Grenze International Journal of Engineering and Technology, Jan Issue

Revolutionizing Shopping Experience: Smart Carts and Shelves

Milind Rane[1], Ajinkya Ghansham Ghusarkar[2], Girish Anil Nikam[3], Atharva Rajesh Thokal[4], Sourabh Bholanath Shintre[5] and Atul Kulkarni[6]
[1-5]Department of IT, VIT, Pune
[6]VIIT, Pune
Email: milind.rane@vit.edu, ajinkya.ghusarkar22@vit.edu, girish.nikam22@vit.edu, atharva.thokal22@vit.edu, sourabh.shintre22@vit.edu, atul.kulkarni@viit.ac.in

***Abstract*— Efficient inventory management is essential for businesses to optimize their supply chain, reduce costs, and enhance operational efficiency. At the same time due to manual scanning at the checkout processes, customers have to wait for a long time in the queue. As a solution to these different problems, we have proposed a system using IoT. This research paper presents a novel approach to inventory management by integrating two cutting-edge technologies: Load Cell Sensor HX711 and Smart Cart System using Radio Frequency Identification (RFID) technology. By combining the capabilities of these technologies, the paper aims to automate inventory tracking, monitoring, and replenishment, providing real-time data for accurate inventory control and decision-making. The Smart Cart System enhances the customer satisfaction while the Smart Shelves increase efficiency of inventory management by automating the data capture process. It provides convenience by eliminating the need for manual scanning or checkout processes, and generating bill on webpage allowing customers to simply place items in the cart and proceed with their shopping. Also we present the machine learning aspect of our project aimed at revolutionizing the shopping experience using RFID technology and load cells. We explore the implementation of three prominent algorithms - Linear Regression, Random Forest, and XG Boost - to predict future sales.**

***Index Terms*— Smart shopping, smart cart, machine learning**

I. Introduction

Efficient inventory management is a critical aspect of successful businesses across various industries. It directly impacts operational efficiency, customer satisfaction, and profitability. Traditional inventory management methods often involve manual processes, which are time-consuming, prone to errors, and lack real-time visibility. As a result, businesses face challenges in accurately tracking inventory, preventing stockouts, optimizing replenishment, and enhancing overall operational efficiency. At the same time, the traditional shopping experience often involves manually selecting items, queuing up for checkout, and managing shopping carts laden with products. This process can be time-consuming, cumbersome, and prone to errors.

To address these challenges, this research project proposes a system by integration of two cutting-edge technologies: Load Cell Sensor HX711 and Smart Cart System using Radio Frequency Identification (RFID) technology. The combination of these technologies offers a comprehensive solution for automating and improving inventory management processes.

Grenze ID: 01.GIJET.10.1.814

In this system, IoT-enabled devices such as smart carts and shelves are equipped with RFID tags that communicate with readers and microcontrollers to track inventory levels and provide real-time data on product availability. This data is then analyzed using machine learning algorithms to optimize inventory management and reduce waste and also provides valuable insights into inventory levels, movement, and consumption patterns. Additionally, the use of microcontrollers enables retailers to automate processes such as checkout, payment, and restocking, leading to increased efficiency and reduced labor costs. This integration ensures accurate inventory counts, reduces manual errors, and provides insights into stock levels for proactive replenishment.

II. Literature Review

[1] The proposed idea involves providing customers with a trolley equipped with a barcode scanner and touch screen display, which can be used to scan products and display their information, cost, and the customer's total bill. Customers can then pay using digital payment methods like Paytm, UPI, Phone Pay, etc. This not only improves the customer experience but also reduces the need for human resources at billing counters. Such systems can also help in inventory tracking and personalized customer experiences, making them a transformative technology for the retail industry. [2] The retail industry faces the challenge of recovering shopping carts and arranging them in large supermarkets and shopping malls. This process requires significant financial and manpower resources and has low recovery efficiency. To address this challenge, an improvised algorithm has been proposed to achieve collision-free recovery and self-driving carts. The algorithm is based on the Rapidly-exploring Random Tree (RRT) algorithm, which incorporates an artificial potential field and node selection range to improve tree growth. Experiments have shown that the improved algorithm has high obstacle avoidance, short search time, and strong real-time capabilities. This innovation has the potential to revolutionize the retail industry by reducing labour costs and increasing efficiency in cart recovery and management.

