Development of Intelligent Basket System by Using Image Detection with Convolution Neural Network (CNN)

Sahazati binti Md Rozali[1], Eliyana binti Ruslan[2], Muhammad Nizam bin Kamarudin[1], Muhammad Iqbal bin Zakaria[3]

[1]Faculty of Electrical Technology and Engineering, Universiti Teknikal Malaysia Melaka

[2]Faculty of Electronic and Computer Technology and Engineering, Universiti Teknikal Malaysia Melaka

[3]School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Selangor, Malaysia

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ABSTRACT

Conventional shopping methods are often hindered by inefficiencies such as prolonged queues, delayed checkout process and the absence of real-time expenditure monitoring. All these problems contribute to a time-consuming and potentially frustrating shopping experience. Besides, manual item scanning at checkout counters is susceptible to human error leading to inconsistent billing and customer dissatisfaction. All these operational shortcomings raise broader concerns regarding the societal and environmental implications of traditional retail practices. In response to these challenges, this study proposes the development of an Intelligent Shopping Basket (ISB) system designed to streamline the shopping process through automation and real-time data integration. The ISB implements machine learning technique which is Convolutional Neural Networks (CNN) implemented via TensorFlow to facilitate accurate and real-time object detection. The items that are placed into or removed from the basket will be automatically identified, with updates reflected instantly through a mobile application that displays both cart contents and total cost. The system is powered by a Raspberry Pi 4B, which serves as the central processing unit, coordinating hardware components including a webcam, LEDs, a buzzer, and a push button. This embedded solution eliminates the need for conventional point-of-sale systems and external payment devices, thereby offering a modern, efficient, and user-friendly alternative to traditional shopping methods.

Keywords: Conventional shopping methods, Intelligent Shopping Basket, Machine Learning, TensorFlow, Raspberry Pi 4B

INTRODUCTION

Conventional shopping practices present several persistent challenges for consumers including prolonged queuing times and inefficient checkout processes. These issues result in time-consuming experiences and customer dissatisfaction. Additionally, unintended overspending might be happened because of the absence of real-time expenditure tracking. Besides, manual item scanning at checkout counters introduces the risk of invoicing inaccuracies due to human error. These inefficiencies reflect broader operational shortcomings in traditional retail systems and raise concerns regarding their societal and environmental impacts. Notably, the reliance on paper receipts and resource-intensive processes underscores the need for more sustainable engineering approaches in retail. Therefore, this research proposes the development of an Intelligent Shopping Basket (ISB) system to enhance the overall shopping experience for both retailers and consumers. The proposed system integrates hardware components with a robust backend architecture and an intuitive user interface. The main hardware elements are a Raspberry Pi 4B, webcam, buzzer, and LEDs, which collectively facilitate real-time product recognition and cart status updates. The backend which is developed using PHP and MySQL will manages product information and transaction data to ensure efficient data processing and storage. A mobile application, built with HTML, CSS, and JavaScript, provides users with real-time feedback on cart contents and checkout details. It will improve user engagement and transaction transparency. In additional to operational efficiency, the ISB system also contributes to public health efforts. It can be done by minimizing physical contact during the shopping process which offering a viable alternative to reduce the transmission of infectious diseases.

LITERATURE REVIEW

The evolution of shopping technologies has increased awareness about the inefficiencies of conventional retail methods. Traditional checkout systems are frequently associated with long queues, delayed processing times, and customer dissatisfaction due to manual item scanning and inadequate real-time pricing feedback [1]. These issues affect customer experience and is also contribute to operational inefficiencies and increased labor costs in retail environments [2]. [3] bring out a Raspberry Pi-based smart cart that gives an intellectual approach to this tedious process. The main purpose of the project is to reduce the queuing delays at the cash counters of supermarkets with a scanning system employed in the trolley that makes the billing process easy. In addition, the system also detects the discrepancy done by untruthful customers using a load cell. [4] also proposed smart shopping cart system to overcome the same problem. The purpose of this research is to create a system that consists of smart shopping carts, a smartphone application as an interface, an application for the cashier integrated with the server and database to support data transmission that enables people to do self-scanning of items and their payment. The system is developed using the waterfall methodology and involves tools such as Arduino Uno, RFID, Visual Studio Code, Flutter, PostgreSQL, REST, React and Node.js. [5] provide a handsfree and hassle-free shopping experience to the user in the supermarket who suffers from the problems such as having chaotic time moving the baskets, overcrowding at one place for a certain product on sale, theft, pending a very long time standing in the queue in the counter for bill payment, etc. The project follows the user as per the command given in the smartphone application provided along with the smart shopping basket and installed on his phone. Customer will receive the total net amount of the bill he has to pay on the same application. The basket consists of the Bluetooth module to connect with the user's smartphone through which the basket's movements are commanded over. The basket also avoids meeting any obstacles that it faces by taking deviation while following its user using ultrasonic sensors. [6] determine the factors affecting the intention to use mobile commerce by integrating the Technology Acceptance Model and the updated IS Success Model. A non-probability convenience sampling is employed, collecting 395 questionnaires from Klang Valley residents of Malaysia. Two-stage structural equation modeling is employed to test the hypotheses. The findings indicate that system quality, service quality, and perceived enjoyment significantly affect the intention to use mobile commerce. In [7], introduce an "Intelligent Shopping Cart". In this research, customers may enjoy their shopping experience and focus more on their shopping list by using this trolley instead of pushing a shopping cart. The trolley will follow the customer throughout the shopping period leaving a certain distance. If the customer stops then the trolley will also stop at maintained distance by using sharp IR sensor. A smart shopping cart system based on low-cost IoT equipment and deep learning object detection technology is proposed in [8]. The system consists of a camera for real-time product detection, an ultrasonic sensor as a trigger, a weight sensor to determine if a product enters or exits the shopping cart, and a smartphone app providing a virtual cart interface. The server uses YOLO, an object detection library, for product recognition. Communication occurs via TCP/IP and HTTP, allowing users to monitor items in their cart and make automatic payments. [9] presents the hardware and software design of a smart trolley system. Our smart trolley used IOIO microcontroller and Android smartphone as sensors and controller. The trolley is modeled as a two-wheeled mobile robot. Android smartphones will control the robot by sending a signal to IOIO microcontroller paired with a robot's actuator and monitor the situation using the smartphone camera. Furthermore, we exploited the smartphone compass for robot navigation. This system is also equipped with an indoor positioning system to detect user positions using Navisens which are based on gyroscope and accelerometer in the smartphone. Finally, the results of the test on robot navigation are presented. The result is our smart trolley system based on Navisens framework can move and show its location to the user. A comprehensive analysis of active machine learning algorithms designed to improve the classification precision of image and text models is provided by [10]. This study introduces the

ALiPy (Active Learning in Python) library, which provides a platform for readily integrating active learning algorithms into classification models. The proposed method enhances model performance and reduces annotation costs by selecting informative cases for annotation using the query-by-committee (QBC) procedure. The technique's efficacy is evaluated utilizing the AG News text dataset and the CIFAR-10 image dataset. Experimental results indicate that using active learning strategies significantly enhances classification accuracy in both domains. Additionally, the technology is introduced for intelligent retail systems aimed at automating the checkout process. The famous recent technologies are smart carts, self-checkout kiosks, and mobile payment systems. It is designed to reduce human error and improve transaction speed. These innovations shift towards smart retail, which integrates Internet of Things (IoT) technologies, machine learning, and real-time data processing to enhance shopping experiences [11]. Deep learning methods such as Convolutional Neural Networks (CNNs) are one of the machine learning techniques. It has shown remarkable effectiveness in object detection and classification tasks. CNNs have been widely adopted in real-time image recognition applications due to their ability to learn hierarchical features from visual inputs [12]. Frameworks like TensorFlow provide scalable tools for deploying such models in embedded systems. It allows for real-time inference in low-powered environments [13]. By applying these models in retail automation, the identification of products placed in shopping carts is enabled without the need for barcode scanning. Thus, human error can be minimized, and checkout times can speed up [14]. Embedded systems such as the Raspberry Pi are portable, cost-effective, and scalable deployment of intelligent systems. This is because it has compact size GPIO interfacing capabilities, and sufficient processing power make them suitable for edge computing applications in smart retail environments [15]. Integration with peripheral devices such as webcams, buzzers, and LEDs can support interactive functions including object detection, alert signaling, and user feedback mechanisms. In addition, mobile applications integrated with smart shopping systems provide real-time updates to users, displaying cart content and total expenditures. Such integration enhances human-computer interaction and offers users a transparent and responsive shopping experience [16]. This feedback loop is essential for empowering users to monitor their spending and make decisions during the shopping process. In addition to enhancing user experience and system efficiency, smart shopping technologies also offer potential environmental benefits. This is because the need for paper receipts and excessive plastic packaging is reduced. Unnecessary hardware components such as traditional point of sale systems are also decreased. Thus, these technologies contribute to more sustainable retail practices [17]. The transition toward automated and intelligent retail systems therefore aligns with technological innovation and goals of environmental sustainability and resource efficiency. Collectively, existing studies underscore the potential of integrating deep learning, embedded systems, and real-time data processing into retail environments. However, there remains a gap in low-cost, user-friendly solutions that fully eliminate the need for traditional checkout mechanisms. The Intelligent Shopping Basket (ISB) system proposed in this study aims to address this gap by leveraging CNN-based object detection, real-time mobile feedback, and Raspberry Pi–driven edge computing to deliver an efficient and sustainable shopping experience.

