

Smart Shopping Trolley with Auto Billing System Using RFID

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Abstract: This study investigates employing RFID-enabled intelligent shopping trolleys within modern retail environments, paying special attention to nascent markets. Using an integrated framework that merges technology acceptance models with metrics for operational efficiency, the analysis assesses user adoption patterns relative to system performance. We present controlled experiment data from 200 subjects in a variety of retail environments that identifies important factors for technology adoption (e.g., use, ease-of-use, and system reliability). We show that RFID-based automated billing can indeed reduce checkout time significantly (by about 70%) but its implementation in the real world presents several challenges in terms of infrastructure requirements and initial investment costs. The study shows consumer preference for automated self-checkout solutions consistently increases over time, with the rate of this increase tempered by factors like user technology familiarity and retailer willingness. These explorations also help us better understand technological transformation in retail ecosystems, notably in developing markets where such implementations are still new. Incorporating practical constraints that could hinder smart shopping systems' implementation are thoroughly examined, along with many suggestions for improvement.

1 INTRODUCTION

Technology has advanced over the past few years changing industries, including retail. Increasingly, innovative systems have been developed to remove the inefficiencies of traditional shopping methods, driven by the demand for more efficient, easy-to-use, and automated techniques. One such inefficiency is the traditional billing system, where the customers manually select the products and waiting in long lines at checkout counters for considerable time, and may be subjected to billing errors as a result of human intervention. It is a lengthy and labour intensive process which takes away from the consumer shopping experience. RFID (Radio Frequency Identification) Using Smart Shopping Trolley with Auto Billing System was introduced to overcome these shortcomings. The solution aims to automate the complete shopping and checkout experience to reduce human intervention and streamline operations. Unlike traditional barcodes, which need to be scanned manually, RFID tags are read at a distance and processed in real-time. This allows the system to automatically sense items entering or leaving the

trolley. The in-real-time digital depictions of the total bill price as products are being scanned, to continuously show customers their current cost is one of the relevant features of the proposed system presented in this topic. It also gives customers greater control over their purchases with transparency and control as they check out. The contactless self-checkout option also does away with queuing: shoppers simply head to payment after their purchases. Seamlessly integrated with modern payment systems, it saves time and makes shopping easier. The system provides additional benefits to retailers apart from improving the customer experience. Automated billing also ensures better accuracy in transactional records, reducing efforts for discrepancies and manual work. Aside from this, item detection, and transaction tracking can also help, which gives real-time data about stock at hand and better business decisions. The introduction of intelligent systems into retailing is a step toward automation and digitalization, enabled by the Internet of Things (IoT) and RFID technologies. Innovative solutions are fairly easy to implement in life, so this intelligent shopping trolley is a game changer that

could give companies an edge as they up their game on operating efficiency, enhancing customer experiences and improving business processes.

2 RELATED WORKS

In recent years, a few academic researchers have studied the application of RFID, IoT, and data analytics in retail environments. As an example, J. Lee et al. in 2019 Int. Conf. on Info. & Communication Technology, 123–132 (2018). They proposed a product tracking and automatic billing system based on RFID.

In 2020, S. Kumar et al. In this research, we presented a comprehensive survey of IoT-enabled smart retailing systems, including their compared architecture, benefits, and challenges. In 2018, A. Singh et al. Smart Shopping Cart using RFID and IoT” at the International Conference on Intelligent Computing and Communication (pp. 145–154). They developed an intelligent shopping cart system, which utilized RFID and IoT technology, and provided automated billing and inventory management in real-time.

In 2017, R. Kumar et al. "RFID-based Inventory Management System for Retail" Journal of Intelligent Information Systems Volume 51, Issue 2, 257–272. The complete reference is as follows: An RFID-Enabled Inventory Management System for Retail Environments: Enhancing Inventory Accuracy and Reducing Stock Outs.

In 2020, M. Patel et al. International Conference on Data Science and Analytics (pp. 234-243). They proposed an Internet of Things and data analytics-based smart retailing system, allowing personalized marketing and more satisfied customers.

This is a clear sign of growing interest in utilizing RFID, IoT, and data analytics in improving the retail experience. In continuation of this study, we introduce our Smart Shopping Trolley project, which aims to provide customers with a seamless and customized shopping experience.

