A

PROJECT REPORT

On

"SELF-CHECKOUT SMART STORE SYSTEM"

Submitted in partial fulfillment of the requirements for

the degree of

Bachelor of Technology

in

Information Technology

By

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Academic Year 2023 - 24

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CERTIFICATE

This is to clarify that the B. Tech project Report Entitled

"Self-Checkout Smart Store System"

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is a record of bonafide work carried out by him/her, under our guidance, in partial fulfillment of the requirement for the award of Degree of Bachelor of Technology (Information Technology) at Shri Vile Parle Kelavani Mandal's Institute of Technology, Dhule under the Dr. Babasaheb Ambedkar Technological University, Lonere, Maharashtra. This work is done during semester VIII of Academic year 2023-24.

Date:
Place: SVKM's IOT, Dhule

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Project Guide & Coordinator	**HOD**	**Principal**

Name and Sign with date	Name and Sign with date.
Examiner 1	Examiner 2

DECLARATION

We declare that this written submission represents ideas in our own words and where other's ideasor words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have notmisrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will cause disciplinary action by the Institute and can also invoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ACKNOWLEDGEMENT

We have immense pleasure in expressing our interest and deepest sense of gratitude towards ourproject guide **Prof. Rubi Mandal** for the assistance, valuable guidance, and co-operation in carrying out this project successfully. It is a privilege for us to have been associated with our Project Guide during our Project work. We have greatly benefited from his/her valuable suggestions and ideas. It is with great pleasure that we express our deep sense of gratitude to him/her for his/her valuable guidance, constant encouragement, and patience throughout this work. We express our gratitude and are thankful to all people who have contributed in their wayin making this final year project success. Particularly we want to thank **Prof. Rubi Mandal**, Project Coordinator for our department for making this process seamless for us and arranging everything so perfectly. I take this opportunity to thank all the classmates for their company during the course work and for the useful discussion I had with them. We take this opportunity to express our heartfelt gratitude towards the Department of Information Technology of Shri Vile Parle Kelavani Mandal's Institute of Technology, Dhule Head of the Department, **Dr. Bhushan Chaudhari** and **Dr. Nilesh Salunkhe,** Principal of Shri Vile Parle Kelavani Mandal's Institute of Technology, Dhule, that gave us an opportunity for the presentation of ourproject phase 1 in the esteemed organization and for providing the required facilities in completing this project. We are greatly thankful to our parents, friends and other faculty members for their motivation, guidance and help whenever needed

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ABSTRACT

The self-checkout store system is a retail solution aimed at revolutionizing the traditional shopping experience. This innovative concept leverages advanced technology and automation to provide customers with a seamless and efficient checkout process. The project aims to addresscommon challenges faced by both customers and retailers, such as long queues, cashier errors, and inventory management inefficiencies. The self-checkout store utilizes computer vision, machine learning and Digital Payment System to enable customers to shop freely without the need for traditional checkout counters or cashier assistance. Upon entering the store, customers can use a smartphone app to check in the store by scanning a QR code generated by the application and add items in their shopping cart. The system automatically detects objects withinan image or video frame and links each customer to the items they add to their cart. When the item is placed in the cart the total cost is calculated, providing real-time information on the purchased items. By adopting the self-checkout store model, retailers can reduce labor costs, minimize checkout waiting times, and improve customer satisfaction. The project aims to demonstrate the feasibility and advantages of this innovative retail solution through a prototype implementation in a real-world retail environment. As the retail industry continues to evolve, this self-checkout store system presents a forward- thinking approach that has the potential to shape the future of retail shopping.

Keywords: computer vision, machine learning.

1. INTRODUCTION

1.1 Basic Concept

The self-checkout store system is a retail solution aimed at revolutionizing the traditional shopping experience. This innovative concept leverages advanced technology and automation to provide customers with a seamless and efficient checkout process. The self-checkout store utilizes computer vision, machine learning, Sensor technology, and Digital Payment System to enable customers toshop freely without the need for traditional checkout counters or cashier assistance. The self- checkout store system is a cutting-edge retail solution designed to transform the conventional shopping experience. Through the integration of sophisticated technologies such as computer vision, machine learning, sensor technology, and digital payment systems, this innovative concept eliminates the need for traditional checkout counters and cashier assistance. Customers can now shop freely, navigating the store without the constraints of conventional checkout processes. Computer vision enables seamless item recognition, while machine learning refines the system's efficiency over time. Sensors facilitate a hands-free experience, detecting and tallying items in thecustomer's cart. The digital payment system adds convenience, allowing for swift and secure transactions. This self-checkout approach not only enhances customer autonomy but also streamlines the overall shopping journey, making it more time-efficient and reducing wait times. The store's reliance on automation and advanced technologies reflects a shift towards a more modernand customer-centric retail landscape.

1.2 Motivation of the Project

The motivation to address and reduce queues in retail stores stems from the profound impact that long waiting times have on customer behavior and business outcomes. An alarming 86% of customers actively avoid stores with lengthy queues, leading to immediate losses and diminished potential for repeat business. With the average person spending a considerable amount of time—specifically, one year, two weeks, and a day—waiting in shop queues throughout their lives, there is a growing impatience among modern consumers. The tipping point for dissuading shoppers is identified as seven people in a queue, emphasizing the critical importance of managing queue length. Furthermore, after just 9 minutes, or as little as 6 minutes according to some research, shoppers are highly likely to abandon the queue, underscoring the need for swift and efficient checkout processes. The impact is not limited to immediate purchases; 70% of customers are less likely to return to a store if they experience long waiting times on just one occasion, highlighting the lasting negative impression of a single poor queueing experience. With the average shopping trip including 20 minutes of queuing time, the motivation to streamline the checkout process is clear—by leveraging technology and efficient systems, retailers can enhance overall satisfaction, maintain a brand image, and ultimately increase sales.

1.3 Project Idea

The project aims to revolutionize traditional retail experiences by introducing a self-checkout smart store system. Leveraging cutting-edge technology, such as IoT devices, machine learning algorithms, and cloud services, the system transforms the way customers shop and interact with stores. By enabling seamless navigation, effortless product scanning, and secure payment processing, the project enhances convenience, efficiency, and customer satisfaction. With features like automated inventory management, personalized recommendations, and real-time analytics, the system empowers retailers to optimize operations, increase sales, and deliver exceptional shopping experiences. Ultimately, the project represents a step forward in the evolution of retail, bridging the gap between physical and digital commerce while redefining the future of retail innovation.

2. LITERATURE SURVEY

2.1 Related Work Done

The implementation and optimization of self-checkout systems have become pivotal in the modern retail landscape, offering convenience and efficiency to both retailers and consumers. This discussion focuses on three significant papers exploring various aspects of self-checkout technologies, namely "Self-Checkout System Using RFID (Radio Frequency Identification) Technology: A Survey," "Shop and Go: An Innovative Approach Towards Shopping Using Deep Learning and Computer Vision," and "Just Walk-Out Technology and Its Challenges: A Case of Amazon Go. “The "Self-Checkout System Using RFID Technology" paper delves into the challenges and parameters associated with implementing RFID technology in self-checkout systems.[7][10] It addresses issues such as tag accuracy, interference, and the overall cost of implementation. The work primarily revolves around overseeing the integration and optimization of RFID self-checkout systems. This involves ensuring the accuracy of RFID readers and antennas, managing the cost of implementation, and implementing robust security measures to safeguard user privacy through RFID tags. Collaborative efforts with cross-functional teams play a crucial role in achieving seamless integration, accuracy, and user-friendly experiences.

The "Shop and Go" paper explores an innovative approach to self-checkout by incorporating Deep Learning and Computer Vision.[5] Key issues highlighted include user privacy concerns, adoption rates, and overall user experience. The work encompasses overseeing the deployment of the "Shop and Go" autonomous shopping system. This includes integrating advanced security protocols and surveillance systems, addressing user privacy concerns, and optimizing the system's performance through high-performance computing and efficient algorithms. The goal is to ensure the system's accuracy, security, and user privacy while maintaining compatibility with existing retail infrastructure.[9] The "Just Walk-Out Technology and Its Challenges" paper focuses on Amazon Go's revolutionary cashier-less shopping experience. It addresses challenges related to customer education and trust, loss prevention, and the user experience learning curve. The work involves overseeing the deployment of Amazon Go's "Just Walk-Out" technology, ensuring sensor accuracy through advanced technologies like cameras and weight sensors. Additionally, robust data privacy and security measures are implemented, including secure data storage systems, encryption techniques, and access controls. The aim is to protect customer information from unauthorized access and data breaches while providing seamless and efficient cashier-less shopping. experience. In conclusion, these papers collectively underscore the multifaceted nature of self-checkout systems, emphasizing the importance of accuracy, security, user privacy, and seamless integration with existing retail infrastructure. The collaborative efforts and strategic deployment of advanced technologies are pivotal in realizing the full potential of self-checkout systems and reshaping the future of retail.[3][5]

Reference No. /Paper Title	Issues Found	Parameters / Tools Used	Work Description
Self-Checkout System Using RFID (Radio Frequency Identification) Technology: A Survey	Tag Accuracy and Interference, Cost of Implementation	Read Accuracy/ RFID Readers and Antennas Security Measures/ RFID Tags	Oversee the integration and optimization of RFID self-checkout systems, ensuring accuracy, security, anda user-friendly experience while managing costs and privacy compliance. Collaborate with teams for seamless implementation.
Shop and Go: An innovative approach towards shopping using Deep Learning and Computer	User Privacy Concerns, User Adoption and Experience	Security Measures/ Advanced security protocols and surveillance systems (e.g., CCTV) to prevent theft, and secure payment processing. Technological Optimization/ High-performance computing systems (e.g., GPUs, TPUs) and efficient algorithms for real-time processing (e.g., ApacheKafka).	Responsible for deploying the "Shop and Go" autonomous shopping system, overseeing the integration of Deep Learning and Computer Vision tools, optimizing accuracy, security, and user privacy, and ensuring seamless compatibility with existing retail infrastructure.

Just Walk-Out Technology and its Challenges: A case of Amazon Go	Customer Education and Trust, Loss Prevention, User Experience and Learning Curve	Sensor Accuracy/ Advanced sensor technologies, including cameras and weight sensors, for precise and reliable tracking of customer movements and product interactions. Data Privacy and Security Measures/ Secure data storage systems, encryption techniques, and access controls to protect customer information from unauthorized access or data breaches.	Oversee the deployment of Amazon Go's "Just Walk-Out" technology, managing integration, scalability, security, and user experience enhancements to ensurea seamless and efficient cashier-less shopping experience.

2.2 Limitation of Existing System

Existing self-checkout systems often face limitations such as scalability constraints, fixed hardware installations, and functional rigidity. These systems may struggle with accuracy issues during product scanning and may not efficiently handle high transaction volumes. Moreover, they often require significant upfront investments for hardware and lack flexibility in adapting to diverse store layouts. In contrast, the proposed project offers a modular and scalable architecture, leveraging IoT devices and cloud services to reduce hardware dependencies and enable seamless updates. Advanced machine learning algorithms enhance product scanning accuracy, while real-time analytics empower retailers with actionable insights for inventory management and personalized customer experiences. By addressing these limitations and offering enhanced functionality and efficiency, the project represents a significant advancement in self-checkout technology.

3. PROBLEM DEFINITION AND SCOPE

3.1 Need of Project

The project addresses the pressing need for modernizing traditional retail checkout processes to meet evolving consumer expectations and industry demands. With the rise of e-commerce and the demand for contactless experiences, traditional checkout systems are increasingly seen as outdated and inefficient. Consumers seek convenience, speed, and personalized interactions during their shopping journeys, which traditional checkout systems often struggle to deliver. By introducing a self-checkout smart store system, the project aims to bridge this gap by offering a seamless, efficient, and intuitive shopping experience that aligns with contemporary consumer preferences. Through automation, real-time data analytics, and integration with mobile applications, the project seeks to enhance operational efficiency, streamline checkout processes, and elevate the overall retail experience for both customers and retailers.

3.2 Problem statement

The traditional checkout processes are plagued by persistent challenges such as extensive queues, cashier errors, and a lack of efficiency. These issues not only contribute to customer dissatisfaction but also result in increased operational costs for businesses. To address these pressing concerns, the project aims to develop a revolutionary Self-Checkout Store System that leverages cutting-edge technologies, including computer vision, machine learning, and a Digital Payment System.

