

Smart Tracking Basket

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Abstract: The smart shopping cart integrates embedded electronics, sensors, and cloud technology to simplify shopping and billing. It uses barcode scanning and load cells for product identification and weight verification, while geared DC motors enable controlled movement. An OLED display provides real-time updates, and a web dashboard supports inventory management, order tracking, and billing validation. This system improves billing accuracy, reduces checkout delays, and enhances the overall shopping experience.

Keywords: Smart shopping, cloud technology.

I. INTRODUCTION

The retail industry is increasingly adopting smart technologies to improve convenience, reduce waiting time, and enhance efficiency. However, traditional shopping baskets lack automated item tracking, guided movement, and real-time assistance. Smart Tracking Basket addresses these limitations using intelligent technologies to simplify shopping, improve billing accuracy, and reduce physical effort. It aims to provide a convenient and accessible shopping experience while supporting efficient retail operations.

II. OBJECTIVE

The objectives are:

1. To Build expertise in embedded systems through hands-on hardware, microcontroller, and sensor integration.
2. Design autonomous basket movement using smart sensors and control systems.
3. Create an automated shopping solution with efficient barcode-based billing and enhanced security

III. METHODOLOGY

A. Block Diagram

The block diagram Figure1, The Smart Tracking Basket methodology involves power management, item sensing, mode-based processing, autonomous tracking, data synchronization, and billing verification. Components such as the ESP32, L298N motor driver, LM2596 converter, load cell with HX711, OLED display, and IP camera are integrated and tested systematically. The system operates through four modes: Add, Remove, Bill, and Reset, ensuring efficient operation and user-friendly interaction.

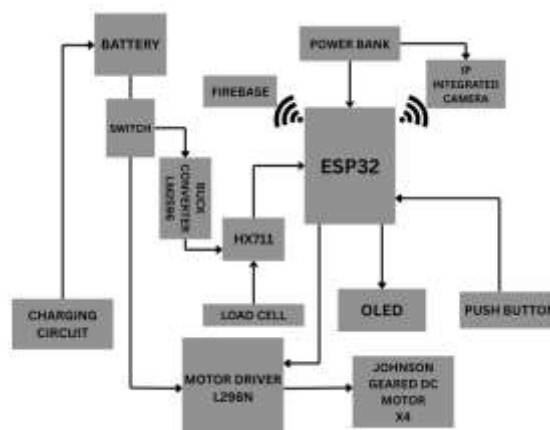


Figure 1. shows the block diagram

- a. Power Initialization and System Boot: The 12 V supply powers the motors, while the LM2596 converts it to 5 V for the ESP32 and other modules. The ESP32 initializes all interfaces and enters standby mode.
- b. User Detection and Registration: The IP camera detects the user, and dashboard registration creates a unique shopping session to store item, weight, and billing data.
- c. Mode Selection and Shopping: The user selects Add, Remove, Bill, or Reset mode through the dashboard. The ESP32 updates its logic and displays the active mode on the OLED.
- d. QR-Based Item Detection and Weight Measurement: The camera scans product QR codes, while the load cell measures basket weight. The ESP32 validates product details and updates the cart, bill, and dashboard.
- e. Autonomous Human Tracking: The camera identifies the user's left, center, or right position. The ESP32 controls motor speeds through L298N drivers to follow the user.
- f. Billing Verification and Payment: In Bill Mode, the system compares measured and expected basket weight. Payment is enabled only when both values match.
- g. System Reset: Reset Mode clears session, cart, sensor, and navigation data, preparing the basket for the next user.

B. Flow chart

This flowchart illustrates an autonomous shopping basket system that uses face detection to identify the user and allows them to add or remove items by scanning. The system generates a bill, sends the bill and order status to the user and admin dashboards, and checks whether the total basket weight matches the billed weight. If the weights match, the user can pay through UPI or cash. If they do not match, an error message is displayed. The system then resets for the next shopping session.

