Developing the Smart Basket: Smart Shopping Basket and Shopping Behavior Analysis

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***Abstract*—Smart shopping baskets with IoT technology transform the retail experience by bringing efficiency, personalization, and convenience. The smart baskets are equipped with a tablet, barcode scanner, and powered by a Raspberry Pi microcomputer that allows for real-time identification of products and seamless communication with the store's central system via Wi-Fi or Bluetooth. This combines with an IoT platform to make the management of interactions between the smart baskets and the store servers seamless, therefore making the process of shopping straightforward. The shopping basket can reflect real-time integrated update for shopping lists, and it is possible for automatic billing where wireless data transfer does away with check out lines. The predictive analytics model of the system uses the real-time data and algorithms, such as the Apriori algorithm, which optimizes its inventory management via analysis of customer shopping patterns and behavior for targeted promotions and personalized recommendations by reducing overstock and stockout. By addressing the frequent issues of long queues for checkout, products that customers are unable to find on the shelves, and slower service, this innovative merging of IoT and predictive analytics makes shopping intuitive, efficient, and enjoyable for customers while generating increased sales and operational efficiency in the case of retailers.**

***Index Terms*—Item detection,Smart basket,Smart shopping system ,RFID tags,RFID reader,Shopping trolley,Product tracking,LCD screen,Real-time updates,Product info ,Total amounts,Delete items,Rescan product tag,Payment ,UPI system ,Seamless checkout,Efficient checkout**

I. Introduction

A. Introduction to IoT

The term ”Internet of Things” (IoT) refers to a network of connected, web-connected things that may gather and transmit data across great distances without the intervention of a human. The moment anything is connected to the web, it's assumed that it can both send and receive. Thus, the ability to both send and receive data makes it ”Smart.” Our system likes to predict the interest of the customer based on the previous purchase data from customers and with the help of loT, our system likes to track every item purchased and wants to provide item information and important details on a customer's mobile device.

B. Introduction to Project

A shopping center is the place where the people get their daily essentials, varying from foodstuffs, clothes, electrical appliances, etc., where the issue with customers arises in terms of lack of information regarding the product that is being sold and wasting unnecessary time at charging counters. In several cases, there are problems that arise due to lack of complete information about a certain product, and a person has to stand in lines or queues at charging counters. From now onwards, the traditional charging scheme has to be developed to make the search quality for customers better. In this scheme, items' price-related information and also the whole cost of the item will be available to the customer. Time in malls is going to be saved through this scheme. All the filtered items are automatically displayed in the GUI, thereby thus only reducing turn-around time. One of the fantasies that every customer envisions of fast and easy bill payment in the supermarket. So we will propose a ”SMART SHOPPING CART” here we will utilize an RFID sensor. The main target of loT is to screen individual items and the environment wirelessly. This introduces electronic tags connected with individual items. This reads the stored data of the object wirelessly in which time these tags come within the reach of the reader called RFID innovation. RFID plays a very significant role in using IoT. It consists of three parts, for instance, RFID tags attached to the object that carries personality or information about an item, RFID Reader reads the tags. The most significant use of RFID technology is to trace the item. In addition to that, all these are controlled by the microprocessor ”Raspberry Pi 5” which will load and process the data and to predict the upcoming product trends, and in terms of customer perspectives it will also provide a recommender system.

II. Problem statement and objectives:

A. Problem statement:

Modern retailing confronts long bill wait times, inappropriate demand estimation, and misuse of inventory stock. The possible causes are that of stock outs, over stock, and even customer dissatisfaction. Purchase patterns or trends cannot be known, and so this affects recommendation and cross sell. Historical information is not rightly used to build decisions based upon data. In this regard, the problems referred to above will have to be met to ensure healthy customer experiences with sustainable growths.

B. Proposed solution

The proposed solution introduces an advanced ”Smart Basket” system, which is intended to revolutionize the shopping experience and improve operational efficiency. The smart basket is equipped with RFID readers and RFID tags that help in real-time identification of items and tracking in case of products added in the basket. It uses the microcontroller Raspberry Pi 5, ensuring high process efficiency and robust integration abilities. For scalability and adaptability, NFC tags will be used as secondary identification elements. The solution uses the Apriori algorithm in three important areas: first, it helps to analyze historical purchase data with precision in terms of product demand and optimize the management of inventory; second, it helps to enable a recommendation system suggesting complementary products based on the behavior of customers, thus enhancing cross-selling opportunities manifold; and third, it implements a content-based recommendation system suggesting products that have similar attributes or characteristics. For example, if a customer has bought a particular product, the system will recommend other products that will probably be of interest to that customer based on past purchasing patterns of customers. Introducing these technologies together, the Smart Basket aims to eradicate billing delays while providing a very personalized shopping experience and equipping retailers with a data-driven platform for decision making. This integral approach not only enhances customer satisfaction through intelligent recommendations of products but also deals with inefficiencies related to inventory and checkout processes. This helps promote profitability and sustainable growth for a business in modern retail.

C. Proposed objectives

1) Objective 1: : Smart Basket Construction: The first objective relates to the developing of the infrastructure for the physical implementation of the ”Smart Basket” system, using a basket with RFID tags, RFID readers, and Raspberry Pi microcontrollers as the center controller. Also, a graphical user interface will be developed to integrate products in order to track them and manage things put in the basket in real time.

2) Objective 2: : Content-Based Recommendation System: The second objective is to design a software system that has a content-based recommender. This system will scan through the products purchased by the customer and give related or complementary products based on the purchase history and features of the products. This feature will enhance the shopping experience as it will give the customers recommendations that are personalized, thereby increasing additional sales.

3) Objective 3: : Content-Based Prediction System: The third objective is to apply a Non Negative Matrix Factorization (NMF) based Collaborative Filtering (CF) model to predict future product demand trends from historical purchase data. A feature of this system will be its ability to help the retailers predict product demand with more accuracy, optimize inventory management, and reduce waste by knowing which products are popular and which trends in customer taste will take off. This model can be used by businesses to improve their capability to understand and adapt to changing customer behavior dynamically.

