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A Smart Shopping Trolley using Machine Learning

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***Abstract*—Over time, supermarkets have emerged as an important place to visit for us to buy our day -to-day essentials. We all desire to have a peaceful shopping experience, but nowadays supermarkets often get crowded, resulting in long queues at the billing counter. This paper introduces an innovative solution to offer customers a hassle-free shopping experience. In this model, we use machine learning to identify the products as they are put in the cart, and at last, the bill is generated and payment is done with the customer's rechargeable RFID card. Once the payment is successful, the bill is sent to the customer's email. This model uses a Raspberry Pi 4 model B, the Edge Impulse platform to build the machine learning model, a 16x2 LCD, a Raspberry Pi camera module (5 MP), a MFRC-522 RFID, three push buttons, and a power supply (20000mAh power bank). Edge Impulse Studio is a platform used to develop the machine learning model. This machine learning model aims to identify the product using a Pi camera as it is dropped into the shopping cart. This machine learning model has achieved a precision score of 76.5% and an accuracy of 81% to 90%. This strategy intends to simplify the billing process by reducing time at the counter and simplifying transaction tracking through email receipts. This paper discusses the intricate hardware-software implementation.**

Keywords- Raspberry Pi, Edge Impulse, machine learning, supermarket, LCD, RFID

I. INTRODUCTION

In our daily lives, we are all habituated to visiting supermarkets to purchase our groceries. In supermarkets, we load up on the essentials in a cart or basket before heading to the checkout area [1]. Nowadays, supermarkets entice customers with discounts and promotions, leading to overcrowding, particularly on weekends, causing long lines at checkout counters. Billing at supermarkets requires us to wait in long lines to finish the billing procedure, which is time-consuming and includes scanning the barcodes of every product at the checkout counter. Minimizing the time spent at the checkout counter will simplify the purchasing process, making it more convenient and efficient. By utilizing technology more efficiently, people hope to reduce these tasks.

In this smart shopping model, a shopping cart is connected to a system that uses the Edge Impulse tool to identify products by machine learning and an automated billing system with a RFID system to complete the payment. The automated billing system comprises an LCD, a

5MP Pi camera module, and a Raspberry Pi 4 model B. Push buttons are utilized for adding products, deleting products, and generating the bill. The machine learning model is built using the Edge Impulse Studio tool and downloaded on the Raspberry Pi. As the customers show the product to the camera module, it is recognized and included in the bill. Additionally, the quantity of a specific product that is already in the cart can be increased or decreased. Once the customer has completed their purchase, they are required to press the push button to initiate the billing process. To complete the transaction, they are instructed to position their RFID card on the RFID reader. Once the payment is successful, the bill is mailed to the customer. This model makes the shopping process faster, and people can track their purchases as bills are sent to their mail ID.

II. RELATED WORK

Supermarkets currently operate on a paradigm where customers gather the necessary items, and the cashier scans each item's barcode to produce a bill at the checkout counter. This process is time-consuming, as the counters get crowded and scanning all the products by the cashier takes time. The most recent smart store launched in some parts of the US and UK by Amazon – 'Amazon Go', which is cashier-less and partially automated by AI, it combines computer vision, deep learning, and sensor fusion [5].

T. K. Das et al. use RFID reader to scan products instead of a barcode scanner, Arduino, LCD, and ESP8266 Wi-Fi module. In this paper, the proposed system makes use of a database to store product details, and all the items in the supermarket should be attached to RFID tags [1]. M. Sanap et al. use an ATmega 16 microcontroller, RFID reader to scan products, and XBee ZigBee S2D. Here, RFID tag needs to be attached to all products for product identification [2]. S. R. Rupanagudi et al. use FPGA to devise an effective strategy to assist customers in identifying the product location in the supermarket with web camera assistance [3]. Kowshika. S et al. use a Raspberry Pi and RFID to scan products, and a load cell is attached to the bottom of the cart. Here, the billing process is carried out in a mobile application [4]. B. Kumar Yadav et al. proposed a system that use RFID system to identify the items, and the bill generated in the cart is given to the customers at PoS counters [8]. A. A. Bita et al. use RFID, barcode scanner, and Arduino nano. In addition, it uses a Wi-Fi module for synchronizing mobile application, where mobile application is used for paying the bill [5]. S. Nithya Priya et al. aims to create a model that can guide customers through the supermarket and assist them, and they also propose deep learning to identify the products as they are dropped in the cart (auto billing) [6].