3.3 Objectives of Project

The project is designed to tackle prevalent challenges experienced by both customers and retailers, including issues such as extended queues, cashier errors, and inefficient inventory management. Its primary goal is to offer customers a seamless and efficient checkout process. The outlined project objectives aim to achieve several key outcomes. Firstly, retailers stand to benefit from a reduction in labor costs, a critical factor in optimizing operational expenses. Secondly, the project seeks to minimize checkout waiting time, recognizing the impatience of modern consumers and their avoidance of stores with prolonged queues. Lastly, by addressing common pain points in the retail experience, the project aims to enhance overall customer satisfaction, contributing to a positive brand image and fostering customer loyalty. Collectively, these objectives align with the overarching goal of creating a more efficient and satisfying shopping experience for both customers and retailers alike.

- **Labor Cost Reduction:**

  Streamline the checkout process to reduce reliance on human cashiers, leading to a significant reduction in labor costs for the retailer.

- **Minimization of Checkout Waiting Time:**

  Implement a self-checkout system that ensures swift processing of transactions, minimizing customer waittimes and addressing the impatience associated with prolonged queues.

- **Error Reduction in Checkout Process:**

  Eliminate cashier errors through the implementation of automated systems, enhancing transaction accuracy and reducing the likelihood of billing discrepancies.

- **Efficient Inventory Management:**

  Integrate the self-checkout system with the inventory management system to ensure real-time tracking ofproduct quantities, reducing instances of stockouts and overstock situations.

- **Enhanced Customer Satisfaction:**

  Focus on improving the overall customer experience by providing a seamless and efficient checkout process, leading to increased satisfaction among shoppers.

- **Adaptability and Scalability:**

  Design the self-checkout system to be adaptable to evolving retail needs and scalable to accommodate future growth, technological advancements, and additional features. By addressing these objectives, the project aims to create a win-win situation for both customers and retailers, fostering a more efficient andsatisfying shopping experience.

3.4 Scope of Project

Project offers an intuitive and user-friendly interface for customers to scan and purchase items without the need for traditional checkout counters. The application integrates with a cloud-based backend to manage product inventory, pricing, anduser transactions. It is not a replacement for the entire retail store management system but rather supplementary. Solution focused on enhancing the checkout experience. It does not include features for inventory management, employee management, or advanced analytics typically found in comprehensive retail management systems.

The application will allow users to scan product barcodes using their smartphones cameras to add items to their virtual shopping carts. It will provide real-time pricing information and enable secure online payment options forseamless transactions. The app will generate digital receipts and store transaction history for user’s reference. It will offer features for user authentication and account management to ensure security andpersonalization.

It won't handle physical inventory management tasks such as stock tracking, ordering, or replenishment. The application won't support cash transactions or in-store pickup options. It won't include complex analytical features for sales forecasting or business intelligence.

The application will contain a user-friendly interface with features for product scanning, cart management, and secure payment processing. It will include integration with external APIs or services for product information retrieval and payment processing. The app will store user profiles, transaction history, and preferences securely on the cloud backend.

The application won't contain features for offline shopping or manual entry of product information. It won't include integration with external hardware devices such as barcode scanners or POS terminals. The app won't store sensitive payment information locally but will rely on secure tokenizationmethods for online transactions.

3.5 Major Constraints

- **Technical Limitations:**

  The project may face technical constraints related to mobile device compatibility, camera quality, andnetwork connectivity. Ensuring smooth operation across various Android devices with different specifications and screen sizes poses a challenge.

- **Security Concerns:**

  Implementing robust security measures to protect user data, including personal information and payment details, is crucial. Adhering to industry standards for data encryption, authentication, and authorization while handling sensitive information is imperative to prevent data breaches.

- **Integration Challenges:**

  Integrating the Android application with external APIs, payment gateways, and backend systems requires meticulous planning and coordination. Compatibility issues, API versioning, and changes inthird-party services may pose integration challenges.

- **User Adoption and Acceptance:**

Convincing users to adopt a new self-checkout system may be challenging, especially if they are accustomed to traditional checkout processes. Providing adequate user training, clear instructions, and addressing usability concerns are essential for user acceptance.

- **Regulatory Compliance:**

Compliance with relevant regulations and standards, such as data protection laws, payment card industry standards, and consumer protection regulations, adds complexity to the project. Ensuring adherence to legal requirements and obtaining necessary certifications is vital.

3.6. Expected Outcomes

- **Efficient Self-Checkout Process:**

The Android application will streamline the checkout process by enabling users to scan and pay forproducts using their smartphones, reducing waiting times and enhancing convenience.

- **Real-time Product Identification:**

The application will accurately identify scanned products using image recognition technology, providing users with detailed product information, including name, price, and description.

- **Automatic Price Calculation:**

Upon scanning products, the application will automatically calculate the total bill based on the scanned items, quantities, and prices, eliminating the need for manual calculations, and reducingerrors.

- **Secure Payment Transactions:**

Users will be able to securely complete payment transactions within the application using integratedpayment gateways, ensuring the confidentiality and integrity of financial data.

- **Digital Receipt Generation:**

Upon successful payment, the application will generate digital receipts for users, providing proof ofpurchase and facilitating returns or exchanges if necessary.

3.7. Applications of the Project

- **Enhanced Retail Experience:**

Revolutionize the retail experience by offering customers the convenience of self-checkout, reducingwaiting times, and empowering them to complete transactions independently.

- **Efficient Convenience Stores:**

Transform small-scale convenience stores into efficient operations by implementing self-checkout systems, catering to customers seeking quick purchases without the hassle of traditional checkout queues.

- **Empowering** Small Businesses:

Empower small businesses, including boutique stores and specialty shops, with self-checkout technology to optimize operations, reduce staffing needs, and provide exceptional customer service.

4. PROPOSED SYSTEM

4.1 Tools and Technologies used.

ESP32 CAM Module:
The ESP32-CAM module plays a crucial role in the self-checkout smart store system project, primarily as a component of the product recognition and scanning system. Here's how it contributes:

- Image Capture: The ESP32-CAM module is equipped with a camera that captures images of products placed on the checkout counter. These images are then processed by the system to identify the products and their details.
- Product Recognition: Using image processing and machine learning algorithms, the ESP32-CAM module helps in recognizing the products based on their visual features. This recognition enables the system to identify the items being purchased by the customers.
- Data Transmission: Once the products are identified or their barcodes are scanned, the ESP32-CAM module communicates this information to the central system or backend server. This enables real- time updating of the shopping cart and facilitates seamless transaction processing.

Arduino UNO:

- Hardware Interface: The Arduino Uno acts as a bridge between various sensors and actuators deployed in the physical store environment and the central system. It facilitates communication between different components such as RFID readers, weight sensors, and display units.
- Real-time Data Processing: Arduino Uno processes sensor data in real-time and communicates relevant information to the central system. It helps in updating the shopping cart, managing inventorylevels, and generating alerts for staff members.
- IoT Integration: Arduino Uno can be integrated into the IoT ecosystem of the smart store system, enabling seamless communication with other IoT devices and sensors. It contributes to creating a connected and intelligent store environment.

Android Studio:

- User Interface Development: Android Studio is used to develop the mobile application interface thatcustomers interact with during their shopping experience. It includes screens for product browsing, adding items to the cart, and completing the checkout process.
- QR code Scanning: Android Studio integrates barcode scanning functionality into the mobile application, allowing customers to scan product barcodes using their smartphone cameras. It utilizes APIs such as Firebase Vision to process barcode information and retrieve product details.

- User Authentication: Android Studio facilitates user authentication and login features within the mobile application. It ensures secure access to user accounts, personalized shopping experiences, andorder history tracking.

4.2 Methodology.

Data Collection and Preparation:

- Collect a dataset of product images along with their corresponding labels and attributes such as name,price, and size/capacity.
- Clean and preprocess the dataset to remove any inconsistencies, duplicates, or irrelevant information.
- Augment the dataset to increase its diversity and improve the robustness of the machine learningmodel.

Model Building and Training:

- Choose a suitable deep learning architecture for object detection and recognition, such as YOLO.
- Split the dataset into training, validation, and test sets for model evaluation.
- Fine-tune a pre-trained convolutional neural network (CNN) on the dataset using transfer learning toadapt the model to recognize specific product categories and attributes.
- Train the model using appropriate loss functions and optimization algorithms, adjustinghyperparameters as needed to optimize performance.

Model Evaluation and Validation:

- Evaluate the trained model on the validation set to assess its accuracy, precision, recall, and otherperformance metrics.
- Validate the model's ability to correctly identify and classify products, including differentiatingbetween similar items and handling variations in lighting, orientation, and background.
- Fine-tune the model based on validation results, iteratively improving its performance untilsatisfactory accuracy is achieved.

Deployment of Model to Edge Device (ESP32-CAM):

- Convert the trained machine learning model to a format compatible with the ESP32-CAM microcontroller, such as TensorFlow Lite or TensorFlow.js.
- Deploy the model to the ESP32-CAM board, optimizing its memory and computational requirements to ensure efficient inference on the edge device.
- Implement real-time object detection and recognition algorithms on the ESP32-CAM to enable on-device processing of product images captured by the camera module.

Development of Mobile Application (Android Studio):

- Design the user interface (UI) of the mobile application using Android Studio, incorporatingfeatures for barcode scanning, image capture, and user authentication.
- Integrate Firebase ML Kit or custom machine learning APIs to enable real-time barcode detectionand product recognition in the mobile app.
- Implement functionalities for displaying product information, including name, price, and size/capacity, retrieved from the edge device or backend server.
- Develop features for online payment processing, order management, and user feedback to facilitateseamless self-checkout and enhance the overall shopping experience.

5. SYSTEM REQUIREMENT SPECIFICATION

5.1. Hardware and Software Requirement

5.1.1. Hardware Requirement

Sr. No.	Parameter	Minimum Requirement	Justification
1	ESP32 CAM Module	4 GB	To capture the image of products placed in the shopping cart.
2	Arduino UNO	32KB FLASH, 1KB EEPROM	To fetch the data provided by ESP32 CAM using Arduino. IDE.

5.1.2 Software Requirement

1. Operating System: Android Mobile.
2. Programming Language: Python, Java.
3. IDE: Android Studio.

5.2 Functional Requirement

- **Product Scanning:**

  Users should be able to scan product barcodes or QR codes using the mobile application.
- **Product Recognition:**

  The system must recognize scanned products and retrieve their information from the database.
- **Price Retrieval:**

  Upon product recognition, the system should fetch the corresponding price information from thedatabase or an external API.
- **Transaction Management:**

Users should be able to add scanned products to their virtual cart and proceed to checkout.

- **Payment Integration:**

The system must support secure online payment methods for completing transactions.

5.3 Non-Functional Requirement

- **Performance:**

The system should have low latency and respond quickly to user actions, such as scanningproducts or completing transactions.

- **Security:**

The application must implement robust security measures to protect user data, including encryption of sensitive information and secure payment processing.

- **Reliability:**

The system should be highly reliable and available, with minimal downtime or service interruptions.

- **Compatibility:**

The application should be compatible with a wide range of mobile devices and operating systemsto maximize accessibility for users.

