

# SUPERSCAN CHECKOUT SYSTEM

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**Abstract :** This research presents an automated checkout system using machine learning and computer vision to enhance retail efficiency. By leveraging the YOLO model for real-time product detection, the system processes images instead of barcodes, accurately identifying products and retrieving prices from a database. This eliminates long queues, reduces errors, and ensures seamless transactions. The model distinguishes between similar packaging variants, ensuring precise billing. Designed for scalability, the system enhances checkout speed, improves customer experience, and modernizes retail operations. Additionally, it minimizes manual effort, reduces hardware dependency, and can be integrated into various retail environments for a cost-effective and future-ready checkout solution.

**Index Terms:** Automated Checkout, Computer Vision, Image-Based Product Recognition, Machine Learning, YOLO.

## I. INTRODUCTION

The retail industry is rapidly evolving, driven by the need for more efficient, accurate, and customer-friendly solutions to enhance shopping experiences. Traditional checkout systems primarily rely on barcode scanning, which introduces several inefficiencies, such as long queues, scanning errors, dependency on physical barcodes, and increased operational costs. These limitations lead to slower transaction times, customer dissatisfaction, and a greater reliance on manual labor. To address these challenges, this research presents an advanced automated checkout system that leverages machine learning, deep learning, and image processing for real-time product recognition. Instead of relying on barcodes, the system captures images of products at checkout and utilizes the YOLO (You Only Look Once) object detection model to accurately detect, classify, and differentiate items, even when they have similar packaging. By integrating a pre-built product database, the system retrieves item details and pricing, instantly calculating the total bill and streamlining the entire checkout process. This innovative approach significantly reduces checkout time, eliminates the need for barcode scanning, and minimizes human intervention, making it highly adaptable for supermarkets, grocery stores, and self-checkout kiosks. The model is trained on a diverse dataset to improve detection accuracy, even in challenging conditions such as occlusions, lighting variations, and different product orientations. Furthermore, the proposed system enhances scalability by integrating with existing point-of-sale (POS) systems, ensuring widespread applicability and seamless adoption in various retail environments. By incorporating deep learning and computer vision, the automated checkout system not only reduces errors and transaction delays but also enhances operational efficiency and customer convenience. The solution aims to modernize retail operations by automating product identification, accelerating the billing process, eliminating long queues, and providing a contactless, hassle-free checkout experience. This research contributes to the growing field of AI-driven retail automation, offering a cutting-edge, cost-effective alternative to traditional barcode-based systems, ultimately transforming the future of retail transactions.

## II. REVIEW OF LITERATURE SURVEY

### 2.1. Literature Survey

A survey was done on the existing literature and products to find out their shortcomings and research gaps in their systems. This survey consisted of 15 literature papers where the most relevant ones are listed below.

The Study [1] introduces a novel approach for smart checkout systems, enabling the recognition of new product classes without relying on human-annotated data. The paper proposes a data augmentation method that generates pseudo labels, allowing datasets to expand automatically. This technique enhances the scalability of machine learning models, enabling them to generalize and recognize previously unseen products with high accuracy. By reducing dependency on manual labeling, the research significantly lowers operational costs and improves efficiency in retail environments. The study demonstrates the effectiveness of this approach in enhancing automated checkout systems, ensuring seamless adaptation to new inventory while maintaining accurate product recognition.

The Study [2] explores a novel approach to understanding and analyzing activities in dynamic environments. The proposed framework focuses on the segmentation of foreground objects, separating them from background elements to detect and track objects or people over time. By utilizing such data, the system captures both spatial and temporal information about object movements and interactions, allowing for a more detailed understanding of activity patterns. This method enhances the accuracy of counting and tracking in scenarios such as retail environments, surveillance, and crowd monitoring. The framework aims to improve event detection and object tracking by integrating object segmentation with semantic analysis, making it valuable for applications requiring precise activity understanding and monitoring over time.

