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IoT- Based Human Following Smart Shopping Trolley with Automatic Billing System

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Abstract - The IoT-Based Human-Following Smart Shopping Trolley with Automatic Billing System is designed to provide a smart, convenient, and efficient shopping experience. The trolley uses sensors and a camera-based system to automatically follow the customer while maintaining a safe distance and performing obstacle avoidance to ensure smooth and safe movement. It provides automatic product identification using QR-code scanning, and the product details and prices are automatically added to the bill. An integrated weighing scale is used to measure the weight of selected products and can provide accurate weight information for billing. The system continuously calculates the total amount and displays the product and billing information through a display. When the trolley becomes empty after shopping, it is programmed to automatically move back to its designated parking. By integrating human following, obstacle detection, automatic product identification, weighing, billing, and autonomous return functionality, the proposed system reduces manual effort, saves shopping time, and improves the overall efficiency of the shopping process.

Keywords - Smart Shopping Trolley, Human-Following Trolley, Automatic Billing System, ESP32 Microcontroller, QR Code Scanner, Obstacle Avoidance, Load Cell, Internet of Things (IoT), Retail Automation.

I. INRODUCTION

Modern supermarkets and shopping malls are increasingly adopting digital technologies to improve customer convenience and operational efficiency. Conventional shopping trolleys require the customer to continuously push and steer the trolley, while product identification, weighing, billing, and trolley collection are generally handled as separate activities. During busy periods, these steps can increase the time required to complete a purchase and may create inconvenience for customers.

The proposed Io T-Based Human-Following Smart Shopping Trolley integrates these activities into one automated system. The trolley is designed to follow the customer without continuous manual control. A camera or human-following sensing arrangement identifies the customer's position, while distance and obstacle sensors support controlled movement. When an obstacle is detected, the trolley can slow down, stop, or select a safer movement direction. A QR-code scanning unit is used for automatic product identification. Each product can be associated with a QR code containing an identifier that is linked to product information. Once a code is scanned, the corresponding product name and price are obtained and included in the running bill. For products that require billing according to weight, an integrated weighing scale measures the quantity placed in the trolley. The display presents the important transaction information so that the customer can observe the bill during shopping rather than waiting until the end.

The system also addresses trolley management after shopping. When the trolley is empty after the customer has completed the shopping process, the controller can initiate an automatic return sequence toward a predefined parking or charging area. Io T communication can provide a connection between the trolley controller and a local monitoring interface for displaying status and

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transaction information. Therefore, the proposed system combines mobility, sensing, product identification, weighing, billing, and trolley-return functions in a single platform

.II. LITERATURE REVIEW

Smart shopping trolley systems have been widely investigated as a means of reducing customer effort, minimizing checkout delays, and improving the efficiency of retail operations. Early approaches mainly focused on RFID -based product identification and automated billing. In these systems, RFID tags attached to products are read by a trolley-mounted reader, and the corresponding product information is retrieved to update the customer's bill. Such approaches also support online storage of transaction information and electronic billing, thereby reducing dependence on conventional bar code -based checkout procedures [5].

The integration of Io T technologies has further improved the functionality of smart trolley systems by enabling wireless communication and real-time information exchange. Mobile-oriented systems using ESP32, RFID readers, Wi-Fi connectivity, and web-based interfaces allow customers to view product details, quantities, prices, and the running bill through a mobile device [11]. Similarly, cloud-connected trolley architectures have been proposed to synchronize billing and inventory information while providing monitoring through dashboards or mobile interfaces [12].

Several studies have also explored the use of human-following technology to reduce the physical effort required to operate a shopping trolley. One approach combines ultrasonic sensors, Arduino-based movement control, DC motors, and motor drivers to maintain an appropriate distance between the customer and the trolley [3]. Related systems employ RFID -based billing together with ultrasonic sensing, where the trolley automatically follows the user while product prices are updated in real time [4]. These approaches demonstrate the usefulness of combining autonomous movement with shopping assistance.

Obstacle detection and avoidance have been identified as important requirements for safe autonomous trolley operation.Sensor based systems use ultrasonic and infrared sensors to detect the customer's position and surrounding obstacles, allowing the controller to adjust the trolley's speed and direction [11]. Other autonomous trolley studies have also emphasized navigation and obstacle avoidance as essential functions for improving safety when operating in dynamic retail environments [9].