5.4. Data Dictionary

- **User:**

Attributes: User ID, Username, Email, Password, Address, Phone Number, Payment Information

- **Product:**

Attributes: Product ID, Name, Description, QR Code, Price, Category, Quantity in Stock, ImageURL

- **Transaction:**

Attributes: Transaction ID, User ID, Timestamp, Total Amount, Payment Method, Status

6. SYSTEM DESIGN

6.1 Use Case Diagram

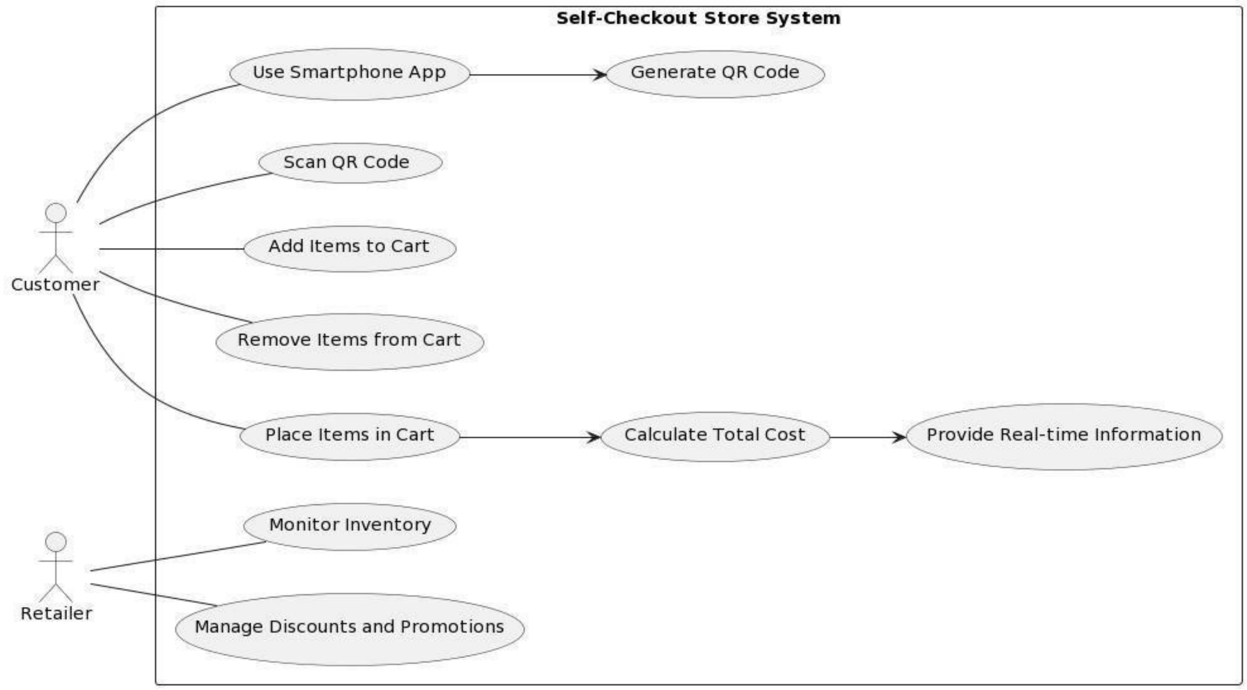


Fig. 6.1. Use-case Diagram.

In this diagram:

Actors:

1. Customer (C): Interacts with the system using the smartphone app, scans QR codes, adds/removes items from the cart, and checks out.
2. Retailer (R): Monitors inventory, manages discounts, and promotions.

Use Cases:

1. Check-In: Represents the process of the customer checking into the store using the smartphone app and scanning the QR code.
2. Shopping: Involves the customer adding or removing items from the shopping cart.
3. Checkout: Encompasses the process of placing items in the cart, calculating the totalcost, and providing real-time information.

Relationships:

1. Customers interact with the system during the Check-In, Shopping, and Checkout processes.
2. The Retailer interacts with the system to monitor inventory.

6.2 State Diagram

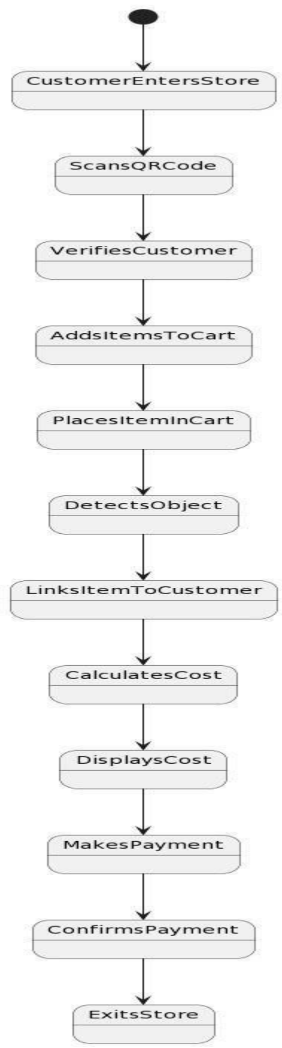


Fig. 6.2. State Diagram

In this state diagram:

- The system starts in the Check-in state.
- The Check-in state transitions to the Idle state when the customer initially checks in.
- From the Idle state, the system can transition to the Shopping state when the customer scans the QRcode.
- In the Shopping state, the customer can add or remove items from the cart, and when ready, transition to the Checkout state to complete the purchase.
- In the Checkout state, the system calculates the total cost and provides real-time information. Thecustomer can continue shopping or go back to the Idle state by scanning the QR code.

6.3 Sequence Diagram

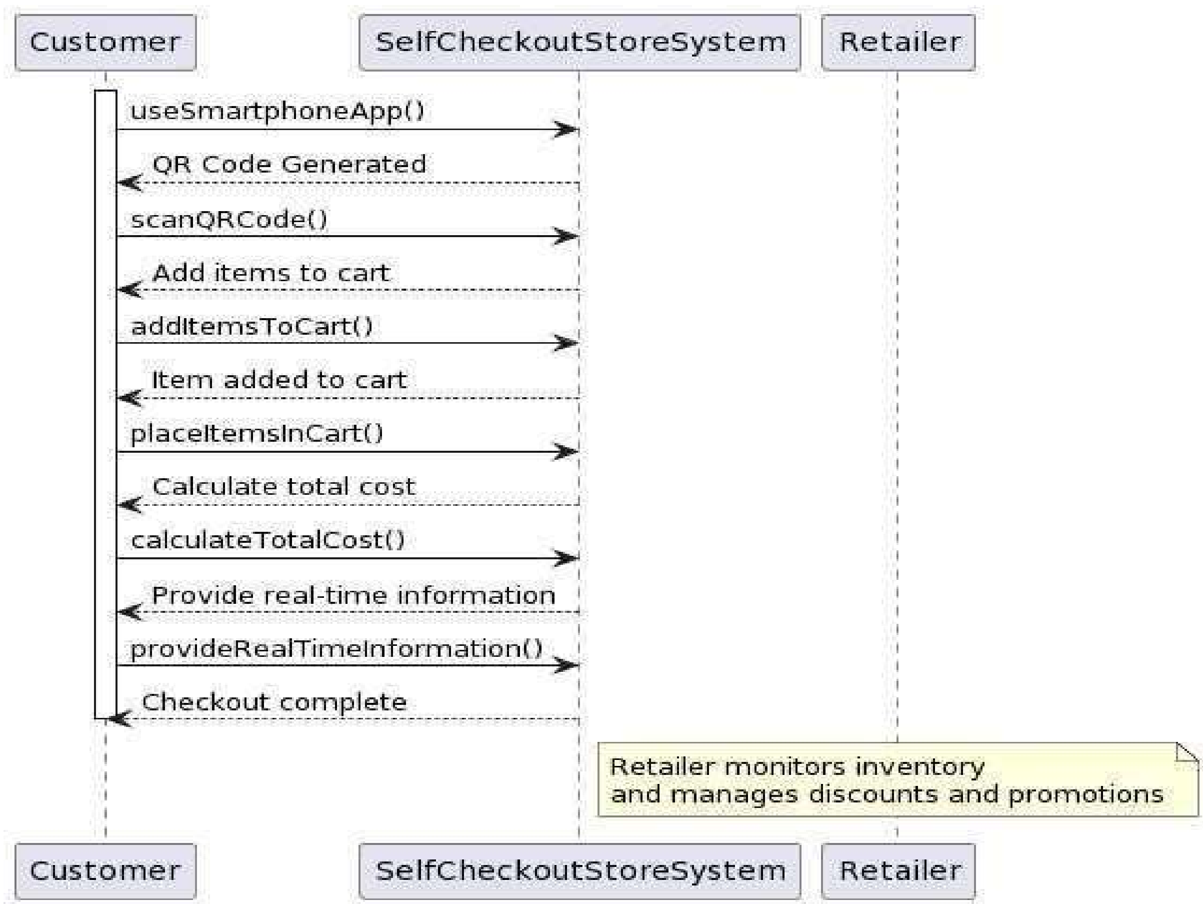


Fig. 6.3. Sequence Diagram

In this sequence diagram:

- Customer, Self-Checkout Store System, and Retailer are the participants.
- Activation bars represent the lifetimes of the objects during interactions.
- Arrows represent the flow of messages between objects.

6.4. System Architecture

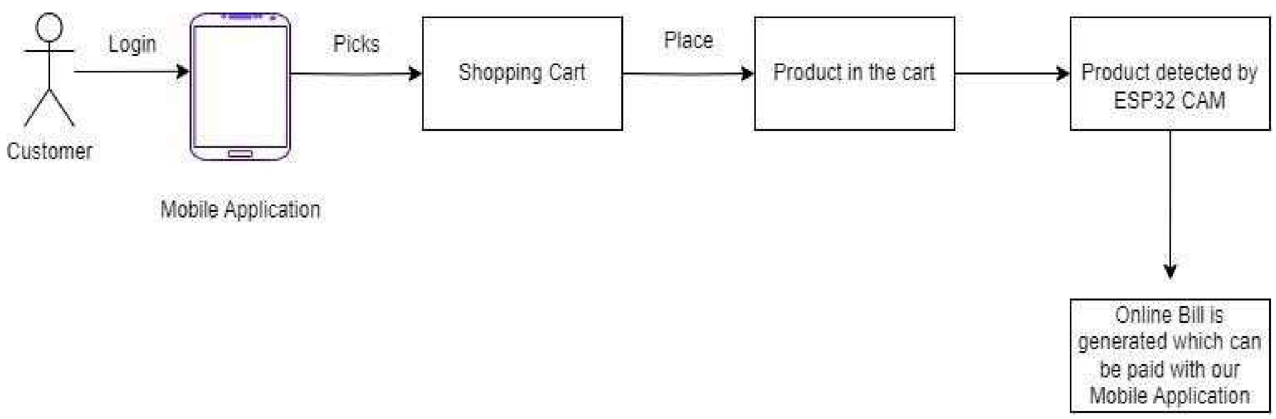


Fig. 6.4. System Architecture

The self-checkout system features a streamlined workflow encompassing customer identification, item tracking, and convenient payment processes. The system architecture begins with customers scanning a QR code on the cart, linking it to their account. This initial step establishes a unique identifier for the cart, ensuring a personalized shopping experience. Subsequently, as customers add items to their physical cart,the system mirrors this in real-time by updating their virtual cart, creating a seamless connection between the physical and virtual shopping experiences.

To enhance security and personalize transactions, customers are required to scan their cart's QR code, linking it to their account. This linkage ensures that the system accurately associates the selected items with the corresponding customer account. This approach not only simplifies the checkout process but also allows for personalized recommendations or promotions based on the customer's purchase history.

The culmination of the shopping journey involves the automatic generation of a bill, reflecting the items in both the physical and virtual charts. The generated bill is then presented to the customer, who can conveniently pay through a mobile application. This payment method leverages the integration of a secureand user-friendly mobile payment system, ensuring a smooth and efficient transaction experience. Overall, the system architecture integrates seamlessly, providing customers with a technologically advanced, personalized, and efficient self-checkout experience.