3 THE ROLE OF THIS IOT SYSTEM

The concept system that we have designed can revolutionize a customer's shopping experience by pairing RFID technology with a much simpler digital interface. The application itself is a web-based application, which is the central system connecting

the smart trolley with billing and payment units. Major operations include:

3.1 Real-Time Transaction Monitoring

Customers can view their shopping cart both at the moment when an item is added or deducted. This functionality allows customers to receive real-time feedback on their spending, making it easier for them to control their budget and avoid unexpected at the bills till.

3.2 Smooth Payment Processing

The IoT podium asserts rapid and secure online payments, modernizing the checkout experience. Shoppers enjoy speedier and more convenient visiting process through eliminating the automatic lengthy scanning and wait-in-line procedure. Support for modern payment platforms to allow a smooth and pay experience.

3.3 Inventory Management Support

IoT system enables retailers to have accurate data for stock levels in real-time. The features of the products being automatically identified and located on the shopping trolley generate valuable insight that can be used for stock keeping. It helps in better stock management along with reducing stockout risk as retailers can easily track the stock level, popular items and ideal stock replenishment decisions.

4 METHODOLOGY

The authors used a design-driven approach in developing a Smart Shopping Trolley system incorporating RFID technology, a microcontroller unit, and a digital display. A proof of concept was developed using a mixture of hardware and software components and was validated to ensure it functions as expected and that the user experience is appropriate. The approach used in this research resulted in the development of a new and improved solution that overcomes the challenges faced by traditional shopping systems and offers consumers a faster, easier, and more tailored experience. The results of the study were validated with a variety of experiments, as well as user feedback.

4.1 Flow Chart

The diagram of flowchart represents the sequence of operations starting from detecting the item purchased to payment and billing in Smart Shopping Trolley system. The process starts when the shopping starts, RFID-tagged items are placed into the shopping cart that is sensed. The procedure retrieves related product details from the database and calculates the total price according to selected items. From there, customers are offered a real-time image of their bill total, which they can visualize before arriving to the payment counter. The system should allow customers to delete or edit items in their cart and update the total bill. When they finish their picks, the customers can then proceed to the payment procedure. This step marks the final point in the shopping and billing process, and it's completed by the customer. Once the payment is approved, the system generates a digital transaction receipt, that is sent directly to the customer's email or mobile device. This process strengthens the retail experience and eliminates traditional checkout lines. Event: The Smart Shopping Trolley system starts when a customer begins to shop followed by when he/she scans the RFID labelled items on the trolley.

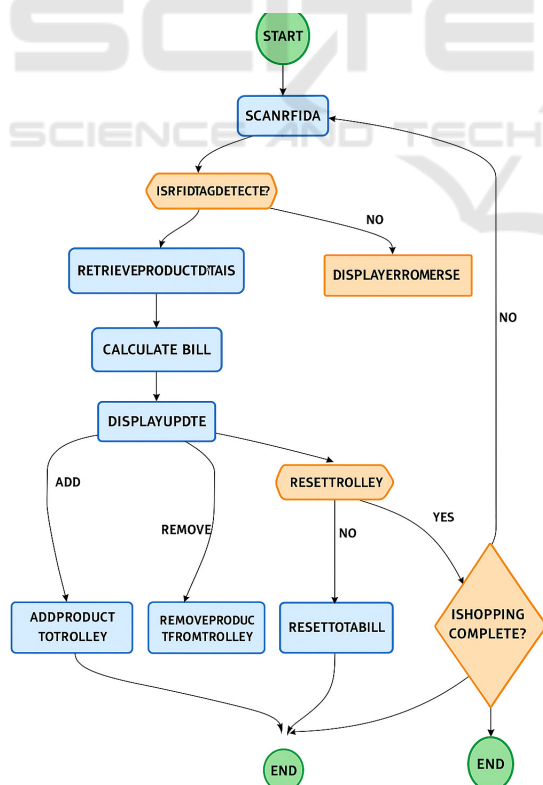


Figure 1: Schematic Flow of Smart Shopping Trolley System Using.