Ghazaleh Sarbishaei and Farahnaz Jowshan [3] The Internet of Things (IoT) has rapidly expanded with the increasing use of communication technologies, enhancing various sectors such as smart homes, healthcare, and transportation. In smart homes, IoT enables remote control of devices like thermostats, lights, and security cameras, offering convenience and energy efficiency. However, security remains a concern as IoT devices communicate over potentially insecure channels. To address this, efficient authentication protocols are essential. This paper introduces a lightweight multi-factor authentication scheme for smart homes, featuring mutual authentication between users, devices, and gateways. Key contributions include a new classification for IoT authentication schemes, a secure protocol using PUF chips, and a comparative analysis showing superior performance. The proposed system enhances IoT security without compromising efficiency, offering a scalable solution for smart home applications.

The Study [4] introduces a cutting-edge self-checkout solution designed to enhance the retail shopping experience by integrating advanced technologies such as computer vision, machine learning, and user-friendly interfaces. The system aims to streamline the checkout process, reducing wait times and improving customer satisfaction. By employing sophisticated object recognition algorithms, the intelligent self-checkout system can accurately identify and process a wide variety of products, even those with similar packaging, minimizing errors during checkout. Additionally, the system leverages real-time data analytics to monitor shopping patterns and inventory levels, enabling retailers to optimize stock management and improve operational efficiency. The paper discusses the architecture and implementation of the system, highlighting its adaptability to various retail environments, from grocery stores to convenience shops. Through comprehensive testing, the research demonstrates significant improvements in transaction speed and accuracy, suggesting that such intelligent systems can transform the retail landscape by making the checkout experience seamless and more enjoyable for customers.

The Study [5] presents an innovative solution for automating the checkout process in retail environments through the use of RFID technology. The paper discusses the challenges associated with traditional checkout systems, such as long wait times and human errors, and proposes an RFID-based checkout system that enhances efficiency and accuracy. By embedding RFID tags in products, the system allows for quick and automatic identification of items as customers place them in their carts. This seamless tracking facilitates real-time inventory management and significantly reduces the need for manual scanning at checkout points. The research details the system's architecture, which integrates RFID readers, a centralized database, and a user-friendly interface, allowing customers to check out with minimal effort.

The Study [6] explores the development and implementation of an advanced checkout system utilizing Radio Frequency Identification (RFID) technology to enhance retail operations. The paper addresses the limitations of traditional checkout methods, such as lengthy wait times, labour-intensive processes, human errors, and inefficiencies in product scanning. By integrating RFID technology, the proposed system enables automatic identification, tracking, and seamless product recognition without requiring manual barcode scanning. This advancement significantly enhances the checkout experience by reducing processing times, improving accuracy, and minimizing reliance on human intervention. Furthermore, the study highlights the advantages of RFID in optimizing inventory management, preventing theft, and enabling real-time tracking of stock levels. The implementation of RFID-based checkout solutions not only improves operational efficiency for retailers but also enhances customer satisfaction by providing a faster, more reliable, and hassle-free shopping experience. The study also discusses potential challenges, such as cost implications and security concerns, while emphasizing the long-term benefits of adopting RFID technology in modern retail environments.

The Study [7] presents a novel framework that integrates text detection with computer vision algorithms to enable real-time product recognition and tracking in dynamic retail environments. By leveraging advanced text detection techniques, the system identifies product names, labels, and key details directly from packaging, enhancing traditional computer vision-based object recognition. This integration facilitates an augmented reality (AR) experience, where users can view additional product information, promotions, or customer reviews overlaid onto physical items through AR-enabled devices. The study evaluates the framework's effectiveness across various retail scenarios, analysing its accuracy, processing speed, and robustness in real-world conditions. Experimental results demonstrate the system's capability to recognize and track products with high precision, even in challenging conditions such as varying lighting, occlusions, or cluttered shelves. This approach enhances customer engagement, streamlines inventory management, and improves the overall shopping experience by bridging the gap between physical retail and digital interaction.

The Study [8] introduces an innovative neural network architecture specifically designed for grocery product recognition, eliminating the need for batch normalization. Traditional convolutional neural networks (CNNs) often rely on batch normalization to stabilize training and improve performance; however, this dependency can introduce computational inefficiencies and challenges, particularly in real-time applications. To address these limitations, the research proposes a feature flow neural network that prioritizes effective feature extraction and propagation, enabling efficient learning without the computational overhead associated with batch normalization. By optimizing feature representation and reducing reliance on normalization techniques, this approach enhances the model's adaptability to varying product images, lighting conditions, and occlusions commonly encountered in retail environments. The study further evaluates the proposed architecture against conventional CNNs, demonstrating its effectiveness in achieving high accuracy and efficiency for grocery product recognition. This advancement contributes to the development of more streamlined and scalable deep learning models for automated retail applications, particularly in checkout systems that require real-time processing.