6.5. Class Diagram

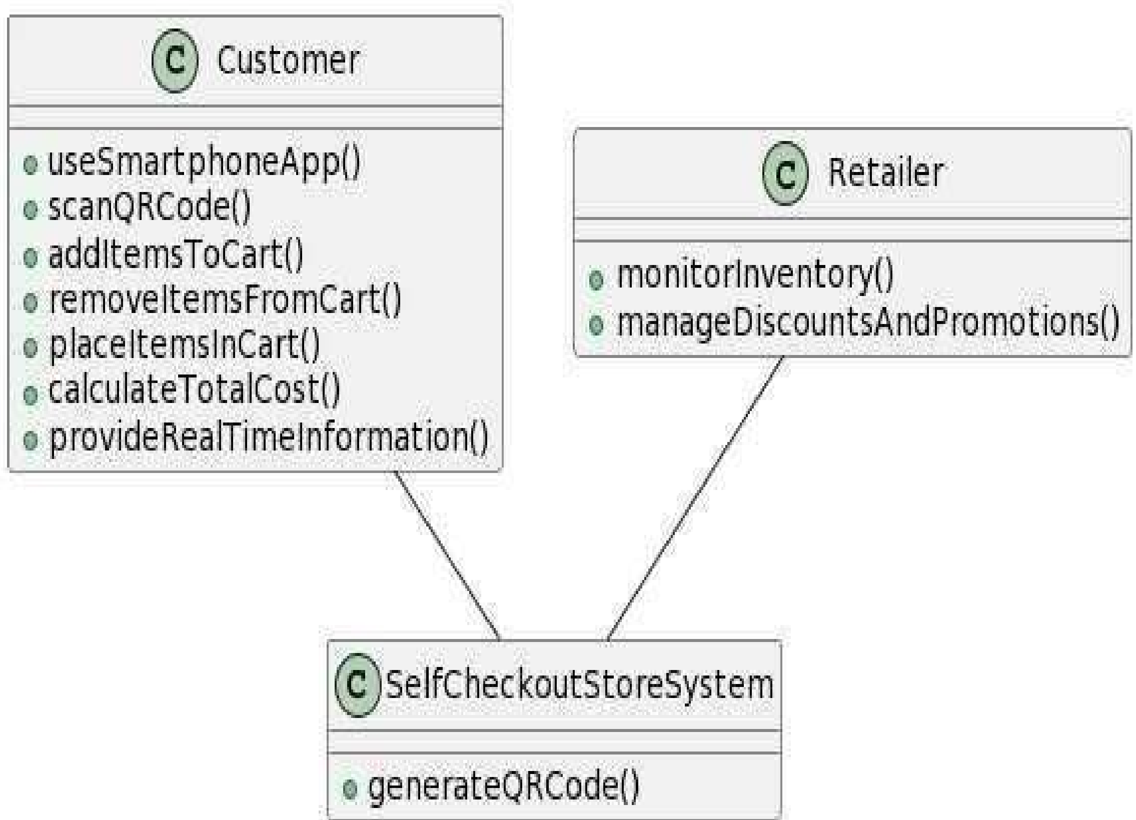


Fig. 6.5. Class Diagram

In this class diagram:

- Customer has methods representing actions such as using the smartphone app, scanning a QR code, adding/removing/placing items in the cart, calculating the total cost, and providing real-time information.
- Retailers have methods for monitoring inventory and managing discounts and promotions.
- Self-Checkout Store System is a class that generates QR codes and is associated with both Customer and Retailer

7. FEASIBILLITY STUDY

7.1 Introduction to Feasibility Study

The feasibility study for the proposed project addressing challenges in the retail sector, such as long queues, cashier errors, and inventory management inefficiencies, is a critical examination of the project's viability and potential success. This study aims to assess the practicality and feasibility of implementing the outlined objectives. As the retail landscape evolves, with customer expectations and technological capabilities advancing, it becomes imperative for retailers to adapt and enhance their operations. This feasibility study will delve into the anticipated benefits, including the reduction of labor costs, streamlined checkout processes, and improved customer satisfaction. By analyzing the economic, technical, and operational aspects, this study seeks to provide a comprehensive understanding of the project's viability, laying the foundation for informed decision-making by stakeholders involved in the retail sector.

7.2. Economic Feasibility

The economic feasibility analysis of the proposed retail enhancement project is integral to assessing its viability and financial impact. By calculating the cost-benefit ratio, determining the return on investment, and scrutinizing operational cost reductions, this analysis aims to provide a comprehensive overview of the project's economic viability. Additionally, it explores opportunities for market expansion, considering potential increases in customer traffic and sales volume resulting from improved customer satisfaction and streamlined operations. The assessment will also delve into the upfront costs of implementing new technologies and training programs, with a sensitivity analysis addressing variables that could influence financial outcomes. In essence, this economic feasibility study is crucial for stakeholders, offering insights that guide decision-making and ensure the project aligns with financial objectives and market realities.

7.3.Technical Feasibility

The technical feasibility analysis for the proposed retail enhancement project is pivotal in determining the project's compatibility with existing systems and its ability to leverage advanced technologies effectively. The assessment begins by scrutinizing the compatibility of proposed systems with the current technological infrastructure of the retail environment, ensuring a seamless integration process that avoids disruptions. Scalability considerations are paramount, evaluating the capacity of the proposed solutions to handle potential future growth and increased transaction volumes. Equally critical is the examination of data security and privacy measures to ensure compliance with regulations and safeguard customer information.

Additionally, the analysis delves into the training requirements for staff to proficiently operate and manage the new systems, emphasizing the need for comprehensive training programs to facilitate a smooth transition. Reliability and maintenance protocols are established to address any technical issues promptly, ensuring minimal downtime and continuous operations. Interoperability, a key factor, is examined to confirm that various systems, including point-of-sale and inventory management, can seamlessly communicate and share data for a cohesive retail operation. In essence, the technical feasibility analysis focuses on practical implementation, aiming to harmonize technology with the existing retail environment and contribute to the seamless execution of the proposed enhancements.

7.4.Behavioral Feasibility

The behavioral feasibility analysis for the proposed retail enhancement project is vital for understanding how the project aligns with the behaviors, attitudes, and acceptance levels of individuals involved, including both customers and staff. This assessment aims to ensure a smooth adoption of changes and a positive reception within the retail environment. It involves evaluating user acceptance among customers and staff, developing effective change management strategies to address resistance, assessing the impact on the overall customer experience, considering employee morale, and establishing feedback mechanisms to continuously refine the project based on real-time insights. The goal is to foster a positive and harmonious integration of the proposed.

changes, promoting a supportive environment for both customers and staff.

7.5.Time Feasibility

The time feasibility analysis for the proposed retail enhancement project is crucial for determining the practicality of implementing transformative changes within a defined timeframe. A well-structured implementation schedule, delineating key milestones and timelines for each project phase, is essential. This schedule considers potential dependencies and critical paths, ensuring an organized and efficient rollout that adheres to realistic timeframes.

Moreover, the analysis assesses the time required for the seamless integration of new technologies into existing systems. This includes factors such as thorough testing, comprehensive training, and potential adjustments to ensure a smooth transition without compromising operational efficiency or causing prolonged downtime.

Additionally, the evaluation extends to understanding the adoption period for users, encompassing both customers and staff, to fully embrace and adapt to the proposed changes. Incorporating robust change management strategies facilitates a gradual and effective transition, acknowledging that behavioral shifts require time and support. To maintain agility and responsiveness, the analysis emphasizes the importance of iterative feedback cycles. These cycles enable continuous refinement of the project based on real-time insights, ensuring that any unforeseen challenges or necessary adjustments are addressed promptly. In essence, the time feasibility analysis aims to strike a balance between ambitious goals and pragmatic timelines, promoting a successful and timely implementation of the retail enhancement project.

7.6.Resource Feasibility

The resource feasibility analysis for the proposed retail enhancement project is crucial to assess the availability and adequacy of resources required for successful implementation. This evaluation encompasses various resources, including financial, human, and technological elements, ensuring that the project aligns with the organization's capabilities.

Financial feasibility is a key consideration, examining the budgetary allocation needed for technology implementation, staff training, and any potential unforeseen costs. This analysis aims. to ensure that the project's financial requirements are realistic and align with the organization's budget constraints. Human resources play a vital role, and the analysis assesses the availability ofskilled personnel required for implementing and managing the new technologies. It also considersthe potential need for additional staff training to bridge any skill gaps.

Technological resources are scrutinized to determine if the existing infrastructure can support the proposed enhancements. This includes evaluating the compatibility of current systems with advanced technologies and assessing the need for any upgrades or integrations.

8. EXPERIMENTATION AND RESULT

8.1.Data Collection

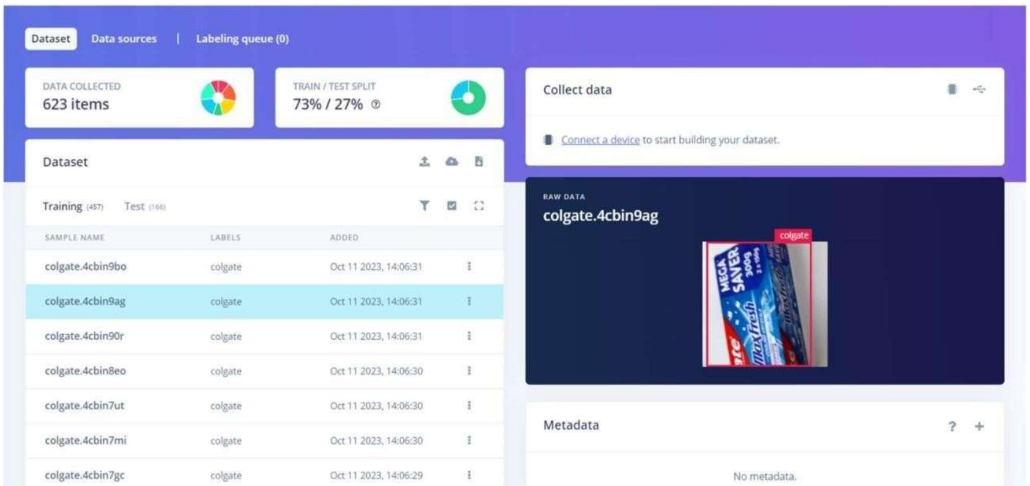


Fig 8.1.1. Data Collection

The Smart Store System utilizes image recognition technology to capture and catalog images of goods within supermarkets, facilitating a seamless self-checkout experience by automatically identifying and associating products with their corresponding prices. This innovative system enhances efficiency and accuracy in the checkout process.