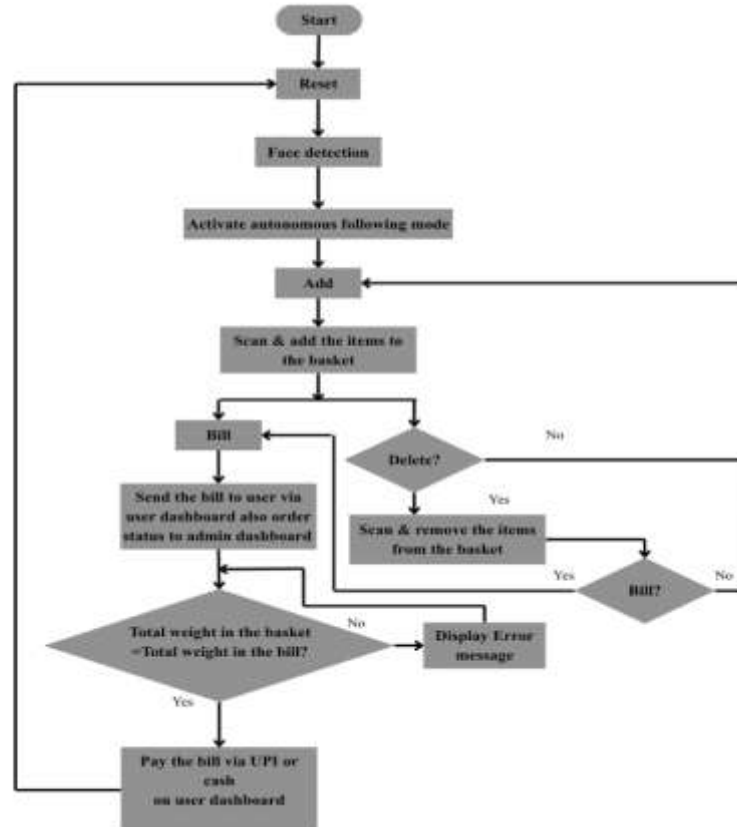


Figure2. flow chart

IV.HARDWARE DESCRIPTION**1. ESP32-WROOM**

The ESP32 is a low-power microcontroller with built-in Wi-Fi and Bluetooth, used as the main controller of the Smart Tracking Basket. It interfaces with sensors, motors, and the camera, processes sensor data for obstacle detection and navigation, and communicates with the Raspberry Pi and Firebase. It also manages product identification, billing data, and real-time synchronization with the web dashboard for efficient system operation.



Figure 3. ESP32 -WROOM

2. Motor Driver L298N

The L298N is a dual H-Bridge motor driver that controls the direction and speed of DC motors. It acts as an interface between the Raspberry Pi Pico WH, ESP32, and the motors of the Smart Tracking Basket. Using input signals and PWM-based speed control, it enables independent forward, reverse, and braking operations for smooth autonomous movement. Flyback diodes provide circuit protection, while a heat sink helps dissipate heat during continuous operation.



Figure 4. Motor Driver L298N

3. Load cell with HX711

The weight measurement system uses four 10 kg load cells connected to an HX711 24-bit ADC amplifier to measure the basket's total weight accurately. It continuously monitors weight changes and filters noise to provide stable readings. This system verifies scanned products against their expected weights, detects unscanned additions or removals, and identifies billing discrepancies, improving the accuracy and security of the Smart Tracking Basket.

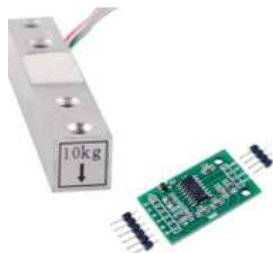


Figure 5. Load cell with HX711

4. Buck converter

The buck converter is a DC-DC step-down regulator that converts the 12V battery input into a stable 5V supply for the ESP32, Raspberry Pi Pico, sensors, and other components. It ensures efficient power distribution, minimizes energy loss, and maintains stable voltage under varying loads, supporting reliable operation and improved battery life of the Smart Tracking Basket.