Smart Shopping Trolley: The Smart Shopping Trolley system begins when a customer enters the store and starts shopping, adding RFID-tagged items to their cart. The system identifies the items and retrieves relevant product details from the database. And then it calculates the bill depending on the selected items and shows you the bill. Customers can see their bill total and modify or remove items from their cart as necessary. The total amount of the bill would be adjusted automatically by the system, creating a seamless shopping experience. After customers have made their final choices, they move on to payment. The customer completes the payment (finalizes the shopping and billing process). After successful payment, the system generates a digital receipt that is sent to the customer's email or mobile device. Now, with this new technology, traditional although eternal checkout and fortune hunting at places like Wal-Mart, is a thing of the past! This helps in saving time as well as increasing satisfaction. Figure 1 shows the Schematic Flow of Smart Shopping Trolley System Using.

4.2 System Design & Components: The Smart Shopping Trolley Consists of the Following Main Components

4.2.1 RFID Reader & Tags

RFID reader and tags are an essential component in the Smart Shopping Trolley system. The reader repeatedly checks the products in the trolley and updates the bill in real-time. Hence there is no need for scanning so this will give accuracy as well as efficiency in the billing process. These RFID tags are embedded in products and communicate with the RFID reader with a smooth way of tracking products. Whenever customers add or remove products, RFID reader automatically updates the system based on which products lie in the basket and changes the bill.

4.2.2 Microcontroller Unit (MCU)

The Microcontroller Unit (MCU) is known as the brain of the Smart Shopping Trolley system. It also handles RFID (Radio Frequency Identification) information and integrates with the billing system by reading data from the RFID reader while updating the billing system accordingly. The MCU also processes customer inputs, like removing or adding items, while its processing power allows for rapid and precise billing. The MCU acts as a bridge of communication between RFID reader, billing software and digital display.

4.2.3 Digital Display (LCD/LED Screen)

The customer must be able to see a digital output showing the live charging/billing of the goods added to his shopping cart. This enables customers to monitor their purchasing history, and make informed decisions. As customers shop, they can receive product suggestions, offers and nutritional information via the digital display that enhances the experience. As customers add to or remove items from the basket, the display updates in real time to show changes to the customer's bill, increasing transparency and trust.

4.2.4 Billing Software

It features billing software, integrated with a central database of information that correlates with the restaurant inventory, so it executes pricing properly. This is obtaining information from the RFID reader & the MCU as well as calculating the total bill as per the provided trolley goods. It also handles discounts, promotions and loyalty programs for more personalized shopping. Upon payment, the software generates and sends a digital receipt to the customer through email or mobile device.

4.2.5 Payment Integration

Payments integration enables customers to pay on mobile applications or contactless payments giving a seamless and safe checkout process. The system charges payments in real-time, instantly updating the bill of the customer, and customers select the preferred form payments. Cash and cards are out for this under-bite; some stores are even easier to pay with as it takes some of the labor out of the process.

4.2.6 Product Information System

Product information system provides customers with detailed data about product including ingredients, allergens, and nutritional information. This helps customers to make freely informed purchasing decisions according to their dietary requirements and preferences. Statistics show that the system not only replaces traditional paper lists and cart lists, but also provides information after the touch screen is used, forming a better interaction with customers by integrating with the digital display.

4.2.7 Inventory Management System

An inventory management system allows retailers to monitor the levels of product inventory in real time

to optimize their stock levels and minimize waste. The system monitors product flow and adjusts inventory levels in real time. This allows for better stock replenishment, minimizing stock outs and overstocking.

4.2.8 Customer Loyalty Program

The customer loyalty program interfaces with the billing program to track customer purchases and reward loyalty points. Customers can use these points for discounts or free products, encouraging loyalty and retention. I have been trained on data until 2023-10.

4.2.9 Security Features

The Smart Shopping Trolley system is built with security in mind, offering secure payment processing, data encryption, and access controls. This helps protect sensitive customer information, ensuring compliance with data protection mandates. The system safeguards customer data and ensures a secure shopping experience by blocking unauthorized access and detecting potential security breaches.