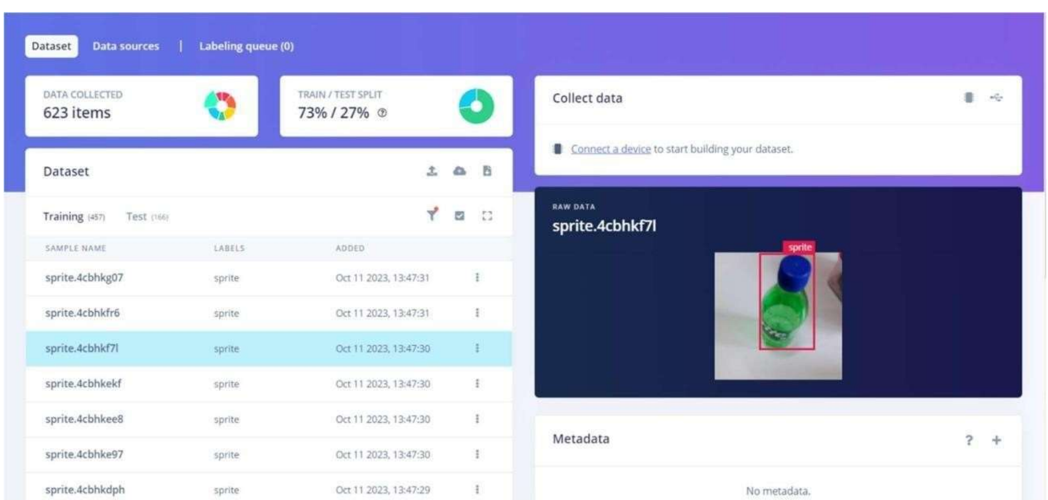


Fig 8.1.2. Data Collection

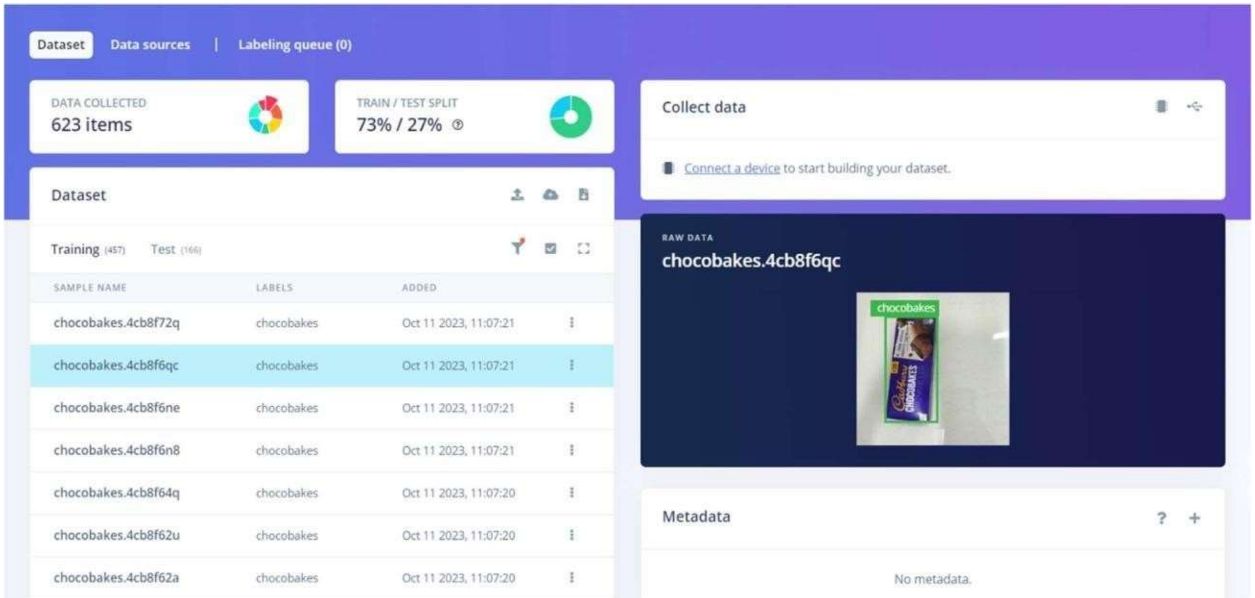


Fig 8.1.3. Data Collection

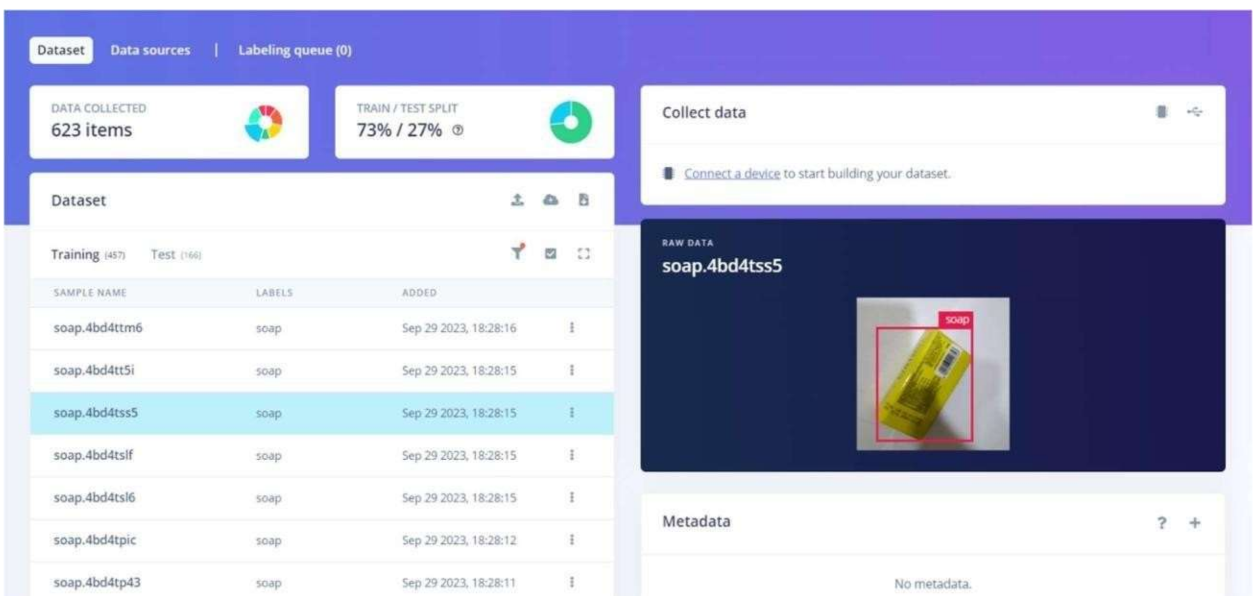


Fig 8.1.4. Data Collection

8.2.Feature Explorer

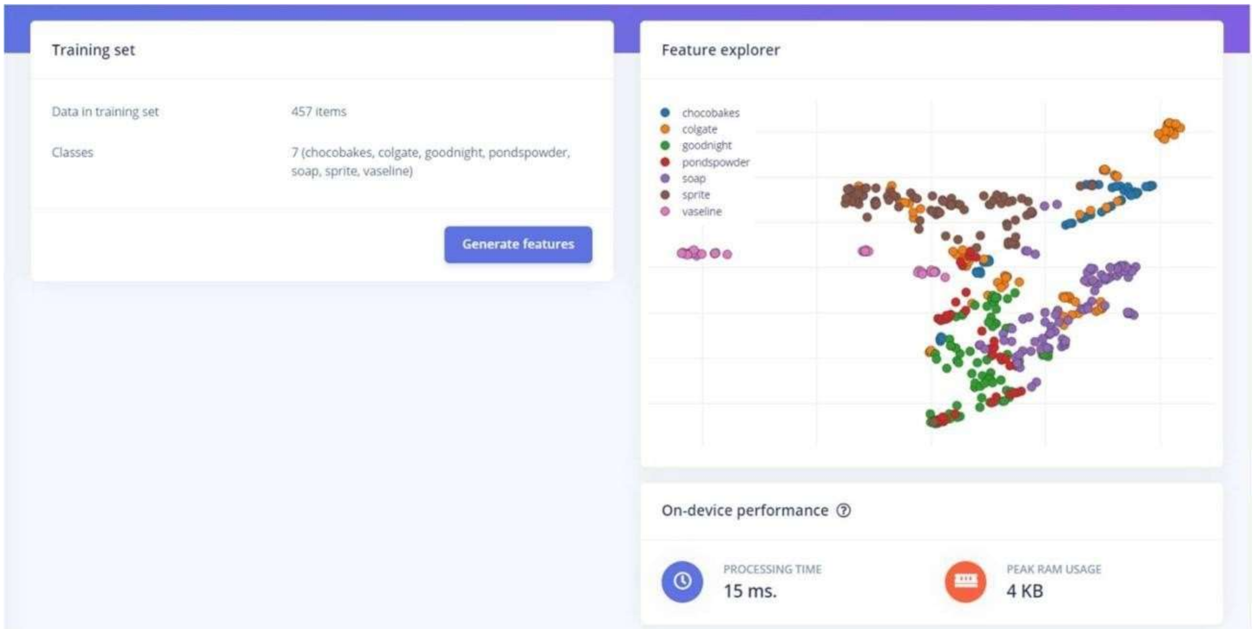


Fig. 8.2. Feature Explorer

Feature explorer is a tool or platform that allows users to interactively explore and analyze the features (columns or attributes) of a dataset. A feature explorer for data aims to make the process of exploring and understanding dataset features more interactive, intuitive, and informative. It should empower users to gain insights into the dataset's characteristics and relationships, supporting data-driven decision-making.

8.3.ML Model and Predictions

8.3.1.ML Model

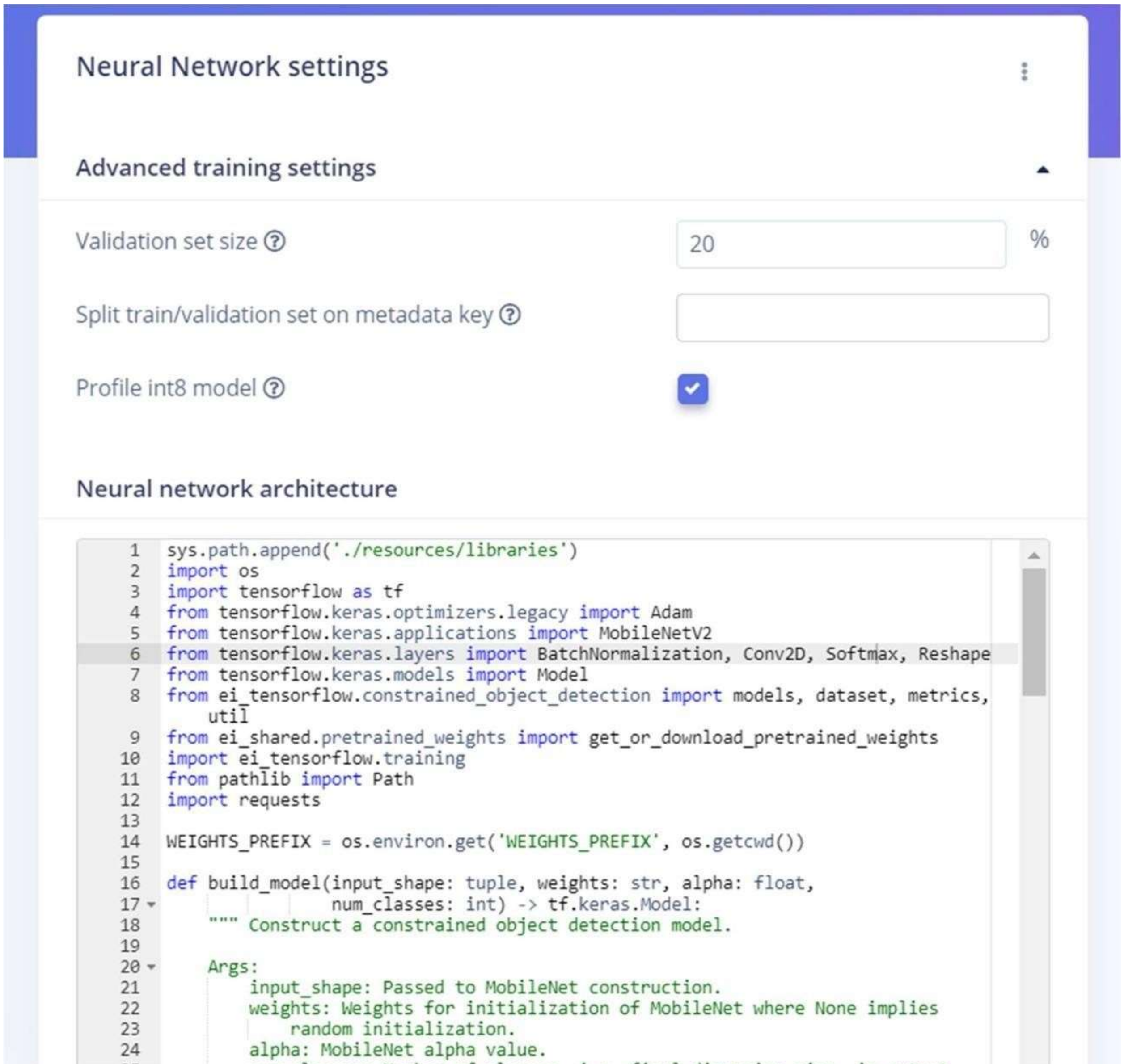


Fig 8.3.1. ML Model

ML model Program

```
sys.path.append('./resources/libraries')
import os
import tensorflow as tf
from tensorflow.keras.optimizers.legacy import Adam
from tensorflow.keras.applications import MobileNetV2
from tensorflow.keras.layers import BatchNormalization, Conv2D, Softmax,
Reshape
from tensorflow.keras.models import Model
from ei_tensorflow.constrained_object_detection import models, dataset, metrics,
util
from ei_shared.pretrained_weights import get_or_download_pretrained_weights
import ei_tensorflow.training
from pathlib import Path
import requests

WEIGHTS_PREFIX = os.environ.get('WEIGHTS_PREFIX', os.getcwd())

def build_model(input_shape: tuple, weights: str, alpha: float,
                num_classes: int) -> tf.keras.Model:
  """ Construct a constrained object detection model.

    Args:
      input_shape: Passed to MobileNet construction.
      weights: Weights for initialization of MobileNet where None implies
        random initialization.
      alpha: MobileNet alpha value.
      num_classes: Number of classes, i.e. final dimension size, in output.

    Returns:
      Uncompiled keras model.

    Model takes (B, H, W, C) input and
    returns (B, H//8, W//8, num_classes) logits.
    """

    #! First create full mobile_net_V2 from (HW, HW, C) input
    #! to (HW/8, HW/8, C) output
    mobile_net_v2 = MobileNetV2(input_shape=input_shape,
```

