Smart Shopping Cart

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Abstract - Recently, many attempts have been made to reduce the time required for payment in various shopping environments. In addition, with advancements in artificial intelligence and IoT technologies, it has become easier to create unmanned environments for shopping, reducing the need for human intervention. This paper proposes a smart shopping cart system based on low-cost IoT equipment and deep learning object detection technology. The system consists of a camera for real-time product detection, an ultrasonic sensor as a trigger, a weight sensor to determine if a product enters or exits the shopping cart, and a smartphone app providing a virtual cart interface. The server uses YOLO, an object detection library, for product recognition. Communication occurs via TCP/IP and HTTP, allowing users to monitor items in their cart and make automatic payments. This system aims to offer a high cost-performance ratio for implementing unmanned stores.

Key words: Deep Learning ,Real-time Object Detection, YOLO , Internet of Things , Smart Shopping Cart .

I. INTRODUCTION

Traditional payment systems in shopping environments are often Labor-intensive and time-consuming. Recent advancements in deep learning have led to the emergence of unmanned stores, with Amazon Go being a notable example, allowing customers to shop without waiting in line.Amazon Go utilizes cameras, microphones, and pressure sensors to track customer interactions in real time. However, it faces limitations, such as a customer cap of around 100 due to AI tracking challenges and the extensive data collection that complicates scalability.

To address these issues, we propose a smart shopping cart that leverages deep learning object detection and Raspberry Pi technology. This system includes a camera, ultrasonic and weight sensors, TCP/IP networking, a deep learning server, and an Android app, enabling real-time modifications to virtual shopping carts.

While existing smart carts often rely on face recognition and RFID technology, our approach eliminates the need for RFID by using camera based product recognition.

This paper is structured as follows: Chapter 2 discusses the system design of the smart shopping cart, Chapter 3 details the implementation and performance evaluation, and Chapter 4 concludes with future research directions.

II. BACKGROUND WORK

The concept of automated shopping systems has gained momentum with advancements in deep learning and IoT technology. Traditional methods like Amazon Go have set a benchmark by using a combination of cameras, sensors, and AI to track customer interactions and automate the checkout process. However, limitations such as scalability issues and high operational costs have driven the search for more cost-effective solutions.

Research in smart shopping carts has proposed various methods to address these challenges. For instance, one study introduced a smart shopping trolley using Raspberry Pi and image processing technology, integrating a camera and display screen for customer interaction. This system enables customers to scan items and make online payments, thereby bypassing the need for traditional cashiers. Key features include cost-effectiveness, a user-friendly interface, and security measures such as two-factor authentication. However, the approach faces potential detection accuracy challenges in high-volume environments.

Another significant work focused on the use of deep learning object detection, specifically the YOLO algorithm, combined with a camera-based system that eliminates the need for RFID tags. This proposed solution integrates sensors and a camera managed by a Raspberry Pi to detect products in real time, with data communicated via TCP/IP and HTTP protocols to an Android app. While this method offers a lower-cost, scalable alternative, challenges remain in optimizing detection accuracy and managing resource constraints on the hardware.

The comparison of hardware options such as Raspberry Pi and ESP32-CAM has become relevant for modern implementations. The Raspberry Pi provides higher processing power and flexibility for integrating complex models, while the ESP32-CAM offers a low-cost, power-efficient alternative with built-in Wi-Fi capabilities, suitable for simpler implementations that may rely on server-side processing.

II. Related Works

2.1 Implementation of Smart Shopping Cart using Object Detection Method based on Deep Learning

This paper presents a smart shopping cart system designed to enhance the shopping experience by minimizing payment times and leveraging advancements in artificial intelligence and IoT. The system integrates a camera for real-time product detection, ultrasonic sensors for triggers, weight sensors to track product entry and exit, and a smartphone app for virtual cart management. Utilizing the YOLO object

detection algorithm, the system recognizes products without the need for RFID tags, significantly reducing costs and operational complexities.
Communication between components is facilitated through TCP/IP and HTTP protocols, enabling efficient data transfer. The proposed smart cart offers a high cost-performance ratio compared to traditional unmanned store solutions, allowing for scalability without substantial increases in computational resources.

The study details the system's architecture, implementation, and performance evaluations, concluding that while YOLO provides rapid detection capabilities, future improvements could enhance detection accuracy further. The findings highlight the potential of this smart cart system for broad application in unmanned retail environments.

2.2 Smart shopping trolley for automated Billing process using Image-Processing

The paper discusses a Smart Shopping Trolley designed to automate the billing process using image processing technology. It addresses the common issue of long wait times at checkout lines in supermarkets and shopping malls, proposing a system that allows customers to complete transactions directly in the trolley. By integrating Raspberry Pi and machine learning algorithms, the trolley recognizes products through a camera and displays their details on an attached screen. Customers register in the system, scan their items, and make online payments without needing a cashier. The literature review highlights similar existing systems, notably Amazon Go, which employs advanced technology but comes at a high cost. The proposed trolley aims to provide a cost-effective, efficient shopping experience, ensuring security against theft and improving overall convenience. Key features include two-factor authentication, online transaction records, and a user-friendly interface. The study concludes that this system offers significant advantages over traditional methods, positioning it as a reliable alternative for modern retail environments. Future improvements could enhance accuracy and incorporate IoT for inventory management.