[3] In this research paper, the authors utilize RFID technology to analyze production data in an IoT-enabled smart job-shop. In manufacturing environments, production and transparency are crucial for efficient operations. However, the increasing amount of production data can be difficult to use due to its discreteness and lack of correlation. To address this challenge, the authors develop an RFID-based production data model that formalizes and correlates the heterogeneous production data. By attaching RFID tags to Work in Progress (WIPs), the authors are able to create smart WIPs that aid in process command execution. This research has the potential to improve production efficiency and reduce errors in manufacturing environments.

[4] The research paper proposes an interactive shopping model that incorporates IoT and cloud computing to facilitate efficient access, ordering, and monitoring of products. The system aims to create an interactive shopping ecosystem that eliminates the need for customers to waste time searching for specific products. Instead, the system acts as a guide for the customers, providing them with a seamless shopping experience. By leveraging IoT and cloud computing, the system can enhance product inventory management and provide valuable data insights for retailers. Overall, the proposed system has the potential to revolutionize the retail industry and elevate the shopping experience for customers

[5 The literature review conducted by M. A. Al-Fuqaha et al. explores the potential benefits and challenges of smart retail systems using IoT and RFID technologies, including smart shelves. The authors highlight the potential of these technologies to revolutionize the retail industry by improving inventory management, enhancing the shopping experience, and providing valuable data insights. The study identifies challenges such as high installation and maintenance costs, cybersecurity concerns, and potential technical malfunctions that must be addressed to fully realize the benefits of these technologies. The authors also discuss potential solutions and future research directions to advance the application of IoT and RFID technologies in smart retail systems. [6] This paper provides an overview of IoT-based smart shelf systems for retail stores. The authors review various aspects of smart shelves, including design considerations, components, and implementation challenges. The paper also presents a case study of a smart shelf system developed by Intel, which uses RFID tags and sensors to manage inventory and monitor product expiration dates. [7] This paper provides a comprehensive review of smart shelf technologies for retail applications. The authors review various types of sensors, IoT devices, and data analytics tools used in smart shelves, and discuss their advantages and limitations. They also analyse the key features and benefits of smart shelves, such as inventory management, product tracking, and customer behaviour analysis. The paper concludes with a discussion of the challenges and opportunities in the field, and proposes future research directions.

[8] This paper presents a review of smart retail shelf systems, focusing on the integration of RFID tags, sensors, and IoT devices. The authors review various design considerations, such as the placement and orientation of the sensors and the communication protocols used in the system. They also discuss the advantages and limitations of smart retail shelf systems, such as improved inventory management, reduced waste, and enhanced customer

experience. The paper concludes with a discussion of future research directions in the field, such as the integration of AI and machine learning algorithms in smart shelves. [9] This paper provides a review of smart retail shelves, focusing on their potential applications and benefits in the retail industry. The authors review various features and components of smart shelves, such as RFID tags, sensors, and IoT devices, and discuss their advantages and limitations. They also analyze the potential benefits of smart shelves, such as improved inventory management, reduced labor costs, and enhanced customer experience. The paper concludes with a discussion of future research directions in the field, such as the development of real-time inventory management systems and the integration of predictive analytics tools in smart shelves. [10] This paper provides a comprehensive review of smart retail shelf systems, focusing on their design and implementation using IoT technologies. The authors review various components and technologies used in smart shelves, such as RFID tags, sensors, and IoT devices, and discuss their integration into a coherent system. They also analyze the potential benefits of smart retail shelf systems, such as improved inventory management, reduced waste, and enhanced customer experience. The paper concludes with a discussion of future research directions in the field, such as the development of advanced analytics tools and the integration of machine learning algorithms for predictive analytics in smart shelves.

III. METHODOLOGY

The proposed system in this project is an integrated smart retail system that combines Smart Cart and Smart Shelves using IoT technology. The system aims to revolutionize the traditional retail experience by leveraging IoT capabilities to streamline inventory management, enhance customer experience, and optimize operational efficiency. The Smart Cart is equipped with IoT sensors, such as RFID sensors to enable automatic item detection and tracking. As customers place items in the cart, the RFID tags attached to the products are scanned, and the bill is updated in real-time on the webpage. The following steps are followed to implement the system.

A. Hardware Setup

Install an RFID reader module on the Smart Cart to enable automatic item detection. Ensure proper wiring and connectivity between the RFID reader and the microcontroller or processing unit of the cart. Test the hardware components for functionality and compatibility.

B. RFID Tag Integration

Attach RFID tags to each product or item to be used with the Smart Cart system. Encode the RFID tags with unique identification numbers corresponding to each product. Link these identification numbers to their respective prices and other relevant information in the database.