The Study [9] presents a novel approach to product recognition by integrating Histogram of Oriented Gradients (HOG) features with Bag of Words model. This research addresses the challenges of accurately identifying products in diverse retail environments, where variations in lighting, angles, and packaging can hinder recognition efforts. The HOG feature extraction method is employed to capture essential shape and edge information from product images, providing a robust descriptor that enhances the algorithm's ability to distinguish between different items. The paper outlines the process of combining HOG features with the BOW model, which quantizes the feature space into discrete visual words, allowing for efficient representation and comparison of product images.

The Study [10] explores the use of Generative Adversarial Networks (GANs) as a powerful technique for augmenting datasets in the domain of grocery product image recognition. One of the primary challenges in training deep learning models for retail applications is the limited availability of labeled data, which can significantly impact the accuracy and reliability of product recognition systems. The study addresses this issue by leveraging GANs to generate high-quality synthetic images that closely resemble real product images, effectively expanding the dataset without the need for extensive manual labeling. By incorporating these synthetic images into the training process, the model can achieve better generalization, improving its ability to recognize products under varying conditions such as changes in lighting, occlusion, and packaging modifications. Furthermore, the study examines the impact of GAN-augmented datasets on model performance, comparing results with conventional data augmentation techniques. This research contributes to the development of more robust and scalable computer vision-based retail solutions, particularly in automated checkout systems, where accurate and efficient product recognition is crucial for seamless customer experiences.

The Study [11] presents an innovative approach to enhancing online shopping experiences by integrating mixed-reality technologies with advanced product identification methods. This research aims to overcome the limitations of traditional e-commerce platforms by enabling a more immersive and interactive shopping experience. The proposed system leverages computer vision techniques to accurately identify and recognize products in real-time, allowing consumers to visualize items in their own environment through augmented reality (AR). By bridging the gap between digital and physical shopping, this approach enhances consumer decision-making, reduces uncertainty in online purchases, and improves user engagement. The study evaluates the system's effectiveness in various shopping scenarios, demonstrating its potential to revolutionize e-commerce by providing a more intuitive and realistic product interaction.

The Study [12] explores an advanced approach to product recognition and labeling by implementing a multineural network architecture. This research addresses the challenges of accurately identifying and categorizing a wide range of products in retail environments, where variations in packaging, design, and lighting can complicate recognition tasks. The proposed model leverages the strengths of multiple neural networks, each trained on different subsets of product data, to improve overall recognition accuracy and robustness. The paper outlines the architecture of the multi-neural network system, detailing how each network specializes in identifying specific categories or features of products.

The Study [13] explores the use of YOLOv8 for enhancing product brand recognition in retail environments. It focuses on leveraging the inter-class similarities between different product brands to improve detection accuracy. By employing YOLOv8, a state-of-the-art object detection model, the paper demonstrates how the model can recognize and differentiate products based on visual features, even when brands share similar packaging. The research emphasizes the effectiveness of YOLOv8 in capturing subtle differences between brands, offering potential improvements for automated checkout systems and retail applications. The study highlights the model's ability to efficiently handle the complexities of real-world retail scenarios where product differentiation is challenging.

The Study [14] presents a self-checkout system tailored for fruit supermarkets, utilizing intelligent recognition technology to streamline the checkout process. The system employs advanced computer vision techniques to identify and classify various fruits based on their visual characteristics, such as shape, size, and color. By automating the identification process, the system reduces the need for manual input from customers and staff, improving the efficiency and accuracy of transactions. The research highlights the use of machine learning models to optimize product recognition and enhance the customer experience, offering a seamless and fast checkout solution. The paper suggests that this intelligent system can be particularly beneficial in fruit supermarkets, where product variety and labeling can be challenging.

The Study [15] focuses on leveraging self-supervised contrastive learning for developing an automatic retail checkout system that does not require labeled data for training. The proposed method aims to recognize and classify products in retail environments using a zero-shot learning approach, where the model is capable of identifying products it has never seen before without any human-annotated labels. The system employs contrastive learning, which helps the model learn representations by comparing positive and negative samples, enabling it to generalize to new items effectively. The research demonstrates how self-supervised learning can enhance the adaptability of retail checkout systems.