METHODOLOGY

The operational workflow of the Intelligent Shopping Basket (ISB) system is started when a customer places an item into the basket. A web camera which is interfaced with a Raspberry Pi 4B microcontroller captures an image of the product in real time. The captured image is then processed using a Convolutional Neural Network (CNN) implemented via the TensorFlow framework to perform accurate product identification. Upon successful recognition, the system updates the customer's shopping cart, reflecting the identified item, its associated price, and the updated total of items. The user can access these details through a mobile application installed on their smartphone such that the real-time cart monitoring is enabled. Visual and auditory feedback mechanisms are incorporated to indicate the status of the recognition process. A green LED is activated to indicate successful recognition whereas a red LED signals a recognition error supplemented by a buzzer alert. The system supports a fully cashless transaction model requiring users to pre-load credits into their accounts. As shopping progresses, the corresponding amount is automatically deducted with each recognized item. Upon completion, the mobile application generates a comprehensive summary of the purchased items along with the updated account balance, thereby enhancing transactional transparency and user convenience. The system's flow chart is illustrated in Figure 1.

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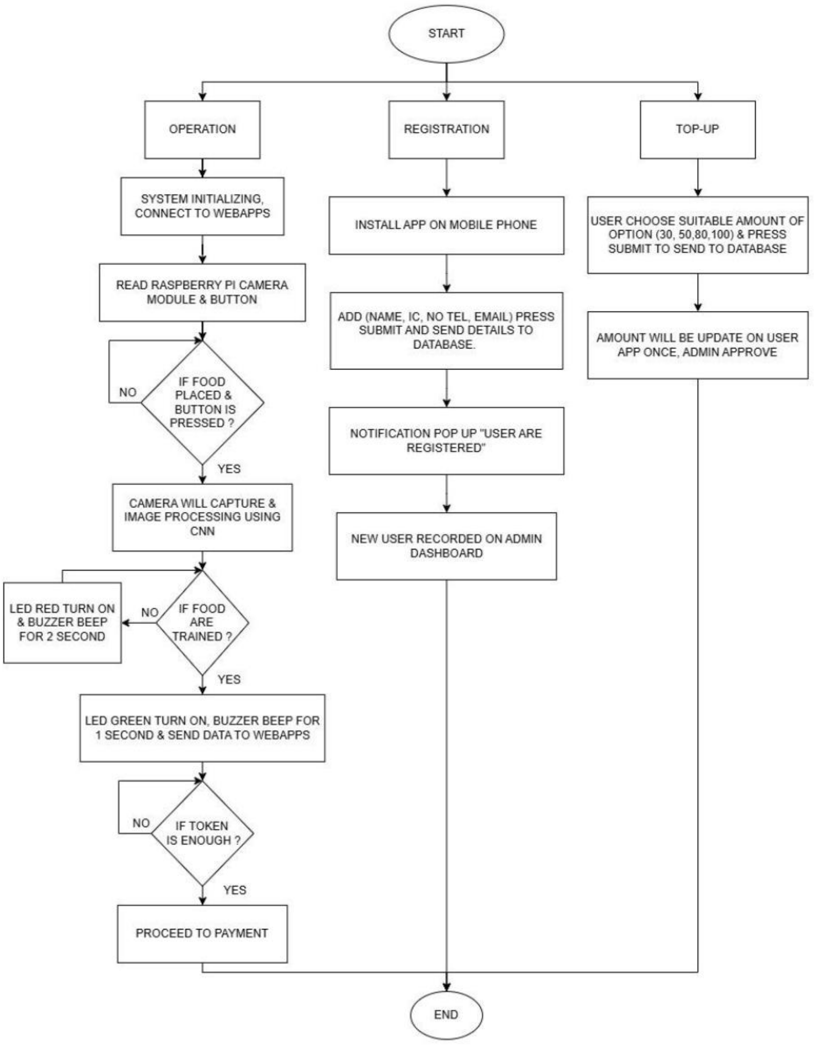

Figure 1. System's flow chart

MySQL is an open-source database management system (RDBMS). It is known for its efficiency in storing, managing, and retrieving structured data particularly in web-based applications. It supports data manipulation through Structured Query Language (SQL) such that the developers able to execute complex queries with ease. In this project, MySQL is utilized as the core database system to manage product information such as item names, prices, and users' in-store credit balances. The database is accessed and updated dynamically through PHP scripts. This allows real-time synchronization between the backend system, hardware components, and frontend interface. This integration enables the system to manage large datasets effectively, ensure rapid query responses, and uphold data integrity to deliver a seamless and efficient shopping experience. The Raspberry Pi 4 Model B has robust capabilities in handling multitasking operations. This is the reason it was selected as the central processing unit for this project. It can manage image acquisition, hardware communication, and database interaction concurrently since it is equipped with a quad-core processor and ample memory. The General Purpose Input/Output (GPIO) pins on the Raspberry Pi allow for direct interfacing with peripheral components such as LEDs, a buzzer, and a push button. The Camera Serial Interface (CSI) port facilitates the connection of a webcam, which is pivotal for real-time product recognition. The operational sequence begins when the user presses the push button to initiate the system. The webcam mounted on the shopping basket captures images of items as they are added. These images are processed in real time using a TensorFlow-based detection algorithm employing Convolutional Neural Networks (CNN) to identify the products accurately. The recognized product details are then transmitted to the MySQL database to be recorded and displayed via the user interface. A green LED indicates successful product detection while a red LED signifies recognition failure or signal errors. Additionally, an audible buzzer serves as an alert mechanism to notify users of the error. The accurate and reliable performance of the webcam is essential to the system's ability to perform correct image-based recognition and database matching. Figure 2 presents the schematic diagram illustrating the interconnection between the system's components.

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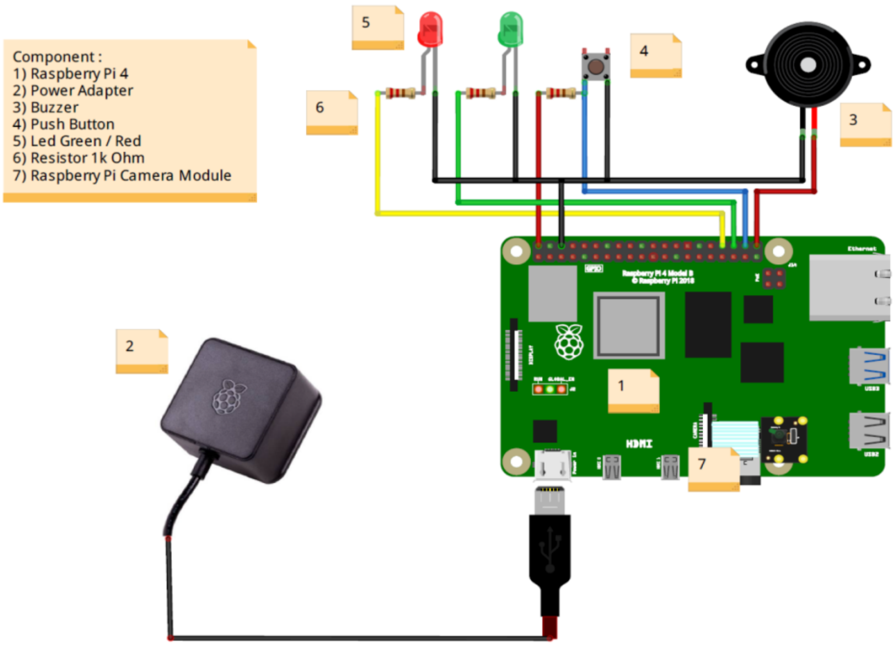

Figure 2. Connection of each component of the system

To ensure the accuracy of image detection of the object, approximately 200 images were collected for each product to train the machine learning model.

RESULTS AND DISCUSSION

The prototype of Intelligent Shopping Basket System is illustrated by Figure 3.