Automatic billing remains one of the major areas of development in smart trolley research. RFID -based systems can automatically identify products and update the total bill as items are added or removed from the trolley [2], [14]. Some approaches also combine RFID with bar code scanning and wireless communication to improve product identification and transaction processing [13]. These methods reduce manual billing activities and provide customers with continuous access to purchase information during shopping.

The integration of weighing mechanisms has also been explored to support products sold according to weight. Smart trolley designs incorporating load cells or weight sensors together with RFID -based product identification can determine the quantity of products and associate the measured value with billing information [11]. This capability is particularly useful for extending automated billing beyond fixed-price products and improving the flexibility of the shopping process.

Recent systems have additionally focused on improving accessibility, communication, and operational efficiency. The Shop Ease smart trolley system integrates ESP32, RFID, cloud communication, voice assistance, and real-time billing, while also incorporating a docking mechanism for trolley return [12]. Experimental evaluation of the system reported reliable billing performance and real time communication, demonstrating the potential of integrated Io T - based architectures for smart retail applications [12]. Other studies have also investigated mobile application support and autonomous trolley navigation to improve customer convenience and accessibility [14].

Although existing research has demonstrated significant progress in automated billing, RFID -based product identification, Io T communication, and autonomous movement, many systems concentrate on only a limited number of these functions. Some systems provide efficient billing but do not include human-following capability, while autonomous trolley systems may not integrate comprehensive billing and weight-based product handling. Similarly, advanced cloud-connected systems may require additional infrastructure for implementation. Therefore, there remains a need for an integrated smart shopping trolley that combines human following, obstacle avoidance, QR-code-based product identification, weighing-scale support, automatic billing, IoT monitoring, and automatic return of the trolley after shopping. The proposed system addresses these requirements by integrating the major shopping-assistance functions into a single automated platform.

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III. PROPOSED METHODOLOGY

The proposed Eco-Smart Irrigation System integrates ESP32 controllers, Lo Ra-based wireless communication, soil-moisture and rainfall sensing, automated water control, and cloud-based monitoring. The system is designed to provide zone-specific irrigation based on real-time field conditions while allowing remote monitoring and manual control. The overall architecture of the proposed system is shown in Fig. 1.