III. System requirements and specifications:

A. Hardware components:

1) The RFID RC532 module: : For simple identification and tracking of items, the RFID RC532 module is fundamental to smart shopping systems. The module uses Near Field Communication technology to scan tagged products left within the basket in real time, and high-speed data transmission along with a reliable read range, to detect added and removed items without loss of data transmission. The RC532 works with central processing unit like the Raspberry Pi to simplify inventory management while cutting down on manual intervention. Automation and precision improves the overall shopping experience with this efficient and cost effective solution.

IV.

Fig. 1. RFID RC532 Module

1) The 13.56Mhz NFC Card : RFID cards running at 13.56 MHz complement smart shopping basket system for user identification and authentication. With the cards they perform a secure and efficient login enabling users to start their session by scanning the card on the NFC reader. After login(if successful), it lets users add products to the basket, as well as personalized tracking and billing. This integration of RFID cards is perfect, very secure, no unauthorized usage and simplifies the shopping process. Combining this RFID technology into the system has promoted the fastest, most reliable and easiest method for arranging the retail experiences in the present times.

V.

Fig. 2. NFC 13.56Mhz Card

1) The role of Raspberri Pi 5 : The Raspberry Pi 5 with 8GB of RAM model is the main central processing unit as well as the core component of the smart shopping basket system. It is used as the main processor of the program and processes all data including adding and deleting products, real time operation and user interaction. The display system is supported by Raspberry Pi as well, which informs the product details, billing and personalized suggestions. Moreover, it processes the collected data to make predictions of the consumer trends, which are highly useful for retailers to revise the inventory and market strategies. Indeed, it is a hugely versatile and powerful module, providing a sure footed, seamless integration, robust performance and sophisticated analytics which is the corner-stone of the entire system.

VI.

Fig. 3. raspberry-pi-5-8gb-top

1) LCD Touchscreen 5inch Display : A key part of the smart shopping basket system is the 5inch LCD touchscreen display, intended to enhance user interaction of the interfaces. As the main interface, it gives real time updates on what products are being added or removed, running and displaying the total bill as it changes. There is also a screen on which user is authenticated by means of a login and logout feature that provides a personalized shopping. Furthermore, it improves the engagement of users by displaying personalized product recommendations which are associated with user's different tastes and buying habits. This user friendly and interactive backend process display appears to be smooth and efficient shopping journey.

VII.

1) RFID 13.56Mhz Stickers : RFID 13.56Mhz stickers are an integral part of the identification and tracking of the products to be used in the smart shopping basket. The information on these stickers—on individual products—are what already has already been pre-programmed with the product ID, name, and price, after which you can stick them to products. When that product falls within an RFID module's range the system automatically detects and adds it to the virtual shopping basket

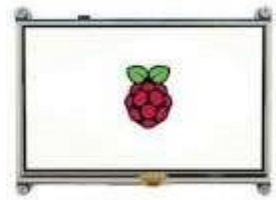

Fig. 4. 5Inch Display

updating the bill in real-time. The same is applicable when a product is not available because we know when a product is removed too, the absence of that sticker is detected as well as deductions from the virtual basket, which means it is always in sync with the actual inventory data and it frees the human experience from so much human intervention and becomes so efficient within the system.

VIII.

Fig. 5. NFC 13.56Mhz Stickers

A. Software stacks:

1) Programming Language and Framework : It is implemented with Python, a popular flexible programming language famous for being simple to use and having data handling, machine learning and system integration capabilities. The scale and efficiency qualities of Python are very well suited for defining complex solutions by its vast library collection.

2) Data Processing and Storage : 1. Pandas: The data is stored in CSV files referred to by "userpurchases.csv" and "interactionlog.csv" and are handled and processed with the help of this Python library for preprocessing. It cleans data, makes it ready to manage missing values and makes the interaction values readable for model training. It also enables

converting unprocessed purchase logs into user item matrix, a fundamental component for recommendation algorithm.
2. CSV Files: In this project, user purchase interactions and timestamps data are stored in CSV files and contain product details. These files are a database in trainable machine learning models and shopping tracking.

3) Machine Learning and Recommendation Engine : 1. Collaborative Filtering Algorithms

Singular Value Decomposition (SVD): The above algorithm works for identifying latent relationships between users and items based on factorizing the user item interaction matrix. Personalized recommendation system works based on SVD, which predicts the products users may want to buy when they look at the history.

o Non-Negative Matrix Factorization (NMF): This technique is used for predicting trends in items to which users are currently looking at. By being able to both maintain non-negative constraints and be interpretible, it is suitable for analyzing interaction scores.

2. Surprise Library: This library for building and evaluation of recommendation systems is specifically written in Python. It supplies SVD, and NMF algorithms' implementation tools, as well as splitting, training, and predicting functionality.

4) Evaluation Metrics : a) Root Mean Square Error (RMSE): The recommendation and trend prediction models are evaluated using this metric. RMSE helps you fine tune the model with the help of measuring disparity between the predicted and actual values.

b) Training and Testing Split: Having an 80-20 dataset split means that the models are trained on historical data and validated on non training data splitting to not overfit and improve generalizability

5) Payment Integration : The system works with Unified Payment Interface (UPI) platforms like Google Pay and PhonePe. With these digital payment systems, we can carry out secure and sophisticated transactions without any hassle in checkout.

6) Key Features of the Software Stack : • Dynamic and Real-Time Updates: As users add or remove items, the recommendation engine and shopping basket details are being updated continuously. • Cold Start Handling: Default recommendations based on popularity or content based filtering are used for new users and new items. • Data Logging: Interaction log (interaction log csv) allows history of every user action to be saved and themselves analyzed and later improved the system.

B. Tools and technologies identified

1) Hardware and Embedded Technologies : RFID Technology: 1. RFID Readers: In shopping trolleys to scan product tags and user login cards. 2. RFID Tags: Stores product info and user credentials on each product and user smart card.Being mounted on shopping trolleys to provide real time updates in basket contents, total costs product recommendations.s Used for user authentication by scanning with RFID readers.ded Technologies 3. LCD Screens: o Mounted on shopping trolleys to provide real-time updates on basket contents, total costs, and product recommendations. 4. Smart Cards: o Used for user authentication by scanning with RFID readers.