C. Web-Based Billing System

Develop a web-based billing system that receives the transmitted product information from the Smart Cart. Implement the necessary backend functionalities to generate the bill based on the received data. Ensure that the web page is user-friendly and provides accurate and real-time billing information.

D. Testing and Validation

Test the Smart Cart system in a controlled environment. Verify the accuracy of RFID tag detection, data capture, and data transmission. Perform thorough testing of the web-based billing system to ensure correct bill generation based on the received product information.

E. Data Analysis and Optimization

Analyze the collected data and feedback to evaluate the performance of the Smart Cart system. Measure metrics such as RFID tag detection accuracy, bill generation speed, and user satisfaction. Identify areas for optimization and refinement based on the analysis.

F. Iterative Refinement and Documentation

Based on the analysis and user feedback, make necessary refinements and improvements to the Smart Cart system and the web-based billing system

Smart shelves using load cell sensors are an innovative solution that leverages the power of IoT and weight measurement technology to provide real-time inventory tracking and management. By integrating load cell sensors into the shelves, these intelligent systems can accurately monitor the weight of items placed on them. This enables automated inventory updates, precise stock level tracking, and timely replenishment notifications. Determine the desired functionalities, such as accurate weight measurement, real-time inventory tracking, and compatibility with the overall IoT infrastructure.

G. Load Cell Selection

Research and select suitable load cells based on the requirements of the smart shelves system. Consider factors such as weight capacity, precision, and compatibility with the HX711 amplifier. Ensure the load cells are appropriate for the expected product weights and dimensions.

H. HX711 Amplifier Integration

Connect the load cells to the HX711 amplifier. Follow the manufacturer's guidelines and datasheet to ensure correct wiring and proper electrical connections. Calibrate the HX711 amplifier to achieve accurate weight measurements.

I. Shelf Design and Construction

Design and construct the shelves to accommodate the load cells and the items to be placed on them. Ensure that the shelves are sturdy and capable of withstanding the expected weight loads. Integrate the load cells into the shelves, providing proper support and alignment.

J. Load Cell Calibration

Calibrate the load cells to ensure accurate weight measurements. Use known weights or calibration masses to determine the calibration factors for each load cell. Follow the manufacturer's instructions for calibration procedures and take multiple readings to ensure accuracy.

K. Data Acquisition and Processing

Implement the software components necessary for data acquisition and processing. Connect the load cells to a microcontroller or processing unit capable of communicating with the IoT infrastructure. Develop algorithms to capture weight measurements from the load cells and process the data.

L. IoT Integration

Integrate the smart shelves system with the IoT infrastructure. Establish a communication link between the microcontroller or processing unit and the central database or backend system. Utilize wireless technologies like Wi-Fi or Bluetooth to transmit the weight data to the central server.

M. Real-Time Inventory Tracking

Develop software functionalities to enable real-time inventory tracking. Ensure that the weight data from the load cells is translated into accurate inventory information, such as item presence, quantity, and stock levels. Update the inventory database in real time based on the weight measurements.

N. User Interface and Visualization

Design a user interface to visualize the inventory information. Develop a web or mobile application that allows users to access the inventory data and monitor the stock levels on the smart shelves.

0. Testing and Validation

Test the functionality and performance of the smart shelves system in a controlled environment. Verify the accuracy of weight measurements, real-time inventory tracking, and data transmission. Conduct thorough testing to ensure the system meets the desired requirements.

P. Testing and Validation

Test the functionality and performance of the smart shelves system in a controlled environment. Verify the accuracy of weight measurements, real-time inventory tracking, and data transmission. Conduct thorough testing to ensure the system meets the desired requirements. By leveraging load cell sensors and IoT integration, smart shelves offer a transformative solution for retailers seeking to enhance their inventory management practices. The machine learning models in this project are employed to predict future sales using RFID technology, load cell data, and historical sales records. The specified approach involves the following steps:

Q. Data Collection

Relevant data is collected from various sources, including RFID sensors that track customer movement and interactions with products, load cells that measure changes in product weight, historical sales data to understand past buying patterns, product information, and customer demographics.

R. Data Preprocessing

The collected data undergoes preprocessing steps to clean and transform it into a suitable format for machine learning. This process involves handling missing values, outlier detection, and normalization or scaling of features.

