prototype

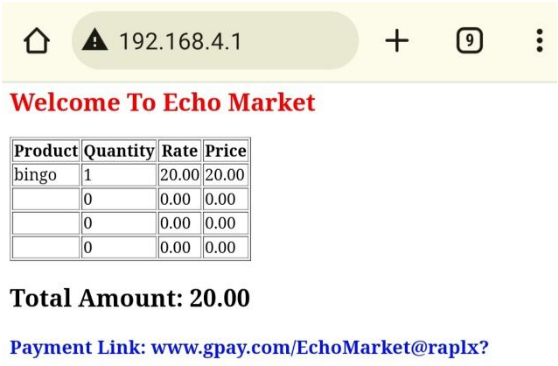
Fig. 8 illustrates the prototype circuitry of the CartMate system. Upon initialization (powering on), the user is required to connect to the CartMate's local Wi-Fi network. It is essential for the user to remain within the operational range of the CartMate for it to effectively follow the user. This range is typically set between 30 to 40 centimeters to prevent interference from other users within proximity of the CartMate.

Fig. 9. CartMate Greeting Customers

Fig. 9 demonstrates that the CartMate system is in 'follow' mode, ready to accompany the user. This state is signified by a specific greeting displayed on the LCD dashboard of the CartMate.

Fig. 10. After scanning the item

Fig. 10 depicts the initial item scanned (represented by 'bingo' in the referenced image). This action is accomplished by utilizing the RFID scanner located on the CartMate's dashboard.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Welcome To Echo Market

Product	Quantity	Rate	Price
bingo	1	20.00	20.00
	0	0.00	0.00
	0	0.00	0.00
	0	0.00	0.00

Total Amount: 20.00

Payment Link: www.gpay.com/EchoMarket@raplx?

Fig. 11. Scanned Item is Updated in Customers Mobile Phone

Fig. 11 illustrates that the information of the initial scanned item is transmitted in real-time to the user's mobile device via Wi-Fi.

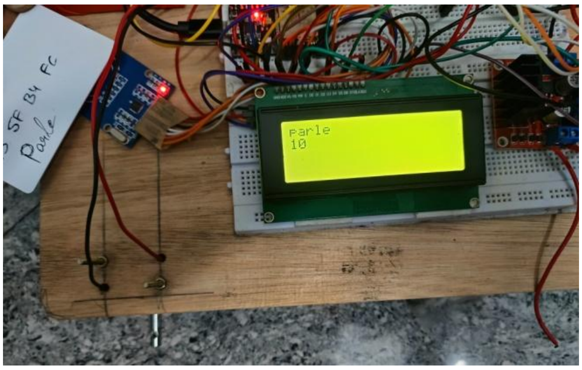
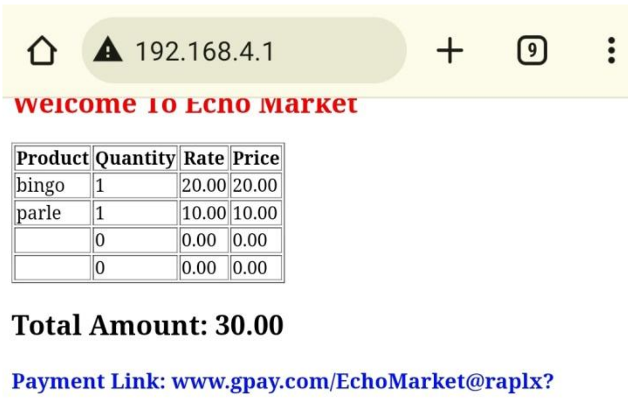


Fig. 12. Next Scanned Item.

Fig. 12 presents the second item scanned (represented by 'parle' in the referenced image). This process is also executed by using the RFID scanner integrated into the CartMate's dashboard.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Welcome To Echo Market

Product	Quantity	Rate	Price
bingo	1	20.00	20.00
parle	1	10.00	10.00
	0	0.00	0.00
	0	0.00	0.00

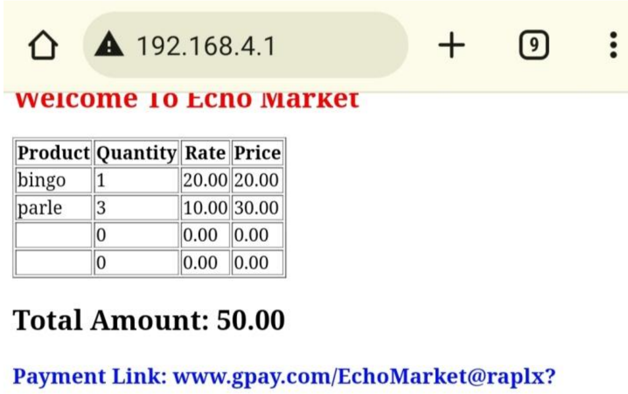
Total Amount: 30.00

Payment Link: www.gpay.com/EchoMarket@raplx?

Fig. 13. Next Scanned Item Updated

Fig. 13 illustrates that the second item, once scanned, is updated in real-time to the customer's mobile phone via Wi-Fi.

Fig. 14 demonstrates that upon completion of the customer's shopping, the website displays the total number of items added to the cart, the total payable amount, and provides a payment gateway integrated within the website for the customer's convenience to complete the payment.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Welcome To Echo Market

Product	Quantity	Rate	Price
bingo	1	20.00	20.00
parle	3	10.00	30.00
	0	0.00	0.00
	0	0.00	0.00

Total Amount: 50.00

Payment Link: www.gpay.com/EchoMarket@raplx?

Fig. 14. Items Incremented, Total Amount and Payment Gateway Displayed

VIII. CONCLUSION

In conclusion, CartMate: An Automated Shopping Companion" is a groundbreaking project in retail technology. It enhances the shopping experience with a human-following feature and an automated billing system. The former provides customer assistance and reduces physical strain, while the latter streamlines checkout, reduces wait times, and improves customer satisfaction by using advanced scanning and payment technologies. This solution allows retail staff to focus on complex customer issues, improving service quality. CartMate sets a new standard for retail experiences, demonstrating the transformative potential of technology in retail operations. It paves the way for future innovations in the sector.

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