2) Software Tools and Technologies : RFID Technology: 1. RFID Readers: In shopping trolleys to scan product tags and user login cards. 2. RFID Tags: Stores product info and user credentials on each product and user smart card.Being mounted on shopping trolleys to provide real time updates in basket contents, total costs product recommendations.s Used for user authentication by scanning with RFID readers.ded Technologies 3. LCD Screens: o Mounted on shopping trolleys to provide real-time updates on basket contents, total costs, and product recommendations. 4. Smart Cards: o Used for user authentication by scanning with RFID readers.

3) Software Tools and Technologies : 1. Programming Language: - Python: Clear syntax being selected for, one with broad selection libraries that support data analysis, machine learning and data visualization.

2. Data Processing and Storage: - Pandas: Used for efficient data manipulation, cleaning, and preparation.
- CSV Files: Used to store user purchase records (user$_p$*urchases.csv), interactionlogs, andtrainingdatasets.*

3. Recommendation Engine: - Collaborative Filtering Techniques: - SVD (Singular Value Decomposition): Used to made personalized product suggestions. - NMF (Non-Negative Matrix Factorization): It is used for identifying trending items. - Surprise Library: A tool that implements different collaborative filtering models, and its performance is therefore evaluated based on RMSE, for instance. 4. Visualization Tools:
- Matplotlib: It is used to map through graphs like bar charts, etc to visualize trending products.

5. Evaluation Metrics: - Root Mean Square Error (RMSE):Used to evaluate the precision of the recommendation algorithms.

4) Payment and Integration : 1. Unified Payment Interface (UPI): o Digital payment platforms like Google Pay and PhonePe for seamless and secure checkout processes. 2. Real-Time Updates: o Dynamic integration between the RFID reader, recommendation system, and LCD displays to ensure updated information after every scan.

5) Machine Learning and Algorithmic Approaches : 1. Collaborative Filtering: o Utilized for analyzing user-item interactions and generating recommendations. 2. Cold Start Handling: o Techniques like content-based filtering and popularity-based recommendations for new users or items. 3. Feedback Loop: o Continuous data logging and model refinement using real-time user interactions.

6) System Architecture and Integration : 1. Real-Time Basket Management: o Dynamic updating of basket contents and costs on the trolley's LCD screen as items are added or removed. 2. Trend Prediction Module: o Aggregating user interaction scores to identify and display trending items.

7) Key Functional Features : 1. Dynamic Recommendations: o Updating product suggestions in real-time based on shopping patterns. 2. Error Handling: o Displaying error messages for invalid scans or system issues. 3. Data Logging and Continuous Learning: o Logging user actions (interaction$_{l}$*og.csv*)*andrefiningmodels with this data.*

IX. Architecture:

The smart basket system begins with the customer logging in using their RFID tag, which serves as their unique identifier. Upon scanning the RFID tag, the system verifies the user by matching it with the user database. If the user is successfully authenticated, their username is displayed on the LCD screen, and they can begin shopping. Each product in the store is tagged with an RFID label having details of the product, which includes the name, price, and other relevant information. The shopping trolley also has an RFID reader inside it, which scans the RFID tag of the product when the customer puts that product into his cart. The RFID reader sends the product details to the system, which retrieves the name and price from the database, adds the item to the customer's basket, and updates the total cost. This total is continuously displayed on the LCD screen in real-time, allowing the customer to monitor their purchases. If the customer decides to remove an item from their basket, he just scans the RFID tag of the product again. The system verifies the item in the basket and subtracts its price from the total cost. The updated basket and total cost are then displayed on the LCD screen. When the customer finishes shopping, he goes ahead to checkout by scanning the checkout RFID tag. The system checks whether the basket is empty or not; if it's not empty, then it will calculate the total cost of the order and display on the LCD. Then comes the part of choosing payment, after which the system will interface with UPI-based payment options like Google Pay or PhonePe. Once the payment is successful, the contents of the basket are saved to a CSV file named user purchases csv file , along with the user's ID and timestamp, and the basket is cleared for the next transaction. In the background, the recommendation system is working. As the customer adds or removes items, real-time product recommendations are created based on the customer's purchase history and the basket. The collaborative filtering model, particularly SVD, predicts what the customer will want to buy next. The recommendations are shown on the LCD screen and changed as the customer interacts with his basket. The system defaults to giving popular products or using content-based filtering methods based on product features for new users or those with very limited purchase histories. All interactions during the process are logged in interactionlog.csv to track which products were added or removed and when. This data is used to train and refine the collaborative filtering model, which continuously learns from user interactions. This will be taken care of in case of new users or new items without a purchase history, and the system gives default recommendations based on popular items or item attributes. This will improve with more data over time.Later using the collaborative prediction algorithm for the prediction purpose where we predict the trend of individual objects which will be in high trend and which will be in low trend. The system adds and removes products and finally ends the purchase itself. All the manual entry is excluded, and thereby the amount of time being spent on checkout is minimal, resulting in a smooth, effective, personalized experience in shopping. The recommendation of actual products in real-time allows for relevant things to be given to the customer every time, which facilitates a smoother, more intuitive shopping experience. All the purchase data and recommendations are logged and saved so that the system can continuously be improved.

X.

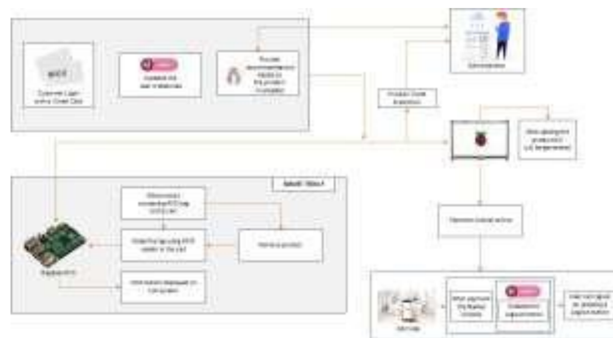

Fig. 6. Final Architecture Diagram

XI. Implementation

A. User login via RFID

A customer is provided with an RFID tag, which is used by him to login to the system.The RFID Tag attached to the trolley is read by an RFID reader to authenticate user for shopping in the system.The RFID tag to the products in the store and it is unique with product information.RFID reader is located in the trolley that scans the tags of products added into or removed from the cart.The trolley is equipped with an RFID reader that scans the tags of products being added to or removed from the cart.