S. Feature Engineering

Domain knowledge and insights are utilized to engineer meaningful features that have a strong impact on sales prediction. These features may include time-based patterns, product attributes, customer preferences, and seasonality effects.

T. Data Splitting

The dataset is divided into two parts: a training set and a validation set. The training set is used to train the machine learning models, while the validation set is used to evaluate their performance.

U. Model Selection

Three machine learning algorithms - Linear Regression, Random Forest, and XG Boost - are selected for the prediction task. These algorithms are chosen due to their suitability for regression problems and their varying complexities.

V. Hyper parameter Tuning

For each algorithm, hyperparameters are optimized to find the best combination that yields the most accurate predictions. This is typically done through techniques like grid search or random search.

W. Model Training

The selected algorithms are trained on the training set using the optimized hyperparameters. During training, the models learn patterns and relationships within the data to make accurate predictions.

X. Performance Evaluation

The trained models are evaluated on the validation set using performance metrics such as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). These metrics measure the difference between the actual sales and the predicted sales, allowing us to assess the models' accuracy.

Y. Results Analysis

The performance of each model is analyzed and compared to determine which algorithm performs the best in predicting future sales. The results are used to draw insights into the effectiveness of the machine learning approach for sales prediction in the context of the project.

Z. Interpretation and Application

The insights gained from the best-performing model, most likely XG Boost, are applied to optimize inventory management, product placement, and personalized customer experiences. These predictions help retailers stay proactive in meeting customer demands and improving overall shopping experiences.

IV. WORKING

A.Smart_cart

The smart cart system using RFID and IoT with billing generation operates seamlessly by integrating hardware components, capturing and processing data, and generating web-based bills. As a customer place an RFID-tagged product into the smart cart, the RFID reader integrated into the cart detects the tag and captures its unique identification number. The captured identification number is wirelessly transmitted to the IoT infrastructure through communication technologies like Wi-Fi or Bluetooth. Within the IoT infrastructure, the identification number is processed to retrieve the corresponding product information from the database, including the item name, price, and stock availability. In real-time, the system calculates the total bill as the customer adds more items to the cart, retrieving the prices from the database based on their respective identification numbers.

The unwanted product removing process from the cart can be facilitated with the help of a 4-pin tactile switch. When the customer decides to remove an item, they press the tactile switch integrated into the smart cart system.

Once the tactile switch is activated, the smart cart system verifies the removal request by cross-referencing the activation with the product's RFID tag. This ensures that the correct item is being removed from the cart. Upon verification, the smart cart system updates the billing information in real-time. The system deducts the removed item's price from the accumulated bill, ensuring that the customer is not charged for unwanted items.

The calculated bill and item details are then transmitted from the smart cart to the web-based billing system, which generates the final bill based on the accumulated item prices. In the billing system of the smart cart, after the final bill is generated based on the accumulated item prices, additional functionalities are incorporated to facilitate a smooth and convenient checkout process.

B. Smart Shelves

Smart shelves using load cells and HX711 operate by integrating load cells within the shelves to measure the weight of the products placed on them. The load cells are connected to an HX711 amplifier, which amplifies the electrical signals produced by the load cells. These amplified signals are then processed by a microcontroller.

When a product is placed on a smart shelf, the load cell within that shelf detects the weight of the product and converts it into electrical signals. These signals are amplified by the HX711 amplifier and sent to the microcontroller or CPU for processing. The microcontroller applies calibration factors and performs necessary calculations to obtain the precise weight measurement of the product.

It provides visual representations, notifications, and alerts for low stock or restocking needs. Real-time monitoring and alerts are implemented through connectivity option like Wi-Fi allowing the system to generate notifications for low stock levels.

A user interface provides access to the smart shelf system, displaying the weight of each shelf, and inventory status, and generating reports or analytics based on the collected data. By employing load cells and HX711 amplifiers, smart shelves can accurately measure the weight of products placed on them. This enables efficient inventory management, minimizes stockouts, enhances theft prevention measures, and provides valuable data for analysis and decision-making in retail environments.

C. Machine Learning

For the machine learning component of our project, we focused on predicting future sales to enhance the shopping experience through RFID technology and load cells. Firstly, we collected relevant data from multiple sources, including RFID data, load cell readings, historical sales records, product information, and customer data. Next, we performed data preprocessing and feature engineering to prepare the dataset for training. Three machine learning algorithms were chosen for the prediction task: Linear Regression, Random Forest, and XG Boost. We divided the dataset into training and validation sets, and hyper parameter tuning was conducted for each algorithm. Performance evaluation was based on metrics such as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). The results offer valuable insights into future sales patterns, enabling improved inventory management and a more personalized shopping experience for customers.