Figure 3. Prototype of Intelligent Shopping Basket System

The system architecture is structured around three fundamental components: a machine learning model, a backend server with database integration, and a frontend user interface. The main part of the system is the Raspberry Pi 4B. It functions as the processing unit to execute the machine learning model. The model is trained using a dataset of product images captured under varying environmental conditions, enabling real-time product classification with high accuracy. The backend server, developed using PHP and MySQL, manages data storage and retrieval related to product information, transaction logs, and checkout operations. It also serves as a bridge between the hardware and user interface by providing RESTful API endpoints that facilitate seamless

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communication and data exchange. The frontend interface implemented using HTML, CSS, and JavaScript, delivers a responsive and interactive user experience, allowing customers to view and manage their shopping carts, access product details, and complete transactions. System operation begins with image acquisition via a webcam connected to the Raspberry Pi 4B. A Convolutional Neural Network (CNN), integrated with TensorFlow, processes the captured image to identify the product and assigns a corresponding confidence score. Once a product is recognized, the Raspberry Pi issues a POST request to the backend server containing the product data. The server then queries the MySQL database to retrieve relevant information such as price, quantity, and availability, and relays this data to the frontend for real-time cart updates. Users can modify cart contents, including removing items, adjusting quantities, and reviewing product specifications. During checkout, the frontend interface compiles and displays a dynamic billing summary. Upon confirmation, the system updates the MySQL database to store the complete transaction data, ensuring consistency and data integrity. The CNN-based machine learning model demonstrates robust performance in real-time scenarios, providing accurate and efficient product recognition. Furthermore, the system incorporates a token-based payment mechanism, allowing users to preload credit for streamlined, device-independent transactions. The use of phpMyAdmin facilitates efficient database management, supporting scalability for larger product inventories and customer volumes. The frontend interface further enhances system usability by reducing the need for manual input and minimizing user errors. To evaluate the system's image detection capabilities, a webcam attached to Raspberry Pi 4B was employed to capture real-time images. The trained CNN model analyzed these images to classify products based on the predefined dataset. As illustrated in Figure 4, the system output including product names and corresponding confidence scores was displayed in a terminal interface following image processing. This component of the system provides immediate visual feedback, supporting accurate product identification and enhancing the overall shopping experience by automating item categorization at the point of selection.

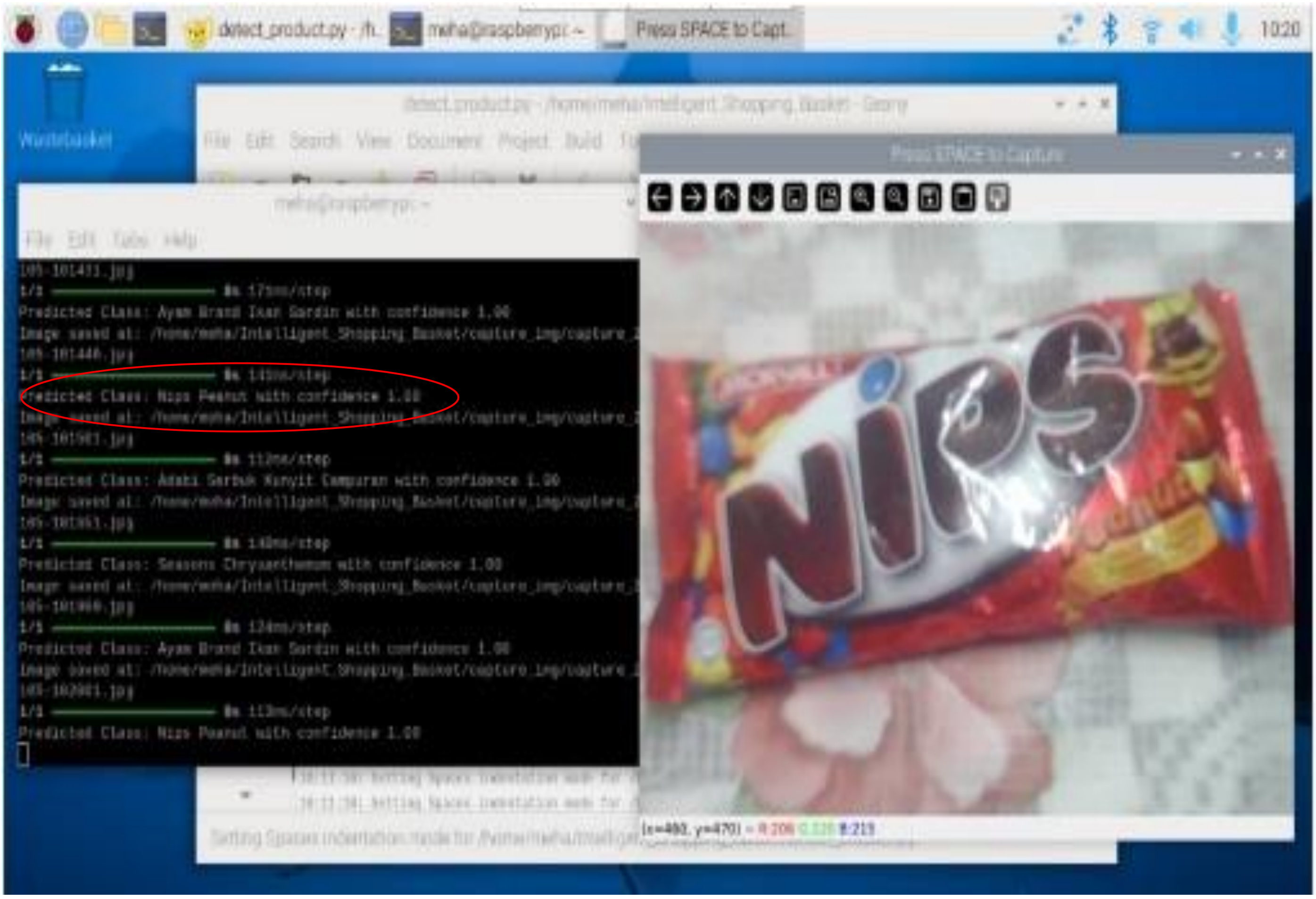

Figure 4. Image Detection Nips

The results presented in the figure indicate that the detection accuracy for the "Nips" product category achieved a confidence score of 100%, demonstrating the model’s exceptional capability in accurate product recognition. The Convolutional Neural Network (CNN) model exhibited a high level of confidence across multiple classifications, reinforcing its robustness in real-time identification tasks. During testing, the predicted class labels and their corresponding confidence levels were output through the terminal interface, providing immediate feedback. Notably, products such as Ayam Brand Ikan Sardin and Seasons Chrysanthemum were detected with confidence scores of 98% and 100%, respectively. These results underscore the effectiveness of the trained model in reliably distinguishing between different product classes. Representative examples of these classification outcomes are depicted in Figures 5 and 6.