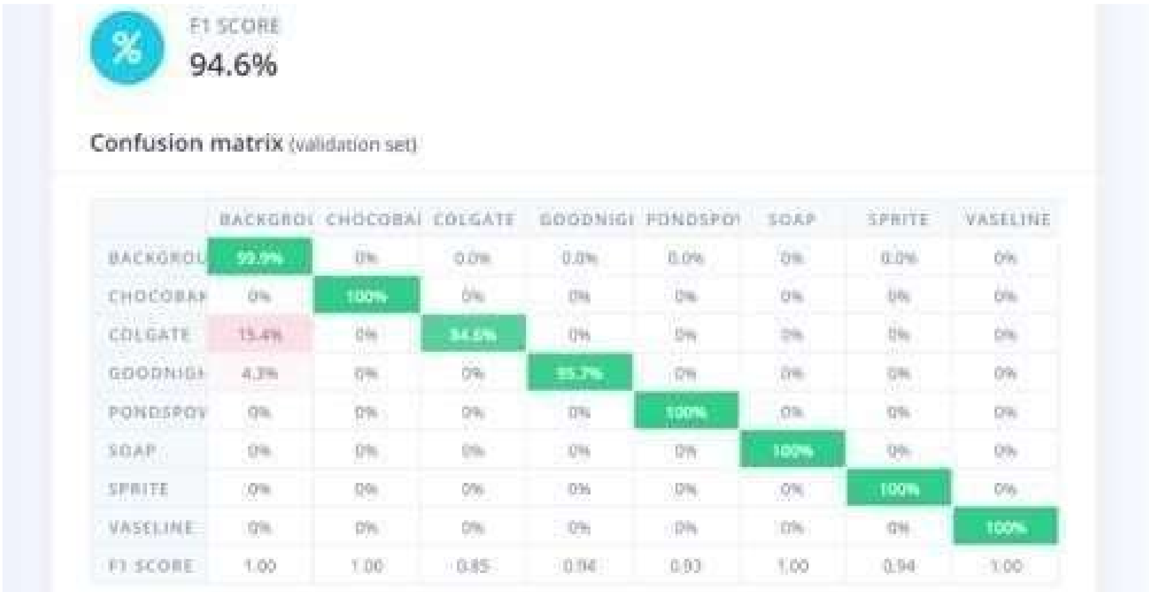
```
                    weights=weights,
                    alpha=alpha,
                    include_top=True)
    #! Default batch norm is configured for huge networks, let's speed it up
    for layer in mobile_net_v2.layers:
        if type(layer) == BatchNormalization:
            layer.momentum = 0.9
    #! Cut MobileNet where it hits 1/8th input resolution; i.e. (HW/8, HW/8, C)
    cut_point = mobile_net_v2.get_layer('block_6_expand_relu')
    #! Now attach a small additional head on the MobileNet
    model = Conv2D(filters=32, kernel_size=1, strides=1,
                activation='relu', name='head')(cut_point.output)
    logits = Conv2D(filters=num_classes, kernel_size=1, strides=1,
                activation=None, name='logits')(model)
    return Model(inputs=mobile_net_v2.input, outputs=logits)

def train(num_classes: int, learning_rate: float, num_epochs: int,
          alpha: float, object_weight: float,
          train_dataset: tf.data.Dataset,
          validation_dataset: tf.data.Dataset,
          best_model_path: str,
          input_shape: tuple,
          batch_size: int,
          lr_finder: bool = False,
          ensure_determinism: bool = False) -> tf.keras.Model:

    nonlocal callbacks

    num_classes_with_background = num_classes + 1

    input_width_height = None
    width, height, input_num_channels = input_shape
    if width != height:
        raise Exception(f"Only square inputs are supported; not {input_shape}")
    input_width_height = width

    #! Use pretrained weights, if we have them for configured
    allowed_combinations = [{'num_channels': 1, 'alpha': 0.1},
                            {'num_channels': 1, 'alpha': 0.35},
                            {'num_channels': 3, 'alpha': 0.1},
                            {'num_channels': 3, 'alpha': 0.35}]
    weights = get_or_download_pretrained_weights(WEIGHTS_PREFIX,
input_num_channels, alpha, allowed_combinations)
```

```
    model = build_model(
        input_shape=input_shape,
        weights=weights,
        alpha=alpha,
        num_classes=num_classes_with_background
    )

    #! Derive output size from model
    model_output_shape = model.layers[-1].output.shape
    _batch, width, height, num_classes = model_output_shape
    if width != height:
        raise Exception(f"Only square outputs are supported; not
{model_output_shape}")
    output_width_height = width

    #! Build weighted cross entropy loss specific to this model size
    weighted_xent = models.construct_weighted_xent_fn(model.output.shape,
object_weight)

    prefetch_policy = 1 if ensure_determinism else
tf.data.experimental.AUTOTUNE

    #! Transform bounding box labels into segmentation maps
    def as_segmentation(ds, shuffle):
        ds = ds.map(dataset.bbox_to_segmentation(output_width_height,
num_classes_with_background))
        if not ensure_determinism and shuffle:
            ds = ds.shuffle(buffer_size=batch_size*4)
        ds = ds.batch(batch_size, drop_remainder=False).prefetch(prefetch_policy)
        return ds

    train_segmentation_dataset = as_segmentation(train_dataset, True)
    validation_segmentation_dataset = as_segmentation(validation_dataset, False)

    validation_dataset_for_callback = (validation_dataset
        .batch(batch_size, drop_remainder=False)
        .prefetch(prefetch_policy))

    #! Initialise bias of final classifier based on training data prior.
    util.set_classifier_biases_from_dataset(
        model, train_segmentation_dataset)
```

```
    if lr_finder:
        learning_rate = ei_tensorflow.lr_finder.find_lr(model,
train_segmentation_dataset, weighted_xent)
    model.compile(loss=weighted_xent,
                  optimizer=Adam(learning_rate=learning_rate))

    #! Create callback that will do centroid scoring on end of epoch against
    #! validation data. Include a callback to show % progress in slow cases.
    callbacks = callbacks if callbacks else []
    callbacks.append(metrics.CentroidScoring(validation_dataset_for_callback,
                                             output_width_height, num_classes_with_background))
    callbacks.append(metrics.PrintPercentageTrained(num_epochs))

    #! Include a callback for model checkpointing based on the best validation f1.
    callbacks.append(
        tf.keras.callbacks.ModelCheckpoint(best_model_path,
            monitor='val_f1', save_best_only=True, mode='max',
            save_weights_only=True, verbose=0))

    model.fit(train_segmentation_dataset,
              validation_data=validation_segmentation_dataset,
              epochs=num_epochs, callbacks=callbacks, verbose=0)

    #! Restore best weights.
    model.load_weights(best_model_path)

    #! Add explicit softmax layer before export.
    softmax_layer = Softmax()(model.layers[-1].output)
    model = Model(model.input, softmax_layer)

    return model


EPOCHS = args.epochs or 60
LEARNING_RATE = args.learning_rate or 0.001
BATCH_SIZE = args.batch_size or 32

model = train(num_classes=classes,
              learning_rate=LEARNING_RATE,
              num_epochs=EPOCHS,
              alpha=0.1,
              object_weight=100,
              train_dataset=train_dataset,
```

```
        validation_dataset=validation_dataset,
        best_model_path=BEST_MODEL_PATH,
        input_shape=MODEL_INPUT_SHAPE,
        batch_size=BATCH_SIZE,
        lr_finder=False,
        ensure_determinism=ensure_determinism)



override_mode = 'segmentation'
disable_per_channel_quantization = False
```

8.3.2.Model Predictions



F1 SCORE

94.6%

Confusion matrix (validation set)

	BACKGROU	CHOCOBAI	COLGATE	GOODNIGI	PONDSPO'	SOAP	SPRITE	VASELINE
BACKGROU	99.9%	0%	0.0%	0.0%	0.0%	0%	0.0%	0%
CHOCOBA	0%	100%	0%	0%	0%	0%	0%	0%
COLGATE	15.4%	0%	84.6%	0%	0%	0%	0%	0%
GOODNIGI	4.3%	0%	0%	95.7%	0%	0%	0%	0%
PONDSPOV	0%	0%	0%	0%	100%	0%	0%	0%
SOAP	0%	0%	0%	0%	0%	100%	0%	0%
SPRITE	0%	0%	0%	0%	0%	0%	100%	0%
VASELINE	0%	0%	0%	0%	0%	0%	0%	100%
F1 SCORE	1.00	1.00	0.85	0.94	0.93	1.00	0.94	1.00

Fig 8.3.2. ML Model Predictions

Evaluating the F1 score, along with precision and recall, provides a comprehensive understanding of the model's performance, especially in scenarios where class imbalances exist. Adjusting the model and parameters based on these metrics helps in achieving a balance between correctly identifying positive instances and minimizing false positives.

8.4. Model Testing

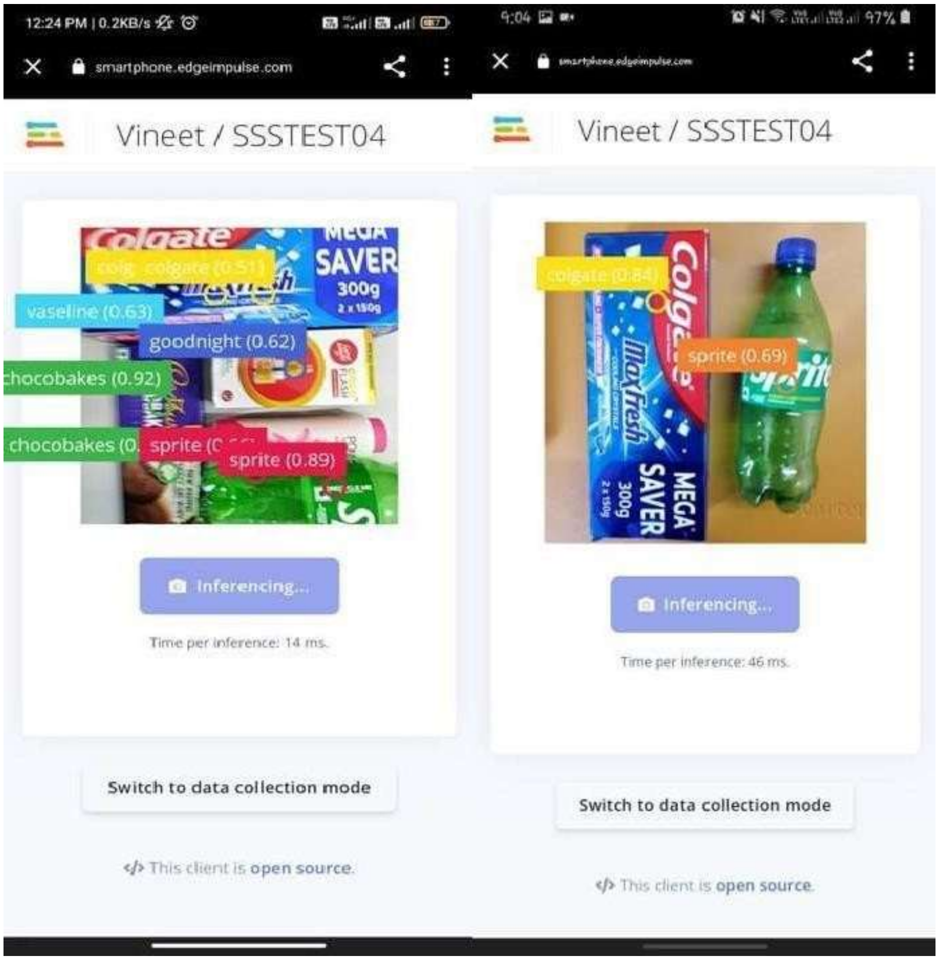


Fig. 8.4. Model Testing

Testing a model and evaluating its performance on a separate dataset is crucial for assessing its generalization capabilities. It helps identify potential issues, such as overfitting or underfitting, and guides improvements to enhance model effectiveness in real-world scenarios.

8.5.Object Detection

Fig. 8.5.1. Object Detection

Fig. 8.5.2. Object Detection

Object detection in a self-checkout smart store system enhances the user experience by automating the identification of items in the shopping cart. The choice of the object detection model should align with the requirements of real-time processing, accuracy, and the specific characteristics of items in your store.