B. RFID reader for product scanning

The store has an RFID tag for every product, with unique product information.The trolley is equipped with an RFID reader that scans the tags of products being added to or removed from the cart.Once a product is scanned, its details including name, price, and description are fetched from the server.

C. Displaying the product information

The trolley is engineered to be hooked on to the trolley mounted LCD screen with product information and the updated price of the product the trolley displays with.This display is actually updated in real time, as the items are added and subtracted from the basket.The details of each product are added to the shopping basket every time a product is scanned.ted LCD screen with information on the product it displays with the updated price as well. This display actually is updated in real time while the items are added and subtracted from the basket.

D. Up-dating the Basket

Every time a product is scanned, its details are added to the shopping basket. When a product is removed then the same item from the basket is deleted.Total cost changes dynamically as items are added or removed.It is made through a Unified Payment Interface such as Google Pay, PhonePe etc. When the system has confirmed payment, the customer receives a receipt.reen with information on the product it displays with the updated price as well.It is made through a Unified Payment Interface such as Google Pay, PhonePe etc.This display actually is updated in real time while the items are added and subtracted from the basket.

E. Checkout process

Once all items have been scanned and the basket is updated, the customer proceeds to the checkout.Payment is made through a Unified Payment Interface like Google Pay or PhonePe.After payment, the system confirms the transaction and issues a receipt to the customer.

F. Removing the items from the basket

The customer would then scan the RFID tag of the product again to remove an item from the basket.When o is triggered, the system makes a request to the server to delete the item, the total price is reupdated and the LCD screen is updated respectively.Once the pay for the transaction is then made through, the system generates proof that a transaction went through perfectly well.It allows QR code generation when opening an exit out event or even at will.more.This triggers a request to the server to delete the item, and the system updates the total price, reflecting the change on the LCD screen.

G. Transaction confirmation

Once the pay for transaction has been conducted through, the system generates proof that a transaction had gone on perfectly well.Provides for QR code generation during an exit out should there be a store type mechanism with it, or even freely goes off.

H. User Data Collection and Purchase History:

The system collects and logs user interactions with the smart basket, including the products added or removed from the basket.
When the user scans the RFID tags for products are stored in userpurchases csv file, along with product details (name, price), user ID, and timestamps. This purchase history is important for building personalized recommendations for each user.

I. Feature Extraction for Items:

Each product is associated with certain features such as category, brand, and price.
These features are stored in a product database, and they will be used to determine the similarity between products for recommendation purposes.

J. Product Similarity Calculation:

The content-based recommendation system calculates the similarity between products based on their features (e.g., using cosine similarity or other distance metrics).
The system evaluates which products are most similar to the ones a user has previously purchased or added to their basket.

K. Generating Recommendations:

As the user interacts with the smart basket (adding or removing items), the system updates the user's profile and suggests similar items.
The system selects the top N products that are most similar to those already in the user's basket and presents them as recommendations on the LCD screen in real-time.

L. Real-Time Display of Recommendations:

The recommendations are displayed on the LCD screen of the trolley as the user adds or removes items.
The system ensures that the recommendations are updated dynamically with each new interaction, displaying products that the user may be interested in purchasing next.

M. Feedback Loop and System Refinement:

The recommendation system learns from user interactions. If a user consistently adds items from specific categories or brands, the system gives more weight to those features for future recommendations.
This feedback loop improves the accuracy of recommendations as more data is collected from the user's shopping habits.

N. Handling New Users and Items:

For new users (with no purchase history), the system can make recommendations based on product categories, popularity, or price range.
For new products with limited purchase history, the system uses a hybrid approach, combining content-based filtering with popularity-based suggestions to generate relevant recommendations.

O. Continuous Data Logging and Improvement:

All interactions and recommendations are logged in recommendationlog.csv for tracking purposes.
This data helps refine the system's recommendations over time, making them more personalized and effective as the model learns from user behavior.

P. Integration with Smart Basket and Checkout:

The recommendation system seamlessly integrates with the smart basket, updating in real-time based on the user's actions. During the checkout process, the final recommended items are displayed, encouraging additional purchases if relevant items are still unpurchased.

Q. Transaction and Data Saving:

Once the user checks out, the system saves the basket contents to userpurchases.csv, including any purchases made based on the recommendations.
The transaction is completed, and the system resets for the next shopping session, ensuring the recommendations are refreshed for future use.

R. Collaborative Filtering (CF):

User-item interaction matrix is factorized to find latent features of users and items.
NMF (Non-Negative Matrix Factorization) is used due to its interpretability and non-negativity constraint.

S. Evaluation Metrics:

RMSE is calculated to assess prediction accuracy.
Low RMSE indicates good model performance.

T. Trending Item Selection:

Interaction scores predicted by the model are aggregated.
Items with the highest scores across users are marked as trending.

XII. Results

A. Objective 1:

The RFID Shopping System enables a convergence between hardware and software component to improve the shopping experience. The GUI is built using tkinter and updates dynamically the total cost with the logged in user's name. The scanned item, which purports to be 'Red Label' with a price of Rs:10, is identified with RFID technology: the unique tags of the products. The system then shows how the total cost is dynamically calculated after each scan and updated immediately. In addition, the availability of CSV files for logging interactions, user purchases and recommendations implies the capacity to keep historical data and even make personalized suggestions. That is the most effective implementation that automates billing, thus getting rid of the hassle and reducing inefficiency in retail environments.

XIII.

Fig. 7. Results and Discussion

A. Objective 2:

Analysis of performance of a collaborative filtering model by RMSE measurements on a baseline of 10 training epochs. RMSE is an important measure of model accuracy; it is a way of calculating disparity between actual and predicted values and lower values indicate better performance. The data reveals a notable pattern in the model's learning progression: It is notable however that the RMSE falls sharply during the early epochs, which implies that the model learns quickly the underlying patterns present in the data. This preliminary rapid improvement is followed by a Resident Mean Squared Error that exhibits general downward trend, though with some fluctuation, suggesting a continuing but lesser degree of learning.
With the stabilization of RMSE values in the later epochs, the model has converged because it has reached to a relatively steady state of its performance. The observed fluctuations in later epochs imply interesting questions regarding the model's optimisation potential. This variation is likely an indication that the model may benefit from some extra fine tuning, like allowing to adjust hyper parameters or early stomping of the model to avoid the potential of overfitting. To potentially enhance the model's performance further, two main recommendations emerge: Then, we first conduct an experiment exploring to see whether more benefits can be gained from longer training periods that extend to beyond the current 10 epochs; and second, we perform a hyperparameter optimization to reduce the range of RMSE fluctuations in the training process. And this is a graph of the Prediction Accuracy Over Epochs of what looks like a machine learning model, but of mostly the Root Mean Square Error (RMSE) over 10 training epochs.
Let me break down the key observations:

In actuality, RMSE values plotted on the y axis (very small) represent a scale of 1e-12 (extremely small), so the overall prediction is very high. The pattern shows notable fluctuations across epochs:

1. Starting Point: The model begins with a relatively low RMSE around 1.3×10^{12}
2. Peak Points: There are two major peaks:
- At epoch 2, reaching approximately 4.0×10^{12}
- At epoch 7, reaching about 3.8×10^{12}
3. Lowest Points: The model achieves its best performance (lowest RMSE) at:
- Epoch 4, dropping to about 1.0×10^{12}
- Epoch 9, reaching similar low levels

The results indicate a variable pattern that indicates the model is stable overall (errors are extremely small) but becomes unstable during training. That more stable convergence might be realized if the learning rate is adjusted to oscillate more or less beaten but perhaps not beaten down by the error rate.

The final RMSE of about 2.2×10^{12} calculated at epoch

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10 is good performance in predicting errors with these magnitudes. The graph however has these fluctuations which may indicate there might be some room for hyperparameter tuning in order for it to perform more stable across epochs.

The Recommendation system implemented in RFID Shopping System is thoroughly studied in the report. The proposed system uses collaborative filtering as a function of Singular Value Decomposition (SVD) to make the product recommendations tailored to user activity. To this end, we evaluated on a large dataset of 100,006 interactions, which were each encoded by RFID tagged user ids and trinary data denoting whether or not a product was purchased.
A structured methodology was carried out consisting of thorough data preprocessing to handle such missing values and generate an interaction matrix. An 80-20 split of data between training and testing data, and Root Mean Square Error (RMSE) was used as the main measure of evaluation for the SVD algorithm implemented. The results were quite strong on early RMSE of 0.0000 and then result of 2.3357 × 1011, which means nearly perfect prediction accuracy.
The report acknowledged, while these exceptional results show the system is an effective tool for capturing user preferences, the possibility of overfitting.
Nevertheless, concerns of this performance on unseen test data were allayed by consistent performance there. Finally, forward looking recommendations are made, which includes implementing diversity mechanisms in the recommendations, real time model updates and contextual data, to further expand system capabilities. Using both the Surprise Library for SVD implementation via Python and Matplotlib and Pandas for data processing and visualization, the analysis was conducted.
Since this comprehensive evaluation indicates that the recommendation system is a highly efficient part of the RFID Shopping System, it sets a firm ground for development of its further improvements and extensions of the system's functions.

XIV.

Fig. 8. Result and Discussion

A. *Objective 3:*

• We found that the RMSE of the trend prediction model is 0.0593, which means that the predictions are close to the actual values
.• This low value of RMSE shows the model's can accurately identify trending items and predict future demand.Yet, the model works well in reality even with minor error, which guarantees a predictability of customer trends..
•This low RMSE value demonstrates the model's ability to accurately identify trending items and predict future demands. The model performs well in practical settings, even with minor errors, ensuring reliability in predicting customer trends.

XV.

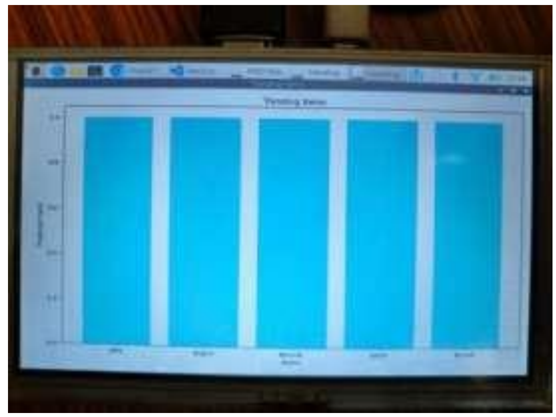

Fig. 9. Objective 3 results

XVI. Discussions:

A. *Model Performance:*

o The low RMSE highlights that the model is effective for identifying trending items and emerging customer preferences.
o However, extremely low RMSE values close to zero in earlier tests suggest potential overfitting or a small dataset size10†source.

B. *Business Implications:*

o The system helps retailers manage inventory effectively by identifying popular products and reducing wastage.
o Trending items identified by the model can also drive targeted marketing campaigns and promotions.

C. *Challenges:*

o The model may face difficulties with the cold start problem (new users or items with no interaction history).
o Scalability could be a concern for very large datasets.

D. *Future Enhancements:*

o Incorporating time-based trends and item categories can improve prediction accuracy.
o A hybrid approach combining CF with content-based filtering can mitigate cold start issues.

XVII. Conclusion

The smart shopping basket project integrates the latest technological innovations including IOT, RFID and machine learning in order to assist with billing, getting the latest offers as well as to keep track of stock levels. By using Raspberry Pi, collaborative filtering models (SVD and NMF) and UPI based payment, it makes it convenient for customers, simplifies process and optimizes technology. It deals with issues, like long checkout lines and inefficient inventory management, it also highlights issues like the cold start problem and scaling. This unique framework shows how technology can completely transform retail and create a space that is increasingly seam-less, efficient, and customer-centric to achieve smarter and, more sustainable shopping solutions.

XVIII. Literature survey

This [1] reported, this intelligent shopping basket is based upon the Bolt ESP8266, a compact Wi-Fi chip acting as the system brain. A barcode reader is embedded inside the basket scanning through unique tag barcodes with each product so that you wouldn't have any delay in having to scan manually for every product item. The visual center has an LCD module showing the name and price of the scanned item-both update live, so you can see how much you're spending. Cloud integration through the Bolt ESP8266 securely moves scanned information over while offering you a library of functions to create centralized inventory tracking. With its feature of wireless communication capabilities, it also allows efficient transfer of data which may easily be transferred to a central server wherein automatic billing automatically takes place as the items are scanned. Of course, the existing problem is its limitation in terms of removing the scanned items. Still, development might solve that. The intelligent shopping basket with Bolt ESP8266 technology gives a peep into the future shopping experience for customers and retail stores.