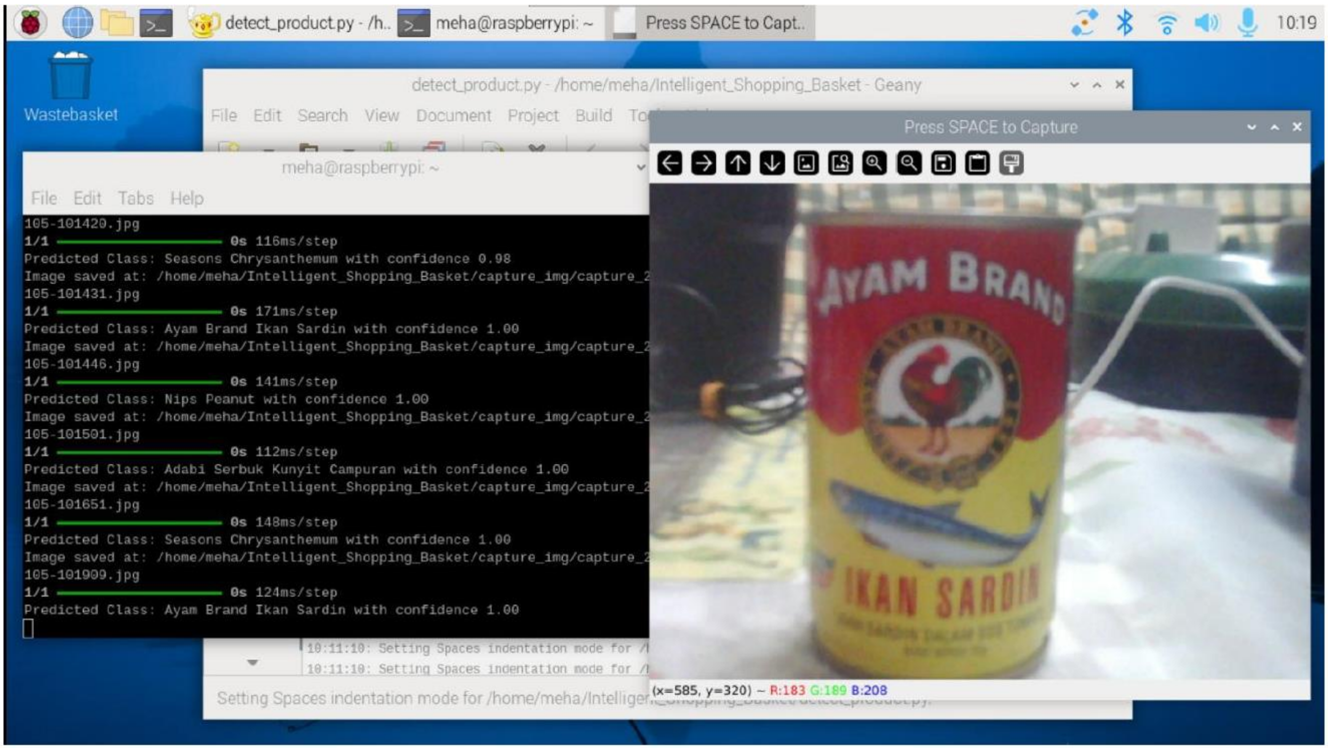

Figure 5. Image Detection Ayam Brand Ikan Sardin

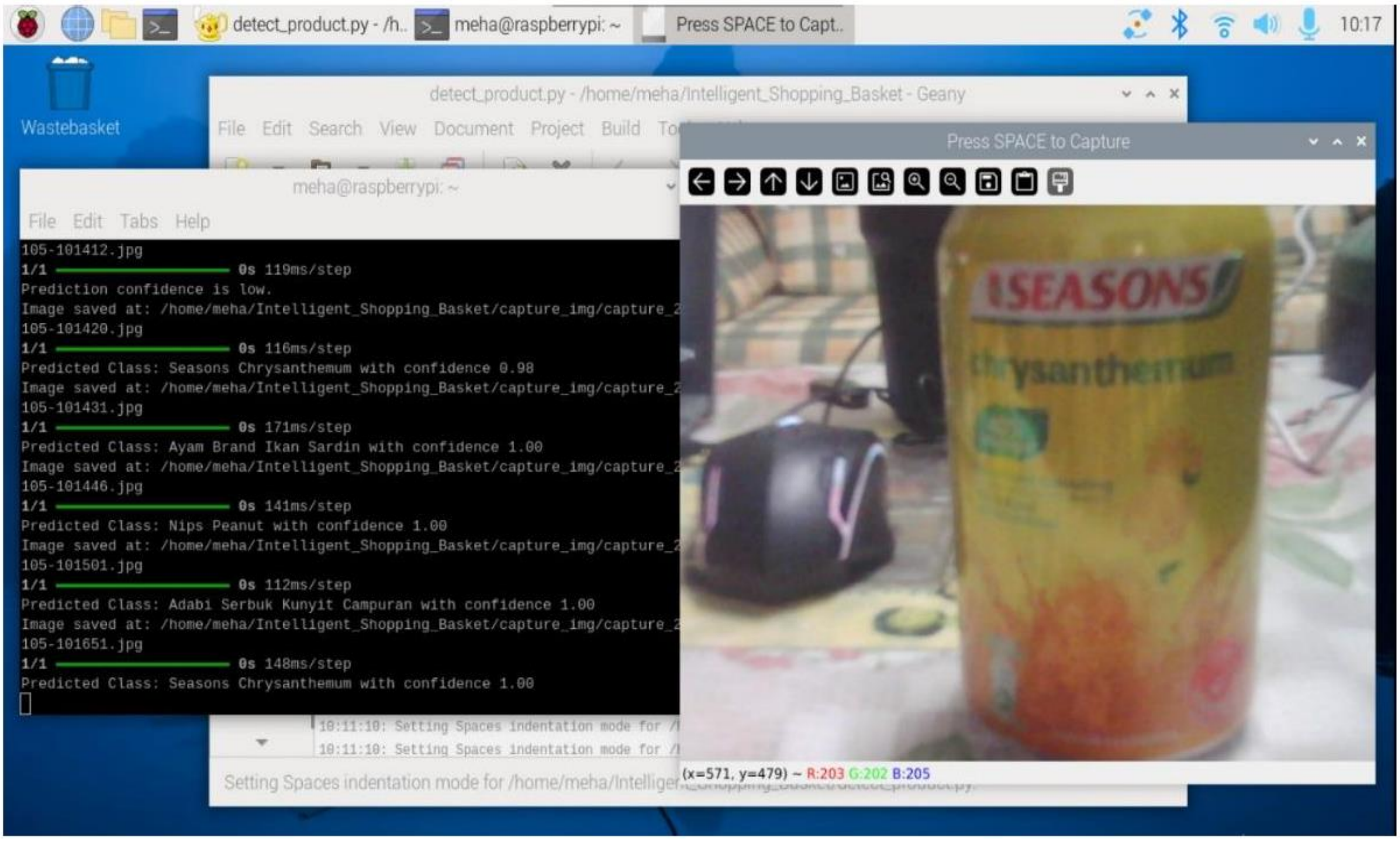

Figure 6. Image Detection Seasons Chrysanthemum

To facilitate further analysis and continuous improvement of the model, the system stores all processed images in a designated directory. These stored images serve as valuable data for subsequent retraining procedures, enabling the model to enhance its classification accuracy under diverse environmental and operational conditions. Database of the Intelligent Shopping Basket System is divided into two sections: the backend and the front end of the system.

Backend System

The backend of the Intelligent Shopping Basket system is designed to manage and store essential data related to users, transactions, and products. It supports real-time data retrieval and interaction by supplying critical information such as product names, pricing, and transaction statuses to the frontend user interface. It consists of user data management, purchase token management, purchase product detail, cart management, customer token management and bank account management.

User data management: Management of the data user employs a MySQL database to systematically store and manage user-related data, including sensitive information such as usernames, hashed passwords, and contact details. The user data is organized within a dedicated table, as illustrated in the accompanying figure, which comprises several key fields; user id, full name, email address, phone number, username, password and user type. The system demonstrated successful insertion and retrieval operations within the user table. Sample entries, including administrative and customer accounts such as Admin_01, confirm the proper functioning of user data management. This is shown in Figure 7.

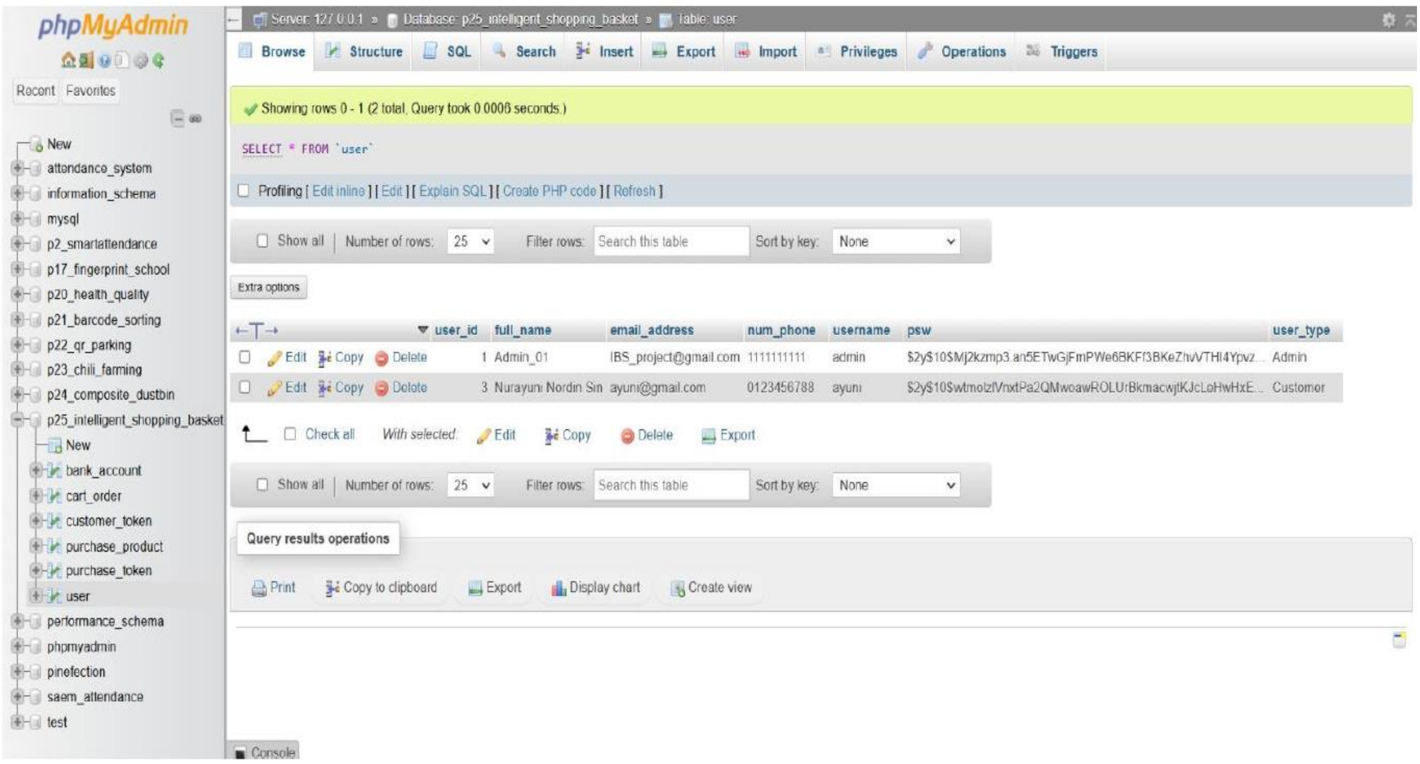

Figure 7. User Table Backend

Purchase token management: The status of each transaction is systematically monitored through the purchase token table within the MySQL database. This table records critical transaction-related information, including the transaction status, the uploaded image of the transaction receipt, and the associated token value, which represents the monetary amount involved in the transaction. During system testing, the purchase token table effectively demonstrated the backends' capability to manage and track transaction flows. Status indicators such as "In Progress" and "Disapprove" were used to reflect the current state of each transaction, thereby ensuring transparency and control over user activities. Each token entry corresponds to a distinct purchase attempt, enabling the system to log and monitor customer interactions. Token values such as 10 and 50 represent credit amounts within the user's shopping balance, as illustrated in Figure 8.