8.6.Android Application

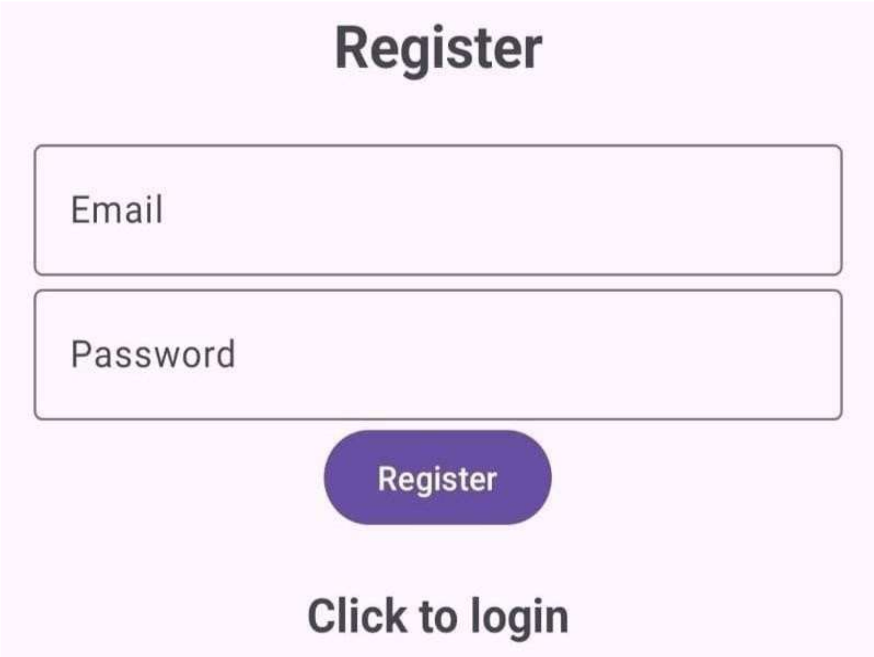


Fig 8.6.1. Registration page for new user

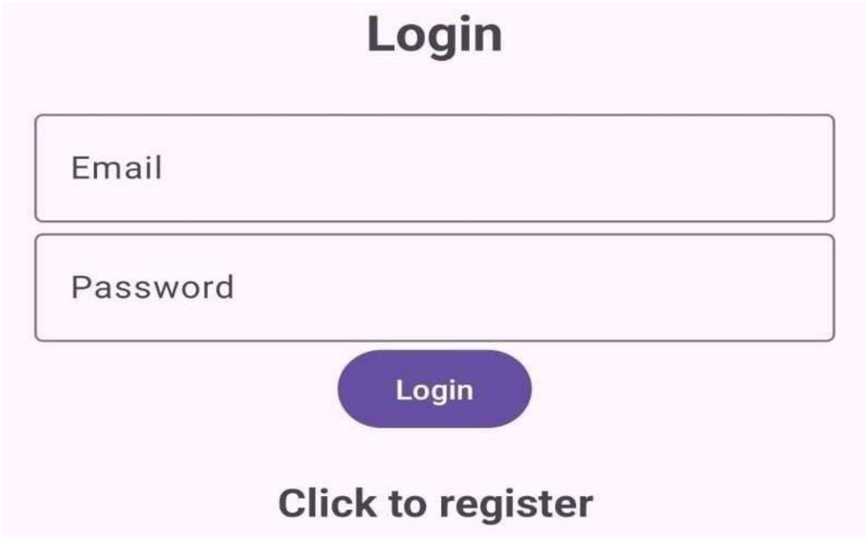


Fig 8.6.2. Login Page for the user

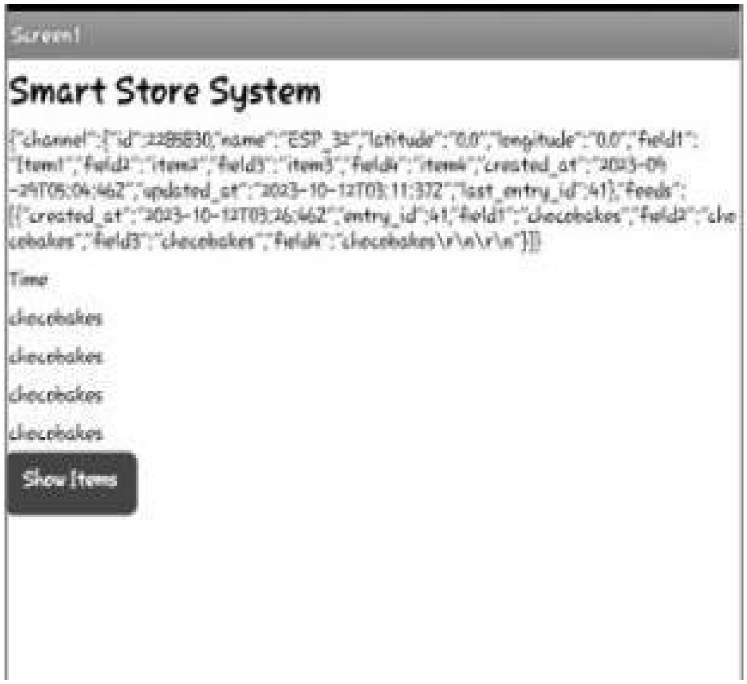


Fig 8.6.3. Home Page

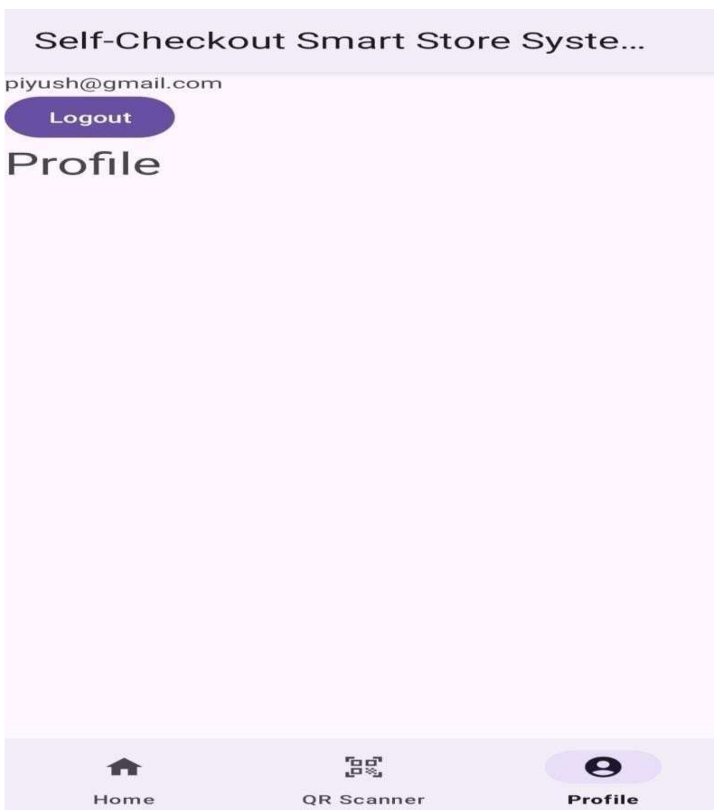


Fig 8.6.4. Profile Page

The front-end interface of a self-checkout smart shop system is provided by this Android app. It offers clients interacting with the smart store ecosystem an easy-to-use experience. Below is a summary of its salient attributes:

- User authentication is made possible by the app, which guarantees safe access to customized features and information. Users may be easily authenticated by using Firebase Authentication.

- Home Screen Navigation: Users are welcomed with an easy-to-navigate home screen upon login. Simple choices to browse products, use the QR code scanner, and manage user profiles are presented on this screen.

- QR Code Scanner: Users may quickly and easily scan product barcodes with this dedicated function. The program accurately reads and detects barcodes by using Firebase ML Vision technology. This makes it possible to quickly identify products, which improves the entirepurchasing experience.

- Management of Profiles: Users can effectively manage their accounts via the profile screen. It offers choices for viewing order history, updating personal data, and making necessary configuration adjustments.

By fusing these functions, the Android app simplifies the self-checkout procedure and gives users aneasy-to-use, safe interface for browsing, scanning, and making purchases.

9. CONCLUSION

Self-checkout smart stores revolutionize the shopping experience by providing enhanced convenience through quick payments and eliminating long queues, saving customers valuable time, and reducing frustration. The user-friendly interface contributes to improved customer satisfaction by minimizing checkout bottlenecks and reducing human errors. Additionally, the integration of advanced security measures, including surveillance cameras, leads to a reduction in theft and fraud, enhancing store profitability. In response to the growing demand for contactless experiences, these smart stores offer a safer shopping option by minimizing physical interactions during the checkout process. Overall, the adoption of self-checkout technology brings about a more seamless, efficient, and secure retail environment, meeting the evolving preferences of modern consumers.

1.Enhanced Convenience: Self-checkout smart stores provide shoppers with a more seamless and efficient shopping experience. Customers can quickly make payments, and exit the store without waiting in long queues, saving valuable time, and reducing frustration.

2.Improved Customer Satisfaction: With fewer checkout bottlenecks and a user-friendly interface, customers experience higher satisfaction levels when shopping at smart stores. The reduction in human error during the checkout process also contributes to a more positive shopping experience.

3.Reduced Theft and Fraud: The integration of advanced security measures, such as surveillance cameras, helps minimize theft and fraud instances, improving store profitability and loss prevention efforts.

4.Contactless Shopping: In growing demand for contactless experiences, self-checkout smart stores offer a safer shopping option, minimizing physical interactions.

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Appendix A : Project Plagiarism Report

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Appendix B : Research Paper

Self-Checkout Smart Store System

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***Abstract*—Indian retail industry has emerged as one of the most dynamic and fast-paced industries It accounts for over 10% of the country's gross domestic product (GDP) and around 8% of the employment, grocery shopping habits are changing due to technological advancements. However, the online grocery market is still in its early stages, with only 0.15% of Indians buying groceries online. The offline retail market has some limitations including long queues and cashier errors, the model offers customers a seamless, efficient shopping experience while enabling retailers to reduce labour costs. To overcome this, we came up with the self-checkout smart store system this represents a transformative approach to retail, leveraging advanced tech- neologies like computer vision, machine learning, and a Digital Payment System to streamline the checkout process. This system will be utilizing a machine learning model and TensorFlow an open-source machine learning library, MobileNetV2 a pre-trained deep neural network architecture for object identification. For this purpose, we created a dataset that consists of product images consisting of 4500 images that will be used for model train- ing. Motivated by the desire to revolutionize retail, the project fills a research gap by integrating comprehensive technological solutions. The prototype implementation in a real-world retail setting demonstrates the feasibility and potential of this forward- thinking self-checkout smart store system, positioning it as a catalyst for the future of retail shopping.**

***Index Terms*—Machine learning, Computer vision, Digital payment system, MobileNetV2, TensorFlow, Neural network.**

INTRODUCTION

In today's fast-paced world, customers waiting in line is a big problem for businesses. A whopping 75% of customersleave if they wait too long, and 74% would rather go to a competitor for faster service. This waiting game costs businesses £12 billion each year! To break it down, £6.4billion goes to other stores because frustrated customers decide to shop somewhere else. The remaining £5.6 billion is lostbecause people leave the store before they even buy anything. Long queues at billing counters are due to limited billing counter availability during peak times, inefficient staffing with inexperienced personnel, and complex payment procedures.

Thus, the question is raised: what would happen if we could use cutting-edge technology to tackle this problem and assist businesses make more money? Already some solutions are available which have challenges like limited scalability in

larger retail environments, high initial costs that act as a barrierfor smaller businesses, and complex user interfaces that may confuse customers. Accuracy in product recognition and the lack of personalized customer

assistance can impact the overallefficiency of these systems.

To overcome these lacunae we developed a solution, the Self-Checkout Smart Store System. This approach aims to rev-olutionize the traditional shopping experience by eliminating the frustrations associated with waiting in line.

The self-checkout store system revolutionizes the shopping experience through advanced technology, automation, and a seamless checkout process. Utilizing computer vision, sensor technology, machine learning, and a Digital Payment System, customers can check in via a smartphone app, detect items within the shopping cart via camera attached in cart, and automatically calculate real-time costs.