## 2.2 Analysis Table

**Table 1. Analysis Table**

Sr No	Year	Technology	Advantages	Disadvantages
[1]	(2024)	1.Foreground Object Segmentation  2.RetinaNet-based Frame Classification	1.Accurately understands and interprets spatiotemporal activities in dynamic environments.	1. Requires powerful hardware for real-time processing due to deep learning models.
[2]	(2024)	1.Computer Vision with YOLO Model  2.Machine Learning-Based Image Processing	1.Reduces waiting time by eliminating manual scanning and enabling automated identification.  2. Uses deep learning to differentiate between similar-looking fruits with high precision	1. Poor lighting or occlusion can affect detection accuracy, requiring optimized camera placement.  2. Certain fruits (e.g., apples of different varieties) may require additional classification techniques.

[3]	(2024)	1. Aquila Optimization Algorithm 2. Deep Learning-Based Image Classification	1. The Aquila optimization algorithm improves deep learning model efficiency, leading to better classification accuracy. 2. Reduces training time and enhances model convergence by selecting the most relevant features.	1. Deep learning models, combined with optimization algorithms, demand significant processing power and memory. 2. The system requires well-annotated and diverse datasets for accurate product identification across different retail environments.
[3]	(2024)	1. Deep Learning (CNNs - Convolutional Neural Networks) 2. YOLO Object Detection Model	1. Reduces checkout time by eliminating the need for barcode scanning.	1. Requires large, diverse datasets to ensure accurate classification.
[5]	(2024)	1. Feature Flow Neural Network (FFNN) 2. Deep Learning-Based Image Recognition	1. Reduces computational overhead and memory consumption, making it efficient for real-time processing. 2. Enhances learning stability and accuracy by focusing on rigorous feature extraction techniques.	1. Requires careful tuning of hyperparameters for effective training and convergence. 2. May not always outperform traditional batch normalization-based networks in all scenarios.
[6]	(2023)	1. Pseudo-Labeling with Data Augmentation 2. Deep Learning-Based Smart Checkout System	1. Reduces the cost and time required for dataset expansion by automatically generating pseudo labels. 2. Allows recognition of new products without retraining from scratch, improving adaptability in dynamic retail settings.	1. Pseudo-labeling may introduce inaccuracies, affecting model performance. 2. Requires significant processing power for generating and validating pseudo-labeled data.
[7]	(2023)	1. YOLOv8 for Object Detection 2. DeepSort for Object Tracking	1. Combines detection and tracking to reduce errors and ensure every product is accounted for. 2. Uses video inpainting to reconstruct missing parts of objects, improving detection in crowded checkout areas.	1. Requires high processing power for real-time detection, tracking, and inpainting. 2. Fast object motion may lead to tracking inconsistencies, affecting accuracy in busy retail environments.
[8]	(2023)	1. YOLOv8 Object Detection	1. Effectively identifies products with minimal misclassification, even among similar-looking brands. 2. Ensures fast and efficient brand recognition, enhancing retail checkout systems.	1. Small packaging variations can cause misclassification due to inter-class similarities. 2. Performance heavily relies on a well-annotated dataset to handle complex brand differentiation.
[9]	(2023)	1. Image Enhancement Techniques 2. Deep Learning-Based Object Detection	1. Enhanced image quality leads to better product recognition, even in low-light or blurry conditions.	1. Image enhancement techniques can increase processing time, affecting real-time performance.
[10]	(2022)	1. Text Detection and Recognition 2. Mobile Augmented Reality (AR)	1. Provides users with instant product information, offers, and reviews, improving decision-making. 2. Efficiently tracks products in dynamic environments, even when items are moved or rotated.	1. Performance is affected if product labels are unclear, occluded, or poorly printed. 2. Requires powerful mobile hardware for seamless AR rendering and real-time text detection.
[11]	(2022)	1. Deep Learning-Based Object Detection 2. Ant Colony Optimization (ACO) Algorithm	1. Deep learning models combined with ACO improve classification and detection of products with minimal errors. 2. Reduces checkout time by automating product identification without relying on barcodes.	1. Requires significant processing power and optimized hardware for real-time performance. 2. Adapting the system to new product categories may require additional training and dataset expansion.