In their paper [2], the authors have pointed out that though supermarkets may help to collect a large number of different products at one location, long queues at checkout can make shopping frustratingly painful very soon. The paper focuses on "Shop Go," an innovative smart shopping solution based on IoT technology to overcome this pain point. Shop Go's core technology is based on **Radio Frequency Identification (RFID). Imagine tiny RFID tags attached discreetly to everything in the store, somewhat like digital fingerprints. The RFID scanners are attached to shopping carts. As you throw things into the cart, the scanner detects the corresponding RFID tag, so you don't need to scan them manually. It doesn't end there though. Shop Go is really more than the product recognition that it seems. The system used a Particle Photon microcontroller; that is basically an almost unbelievable minuscule brain that commands all the data to be sent out. That data is then relayed back into the clean and user-friendly mobile app back-end via Firebase. You can access, real time, all those items you input into your shopping list and its price tags within the application. This is where Shop Go takes it up by several notches. The system includes a Razorpay payment gateway for secure, on-the-go payments. A Dialogflow chatbot serves as your virtual shopping assistant. The chatbot can track possible purchases, offer in-store discounts, and even guide you to the place where specific items are kept within the supermarket. Shop Go's dependency on RFID technology is one of its major drawbacks. This system requires dedicated RFID tags on each product in the store for perfect working. However, this could be among the most significant barriers for widespread adoption-the initial expense of tagging every item.

In this paper [3] they approach a revolutionary approach: the 2SBC Retro-Fit Smart Cart. The innovative cart would seek to abolish constant handling of products altogether and to streamline the shopping experience completely. Imagine that with a trip to the shops you just point to items you wish to purchase, and that is taken care of. This the 2SBC cart does by bringing together product selection, bagging, and checkout in one seamless activity. The actual cart has an integrated RFID reader and scanner. Once you insert items, these devices read what those are so there is no need for scanning at the checkout. Then the information gets transmitted wirelessly with a link of Wi-Fi modules to a central database. This database fetches the pricing data and then transmits this information back to the central computer located in the cart itself, a Raspberry Pi. So you will get actual time actual prices without any shockers at the time of check-out. Concept Shopping Basket. The process inherently incorporates a bagging compartment housed within the cart itself, thus negating the requirement to do separate bagging at checkout, and again shines more light on the process. More are included in the 2SBC cart, further making things more convenient. This one comes with a special customer card featuring GPS coordinates from which you can ask the central computer to send someone over for help if you are not sure of a product. In addition, the cart itself is followed by a module that uses GPS coordinates, whose location data, in real time, the store personnel will be having, perhaps even assisting in counting or retrieving the lost carts. The 2SBC cart clearly has many pros. The reduction of redundant handling and provision of real-time data will speed the checkout process for customers, thus making it convenient for them, and an approximate cost of 100 dollars for each cart indicates that it is a cost-effective solution for the retailers. Challenges, though, will definitely arise in aspects of design and probable problems given the constant exposure to usage; before, 2SBC cart becomes vital in our supermarket. For an instance, its design must enable it to less bulky, taking aisles piled with numerous consumers and the means of passing conveniently through the most crowded aisles. Last comes the durability based on the span of usage applied.

In this paper[4] the revolutionary Smart Shopping Basket transforms our shopping experience. It offers a comfortable handsfree world from most aggravations. Using Bluetooth, it becomes your personal shopping guide. Without exerting effort, navigating crowded aisles-the basket follows your movements, hence freeing you from maneuvering a bulky cart-it is not an end to the magic; imagine skipping those dreadful lines at check-out! The Smart Shopping Basket uses the same type of RFID technology that is used in the Shop Go system. Therefore, as you fill up your basket with items, it scans unique digital tags for these items. Information regarding these items thus gets transmitted directly to the server of the supermarket so you do not have to scan products during checkout. Guess what? Your total bill pops up in your smartphone app. You just whip out your phone, select your preferred online payment app, and complete the transaction securely without waiting in line. This innovative solution doesn't end here with the aspect of convenience. The ultrasonic sensors are embedded in the basket and work like a virtual umbrella: they constantly scan for any obstacles and prevent collisions. Navigate through congested aisles without any qualms with Smart Shopping Basket-all right behind your groceries. With its huge list of pros: free hands to roam about the aisles, no billing to wait for, online secure payments, and collision avoidance, one major factor with this system that has to be considered is this: All the products in the store are carrying RFID tags. Although this technology brings many advantages, the expensive cost of an initial investment to tag every product could be the drawback for this widespread adoption of the Smart Shopping Basket concept.

Paper[5] introduces a fresh concept for intelligent shopping carts built with a focus on affordability and modularity that are relatively friendly to the retailers. It introduces a solution suitable for almost every kind of retailer, ready straight from the box without any form of amendment. The innovation's long-term aim of pleasing many sorts of customers simplifies shopping for retailers. That vision rests core on camera technology combined with AI. Unlike a standard RFID tag-based system, it uses a camera to scan images of the product that you place within the cart. It feeds the pictures into a compact Intel NCS with a pre-trained neural network to recognize them. No internet access is necessary; it works well even without access to good Wi-Fi.This paper refers to a user-friendly smart shopping cart and automatic billing system that will simplify and modernize the shopping experience. Instead of long lines before cheking out, it might replace the traditional use of the old-age carts, using modern technology equipment like sensors and RFID scanners.