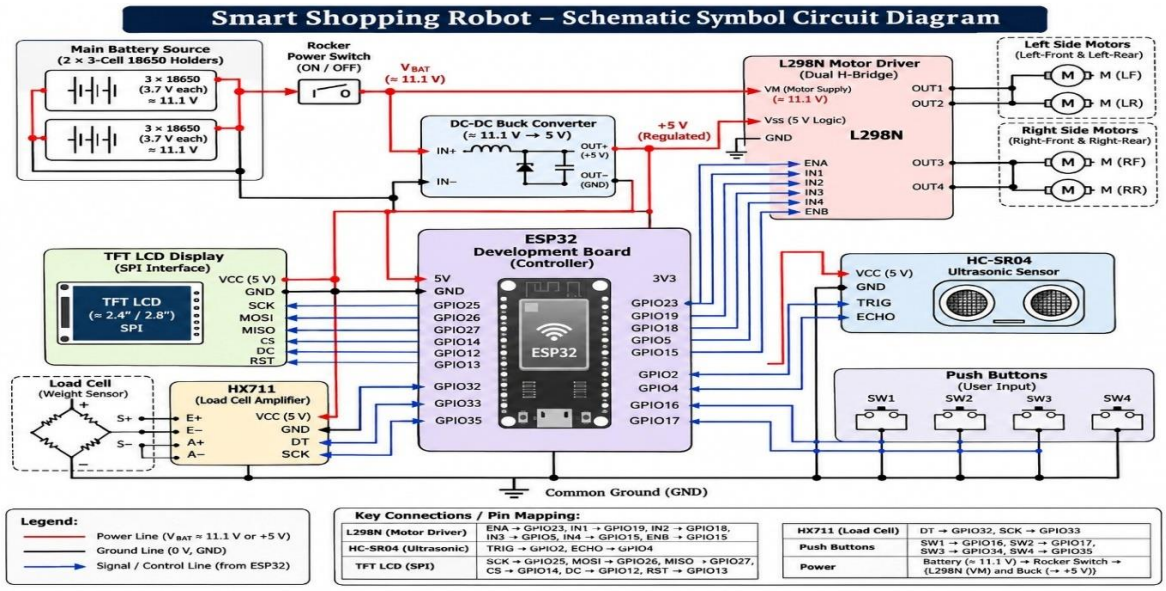


Fig.1. Block diagram of the proposed Smart Shopping Trolley

A. System Architecture

The proposed system consists of an intelligent shopping trolley controlled by an ESP32 microcontroller, which acts as the main control unit. The system integrates a camera for customer following, a QR code scanner for product identification, a load cell for weight measurement, and control buttons for user interaction. The ESP32 processes the input data and controls trolley movement, display operations, and wireless communication. A rechargeable battery pack supplies power to the system. The L298N motor driver controls the DC gear motors connected to the four wheels. A 5-inch display presents product information, cart details, billing information, and navigation instructions. The built-in Wi-Fi enables communication with a web application or cloud server, while internal flash memory or an SD card stores product information and transaction records.

B. Customer Following and Obstacle Avoidance

A camera is used to support customer detection and following. The captured information is processed to determine the customer's position, allowing the ESP32 to generate suitable motor-control commands. The trolley can move according to the customer's direction and position.

Obstacle detection sensors, such as ultrasonic sensors, can be integrated to detect objects in the trolley's path. When an obstacle is detected within a predefined safety distance, the controller stops or adjusts the trolley's movement to reduce collision risks and improve shopping convenience.

C. QR Code-Based Product Identification

A QR code scanner identifies products during shopping. Each product has a unique QR code associated with its name and price in the product database. When a product is scanned, the ESP32 processes the product identifier and updates the shopping cart with the corresponding details. The system maintains product names, quantities, individual prices, and the running bill. Control buttons allow users to add or remove products, reset the cart, and generate the final bill. This process reduces manual billing activities and allows customers to monitor their purchases in real time.

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D. Weight Measurement and Automatic Billing

A load cell measures the weight of products placed in the trolley. Its output can be processed using an HX711 amplifier before being read by the controller. The measured weight is displayed along with the shopping information. The billing system combines scanned product details with prices stored in the database. For weight-based products, the measured weight can be used to calculate the cost according to the applicable price per unit. The ESP32 updates the total bill and displays the transaction details on the 5-inch display. Billing information can also be transmitted to the web application for further processing.

E. Hardware Implementation

The main hardware components include an ESP32 microcontroller, camera, QR code scanner, load cell, HX711 amplifier, L298N motor driver, four DC gear motors, 5-inch display, control buttons, rechargeable battery, and power-management circuitry. Obstacle detection sensors may also be included for safer movement. The ESP32 coordinates the sensing, processing, and control functions. The motor driver controls the wheel motors, while the display provides shopping and navigation information. The weighing unit measures product weight, and the battery supplies power to the electronic and motor-control sections.

F. IoT Monitoring and User Interface

The built-in Wi-Fi of the ESP32 enables communication with a web application or cloud server. The local display shows product names, prices, quantities, total weight, running bill, and navigation information. Transaction records can be synchronized with the cloud platform when network connectivity is available. The system provides cart-management functions through control buttons and supports the integration of online payment facilities when the required backend services are implemented.

G. Power Supply

A rechargeable battery pack supplies power to the controller, camera, display, sensors, and motor-control circuit. Suitable voltage regulation and power-management circuits provide the required operating voltages. Proper power distribution is essential because the motors and electronic components have different power requirements.

H. Experimental Setup and Evaluation

The system can be evaluated by testing customer following, obstacle avoidance, QR code recognition, weight measurement, billing accuracy, and display operation. Multiple products can be scanned to verify quantity updates and total bill calculations. Weight measurements can be compared with known reference weights to assess accuracy. Wi-Fi communication and data synchronization can also be tested under different network conditions. The test conditions and measured results should be recorded to support reproducibility.

