Smart Trolley

TLABO BODIRWA
Department Of Computer Systems Engineering
Tshwane University Of Te nology
Pretoria, RSA
ife.a

Prof P.A OWOLAWI
Department Of Computer Systems Engineering
Tshwane University Of Technology
Pretoria, RSA

Dr V MALELE
Department Of Computer Systems Engineering
Tshwane University Of Technology
Pretoria, RSA

Abstract— Retail establishments often face challenges related to long queues and delays at billing counters, leading to customer dissatisfaction and revenue losses. This study delves into the challenges faced by stores and malls, particularly the hassle of long lines at checkout during busy times. The conventional manual checkout process is slow and error-prone, prompting the need for a solution to make the shopping experience smoother. This project introduces a smart cart system to address these issues. The main goal is to improve traditional shopping carts by adding a user-friendly barcode scanner directly to the cart. This allows customers to scan their items, pay instantly, and adjust their shopping list on the go. This not only makes shopping more convenient but also reduces wait times at checkout, creating a more efficient and personalized experience. The impact of this smart cart system goes beyond just keeping customers happy. By using technology to streamline the shopping process, the project aims to make things more efficient for retailers too. Through simplified processes and better customer service, this innovation could change the way we shop, offering a peek into a future where technology makes the retail experience smoother. This report explores why this project, the goals, and looks at what this smart cart system could mean for shoppers and stores alike.

Keywords— Smart Trolley System, back-end, Barcode Scanner, raspberry pi, User Interface.

I. INTRODUCTION

Shopping is an integral part of our daily lives, and malls and supermarkets serve as popular destinations for fulfilling our needs and desires to provide a modern shopping experience, these establishments frequently use traditional shopping trolleys, which frequently lack the technological advancements needed. Customers frequently encounter inefficiencies and challenges that contribute to a subpar experience, such as long queues at checkout counters, the need to individually scan items at the cashier, difficulty in tracking overall expenditure, limited payment options, and struggles in locating specific products within the store. Sometimes customers have problems regarding incomplete information about the product on sale and waste of unnecessary time at the billing counters. Hence improvement is required in the traditional billing system to improve the quality of shopping for the customer. To address these issues and improve the overall shopping experience, the SMART TROLLEY project aims to design and implement a smart trolley system that leverages modern technology to streamline the shopping process, enhance customer satisfaction, and optimize the operational efficiency of the store.

II. LITERATURE REVIEW

These papers explore various theories, principles, and concepts related to the application of advanced technologies in transforming the shopping experience. Here is an expanded review of the key papers:

Paper[1]: This paper discusses the development and integration of advanced technologies in smart trolley systems. It highlights the use of sensors, displays, and data analytics to create a more efficient and personalized shopping experience for customers. The paper emphasizes the importance of real-time expenditure tracking, product information availability, and multiple payment options in improving convenience and efficiency during the shopping process.

Paper[2]: This paper focuses on the application of Internet of Things (IoT) technologies in the retail industry, specifically in the context of smart trolleys. It explores the use of sensors, wireless communication, and cloud computing to enable seamless interaction between smart trolleys, customers, and the backend systems of retailers. The paper emphasizes the potential of IoT technologies to enhance operational efficiency, inventory management, and customer engagement strategies.

Paper [3]: This paper addresses the broader impact of technology on the retail industry and the customer shopping experience. It discusses various studies and research conducted in this field, highlighting the transformational effects of technology in improving customer satisfaction, reducing wait times, and increasing sales revenue. The paper emphasizes the role of smart

trolleys as a technological solution that contributes to these positive outcomes.

Paper [4]: This paper specifically focuses on the use of smart trolleys in enhancing customer satisfaction, reducing wait times, and increasing sales revenue. It presents empirical evidence and case studies to demonstrate the effectiveness of smart trolleys in improving the overall shopping experience. The paper highlights the convenience and efficiency provided by features such as real-time expenditure tracking, product information availability, and multiple payment options.