This paper[6] projects the ”Design and Implementation of the Smart Shop ping Basket Based on IoT Technology,” with an aim to advance the shopping experience through smart shop ping baskets that work on automation for product scanning and billing processes. One issue that this IoT-based system addresses comes from supermarkets and malls-long check-out lines, manual billing mistakes, and delay at time of peak hours. The smart basket can basically integrate multiple technologies such as IoT framework by connecting the basket to a central server for facilitating immediate transfer of data in real time. Key components are a barcode reader, usually an Android smartphone with an application designed to scan barcodes, which read the barcodes of products and display price details on the screen of the mobile. The microcontroller, ESP8266 NodeMCU, controls the communication between the basket and cloud servers. To ensure accurate measurement in the shopping process, a weight sensor module equipped with a load cell and an HX711 amplifier validates the total weight of scanned items. The core of the system is its mobile application, through which customers can scan products, track their expenditure in real-time, and control budgets, with alerts when purchases approach a predefined limit. Data from scanned products is instantly transmitted to a cloud database via Wi-Fi, which updates the central billing system of the store, thus eliminating the need for manual item-by-item billing at checkout counters. Besides this, the weighing sensor of the basket cross verifies the scanned products so that discrepancies in billing cannot occur, hence increasing security along with accuracy. Smart shopping baskets have great advantages that include decreasing the time required in checkouts, reducing human mistakes, and saving time in purchasing products, mainly during holidays and sales events. Future developments will focus on optimizing the system by upgrading computational efficiency, enhanced security for data during transmission, and the interface to make shopping smoother and more secure. Generally, the smart shopping basket is an example of how IoT can take the most mundane retail experience and make it futuristic by injecting auto mated, real-time data processing into the journey of a consumer while shopping.

In this paper[7],The project titled ”The Smart Shopping Basket Based on IoT Applications” aims to enhance the shopping experience by leveraging Internet of Things (IoT) technology to streamline billing and improve overall efficiency. In conventional shopping environments, long checkout queues and manual billing inaccuracies often lead to delays and customer dissatisfaction. This research tackles these challenges by integrating a barcode scanner and a weight sensor into the shopping basket, facilitating an automated system for scanning and billing. Shoppers can utilize a mobile application to scan product barcodes, displaying the item name and price while updating the total bill in real-time. A weight sensor beneath the basket ensures accurate billing by cross-checking the actual weight of items with their expected weight. The ESP8266 NodeMCU microcontroller transmits both the scanned data and weight measurements to a central server over a Wi-Fi connection, allowing for instant cost calculations and updates. This IoT-based innovation removes the necessity of manual item-by-item scanning at checkout counters. Additionally, it enables users to manage their budgets directly within the application, offering alerts when spending approaches a predefined limit. Shoppers can adjust their budgets or remove items from the basket, with the updates immediately reflected in the app. The smart shopping basket not only reduces checkout times but

also minimizes human errors and elevates the shopping experience, particularly during busy periods or promotional events. Future advancements will focus on optimizing the system's performance, lowering computational requirements, and enhancing data security, showcasing the potential of IoT technology to revolutionize the retail industry.
Paper[8] ”Smart Shopping Application using IoT and Recommendation System” addresses the inefficiencies associated with conventional billing systems operating in supermarkets. It thus develops a mobile-assisted software application that incorporates IoT and data-driven recommendations. Most importantly, the application attempts to eliminate long checkout lines and streamline the shopping process. Users will use the smartphone to scan their products and then place them into a smart cart carrying weight sensors, a Node MCU microcontroller, and an LCD display. These components together work in such a manner that it ensures total item weight in the cart must match the scanned weights within the application, thus preventing unauthorized items from being added into the cart. The application enhances the shopping experience by showing the customers the kind of products they have bought before or are trending, which is obtained through the use of data mining algorithms to ensure that the suggestions are correct. The actual process of payment is ensured only once the weights match, and for security and payment purposes, the system issues a QR code for verification. Modules used in the app architecture include registration and login, scanning of products, and making payments. All modules are written in Java with Firebase for storing data and authentication. It can support a cashless shopping experience: guiding users step-by-step from scanning to checkout and will allow them to manage their shopping lists, monitor expenses, and make payments within the app in a seamless way. This will improve shopping efficiency but, more importantly, provide a contemporary, user-friendly interface to adapt to individualized shopping habits and thus demonstrate efficient use of IoT and data-driven technology in the retail environment. Future work will be completed in the refinement of recommendation algorithms, the enhancement of security features, and the inclusion of more payment options to further refine the user experience.

The paper[9] describes the designing of a ”Smart Mobile Autonomous Robotic Trolley (SMART)” that minimizes time and effort when shopping in stores. Using RFID technology for product identification, an ATmega 16 microcontroller for data processing, and ZigBee modules for wireless transmission between the trolley and the billing station, its main objective is to allow for a more efficient manner of shopping, automate bill generation, and avoid having to wait in long lines. The paper[] titled ”Smart Trolley for Smart Shopping with an Advance Billing System using IoT” proposes a smart shopping trolley that aims to make the shopping process easy and efficient by integrating IoT technology. The system involves a Raspberry Pi, barcode scanner, and LCD display for the automation of product scanning and billing processes directly on the trolley. This trolley is intended to help minimize the wait time experienced by customers at checkout counters, improve convenience for them, and help in the observation of social distancing amidst the COVID-19 pandemic. It supports cart-to-cart communication and makes use of weight sensors that detect any product additions and removals from it, enhancing the experience and efficiency in retail settings.
This paper[10] ”Smart Cart Shopping System with an RFID Interface for Human Assistance” discusses the technology-driven approach to streamlining the shopping experience using RFID technology integrated with the Internet of Things. The system proposed is to reduce billing time and improve the convenience of the customer through RFID readers in the shopping carts with Raspberry Pi 3, Arduino, and LCD screens. Each product of the trolley will be carrying an RFID card, and hence, the system can automatically read, add or remove the products from the trolley based on requirement. While RFID tags on their part, with durability over traditional barcodes, and having the capacity to encrypt data as well, help trace the product information that's then processed and displayed on a screen. The system then directs this information to a central billing server, where the final bill is created that is to be shown on the webpage, therefore, allowing for the digital paying without long lines. The system also has secure cloud storage from AES and DES cryptographic algorithms along with Role-Based Access Control, or RBAC, for legitimate data access. These technologies are integrated in a way that demonstrates the potential of RFID in creating a more efficient and secure shopping.

In the paper[11], ”The Development of IoT-Smart Basket: Performance Comparison between Edge Computing and Cloud Computing System”, the authors develop and analyze the performance of a smart shopping basket using Internet of Things (IoT) technology, comparing two computational approaches: Edge Computing and Cloud Computing. In object detection, the system will make use of Raspberry Pi 4 in combination with a webcam while utilizing software tools, among them Python, TFLite, OpenCV, and Google Cloud Vision API. In Edge Computing, image objects are processed locally in the device while sending images to a cloud server in case of Cloud Computing for the latter. This paper relies on performance measurements of LOS and NLOS cases for the assessment of processing time and RSSI values. From the results, Edge Computing shows to be much stable with the average processing time as 1.74 seconds in LOS cases and 1.75 seconds in NLOS cases, which Cloud Computing average comes out as 10.46 seconds for LOS cases and 5.36 seconds for NLOS cases. Edge Computing's stability is seen in the independence of network stability and signal quality, which, on the other hand, relies on a strong connection for the transmission of data in Cloud Computing. This suggests that Edge Computing is very fit for real-time applications in the smart retail environment, although the needed hardware is robust.