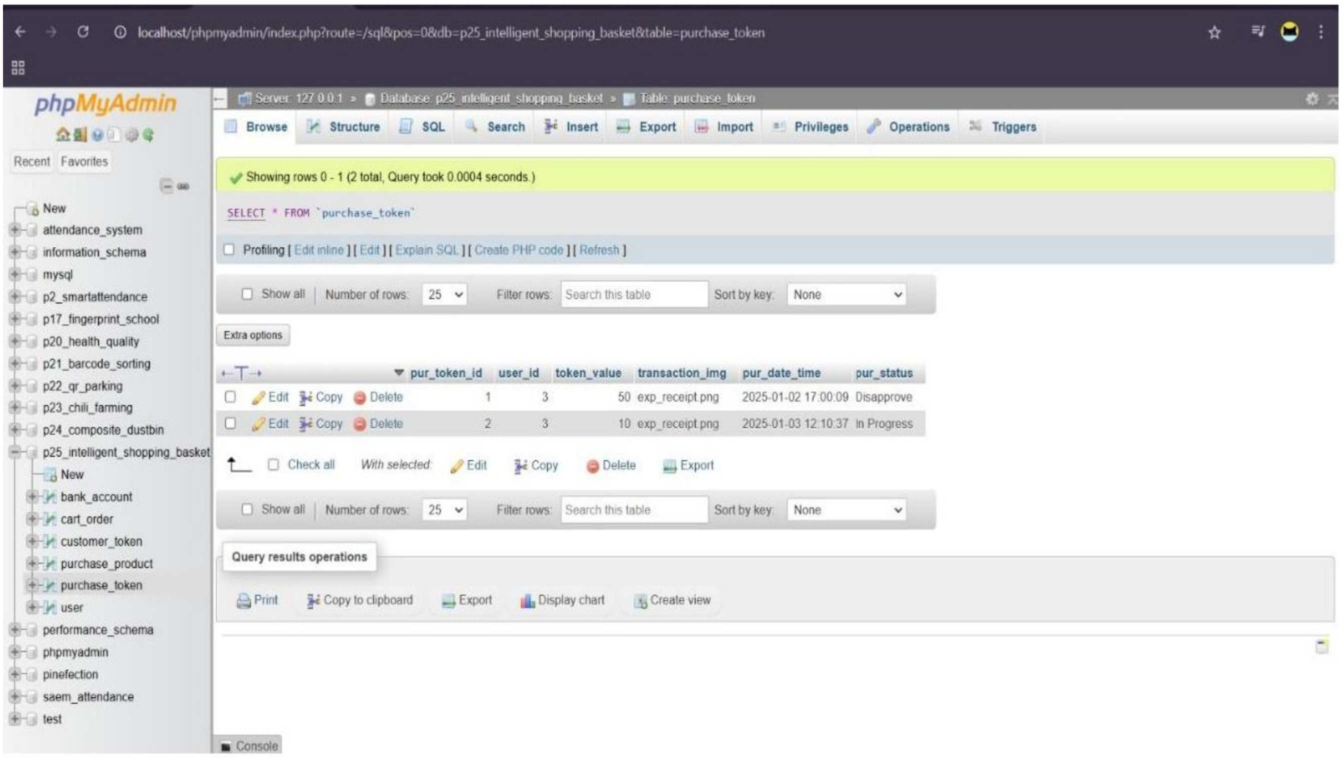

Figure 8. Purchase Token Table Backend

Purchase Product Detail: The purchase product table is responsible for storing detailed records of products purchased by users. Key fields include basket id, user id, product list, total quantity, and the corresponding payment amount. As illustrated in Figure 9, product names such as Seasons Chrysanthemum and Nips Peanut are recorded alongside their respective quantities and total payment values. For instance, the table shows that Nips Peanut was purchased in a quantity of one, while Seasons Chrysanthemum was purchased in a quantity of two. The total payment field accurately reflects the cumulative cost of the items, thereby validating the correctness of the system's transaction calculations.

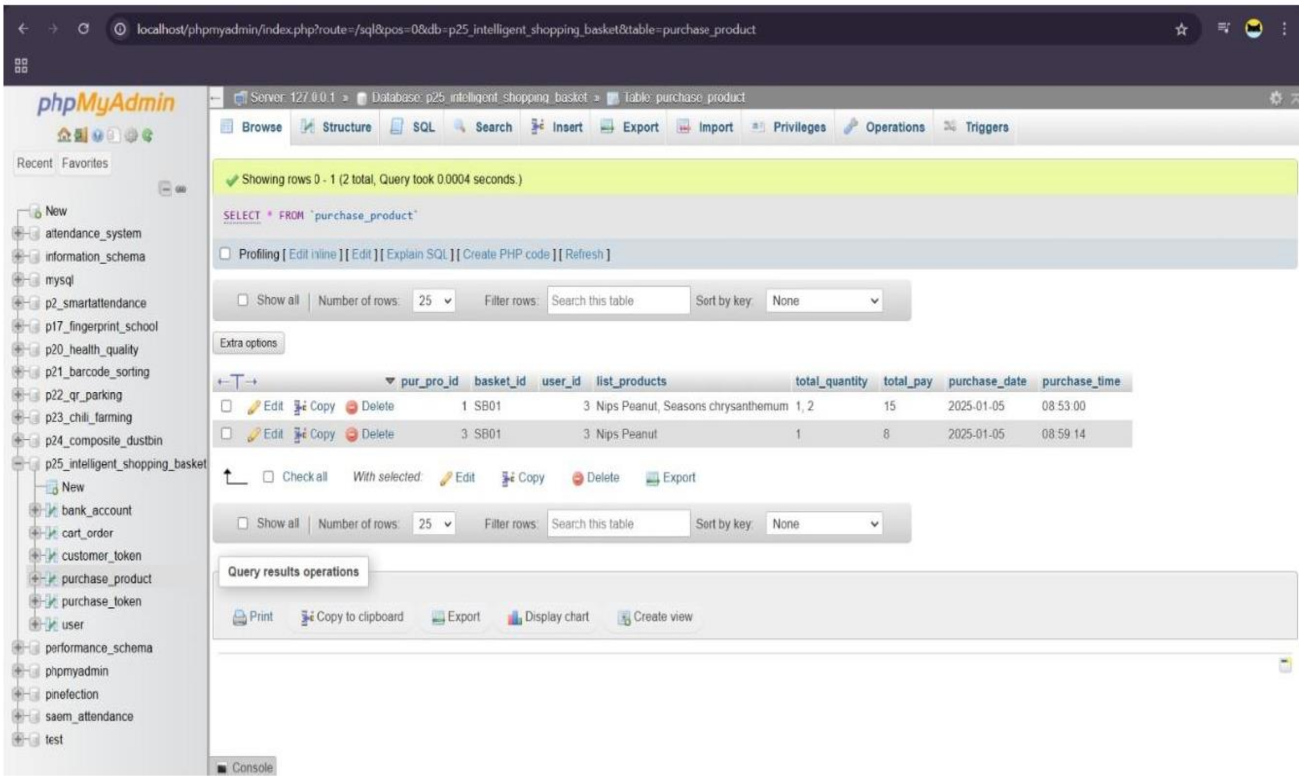

Figure 9. Purchase Product Table Backend

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Cart Management: The cart order table is designed to track and store information on products currently placed in a user's cart. It retains essential attributes such as basket id, product name, price, and product picture, which are used to provide users with accurate product details throughout the shopping process. During the testing phase, the cart order table remained empty, as no products had yet been added to the cart. However, once items are selected, the system dynamically updates the table with relevant data including product name, price, quantity, and associated image. These real-time updates enable customers to review and modify their selected items prior to checkout, thereby enhancing the interactivity and flexibility of the purchasing experience. Figure 10 shows the cart management window.

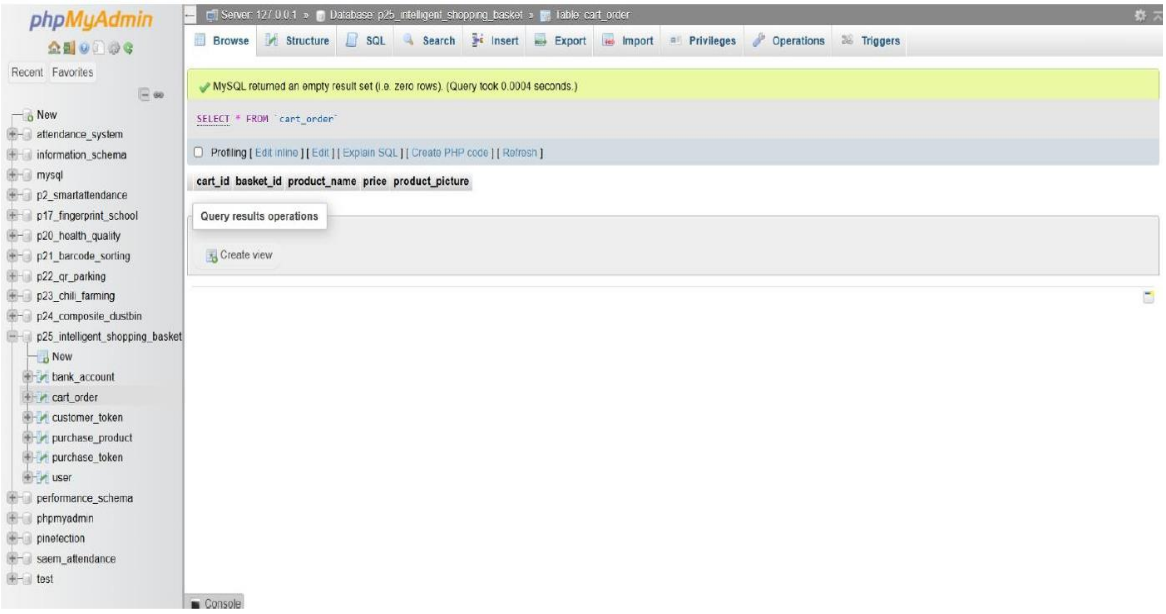

Figure 10. Cart Management Backend

Customer Token Management: The customer token table is utilized to monitor each customer's token balance, ensuring that sufficient funds are available to complete transactions. This table maintains records of the user's current shopping balance for instance; a balance of 27 tokens is shown in the corresponding customer entry. The backend logic supports the accurate authorization of purchases by automatically updating the token values in real time based on completed transactions. This mechanism ensures transactional integrity and enhances the overall reliability of the payment system. It is illustrated in Figure 11.