V. Results And Discussion

The project involved the design and implementation of a smart cart system using RFID technology, along with a web-based bill generation feature. Additionally, a smart shelves system using load cell technology was incorporated into the project. The results of implementing the smart cart system using RFID technology and the smart shelves system using load cell technology were promising. The integration of RFID technology in the smart cart system enhanced product tracking. The convenience offered to customers through automatic billing and personalized shopping experiences improved customer satisfaction.

A. Smart Cart

Accurate Product Tracking: The RFID technology successfully enabled accurate and real-time tracking of products as they were placed or removed from the cart. This feature enhanced inventory management and reduced errors in product tracking.

Convenient Shopping Experience: Customers found the smart cart system convenient, as they no longer needed to manually scan each item at the checkout counter. The automatic tracking of selected products and the generation of digital bills on the webpage streamlined the shopping process.

Real-time Data Analysis: The collected RFID data provided valuable insights into consumer behavior, product preferences, and shopping patterns. Retailers were able to analyze this data to personalize marketing strategies, optimize product placements, and enhance customer satisfaction.

ITEMS	QUANTITY	COST
Biscuit	1	35
Soap	1	38
Rice(1KG)	1	55
Tea(50g)	1	45
Grand Total	4	173.00

Pay Now

Fig1. Billing web page

B. Smart Shelves System Using Load Cell

Accurate Weight Measurement: The integration of load cells within the shelves provided accurate weight measurements of the products placed on them. This enabled precise inventory management and real-time stock tracking. Inventory Optimization: The load cell-based smart shelves system improved inventory management by providing accurate and up-to-date information on stock levels. This allowed retailers to optimize their stock replenishment processes, minimizing stock outs and overstocking. Real-time Monitoring and Alerts: The connectivity options in the smart shelves system facilitated real-time monitoring. Alerts were generated when stock levels were low or when unusual weight changes were detected, enabling prompt action to be taken. Enhanced *Efficiency*: The implementation of the smart shelves system increased the overall efficiency of the store operations. The automation of weight measurements and stock tracking reduced manual efforts and improved productivity. The smart shelves system using load cell technology proved effective in accurately measuring the weight of products on the shelves. This led to improved inventory management, theft prevention, and real-time stock tracking. The integration of connectivity options facilitated real-time monitoring and alerts, further enhancing the efficiency of store operations.

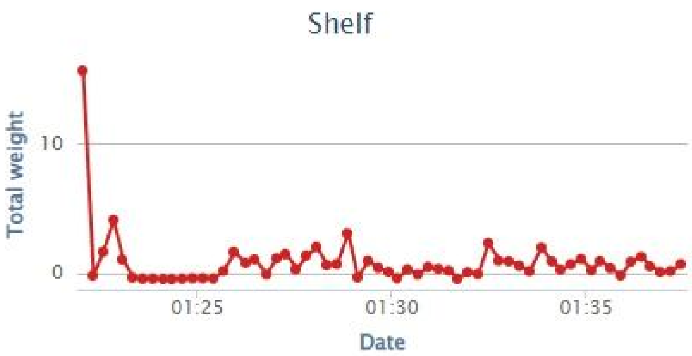

Fig1.Graph of monitoring weight on the shelf

C. Machine Learning

The machine learning models were trained and evaluated on the dataset, and the performance metrics for each algorithm were recorded. The results showed that all three algorithms, Linear Regression, Random Forest, and XG Boost, achieved promising predictive capabilities for future sales. The evaluation metrics used to assess the models' performance were Root Mean Squared Error (RMSE). The RMSE accounts for the squared differences, penalizing larger errors more heavily.

TABLE 1: RESULT OF EXPERIMENTATION

Model Name	Mean Squared Error
Linear Regression	29480
Random Forest	13816
XG Boost	13739

Results of experimentation is shown in Table 1. The findings indicated that XG Boost consistently outperformed both Linear Regression and Random Forest in terms of RMSE. This result was not surprising, as XG Boost is known for its ability to handle complex relationships and nonlinearities in data. The ensemble nature of Random Forest also contributed to its competitive performance.