Using the RFID technique to identify the products would be a tedious process, as attaching RFID tags to all products in the supermarket is both time-consuming and laborious [6, 7]. So, using a machine learning model to identify a product would be a better alternative, as it is simple and easy.

III. PROPOSED MODEL

A. *Block Diagram*

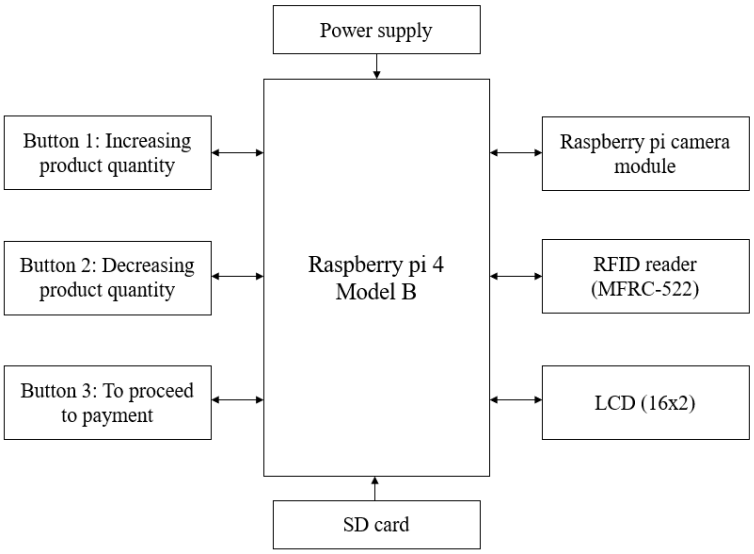

Fig. 1. Block Diagram

1) Machine learning model developed using Edge Impulse Studio

Edge Impulse Studio enables developers to generate and enhance solutions utilizing real-world data, thereby establishing a precedent for the future of embedded machine learning. It simplifies and accelerates the creation, deployment, and expansion of embedded machine learning applications, providing significant benefits to various industries. For high dimensional data such as images, Edge Impulse uses a dimensionality reduction algorithm to project high-dimensional input data into a 3-dimensional space known as UMAP (Uniform Manifold Approximation Projection). Model performance can be assessed by the precision score and accuracy. *Precision score represents the percentage of correctly predicted positive cases,* and accuracy represents the percentage of total correct predictions.

Our model uses image processing and object detection learning block. Our implementation of the model is done for four products: Fevicol, vim, parachute oil, and 50 50. Around 50 images of each product are fed to the model, out of which 80% are considered for training and the remaining 20% for testing.

The MobileNetV2 SSD FPN-Lite 320x320 model is used to train the model. With a number of training cycles of 70 and a learning rate of 0.01, we obtained a precision score of 76.5% and an accuracy of 81% to 90%. After which, the model is linked and downloaded on the Raspberry Pi.

2) Automatic billing system

The automatic billing system utilizes a machine learning model to recognize products placed in the shopping trolley through a Raspberry Pi camera module (5 MP) attached to the Raspberry Pi's CSI interface. A 16x2 LCD is utilized to provide the consumer with product information and additional instructions. Three buttons are connected to the Raspberry Pi: button 1 is used to increase the quantity of the product if it is already in the cart; button 2 is used to decrease the quantity of the product if it is already in the cart; and button 3 can be pressed to proceed with payment. MFRC-522 RFID is used to ease the payment of the bill. For paying the bill,

MFRC-522 RFID is used, and if the payment is successful, the bill is sent to the customer's email immediately.