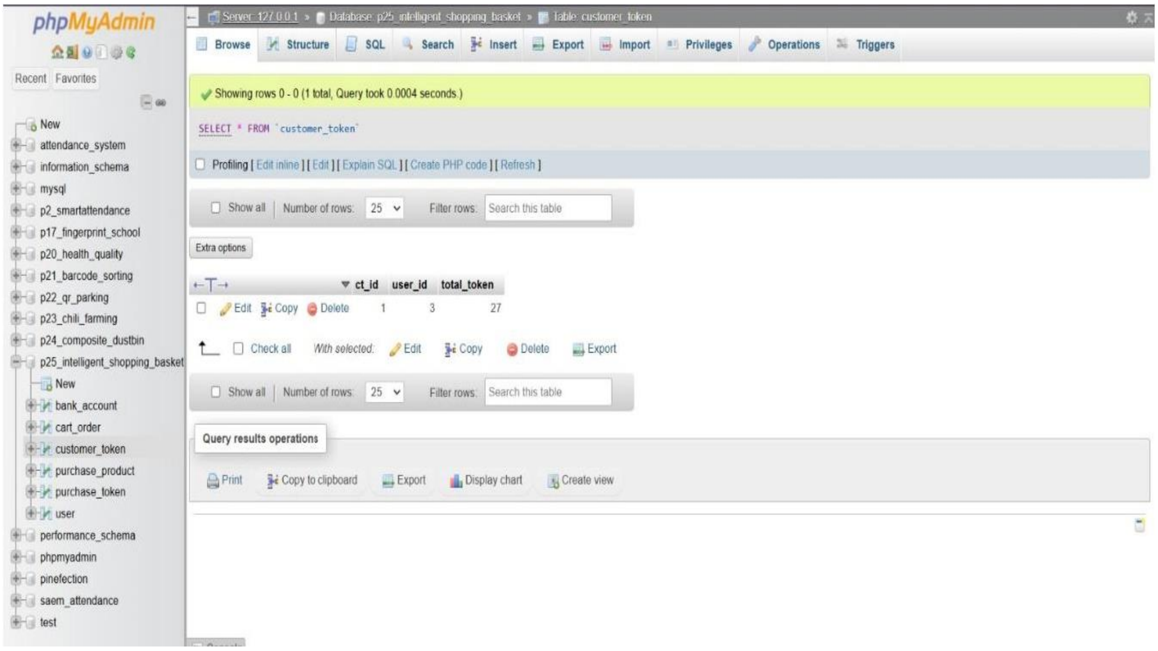

Figure 11. Customer Token Table Backend

Bank Account Management: The bank account table stores essential account information required for processing transactions, including the account holder's name and account number. As shown in Figure 12, a Bank Islam account with its corresponding account number is recorded within this table. These records enable the system to facilitate transactions and support key financial operations associated with the purchasing process, thereby ensuring secure and structured payment handling.

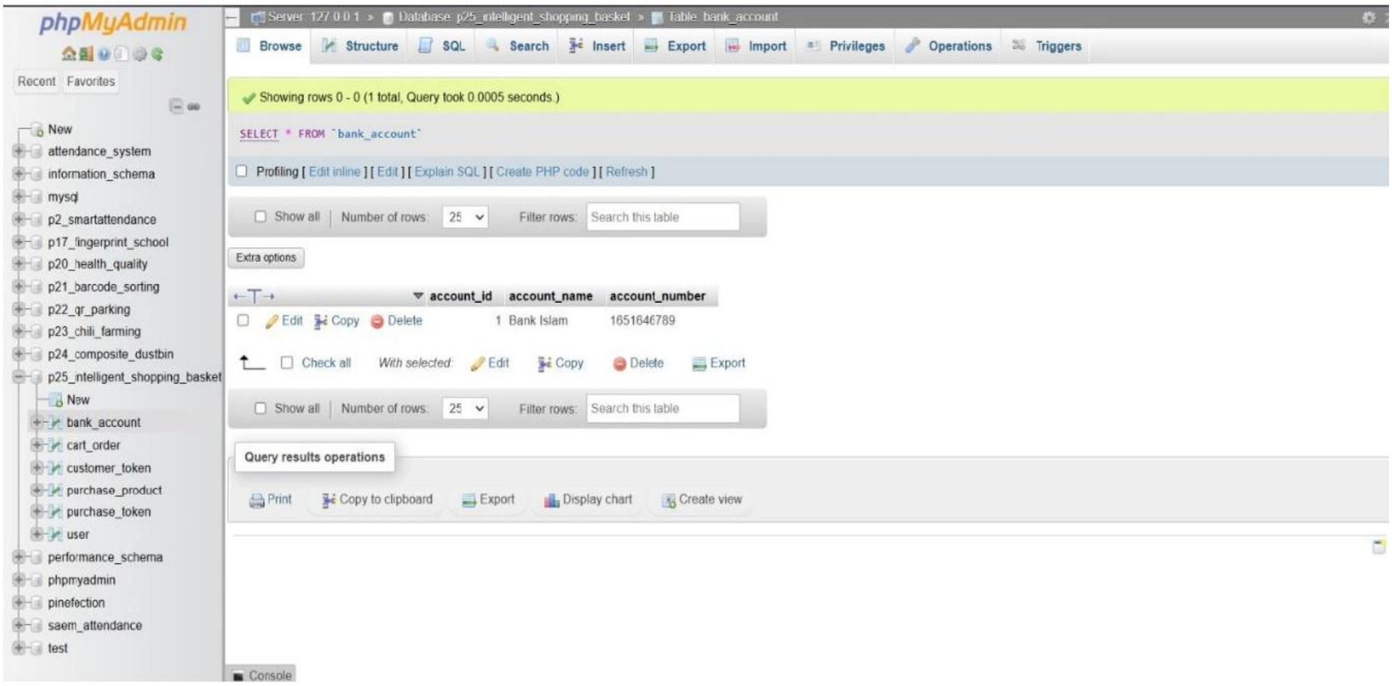

Figure 12. Company Bank Account Management Backend

Front End User Management

User profile interface: The frontend interface was designed to dynamically render product information and update transaction details in real-time, thereby enhancing user interaction and system responsiveness. Interface for user login is illustrated in Figure 13.

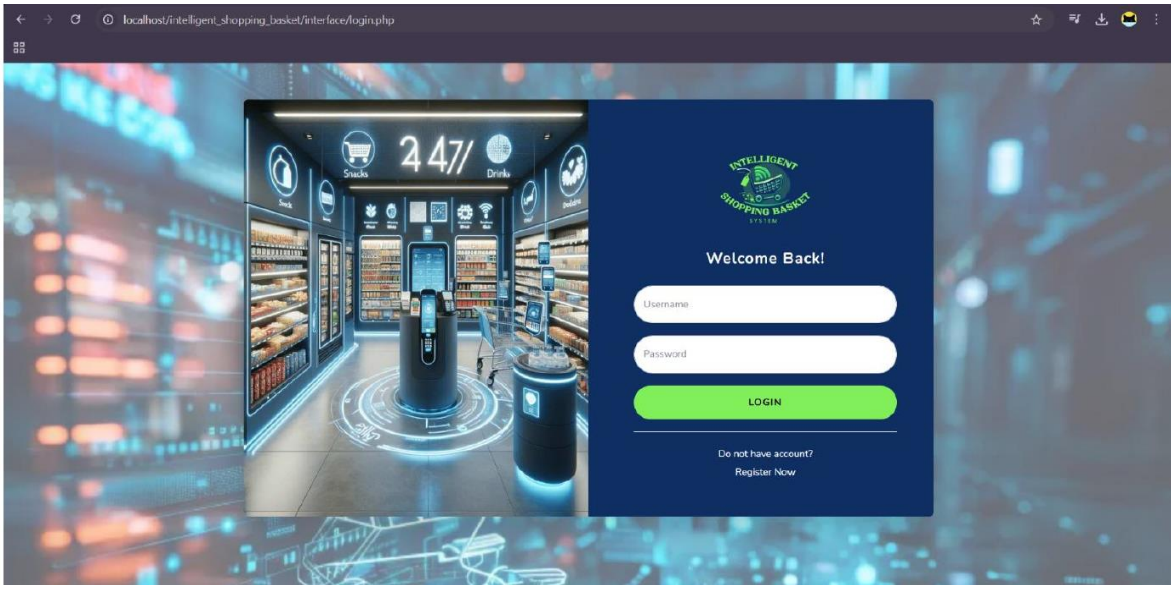

Figure 13. Login Interface

The login interface functions as the primary access point for users of the Intelligent Shopping Basket (ISB) system. It is developed to offer a secure, intuitive, and visually engaging user experience, facilitating seamless and reliable authentication. This interface plays a pivotal role in validating user credentials and granting access to personalized features, including shopping cart management, user profile settings, and core system functionalities. Once the user registered their account their profile will appear as shown in Figure 14.