Figure 6. Buck converter

5. OLED

The OLED display is a compact visual interface that communicates with the microcontroller through the I2C interface using the SSD1306 driver. It displays scanned product details, prices, total bill, and system alerts in real time. This enables customers to monitor their shopping activities, confirm product scans, and identify billing discrepancies, improving the usability and reliability of the Smart Tracking Basket.



Figure 7. OLED

6. IP integrated camera

The IP camera captures real-time video and supports remote monitoring through Wi-Fi or Ethernet connectivity. In the Smart Tracking Basket, it helps monitor customer movement, verify user presence, and record shopping sessions for security purposes. Its motion detection, night vision, and cloud or local storage features enhance system monitoring and complement the basket's sensor-based tracking and automation.



Figure 8. IP integrated camera

V.SOFTWARE REQUIREMENTS

1. Arduino IDE

The Arduino IDE is an open-source software platform used to write, compile, and upload programs to Arduino boards and other compatible microcontrollers. It provides a simple and user-friendly interface for developing embedded and electronics projects using C/C++-based programming. The IDE includes features such as a code editor with syntax highlighting, built-in libraries, error checking, board and port selection, and a Serial Monitor for real-time communication and debugging. In the workflow, users write the program, compile it to detect errors, upload it to the microcontroller through USB, and monitor the system performance using the Serial Monitor.

2. Visual Studio Code

Visual Studio Code (VS Code) is an open-source code editor developed by Microsoft for software and embedded system development. It supports multiple programming languages and features such as syntax highlighting, auto-completion, debugging, integrated terminal, and Git support. VS Code also allows the use of extensions

for technologies like Python, C/C++, Arduino, and ESP32, making coding, debugging, and project management easier and more efficient.

3. Open CV

OpenCV is an open-source computer vision library used for real-time image and video processing. In the Smart Tracking Basket, it processes camera feeds for face detection, customer tracking, and QR code scanning. The processed data helps identify users, track their movements, retrieve product information, and support real-time dashboard updates and accurate billing.

4. Google firebase

Google Firebase is a cloud-based platform that simplifies application development by providing services such as real-time databases, authentication, cloud storage, and hosting without requiring physical servers. In the smart shopping cart system, Firebase acts as the central data hub, storing product details, tracking scanned items, and updating cart information in real time. It manages Add, Remove, and Checkout operations, records payment history, and synchronizes data between the ESP32 controller and user and admin dashboards, ensuring accurate and seamless communication.

VI.RESULTS AND DISCUSSIONS

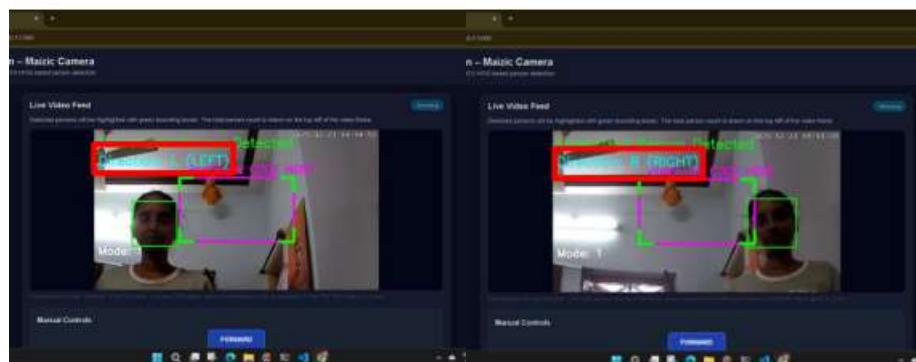
1. User dashboard: The User Dashboard serves as the main interface between the user and the Smart Tracking Basket system. It enables real-time monitoring of cart movement, selection of operating modes, tracking of item updates, and viewing of billing information. It also facilitates smooth data exchange between the camera module, ESP32 controller, Firebase database, and the user.

a. System Initialization and Face Detection: The cart starts in Reset Mode with motors disabled and the bill cleared, waiting for a user. The IP camera continuously captures video frames and detects a person using a face-detection algorithm. Once a person is detected, the automatic human-following mechanism is activated.

b. Real-Time Cart Movement and Manual Control: The User Dashboard displays the cart's real-time movement based on camera input.