[12]	(2022)	<ol style="list-style-type: none"> <li>1. Self-Supervised Learning (SSL)</li> <li>2. Zero-Shot Learning (ZSL)</li> </ol>	<ol style="list-style-type: none"> <li>1. Reduces dependency on manually annotated datasets, making the system more scalable and cost-effective.</li> <li>2. Zero-shot learning enables the system to recognize previously unseen items, enhancing flexibility in dynamic retail settings</li> </ol>	<ol style="list-style-type: none"> <li>1. Since the model learns without explicit labels, it may struggle with fine-grained product differentiation initially.</li> <li>2. Requires advanced contrastive learning techniques and large datasets to achieve optimal performance.</li> </ol>
[13]	(2020)	<ol style="list-style-type: none"> <li>1. Generative Adversarial Networks (GANs)</li> <li>2. Deep Learning-Based Image Classification</li> </ol>	<ol style="list-style-type: none"> <li>1. Increases the diversity of training data, reducing overfitting and enhancing model generalization.</li> <li>2. Helps in balancing datasets by generating more images for underrepresented product categories.</li> </ol>	<ol style="list-style-type: none"> <li>1. Training GANs requires significant computational resources and time.</li> <li>2. Poorly trained GANs may produce unrealistic or low-quality synthetic images, affecting model accuracy.</li> </ol>
[14]	(2019)	<ol style="list-style-type: none"> <li>1. Histogram of Oriented Gradients (HOG)</li> <li>2. Bag of Words (BoW) Model</li> </ol>	<ol style="list-style-type: none"> <li>1. HOG effectively captures object details, making it suitable for product identification.</li> <li>2. BoW allows for lightweight classification compared to deep learning models</li> </ol>	<ol style="list-style-type: none"> <li>1. Struggles with variations in lighting, occlusion, and background clutter.</li> <li>2. Unlike deep learning models, this approach relies on handcrafted features, limiting adaptability.</li> </ol>
[15]	(2018)	<ol style="list-style-type: none"> <li>1. Convolutional Neural Networks (CNNs)</li> <li>2. Recurrent Neural Networks (RNNs)</li> </ol>	<ol style="list-style-type: none"> <li>1. Multi-network integration boosts recognition precision and reduces misclassification.</li> <li>2. Can handle a wide range of products across different categories with minimal retraining.</li> </ol>	<ol style="list-style-type: none"> <li>1. Requires significant processing power, making real-time applications resource-intensive.</li> <li>2. Fine-tuning multiple networks demands extensive labeled data and optimization efforts.</li> </ol>

### III. METHODOLOGY

The Automated Checkout System presented in this study integrates deep learning, computer vision, and database management to enable a seamless and efficient self-checkout experience in retail environments. The methodology begins with data collection, where a diverse set of product images is gathered, ensuring variations in angles, lighting conditions, and occlusions to improve the model's robustness. These images are then annotated using tools like Roboflow, where bounding boxes and class labels are assigned to each product to create a high-quality training dataset. To further enhance the dataset and prevent overfitting, data augmentation techniques such as flipping, rotation, scaling, and brightness adjustment are applied. This ensures the model generalizes well to different conditions encountered in real-world scenarios. For object detection, a YOLO (You Only Look Once) model is chosen due to its speed and accuracy in real-time applications. The selected version of YOLO, such as YOLOv11, is trained using the prepared dataset, and its hyperparameters are fine-tuned to optimize performance. The training process involves using a validation set to monitor the model's learning curve, and adjustments are made to reduce false positives and negatives. After achieving satisfactory accuracy, the trained model is integrated into the system as an Object Detection Module, where it processes real-time images captured from a camera to identify and classify products. Once a product is detected, the system assigns its class label and queries a MySQL database through the Price Lookup Module to retrieve the corresponding price. The detected products and their respective prices are compiled into a checkout list, where a Receipt Generation Module calculates the total amount and formats a digital receipt. A Flask-based user interface is developed to provide real-time visualization, overlaying bounding boxes, product names, and prices on the detected items. This interface ensures transparency and user confirmation before finalizing the transaction. The system undergoes extensive testing and validation to ensure robustness and accuracy under diverse conditions, including different lighting scenarios, cluttered backgrounds, and partial occlusions. Functional testing verifies the correctness of detections and price retrievals, while user testing evaluates usability and overall performance. Additionally, error handling mechanisms are implemented to address misclassifications, false detections, and system latencies. Optimization techniques are applied to reduce processing time and improve the model's inference speed, ensuring a smooth and efficient checkout experience. By eliminating the need for barcode scanning and manual intervention, this Automated Checkout System significantly reduces checkout time, improves user convenience, and enhances the overall retail experience. The integration of machine learning, YOLO-based object detection, and real-time product identification offers a scalable and adaptable solution for modernizing traditional checkout processes in supermarkets and retail stores.