In these papers[4-6], various theories, principles, and laws are discussed in relation to smart trolleys and their impact on the retail industry. These may include theories on customer behavior, technology adoption, human-computer interaction, data analytics, and operational efficiency. The concepts and ideas communicated in these papers revolve around the benefits and challenges of implementing smart trolleys, the integration of advanced technologies, and the potential for improving the customer shopping experience.

III. METHODOLOGY

A. Review of Literature and Needs Gathering:

In this phase, an extensive review of existing literature will be conducted to gain insights into smart trolley systems and similar retail innovations. The aim is to identify gaps, challenges, and opportunities in the current landscape. Simultaneously, systematic gathering of the needs of both customers and retailers will inform the design and development process.

B. System Architecture

Developing a robust system architecture is crucial for the success of the smart trolley project. This step is all about figuring out a detailed plan that shows how the computer parts and physical parts of the trolley will work together. The plan will cover how information moves around, the rules for talking between different parts, and the general setup of the whole smart trolley system. This way, the trolley can work smoothly and be easy for people to use, just like it's shown in figures 1 and 2.

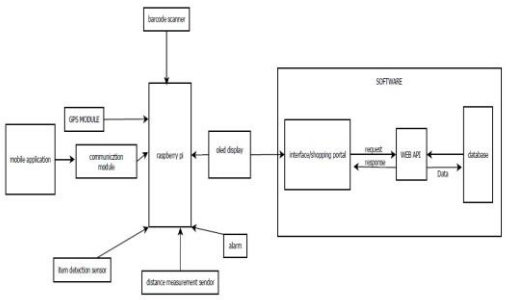

figure 1: Systems architecture block diagram

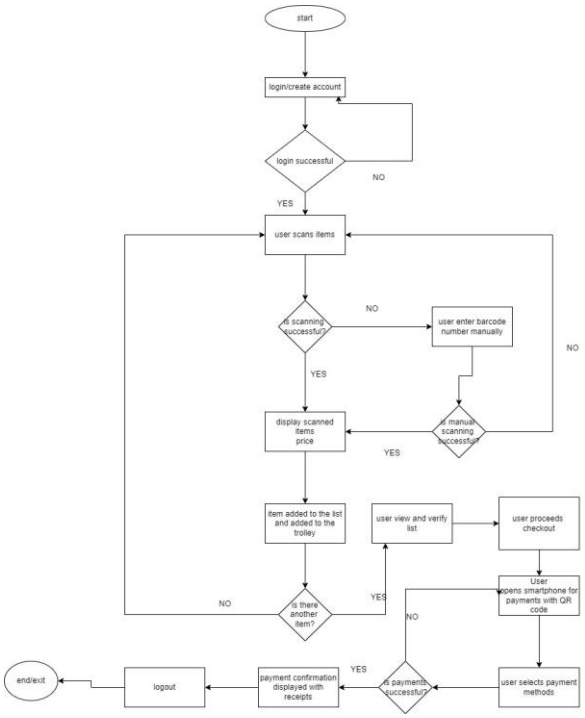

figure 2: operation flow chart

C. Software Development

Developing the software component for the smart trolley system.

This involves designing and programming the software on the Raspberry Pi to integrate data from different components, such as barcode scanner, and item detection sensor and development of back-end system and payment method. The software also connects to a database using a web API to retrieve and update inventory and prices.

The following figure shows the software system design of smart trolley software, backend system and SmartPay android application as payment method:

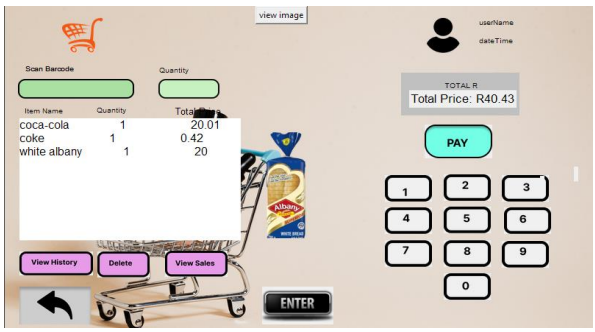

figure 3: Smart Trolley user interface design

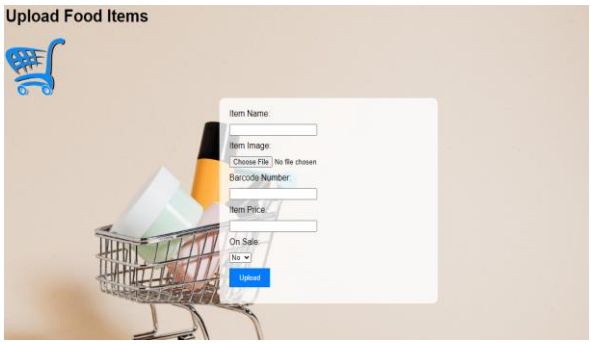

Figure 4: Backend system Design

Figure 5: SmartPay Android application design

D. Hardware Components

Selecting and utilizing various hardware components for the smart trolley system.
This includes barcode readers (barcode scanner), microcontrollers, displays (OLED display), sensors (ultrasonic sensors for distance measurement, infrared sensors for object detection),communication, and power sources such as power bank.

The following components have been carefully selected to ensure seamless integration and reliable performance:

- - Chosen for its functionality and ease of use, providing a sturdy and mobile base for the smart trolley system.
- **Raspberry Pi -** Selected as the central processing unit, offering versatility and compatibility with various hardware components.
- **Pi Screen (LCD Display) -** Incorporated for the user interface, displaying information such as scanned items, prices, and promotional offers in real-time.
- **Barcode Scanner -** Essential for quick and accurate item identification, streamlining the scanning process for customers.
- **Proximity/IR Sensor -** Included to enhance the system's ability to detect items in the trolley, ensuring comprehensive tracking.
- **Enclosure -** Utilized to protect and secure internal components, safeguarding them from external elements.
- **power bank**

figure 6: shopping cart

Figure 7: OLED Display

Figure 8: Raspberry Pi

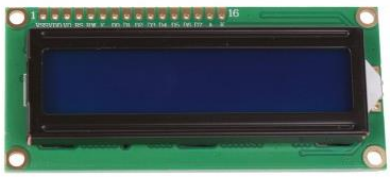

Figure 9: LCD DISPLAY

figure 10: Barcode scanner

E. Touch screen design analysis

The Smart Trolley will have design with a till application with the following components;

- Sign in and sign up panel
- Regitratration
- Panel screen for the scanned items,prices and promotional offers and discounts .
- Panel to display the searched item.
- Help button provides user guidance about using the trolley.
- Search bar for searching any item located in the store.
- Pay button to activate payment function

IV. RESULTS

The implementation of the smart trolley system involved the integration of various components, including the Raspberry Pi, barcode scanner, proximity sensors, LCD display, and the enclosure. The system successfully achieved real-time tracking of scanned items, instant billing through the Android application, and efficient communication with the backend system.

The smart trolley system underwent rigorous testing in a real-world retail environment, evaluating both the prototype's functionality and the user interface's effectiveness as indicated in Figure 11.

A. Results of testing in retail environment

Prototype Testing at Retail Environment:

- **Scenario Simulation:**

The prototype was subjected to scenarios simulating real shopping conditions, including various product types and quantities.

Testing aimed to replicate the diversity of items and user behaviors encountered in retail settings.

Figure 11: Testing of Smart Trolley System in Retail Environment

B. Checkout process results

Checkout Process Evaluation:

- The efficiency of the automated checkout process was assessed, focusing on the accuracy of item detection and real-time cost calculation.
- The prototype demonstrated consistent and reliable performance, successfully automating the billing process.

In Figure 12, the smart trolley's user interface demonstrates its capability to detect and display scanned items in real-time. Each item is accurately identified, and the corresponding information, such as product name and price, is instantly reflected on the interface. This functionality ensures transparency for customers, allowing them to review their selected items throughout the shopping journey. The successful implementation of this feature contributes to the overall convenience and efficiency of the smart trolley system.