A very long paper [12], "YOLOv1 to v8: Unveiling Each Variant—A Comprehensive Review of YOLO" provides a detailed review of the evolution of the YOLO (You Only Look Once) object detection architecture from its inception to its most recent iteration, YOLOv8. Each YOLO variant is explored with architectural improvements, training strategies, and performance metrics. It also shows how YOLO has evolved from a unified architecture that could do real-time object detection to even more complex models with some of the advanced features of multi-scale detection, data augmentation, transfer learning, and innovative backbone networks like Darknet and CSPDarknet. The paper, therefore, highlights the applicability of YOLO in various domains, from surveillance, autonomous vehicles, healthcare, and industrial automation, in showing its practical impact and versatility. The discussion extends to challenges faced by YOLO models, such as dealing with occlusions, variations in scale, and generalization across domains, as well as future research directions, including federated learning and edge computing integration with YOLO for enhancement in robustness, privacy, and efficiency in real-world applications. In all, this review puts YOLO in the context of evolving technology, pushing boundaries with real-time object detection within computer vision.

This paper [13] states that CF is a known technique used by the recommendation system. These systems are prediction-making mechanisms about a user's preferences over the range of preferences by other users. The method of working for CF is it looks into patterns in the behavior or ratings of similar users and recommends items that are liked or interacted with by similar users. However, as the user data size is growing, the scalability and efficiency problems of traditional CF methods may occur. To deal with this, a new CHARM algorithm named Chaining Algorithm for Recurrent Mining is presented. CHARM is a highly powerful frequent pattern mining technique that has been developed especially for large data sets. Prior association mining algorithms are not able to work properly on large data. CHARM can improve the accuracy of recommendation systems through its identification of patterns in large data. It does so using hidden patterns.

This research [14] proposes a new deep learning based collaborative filtering (CF) model for recommendation systems. Traditional collaborative filtering (CF) methods like restricted Boltzmann machines and matrix factorization are limited in their capacity to model multiple types of user-item relationships. RBM's concentrate more on either user-user or item-item correlations, while MF captures the interaction between user and item. However, most of the time, such works do not encapsulate the complex multi-dimensional relationship for recommendations. This paper proposes a new deep learning method to overcome such challenges. At the training stage, it learns low-dimensional vector representations of users and items containing semantic information that can capture user-user and item-item correlations. We feed such vector representations into a feed-forward neural network at the prediction stage. Network simulates the interaction of users and items, thus makes the recommendations richer with more precision and intelligence as it uses features of both user and item characteristics. To confirm the validity of the model, authors have performed some experiments on MovieLens 1M and MovieLens 10M data sets. The results indicate that the proposed CF model based on deep learning outperforms previous contributions that also applied a feed-forward neural network, while it performs competitively with state-of-the-art methods on both datasets. Therefore, this demonstrates that the new model greatly enhances the accuracy of recommendation systems.

According to the article [15] hybrid recommender systems having two or more of the methods avoid drawback of single approaches, are more efficient and advantageous. For example, merging content-based and collaborative filtering methods can enhance the accuracy of recommendations and provide more robust suggestions. The hybrid system proposed works by making recommendations of restaurants. The project also implements the content-based mug collaborative filtering algorithm. This shows the power of hybrid algorithms. In this paper [] matter of recommender systems and how deep learning has revolutionized this field, providing abilities that cannot be offered by traditional methods. Recommender Systems examine user preferences and behavior and generate personalized recommendations of products, movies, or services. Content-based filtering, collaborative filtering and knowledge-based systems are traditional approaches to designing recommendation technologies. But these techniques often have difficulty capturing the intricate and nonlinear associations between users and items, especially when the datasets are sparse or large.

The paper[16] gives an overview of a smart RS that can generate personal recommendations by filtering information on these users' preferences, behaviors, and needs. You can find these systems operating on many e-commerce websites and online services to recommend multiple items. This can be whatever from news, music, research papers, books, consumer products, and more. Recommender systems employ different kinds of data such as personal information by the user, implicit behavior patterns and internet data present in the locality in generating personalized recommendations to users. The paper focuses on several techniques used in recommending with their respective advantages and disadvantages. Some are capable of delivering high accuracy at the cost of scalability, diversity, or sometimes context. The problem of data sparsity and cold start problem are also handled, which portrays the issues in providing effective recommendations for a new user or a new item. However, even considering these challenges, the paper argues that recommender systems have big pros. They simplify decision-making. Also, they personalize choice. Most importantly, they ensure suggested content is relevant. Overall, they play a transformative role.

This paper [17] gives a comprehensive overview of recommender systems in the light of deep learning. The introduction covers basic terminologies and concepts of recommender systems and deep learning. Next, it discusses the new research done in the area and the new developments concerning the area. In this, it lists out several deep learning-based methods that have improved the efficiency and scope of recommendation models. The authors also discuss areas for future research which might involve innovative thinking and significant reconsideration of established algorithmic approaches to tackle challenges and limitations. Summarizing everything, the paper displays impacts deep learning may have on recommender systems. It could rearrange personalized user experiences.

The paper[18] discussed about various machine learning approaches, which could be incorporated in e-commerce recommender system such as SVD, KNN Baseline, CoClustering, ensemble method and so on LISTED PERFORMED THE PERFORMANCE ASSESSMENT OF PRESENT RECOMMENDER SYSTEM PROPOSED RECOMMENDER SYSTEM USING RMSE NDCG METRICS. It is noted that ensemble methods provide the largest accuracy but also need much computation time. SVD is an algorithm with moderate accuracy as well as moderate time complexity which qualifies it for scalability in recommendations. From the research, we find that the merging of the approaches can improve the satisfaction and effectiveness of mobile based systems.

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