B. Model Description

As the model starts, the customer is instructed to hold the product in front of the Pi camera for a few seconds while the machine learning model identifies the product. To increase the accuracy of the model, the system is coded such that the product is included in the bill only if its precision score is above 85%, and then the corresponding product details are displayed on the LCD. To increase or remove a product already in the cart, the product should be shown to the Pi camera, and the quantity of that product can be increased or decreased by pressing button 1 to increase the quantity and button 2 to decrease the quantity. If shopping is over, the customer can press button 3 and then place the RFID card on the reader. The bill amount will be deducted from the customer's RFID card. In case, the RFID card has insufficient balance, the process is paused until the card is recharged and scanned again. After successful payment, the bill will be mailed to the customer's email ID, where they can view the products purchased and the remaining balance in their RFID card. This feature helps customers keep track of their shopping bills. RFID card can be recharged at the store. All the bills generated are stored in the supermarket's database as well, which helps keep track of the stock in the supermarket. Fig. 2, represents the stepwise working of the model as a flow chart.

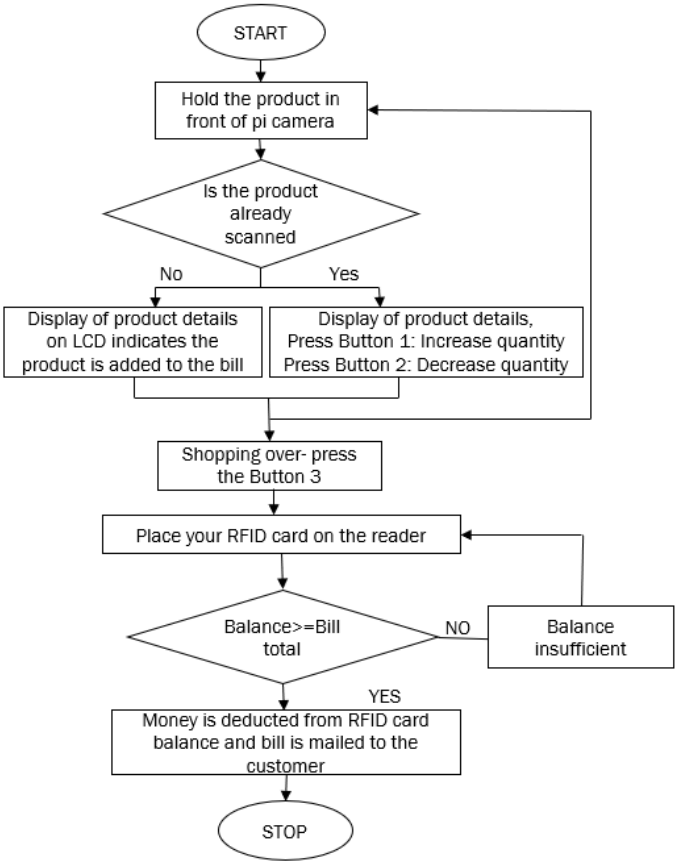

Fig. 2. Flow chart

IV. RESULTS

The coding for this model is done in Python on the Raspberry Pi. The machine learning model is downloaded on the Raspberry Pi and integrated into the code. The machine learning model is developed on an Edge Impulse platform; the obtained precision score is 76.5%, and the accuracy is 81% to 90% as shown in Fig. 3 and Fig.4. The hardware setup and results are shown below.