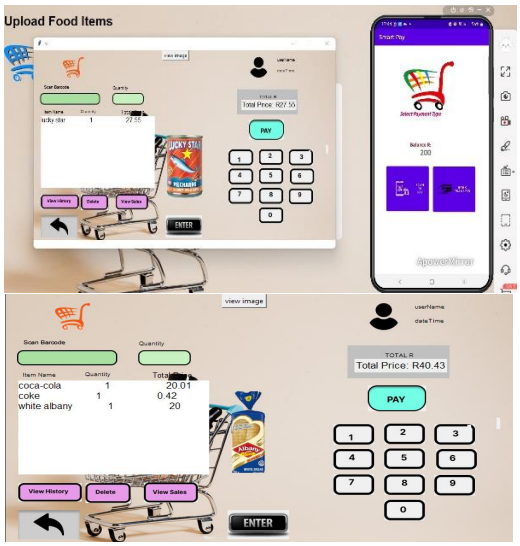

Figure 12: Smart Trolley user interface design

C. Results for backend system for successfully uploading items

The backend system has demonstrated successful functionality in managing and uploading item data. Through rigorous testing, the system exhibited efficient performance in handling data, ensuring accuracy, and maintaining a prompt response time. The successful integration of the backend system contributes significantly to the overall functionality of the smart trolley project, meeting its objectives and ensuring a streamlined shopping experience for users.

D. Equations

The mathematical framework supporting the smart trolley system involves several key equations:

Total Cost Calculation:

$$\text{Total Cost} = \sum_{i=1}^{n} (\text{Price of Item}_i \times \text{Quantity}_i)$$

Total Pixels Calculation:

$$\text{Total Pixels} = \text{Screen Width (pixels)} \times \text{Screen Height (pixels)}$$

$$\text{Total Pixels} = 840 \times 450$$

V. CONCLUSION

In summary, the Smart Trolley project effectively tackles the challenges faced by retail stores, especially the issues related to long queues and delays at checkout counters. By introducing a smart cart system equipped with advanced technologies like a barcode scanner, Raspberry Pi, and proximity sensors, the project aims to transform the way people shop. With a user-friendly interface, quick payment options, and real-time item tracking, the smart trolley makes shopping more efficient and convenient for both customers and retailers.

The methodology, which included a thorough review of existing knowledge and understanding the needs of users, provided a solid foundation for creating a strong system architecture. The development of software, featuring a comprehensive user interface and a backend system, along with the careful selection of suitable hardware components, played a key role in the project's success.

Results from testing the system in a real retail environment demonstrated its efficiency in automating checkout processes and offering a transparent user interface. The backend system proved its ability to effectively manage and update item data. Overall, the Smart Trolley project has the potential to significantly improve the shopping experience for both customers and retailers.

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REFERENCES

[1] T. Leena , R. MF, M. Amalasree , R. Greeshma , and R. K, "Smart Trolley with Advanced Billing System," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,* vol. vol 6, no. Issue 3,March 2017, 2017.

[2] S. Hiba, s. Jee, s. Pal, S. Singh, and M. Marbaniang, "Iot Application Based Advanced Shopping Trolley," *International Journal of Engineering and Advanced Technology (IJEAT),* vol. vol 8, no. issue 4, 2019.

[3] V. S.] A. Shaikh, R. Sawant, C. Singh, R. Harikrishna, and s. Ponmalar, "Smart Shopping Cart for Visually Impaired Individuals," *Symbiosis International Deemed,* vol. 9, no. 2, pp. 122-134, 2022 2022.

[4] Y. KOK LIANG, "Smart Shopping Cart," UNIVERSITI TEKNOLOGI PETRONAS, 2014.

[5] J. Albert *et al.*, "Smart Trolley as Sophisticated Supermarket Facility in Covid-19 Pandemic Era," Universitas Tarumanagara, 2021.

[6] K. Gopinath and B. Sreedevi, "Smart Trolleys System For Smart Shopping," *Elementary Education Online,* vol. Vol 19, no. (Issue 2): pp. 1991-2000, 2020.