To validate the efficacy of our self-checkout system, we conducted rigorous testing using a carefully curated dataset. This dataset comprises 18 different products, each representedby 250 images, totaling 4500 pictures. These diverse product images ensure that our system is well-trained to handle a va- riety of items, providing a robust and comprehensive solution for real-world retail scenarios.

The machine learning model achieved an accuracy of 94.6 percent, indicating that it correctly predicted outcomes for 94.6percent of the cases evaluated. This high accuracy suggests the model's effectiveness in making accurate predictions based onthe given dataset.

The existing systems using various sensors like- pressure sensor, weight measurement sensor, RFIDs, Distance & Dimension measurement that will track what/when items are being picked up or kept back on the shelf and various cameras. Instead of this we are attaching a QR code and esp32 cam to the shopping cart- by scanning the QR code the shopping cart will be linked to the customer's virtual card and esp32 cam will help in detecting the products which are placed in the cart and it will automatically be added to his/her virtual cart by our underlined ML Model. And at the time of exit customer just have to scan the QR which will be generated once he/she pay the bill amount.

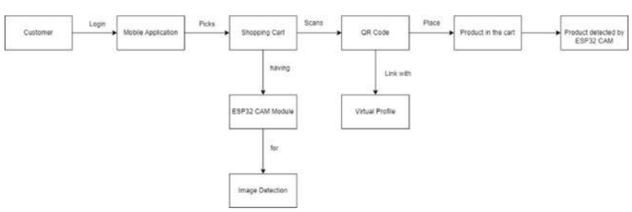
I. LITERATURE REVIEW

The implementation and optimization of self-checkout sys- tems have become pivotal in the modern retail landscape, offering convenience and efficiency to both retailers and consumers. This discussion focuses on three significant pa- pers exploring various aspects of self-checkout technologies, namely "Self-Checkout System

Using RFID (Radio Frequency Identification) Technology: A Survey," "Shop and Go: An Innovative Approach Towards Shopping Using Deep Learn- ing and Computer Vision," and "Just Walk-Out Technology and Its Challenges: A Case of Amazon Go. "The Self-Checkout System Using RFID Technology" paper delves into the challenges and parameters associated with implementing RFID technology in self-checkout systems.[7][10] It addressesissues such as tag accuracy, interference, and the overall cost of implementation. The work primarily revolves around over- seeing the integration and optimization of RFID self-checkout systems. This involves ensuring the accuracy of RFID readers and antennas, managing the cost of implementation, and im- plementing robust security measures to safeguard user privacythrough RFID tags. Collaborative efforts with cross-functionalteams play a crucial role in achieving seamless integration, accuracy, and user-friendly experiences. The "Shop and Go" paper explores an innovative approach to self-checkout by incorporating Deep Learning and Computer Vision.[5] Key is-sues highlighted include user privacy concerns, adoption rates, and overall user experience. The work encompasses overseeingthe deployment of the "Shop and go" autonomous shopping system. This includes integrating advanced security proto- cols and surveillance systems, addressing user privacy con- cerns, and optimizing the system's performance through high-performance computing and efficient algorithms. The goal is toensure the system's accuracy, security, and user privacy while maintaining compatibility with existing retail infrastructure.[9]The "Just Walk-Out Technology and Its Challenges" paper focuses on Amazon Go's revolutionary cashier-less shopping experience. It addresses challenges related to customer ed- ucation and trust, loss prevention, and the user experience learning curve. The work involves overseeing the deployment of Amazon Go's "Just Walk-Out" technology, ensuring sensor accuracy through advanced technologies like cameras and weight sensors. Additionally, robust data privacy and security measures are implemented, including secure data storage sys- tems, encryption techniques, and access controls. The aim is to protect customer information from unauthorized access and data breaches while providing a seamless and efficient cashier- less shopping Self-Checkout Smart Store System Page—6 ex-perience. In conclusion, these papers collectively underscore the multifaceted nature of self-checkout systems, emphasizing the importance of accuracy, security, user privacy, and seamless integration with existing retail infrastructure. The collaborative efforts and strategic deployment of advanced technologies are pivotal in realizing the full potential of self- checkout systems and reshaping the future of retail.[3][5]

Some sensors we are using for this

1) ESP32 CAM: The ESP32 camera in a Self-Checkout Smart System can be employed for object recognition, enabling accurate tracking of items in the cart, user authentication through facial



recognition, and real-time monitoring for security and assistance, enhancing overallefficiency and user experience.

Fig. 4. ESP32 CAM (Camera Module for Object Detection)

2) Arduino UNO: The Arduino Uno plays a pivotal rolein several key functions. Firstly, it facilitates seamless sensor integration to detect and track items in the shop- ping cart, ensuring accurate and efficient self-checkout processes. The Arduino Uno also serves as the brain behind the user interface, allowing customers to interact with the system through buttons or a touchscreen, en- abling smooth item scanning and payment procedures. Additionally, the Arduino Uno contributes to transaction processing, interfacing with a Digital Payment System to ensure secure and reliable financial transactions during the self-checkout experience. Furthermore, the versatil- ity of Arduino Uno extends to RFID integration, provid- ing enhanced item identification and tracking capabili- ties, ultimately streamlining the entire checkout process for improved efficiency and customer satisfaction.

Fig. 5. Arduino UNO

II. ARCHITECTURE AND METHODOLOGY

The self-checkout smart store system comprises three inter-connected modules.

A. Architecture

1) ***Customer Interaction Module****:* The system architecture begins with customers scanning a QR code on the cart, linkingit to their account. This initial step establishes a unique identifier for the cart, ensuring a personalized shopping experience. Subsequently, as customers add items to their physical cart, the system mirrors this in real-time by updating their virtual cart, creating a seamless connection between the physical andvirtual shopping experiences.

Fig. 1. Architecture of Customer Interaction Module

2) ***ML Model Module*** *:* The ML Module trained on a dataset of 4500 images featuring 18 different products, it excels in recognizing items. Using this learned knowledge, the module efficiently identifies products as they are placed in the shopping cart, enhancing the system's ability to track purchases accurately.

Fig. 2. Architecture of ML model module

3) ***Real-Time Transaction Handling*** : The culmination of the shopping journey involves the automatic generation of a bill, reflecting the items in both the physical and virtual charts. The generated bill is then presented to the customer, who can conveniently pay through a mobile application. This payment method leverages the integration of a secure and user-friendly mobile payment system, ensuring a smooth and efficient transaction experience.

B. Methodology

1) ***Customer Interaction Module***:

- User Authentication: Customers initiate the self-checkout process by logging into their profiles using the dedicated

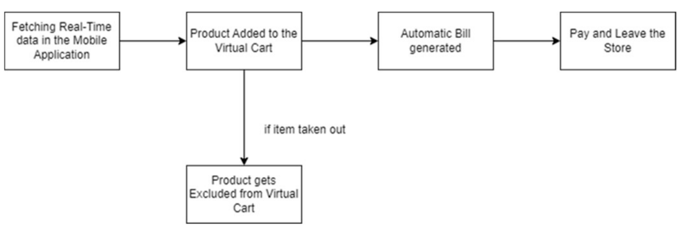


Fig. 3. Architecture of Real-time Transaction Handling

mobile application. This step ensures a personalized and secure shopping experience.

- QR Code Scanning: The physical shopping cart is equipped with an ESP32 CAM. Customers scan a QR code on the cart to establish a connection between their virtual cart and the physical cart, enhancing the accuracy of the shopping transaction.
- Real-Time Product Detection: The ESP32 CAM contin- uously detects and updates the virtual cart in real-time as customers add or remove items, providing an accurate representation of the shopping experience.

2) ***ML Model Module***:

- Dataset Creation: We created a dataset by capturing 250 images for each of the 18 distinct products, resulting in a comprehensive dataset of 4500 images.
- Data Preprocessing: The collected images undergo pre- processing to extract relevant features, enhancing the model's ability to identify and recognize products effec- tively.
- Image Resizing: The collected images are resized to ensure a consistent input size for the machine learning model, facilitating uniform feature extraction.
- Grey Scaling: Converting images to grayscale simplifies the data, reducing computational complexity and aiding the model in focusing on essential features rather than colour variations.
- Normalization: Normalizing pixel values to a standard scale enhances model convergence during training, pre- venting certain features from dominating the learning process.
- Augmentation Techniques: To diversify the dataset, aug- mentation techniques such as rotation, flipping, or zoom- ing may be applied. This helps the model generalize better to variations in product placement.
- Feature Generation: After data preprocessing, relevant features are generated from the curated dataset. These features serve as distinctive characteristics that the ma- chine learning model can use to identify and differentiate between the various products.
- Model Training: The pre-processed data is used to train the machine learning model, teaching it to accuratelyidentify products placed in the shopping cart.
- Model Testing: Rigorous testing is conducted to validate the model's accuracy and reliability, ensuring its effec- tiveness in real-world scenarios.
- Real-Time Prediction: Once trained and tested, the modelis integrated into the overall self-checkout system. Inreal-time, as customers place items in the shopping cart equipped with the ESP32 CAM, the model applies its learned patterns to predict the identity of each product.

3) ***Real-Time Transaction Handling*** :

- Continuous Data Updates: The mobile application is con- tinuously updated with real-time data, reflecting changes in the virtual cart as customers add or remove items.

Automatic Billing: The system automates the generation

- of bills, considering the contents of both the physical and virtual carts, streamlining the checkout process.
- Integrated Payment Process: A user-friendly payment process is integrated into the mobile application, allowing customers to conveniently and securely complete trans- actions before leaving the store.

4) Flowchart :

Algorithm: Self-Checkout Smart Store System
Input:
• Customer needs to feed their details in our Mobile Application. • Place all products in shopping cart which is attached to the ESP32 CAM.
Output:
• After a consumer completes their profile on the mobile application, a QR code is created. • An online Bill is generated. • After a customer pays their bill, a QR code is created, which they may scan to exit the store.
Procedure:
• User Login to our Mobile Application. • scans the shopping carts QR code attached to the shopping cart, which connects to the user's virtual cart. • When a consumer places a product to their cart, the ESP32 CAM will immediately identify it and add it to their virtual cart. • Lastly Bill is generated, which may be paid with our Mobile Application. • A QR code is generated which is used to Exit the store.
End Algorithm

IV. Results

Fig 6. Feature Explorer

Our Model achieved 94.6% F1 Score for the given set of data provided. The F1 score is a metric commonly used in binary classification problems, but it can also be extended to multi-class classification. It combines precision and recall into a single metric and is particularly useful when the class distribution is imbalanced.

Fig 7. Testing

This is the Testing for object detection via our Mobile phone camera. Here we placed all the products in-front of our mobile phone and the ML Model able to detect all the products.

Fig 8. Mobile Application

This is the Mobile Application where customers can see all the products which are added to their Virtual cart by ESP32 CAM Module and can pay through mobile application and leave the store.

V. Conclusion

Self-checkout smart stores revolutionize the shopping ex- perience by providing enhanced convenience through quick payments and eliminating long queues, saving customers valuable time, and reducing frustration. The user-friendly interface contributes to improved customer satisfaction by minimizing checkout bottlenecks and reducing human errors. Additionally, the integration of advanced security measures, including surveillance cameras, leads to a reduction in theft and fraud, enhancing store profitability. In response to the growing demand for contactless experiences, these smart stores offer a safer shopping option by minimizing physical interactions during the checkout process. Overall, the adoption of self-checkout technology brings about a more seamless, efficient, and secure retail environment, meeting the evolving preferences of modern consumers.

- Enhanced Convenience: Self-checkout smart stores pro- vide shoppers with a more seamless and efficient shop- ping experience. Customers can quickly make payments, and exit the store without waiting in long queues, saving valuable time, and reducing frustration.
- Improved Customer Satisfaction: With fewer checkout bottlenecks and a user-friendly interface, customers expe- rience higher satisfaction levels when shopping at smart stores. The reduction in human error during the checkout process also contributes to a more positive shopping experience.
- Reduced Theft and Fraud: The integration of advanced security measures, such as surveillance cameras, helps minimize theft and fraud instances, improving store prof- itability and loss prevention efforts.
- Contactless Shopping: In growing demand for contact- less experiences, self-checkout smart stores offer a safer shopping option, minimizing physical interactions.

VI. References

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