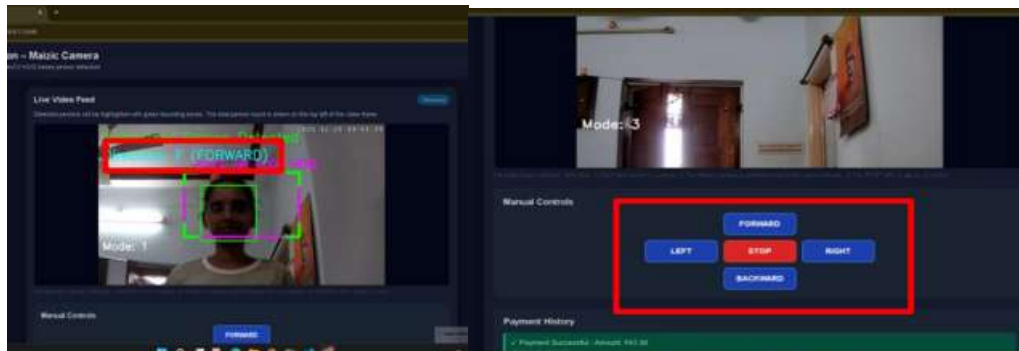
- Left Grid: The ESP32 adjusts motor speeds to turn the cart left.
- Right Grid: The ESP32 adjusts motor speeds to turn the cart right.
- Center Grid: All four motors run at uniform speed, moving the cart forward.

c. Mode-Based Shopping Operation Using Push Button and Dashboard Synchronization: The Smart Tracking Basket has four modes—Add, Remove, Bill, and Reset—controlled by a push button. The ESP32 updates the operating mode and syncs item and weight data with the User Dashboard via Wi-Fi, while the OLED displays the active mode and system status.



(a) Left grid

(b) Right grid



(c) Center grid

(d) manual control buttons

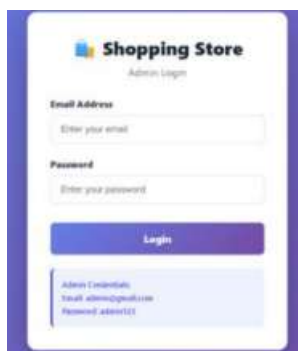
Figure 9 (a,b,c,d) User dashboard

- Add Mode (Mode 1): Scans the product QR code, retrieves details from Firebase, verifies weight through the load cell, and updates the cart, bill, and dashboard.
- Remove Mode (Mode 2): Scans the item QR code, verifies weight reduction, removes the item, and updates the bill and dashboard.
- Reset Mode (Mode 3): Clears cart, weight, billing, and session data, returning the system to standby.
- Bill Mode (Mode 4): Generates the bill and compares measured and expected weights. Payment is enabled only when both match.

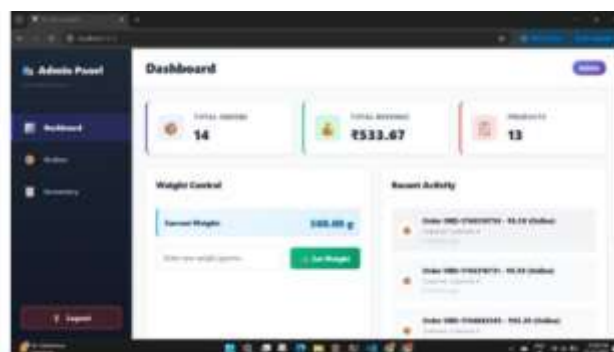
2. Admin Dashboard

The Admin Dashboard provides secure access to store data, inventory, transactions, and real-time performance through Firebase integration.