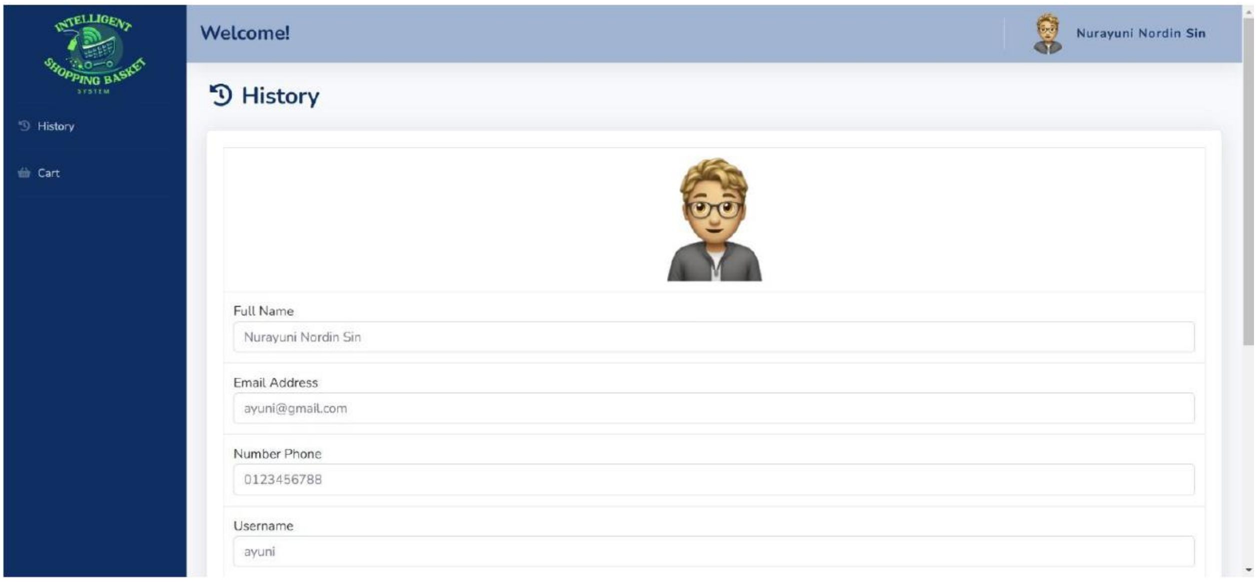

Figure 14. Profile Interface

The profile interface functions as a centralized platform through which users can access and verify their personal information.

User purchase interface:

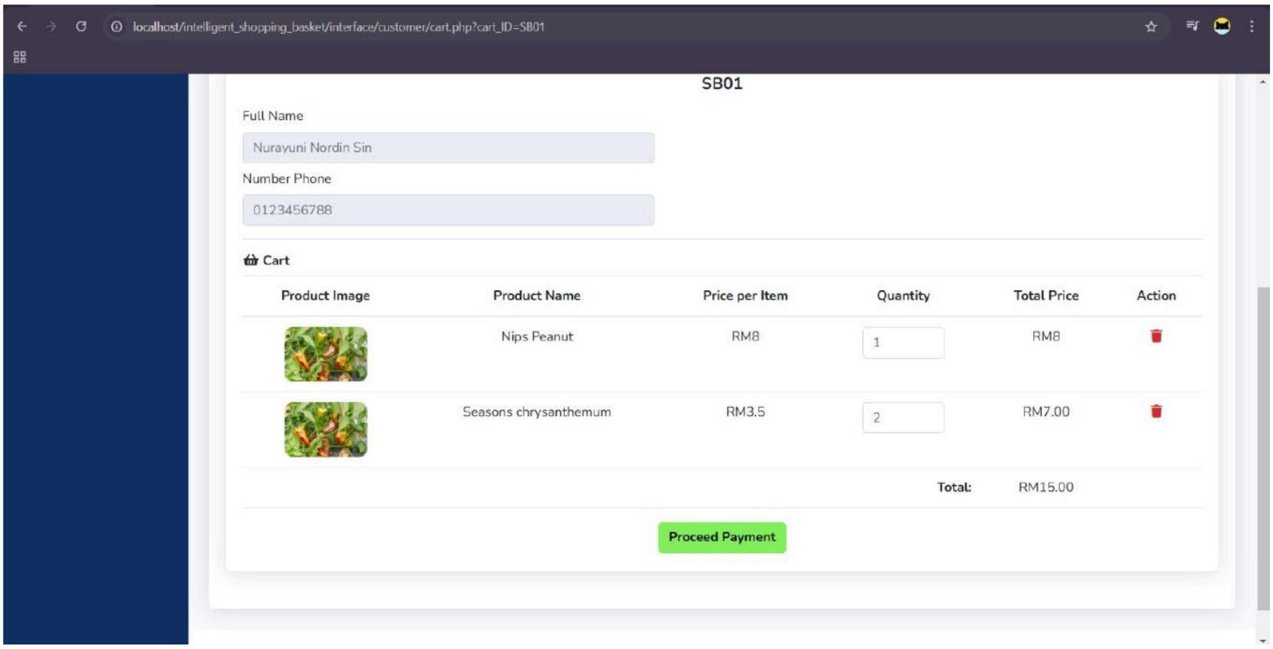

Figure 15. Cart Interface

The Cart Interface as shown in Figure 15 is a key component of the Intelligent Shopping Basket (ISB) system. It is designed to present users with a structured and comprehensive overview of the items added to their shopping cart. This interface enables users to review, modify, and confirm their selected items prior to initiating the payment process. It is a central point for managing transactions. It consolidates essential features such as product information, pricing calculations, and checkout operations within a unified platform. In addition, the functionality is enhanced since the interface incorporates token balance monitoring and access to purchase history. Thus, the users can control their payment processes and transaction records thereby contributing to a more transparent and user-centered system experience.

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The management of user system and interface is monitored by admin. Thus, the admin interface is also developed in ISB system.

Admin System

Admin Profile: The Admin Profile interface within the Intelligent Shopping Basket (ISB) system is designed to facilitate administrative access to account information and management functionalities. This interface emphasizes simplicity and usability, enabling administrators to efficiently review and update their profile details as part of the system's broader user management capabilities. This is illustrated in Figure 16.

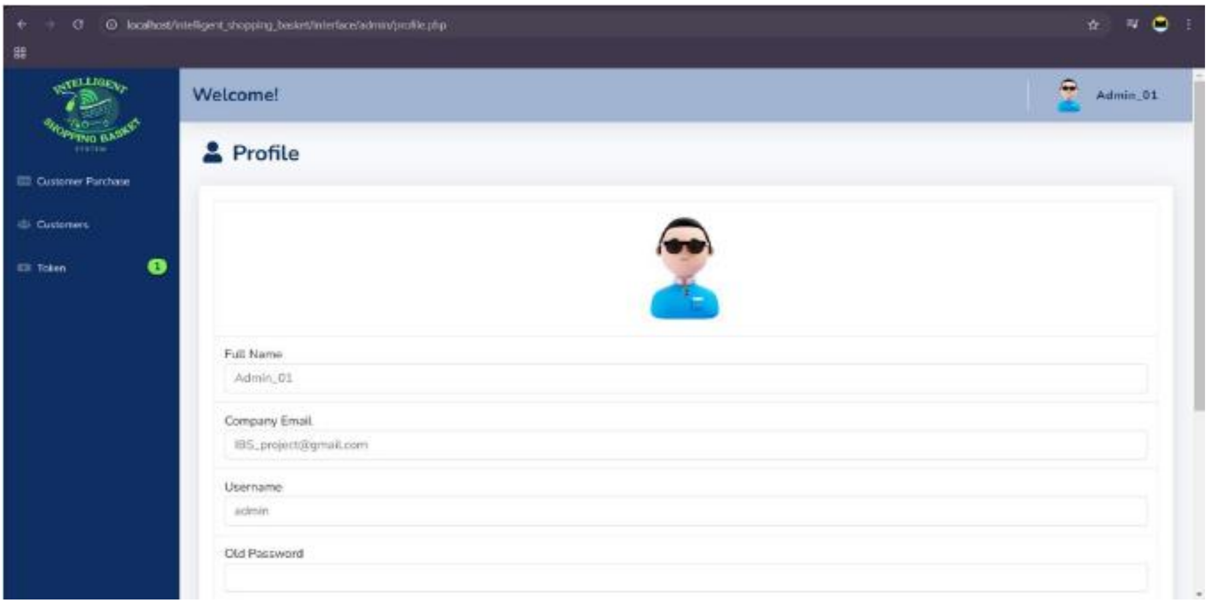

Figure 16. Admin Profile

Customer List: The Customer List interface is illustrated in Figure 17 that it constitutes a key administrative component of the Intelligent Shopping Basket (ISB) system, enabling administrators to efficiently view and manage the registry of registered customers.