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IV. RESULTS

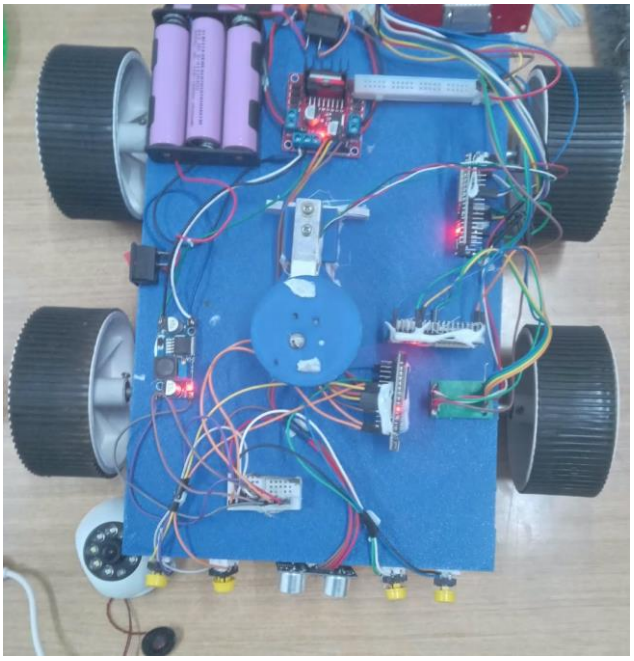


Fig.2.

Fig.

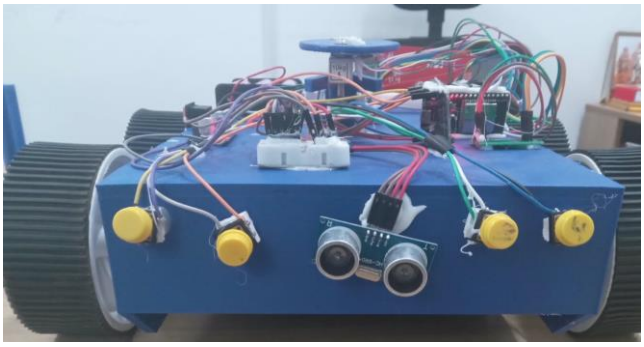


Fig.3.

Fig. 3

V. DISCUSSION

The proposed system integrates human-following technology, QR code-based product identification, weight measurement, and automatic billing into a single smart shopping trolley. The camera-based tracking system enables the trolley to follow the customer, while obstacle detection helps improve movement safety. QR code scanning allows products to be identified and their prices to be added to the running bill, reducing the need for separate manual billing procedures.

The integration of a load cell provides weight information for products placed in the trolley, supporting weight-based billing where applicable. The display presents product details, quantities, weight, and the total bill, allowing customers to monitor their purchases during shopping. Wi-Fi connectivity enables information exchange with the web application for transaction monitoring and further billing operations.

However, the system's performance depends on camera accuracy, QR code readability, weight measurement accuracy, network connectivity, and battery capacity. Further testing in crowded supermarket environments is required to evaluate tracking reliability, obstacle avoidance, billing accuracy, and overall system performance.

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VI. CONCLUSION

The proposed IoT-Based Human-Following Smart Shopping Trolley with Automatic Billing System integrates customer-following technology, QR code-based product identification, weight measurement, and automatic billing into a single platform. The system is designed to improve shopping convenience by reducing the effort required to push the trolley and simplifying the billing process. The camera supports customer tracking, while the motor driver controls trolley movement. QR code scanning enables product identification, and the weighing unit provides weight information for applicable products. The display presents product details and the running bill, while Wi-Fi connectivity supports communication with the web application. Future improvements can include enhanced tracking accuracy, advanced obstacle avoidance, longer battery life, and large-scale supermarket testing.

VII. FUTURE SCOPE

The proposed smart shopping trolley can be further enhanced by incorporating advanced customer tracking, AI-based navigation, improved obstacle detection, and automatic return-to-parking functionality. Integration with digital payment platforms can enable faster and more convenient checkout. Cloud-based data analytics can be used to analyze shopping patterns, manage product inventories, and improve billing efficiency. Future developments may include enhanced weight measurement accuracy, longer battery life, and improved QR code recognition under different lighting conditions. Further evaluation in crowded supermarket environments can assess tracking accuracy, obstacle avoidance, billing reliability, response time, and overall system performance.

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