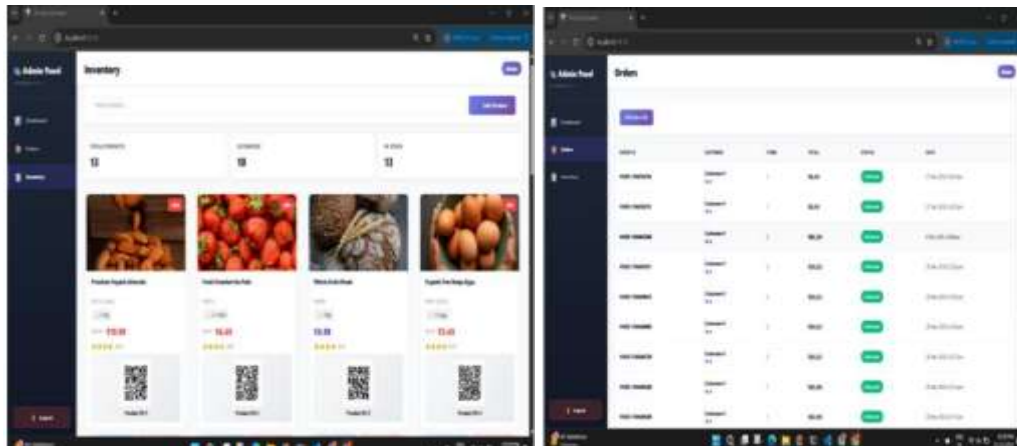
- Admin Login: Authenticates authorized users to prevent unauthorized access.
- Store Analytics: Displays completed orders, total revenue, and available products with automatic updates.
- Inventory Management: Allows admins to add or remove products and update details such as name, price, weight, and product ID in Firebase.
- Order History: Records completed orders, purchased items, and bill amounts for transaction tracking and auditing.



(a) Admin dashboard login page



(b) home page



(c) Inventory page

(d) order history page

Figure 10(a, b, c, d) Admin Dashroad

3. Cart Working: The Smart Tracking Basket integrates sensing, motor control, backend communication, and dashboard monitoring for efficient shopping. Initially, Reset Mode clears previous data. The camera detects the user and activates automatic tracking. The ESP32 processes the user's position across left, center, and right zones and controls the four DC motors through L298N drivers. The User Dashboard displays live camera feedback and cart status, with manual movement controls available when needed.

In Add Mode (Mode 1), QR codes retrieve product details from Firebase, while weight and billing updates appear on the OLED. In Remove Mode (Mode 2), QR scanning and weight reduction verify item removal. Reset Mode (Mode 3) clears session data after payment. In Bill Mode (Mode 4), measured and expected weights are compared, allowing payment only when they match. Overall, the system ensures accurate tracking, real-time updates, and reliable billing.