## 3.1 Block Diagram

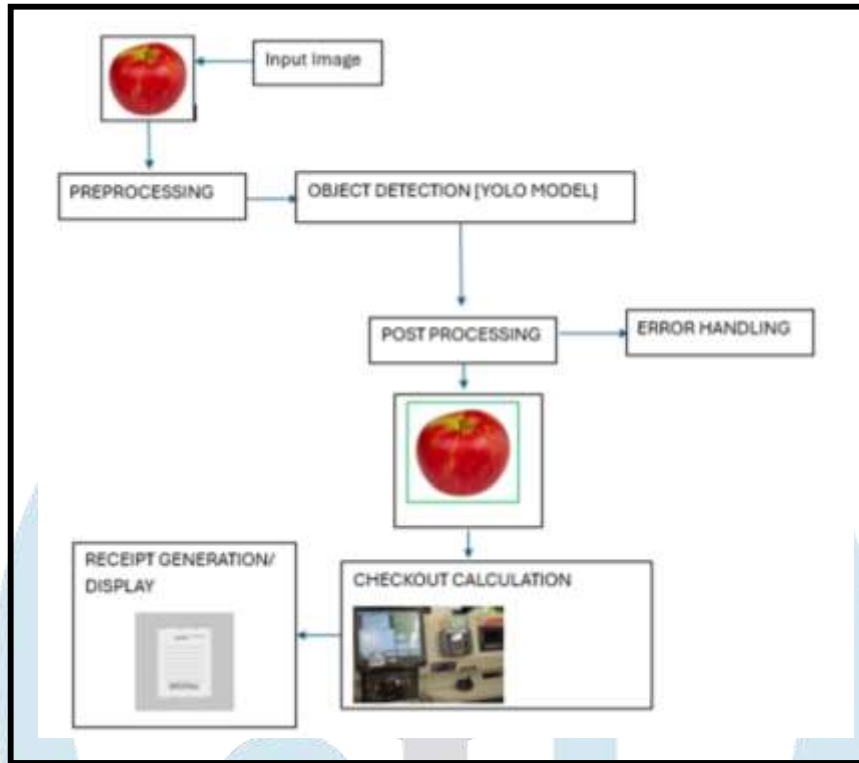


Fig 3.1 Block Diagram

The Fig 3.1 block diagram illustrates the workflow of an Automated Checkout System that leverages YOLO (You Only Look Once) object detection technology to identify and process products without the need for barcode scanning. The process begins with capturing an input image of the product, which serves as the primary data source for further analysis. This image then undergoes preprocessing, where various techniques such as resizing, noise reduction, contrast enhancement, and normalization are applied to improve the quality of the image and optimize it for detection. Once preprocessing is complete, the image is sent to the YOLO object detection model, which analyzes the visual features of the product and assigns it to a specific category by drawing a bounding box around the detected object. After detection, the system enters the post-processing phase, where additional refinement takes place to ensure accuracy by filtering out false positives or low-confidence detections. If the system encounters any inconsistencies, the error handling module is triggered to address misclassifications or low-confidence predictions by either reprocessing the image or prompting the user to capture a clearer image. Once the product is correctly identified, the system retrieves its price from a database and performs checkout calculations, which include adding the detected product's price to the total bill while considering any applicable discounts or taxes. The final stage involves receipt generation and display, where a digital or printed receipt is provided to the customer, summarizing their purchases. This entire process eliminates manual barcode scanning, significantly reducing checkout time and improving efficiency in supermarkets, retail stores, and self-service kiosks. By integrating AI-driven object detection technology, the system enhances customer experience and optimizes retail operations, making the checkout process faster, more accurate, and user-friendly.