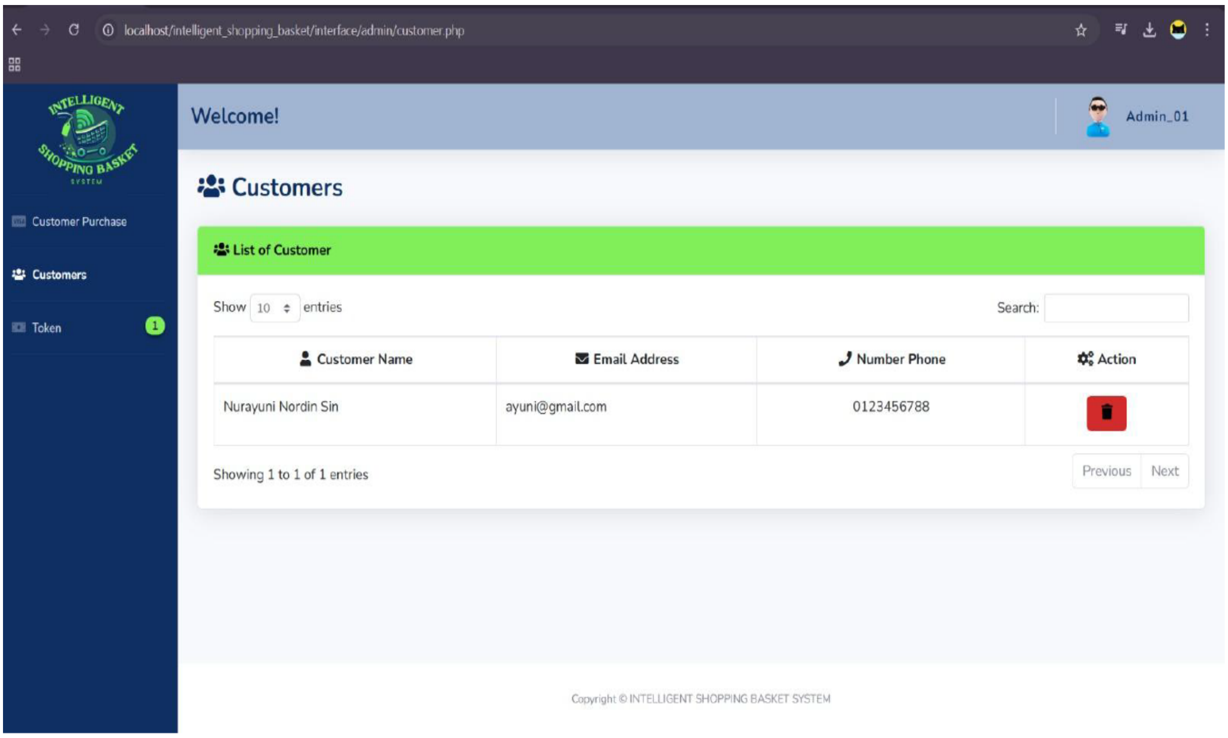

Figure 17. Customer List for Admin

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Approval Token

Figure 18 displays the window for approval token by administrator.

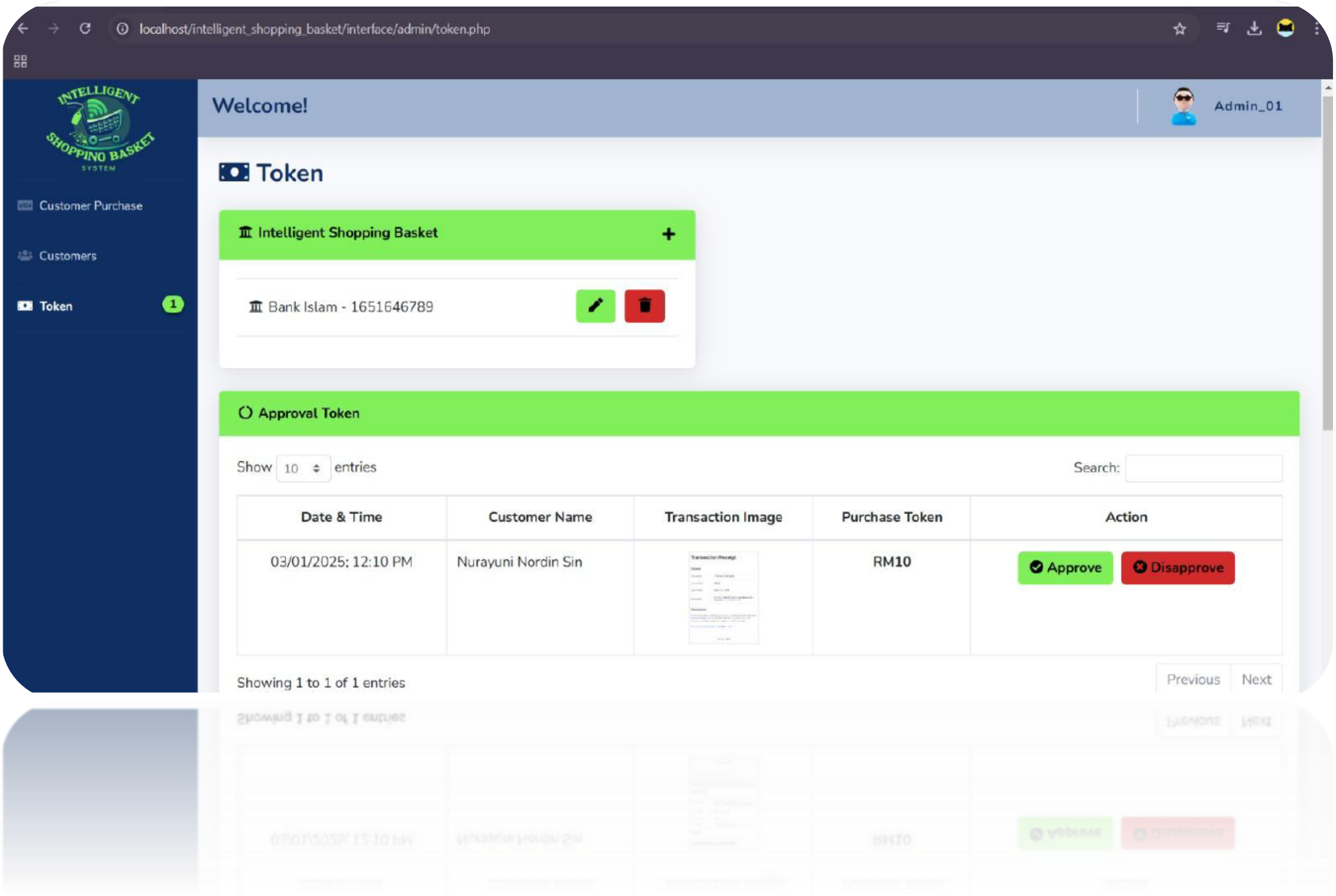

Figure 18. Approval Token

The Approval Token interface serves as a critical administrative component of the Intelligent Shopping Basket (ISB) system. It allows administrators to review and manage token purchase requests submitted by customers. This interface ensures that all transactions undergo proper verification procedures prior to being credited to the respective customer accounts. Therefore, the security and integrity of the transaction process is enhanced.

CONCLUSION

This study presents the development and evaluation of the Intelligent Shopping Basket (ISB), an automated retail system integrating machine learning, Internet of Things (IoT) and a robust backend infrastructure. The system was designed and implemented to address key functional areas, including real-time product recognition, seamless backend integration, intuitive user interface design, and cost-effective deployment. The ISB system demonstrated significant improvements in shopping efficiency. The system achieved high-accuracy, real-time product recognition and able to give immediate feedback for users because it is leveraging convolutional neural networks (CNNs) and the TensorFlow framework. The backend system is developed using PHP and MySQL. Thus, it can efficiently manage user data, product information, and transaction records, ensuring real-time cart updates and reliable purchase processing. A responsive and user-friendly interface was developed to present product and transaction details clearly to enhance user interaction and experience. The integration between the frontend and backend components contributed to overall system usability and operational coherence. The system also was implemented using low-cost hardware components, including a Raspberry Pi 4 and a standard webcam. Thus, the ISB system is suitable for adoption by small and medium-sized enterprises. In conclusion, the ISB project illustrates the practical potential of automation technologies in the retail sector. While the system successfully met its initial objectives, future work may focus on enhancing system performance, extending functionality, and improving user engagement to further increase its applicability and impact.

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