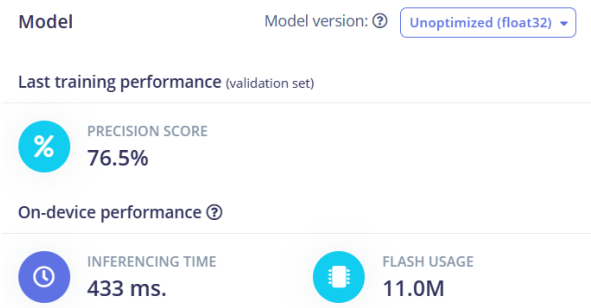

Fig. 3. The model's precision score

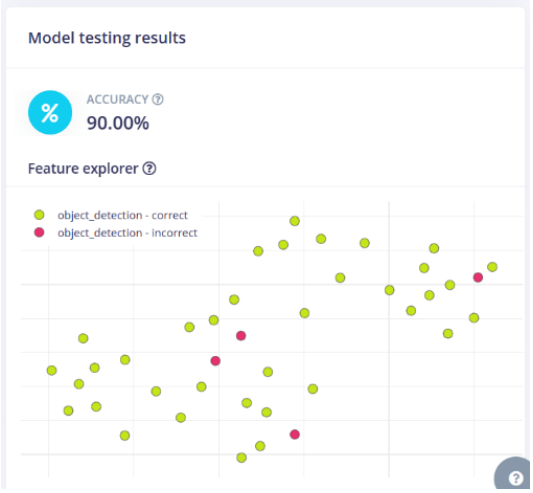

Fig. 4. The model's accuracy

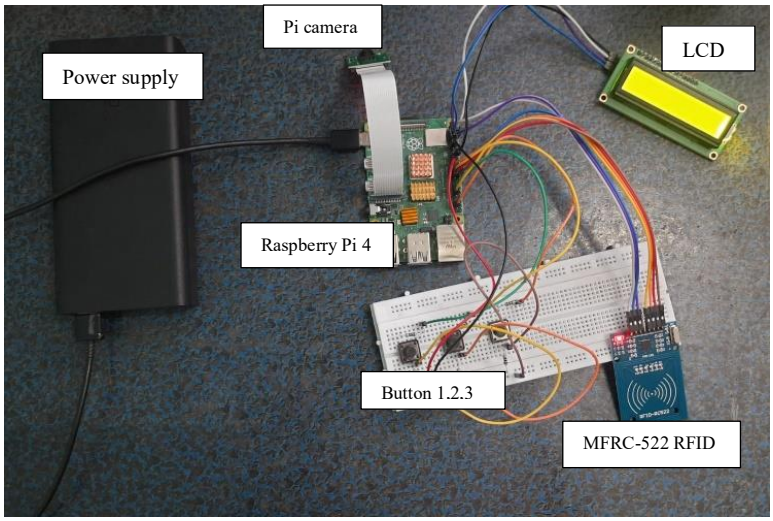

Fig. 5. Hardware setup

Fig. 6. Hardware setup in shopping trolley

Fig. 7. Product details

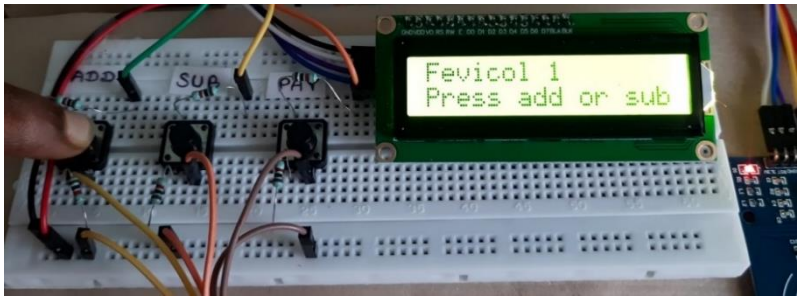

Fig. 8. Changing product quantity

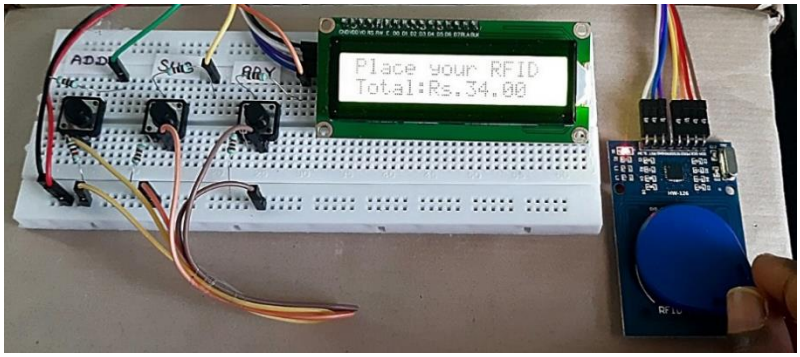

Fig. 9. Payment process

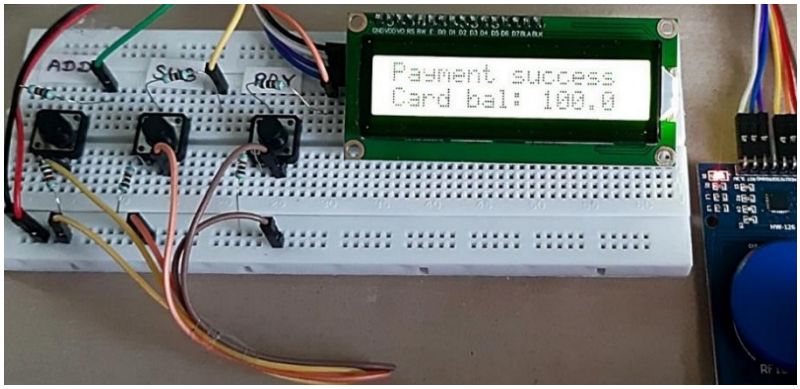

Fig. 10. Card balance

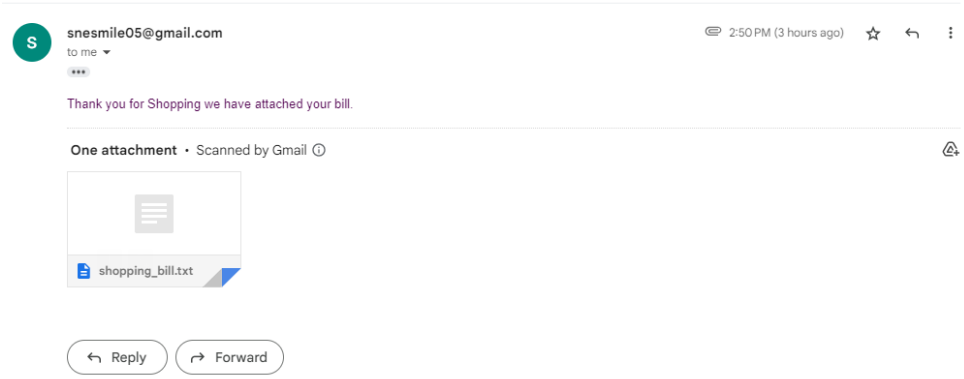

Fig. 11. Mail sent through gmail

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          WELCOME TO SMART SHOPPING

Date: 01-05-2024          Time:14:50:20
Email ID: sr6559@srmist.edu.in

PRODUCT_NAME          QUANTITY    PRICE       TOTAL_PRICE
 50 50                 1           8.0         8.0
 parachute oil         1           7.0         7.0
 Fevicol               2           5.0         10.0
 vim                   1           9.0         9.0

Total:34.0
Card balance:100.0
```

Fig. 12. Shopping bill

The hardware setup for the model is shown in Fig. 5. It includes a Raspberry Pi 4 model B, a 16x2 LCD, a power supply, a RFID (MFRC-522), push buttons, a breadboard, and jumper wires. In Fig. 6, hardware is set up in a shopping trolley. Fig. 7, shows the LCD output as the product 'vim' is shown to the Pi camera. In Fig. 8, the LCD output instructs the customer to press a push button to either increase or decrease the quantity of the product 'Fevicol' as it is already in the cart. Fig. 9, shows the LCD output when the 'pay' button is pressed to proceed with billing. Fig. 10, shows the LCD output of the payment being successful and the card balance, after which the customer receives the bill through his or her email. Fig. 11, shows the bill mailed to the customer. Fig. 12, shows the shopping bill.

V. FUTURE SCOPE

This smart shopping trolley provides an ideal mechanism to improve the shopping experience by integrating machine learning for product identification, an automatic billing system, and RFID for payment. Additionally, integrating a technique to guide the customers through the shop would enable the customers to locate the products easily. In this model, customers' RFID cards can be recharged at supermarkets; enabling an online portal to recharge the customer's RFID card would be beneficial.

VI. CONCLUSION

This paper presents a smart shopping trolley using Raspberry Pi, machine learning (Edge Impulse), a Raspberry Pi camera module, a 16x2 LCD, and RFID technology. The system is designed with machine learning technology using the Edge Impulse platform (precision score: 76.5% and accuracy: 81% to 90%), which allows accurate product identification and speeds up the billing process, thus enabling automatic billing. Payment is done through the customer's RFID card, and the bill is sent to the customer's email.

This system helps to avoid long queues in supermarkets, manages the budget of the customer, and also helps to keep track of purchases as customers can view bills in their mail. Additionally, it reduces the workload of supermarket employees.

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