## IV. RESULTS & DISCUSSIONS

### 2.1. Results

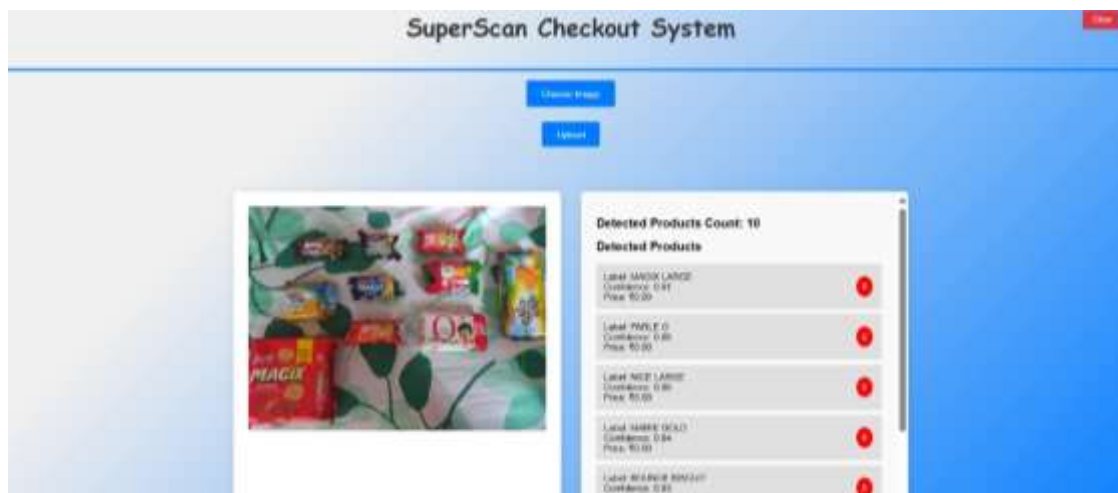


Fig 4.1 Website Dashboard

The website dashboard, as illustrated in Fig 4.1, serves as a user interface for the checkout system, it includes the option of uploading the image where the cashier uploads the images with all the products in the image. The uploaded image is then processed and all the objects inside the image are detected. After detecting all the products, the system fetches the prices of the products from the database and displays the price of the product in the list.



Fig 4.2 Cash Receipt

In Fig 4.2, The Automated Checkout System generates a receipt after detecting products using YOLOv11. The system retrieves product prices from a MySQL database, calculates the total amount, and formats a structured receipt displaying product names, quantities, net prices, and subtotal.

## 2.2. Comparisons with Existing Systems

**Table 2. Comparison Table**

Feature	Barcode Based System	YOLOv8-Based Automated Checkout (Proposed System)
Checkout Speed	~5-7 seconds per item (manual scanning)	~10-12 seconds for multiple items (automated detection)
User Effort	Requires manual barcode scanning	Fully automated, no manual scanning needed
Failure Cases	Fails if barcode is missing/damaged	Works even if the packaging design varies
Scalability	Limited to barcode-printed products	Can detect any trained product, including unpackaged goods

## V. CONCLUSION

The development of the automated checkout system represents a significant advancement in retail technology, addressing the limitations of traditional checkout processes and enhancing the overall shopping experience for customers. By integrating cutting-edge technologies such as computer vision, machine learning, and real-time data management, the system aims to streamline product recognition, reduce checkout times, and minimize human error. Through a comprehensive implementation plan that encompasses requirement analysis, system design, development, integration, and user testing, this project lays the foundation for a robust and user-friendly solution. The anticipated outcomes include improved operational efficiency for supermarkets, enhanced customer satisfaction through quicker transactions, and a more interactive shopping experience. Additionally, the system provides scalability, making it adaptable to different store sizes and formats, from small retail outlets to large supermarkets. It also offers real-time inventory tracking and management, helping retailers optimize stock levels and reduce waste. By eliminating the need for traditional barcode scanning, the solution ensures a smoother and more flexible checkout process, where product identification can be achieved even when labels are damaged or obscured.

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