III. Proposed method

3.1 Design

3.1.1 components

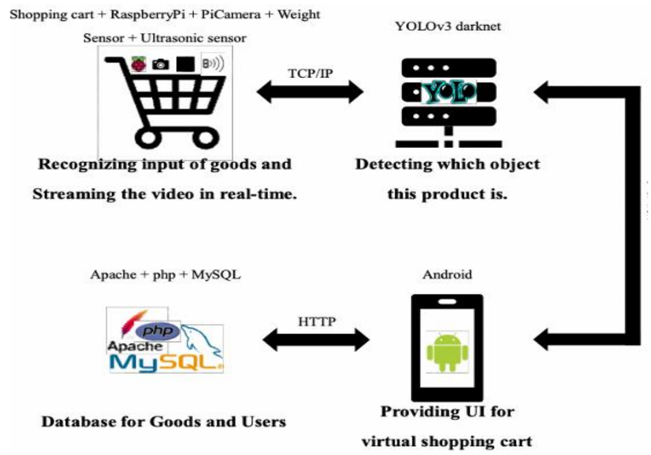
- Ultrasonic Sensor: This sensor detects when a product is placed into or removed from the cart..
- Camera: A Raspberry Pi camera (likely a Pi Camera) captures video of the items being added or removed from the cart.
- Raspberry Pi: Acts as the central controller for the entire system. It handles the input from sensors and camera, performs image processing, and manages communication with other devices.

3.1.2Communication

- TCP/IP Network: Used for communication between the shopping cart, the central server, and an Android app. This setup allows for real-time updates and data transfer.
- HTTP Protocol: Employed for communication between the database server and the Android.

3.2 Working

The smart shopping cart system operates through an integration of various technologies designed to enhance the shopping experience. At its core, the system utilizes a



Raspberry Pi board, which facilitates Wi-Fi connectivity for real-time communication with a central server. This setup allows the shopping cart to stream video via a Pi Camera, enabling the detection of items placed into or removed from the cart. As a customer shops, ultrasonic sensors play a critical role by sensing when products are added or taken out, thereby triggering the video streaming only when necessary, which is essential for conserving battery life.

Upon detecting a change, the system captures and processes video data using the YOLO (You Only Look Once) object detection algorithm. YOLO operates by analyzing the video frames to identify products, providing not only recognition but also localization through bounding boxes for multiple items simultaneously. This rapid detection capability—approximately 1,000 times faster than traditional methods—ensures that the system can keep up with the pace of real shopping.

The Android application complements this hardware setup by allowing users to interact with their virtual shopping carts directly from their smartphones. Upon starting the app, users input a unique identifier corresponding to the shopping cart, establishing a connection to the central server. The app then temporarily stores product information, including quantities, and communicates with the database to update the shopping list in real time.

As the shopping process concludes, the user can easily proceed to payment through the app. The detailed tracking of products throughout this process, from entry to checkout, not only simplifies the shopping experience but also enhances the accuracy of transactions, reducing potential errors during checkout. Overall, the smart shopping cart system exemplifies how combining IoT, deep learning, and user-friendly interfaces can revolutionize retail environments.

IV. RESULT

The smart shopping cart system presents a sophisticated and efficient approach to enhancing the retail shopping experience by integrating various advanced technologies. At its foundation, the system utilizes a Raspberry Pi board, which facilitates wireless connectivity to a central server. This enables the streaming of real-time video through a Pi Camera, which is crucial for detecting items added to or removed from the cart. The system employs ultrasonic sensors to trigger video capture only when necessary, thereby conserving battery life during the shopping process.

When products are added or taken out, the system leverages the YOLO (You Only Look Once) algorithm for object detection, allowing it to recognize and locate multiple items simultaneously. This real-time capability significantly accelerates the detection process, outperforming traditional methods by a considerable margin. Accompanying the hardware is an Android application that allows users to interact with their virtual shopping carts from their smartphones. By entering a unique identifier, customers can synchronize their shopping data with the central server, enabling seamless updates and management of their cart.

As the shopping experience concludes, users can easily check out through the app, which accurately calculates the total based on the items detected throughout their shopping journey. This integration of IoT, deep learning, and user-friendly interfaces exemplifies how technology can streamline retail operations and enhance customer satisfaction, showcasing a modern evolution in how consumers interact with the shopping environment.

V. Future Enhancements

1. **Expanded Product Recognition Database**: Develop a dynamic, cloud-based database for product recognition, allowing the system to automatically update and adapt to new products without requiring manual retraining.

2. **User Behavior Analysis and Personalized Recommendations**: Use AI-driven analytics to analyze user behavior and preferences in real time, offering personalized product recommendations through the smartphone app based on purchase history and real-time browsing patterns.

3. **Multi-Language Support and Accessibility Features**: Add multi-language support and accessibility options in the smartphone app for a more inclusive shopping experience, allowing users of diverse backgrounds to interact easily with the system.

4. **Enhanced Security and Privacy**: Strengthen data encryption and privacy features to secure user data during cart monitoring and payment processes, addressing customer concerns over data handling.

5. **Offline Functionality**: Integrate local processing capabilities to support offline functionality, allowing the cart to operate even in areas with limited internet connectivity, syncing with the server when a connection is re-established.

6. **Automated Inventory Management for Stores**: Connect the smart shopping cart system to the store's inventory management system, enabling automated tracking and real-time updates for stock levels as items are added or removed from carts.

7. **Enhanced Cart Navigation**: Add indoor navigation capabilities to help customers locate items within the store efficiently, using Bluetooth beacons or similar technologies integrated into the cart.

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