The implications of these results are significant for retailers seeking to optimize inventory management and enhance the shopping experience. The accurate predictions provided by XG Boost can aid in proactive inventory replenishment and stock allocation, minimizing product shortages and overstock situations. This, in turn, leads to reduced operational costs and improved customer satisfaction, as customers are more likely to find the products they desire on the shelves.

```
Linear regression predicted Sales after 1 month: 81906.49621212122
Mean Squared Error: 294800273.4848606
Random forest Predicted Sales after 1 month: 82185.48204761902
Mean Squared Error: 138164645.17385694
XG boost Predicted Sales after 1 month: 81325.2421875
Mean Squared Error: 137391644.52090558
As smallest Mean square error is 137391644.52090558 of Xgboost Model, we can consider it as most accurate model
```

Fig3.Output of future sale prediction

V. CONCLUSION

In conclusion, the project successfully implemented a smart cart system using RFID technology and a smart shelves system using load cell technology, along with web-based bill generation. These systems have demonstrated numerous benefits for retailers and customers alike. Customers experienced a convenient shopping process with automatic billing on the webpage, reducing checkout time and enhancing overall satisfaction. The smart shelves system enhanced real-time monitoring and alerts allowed for proactive stock management and increased operational efficiency. The integration of RFID and load cell technologies in the smart cart and smart shelves systems has laid the foundation for a more advanced and connected retail ecosystem, offering valuable insights and opportunities for retailers to stay competitive in the ever-evolving market.

Despite the successes, the project also faced challenges. Data quality, availability, and generalization were crucial concerns in training the machine learning models. The interpretability of complex algorithms like XG Boost raised questions about the transparency of predictions and the potential for biases. Addressing these challenges requires ongoing efforts to collect high-quality data, enhance model interpretability, and employ fairness-aware approaches to mitigate biases.

REFERENCES

[1] “SMART SHOPPING CART”, Viswanadha V, Pavan Kumar P, Chiranjeevi Reddy S, 2018, IEEE.

[2] “RESEARCH ON PATH PLANNING OF INTELLIGENTSHOPPING CART IN LARGE SHOPPING MALL”, Yi Cheng,Yun Wang, 2018, IEEE

[3] Kai Ding,Pingyu Jiang “RFID-based Production Data Analysis in an IoT-enabled Smart-shop”IEEE/CAAjournal of Automatica Sinca.

[4] Abhirup Khanna,Ravi Tomar “IoT based Interactive Shopping Ecosystem” 2nd International Conference on Next GenerationComputingTechnologies,Dehradu India,October 2016.

[5] Mashayekhy, Yasaman, Amir Babaei, Xue-Ming Yuan, and Anrong Xue. 2022. "Impact of Internet of Things (IoT) on Inventory Management: A Literature Survey”.

[6] "Smart Shelf: A Review on IoT-Based Shelf Management System for Retail Stores" by S. S. S. R. S. Murthy, V. R. S. Kumar, and D. V. L. N. Somayajulu. In Proceedings of the 2018 International Conference on Recent Trends in Advanced Computing, Communication and Information Systems (RTACIS), pp. 1-6, IEEE, 2018. DOI: 10.1109/RTACIS.2018.8662846.

[7] "A Review of Smart Shelf Technologies for Retail Applications" by P. D. Agrawal, S. S. S. R. S. Murthy, and D. V. L. N. Somayajulu. Journal of Industrial Integration and Management, vol. 4, no. 1, pp. 1-20, 2019.

[8] Smart Retail Shelf System: A Review" by G. R. B. S. S. Varma and K. R. M. Swamy. In Proceedings of the 2020 IEEE International Conference on Innovative Research and Development (ICIRD), pp. 355-359, IEEE, 2020

[9] "Smart Retail Shelf: A Review" by K. J. Rajendra, S. P. Savant, and G. B. Gaitonde. In Proceedings of the 2020 International Conference on Computer Communication and Informatics (ICCCI), pp. 1-6, IEEE, 2020.

[10] "Smart Retail Shelf System: A Comprehensive Review" by K. S. Akash, S. S. Shetty, and G. K. Prabhu. In Proceedings of the 2021 International Conference on Communication and Electronics Systems (ICCES), pp. 1-6, IEEE, 2021. Aalaa Abdullah, Shahad Al Enazi and Issam Damaj – “Agri Sys: A Smart and Ubiquitous Controlled Environment Agriculture System”, 2016 MEC International Conference on Big Data and Smart City (ICBDSC).

[11] Kalange, P., Mahajan, P., & Rathod, R. (2017). A smart shelf design for retail store real time inventory management automation. International Journal of Computer Applications, 168(12), 1-6.