(a) Front of Camera



(b) Right of camera



(c) Scanned product QR to camera

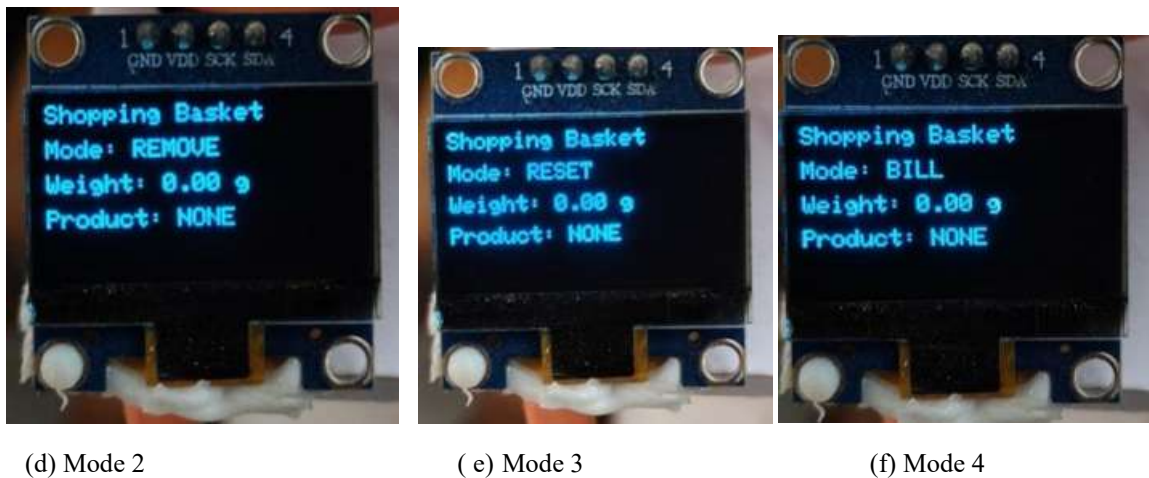


Figure 11(a, b, c, d, e, f) Cart Working:

VII.ADVANTAGES

The advantages are:

1. Autonomous Human-Following Operation: The camera-based human detection system and three-grid navigation logic allow the basket to follow the customer autonomously, reducing manual effort and enhancing shopping convenience.
2. Accurate and Secure Billing Mechanism: The load cell and HX711 amplifier enable real-time weight monitoring, which is compared with scanned product information to ensure accurate billing and detect weight discrepancies.
3. Mode-Based Controlled Workflow: The four operational modes—Add, Remove, Bill, and Reset—structure the shopping process, reducing operational errors and ensuring reliable system behavior at each stage.

VIII.LIMITATIONS

The limitations are:

1. Load Cell Precision Dependency: The accuracy of weight measurement depends heavily on proper calibration and stable mounting of the load cell. Minor vibrations, uneven load distribution, or sudden item placement can introduce small fluctuations in measured weight.
2. Latency in Cart Movement Response: A slight delay may be observed between user movement and cart response due to camera frame processing, data transmission, and motor actuation, especially in crowded or lowlight environments.
3. Camera-Based Tracking Constraints: Human tracking performance can be affected by occlusion, rapid user motion, or multiple users appearing simultaneously within the camera frame.

IX.APPLICATIONS

The applications are:

1. Smart Retail Shopping: Assistance The system can be deployed in retail stores to provide autonomous cart navigation, real-time item tracking, and instant billing validation, significantly reducing manual effort during shopping.
2. Automated Checkout Systems: By integrating QR-based item identification with weight verification, the project can be applied to automated checkout environments to minimize billing errors and eliminate long queues.
3. Customer Assistance in Large Stores: The human-following mechanism enables the cart to accompany customers throughout large shopping areas, reducing physical strain and improving user convenience.

X.FUTURE SCOPE

The future scope are:

1. Integration of Advanced Computer Vision Models: The human-following system can be improved using advanced deep learning vision models for accurate person tracking in different lighting conditions and crowded environments, enhancing navigation reliability and reducing errors.
2. Dynamic Inventory Auto-Update Using Weight Intelligence: The system can automatically update inventory by combining load cell data with product scans in real time, ensuring accurate stock levels on the admin dashboard without manual effort.
3. Mobile Application Integration: A mobile app can be developed to let users monitor cart status, billing, and payments on their smartphones, improving accessibility and user engagement.

XI. CONCLUSION

The Traditional supermarket shopping involves manual cart handling and centralized billing, leading to long queues, delays, human errors, and inefficient inventory management. The Smart Tracking Basket project addresses these issues through human-following navigation, real-time product identification, weight-based verification, and cloud-based dashboards. It enables automatic cart movement, instant billing updates, and secure weight validation, reducing checkout delays and improving shopping convenience, billing accuracy, and inventory monitoring.

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