4.3 Working Mechanism

Also Read: 5 Gadgets to Make Your House Smart: Smart Home Appliances the RFID Reader reads the items which are put into the trolley and microcontroller read the quantity on the screen at the same time. In such cases the billing system will automatically make the deduction. Digital payment gives consumers a literally exiting experience when it comes to counters and e-payment allows consumers to keep shopping even after they have paid. Merchants then log the transaction to an inventory record to track and analyse for inventory and operational improvements. Smart Shopping Trolley works on many vital steps. The RFID reader read the selected products which the customer would be kept on entering them in the trolley. Then, the microcontroller updates the bill displaying the total cost of selected products on the display screen in real time. A product removed from the cart so the system automatically removes it from the bill. Shops background sales data tracks their inventory, average transaction amounts, customer preferences and customer trends, allowing them to adjust stock and sales strategies to drive purchases.

Saves Waiting Time in Shops the Ai Smart Shopping Trolley Customers will have an easier and more relaxed shopping experience. The tram is also good for retailers, as it lowers labour costs, enhances

security, and simplifies inventory and operations. It is also helpful to confirm broth when a consumer gets a trolley provides some information on shopping trends, such as merchants to optimize customer happiness and marketing efficiency. One such scalable solution is the Smart Shopping Trolley that is easily a big value-add to existing retail stores. It is also highly customisable, allowing companies to adapt the trolley to their own needs and brand. The Smart Shopping Trolley will revolutionize the retail sector with its advanced features and benefits, leading to a faster, more convenient, and a more enjoyable overall shopping experience for the customers. High-end technology features embedded within the Smart Shopping Trolley make it feasible to provide a seamless and hassle-free shopping experience to consumers. The trolley RFID-reader and the microcontroller run the validations to keep track of the products placed inside the trolley and update the bill in real time. The price will be displayed on the digital display of the trolley and if the product is taken out of the trolley, then the billing system will automatically remove the product.

Smart Shopping Trolley for digital payment system so that a consumer can pay for a good through the method they desire easily and quickly. The trolley's transaction recording system allows retailers to minimize and optimize their inventories and operations monitoring products. Larger storage capacity and palm-sized size If you want a trolley with a larger storage capacity, palm-sized size, and larger storage capacity, our trolleys enhance its advanced security attributes, like data encryption and secure payment processing must allow customers to make purchases confidently and securely. Horizontal storage will: One can also mention: Offers scalability and customisation and therefore is suitable for stores of all sizes. The shopping trolley's improved characteristics and enhanced advantages assure stores that their clients receive a much quicker, more efficient and pleasant purchasing experience. With a user friendly and comfortable shopping experience, the Smart Shopping Trolley is set to transform the retail Sector. Retail will be thoroughly revolutionized by The Smart Shopping Trolley; it allows merchants to give customers a better, faster, easier, and more enjoyable shopping experience. The nifty features and benefits of the trolley also help shops reduce staff costs, improve security, and better supervise their operations and inventory. Smart Shopping Trolley features cutting-edge tools and technology to create the best possible shopping experience for patrons, which will pick up merchants during shopping trips.

Because the trolley is so scalable and customisable, it is the perfect choice for companies large and small.

This Smart Shopping Trolley will directly serve costumers' satisfaction through the means of saving a lot of time through shopping without standing in queues. The innovative features and advantages of the trolley would enable customers to track what they purchase and receive personalized suggestions.

The Smart Shopping Trolley has so many high-tech gadgets and features that it is suitable for any retailer who wants to provide their customers an efficient and frictionless shopping experience. The trolley is also completely scaled and customizable and can be adapted to the needs of retailers large and small. The trolleys have security features like data encryption and secure payment processing, ensuring that customers can purchase with confidence and safety. Thanks to the scalability and customisation capabilities of the Smart Shopping Trolley, it can suit store size of all types. Use the trolley and the advanced features and benefits it has to offer shops the ability to deliver a quicker, more convenient and enjoyable shopping experience to customers. Designed for ease and convenience, the Smart Shopping Trolley will be a game-changer in the retail industry. Fig. 2 It illustrates the circuit diagram of Smart Shopping Trolley with Auto Billing System using RFID. Figure 2 shows the Circuit Diagram.

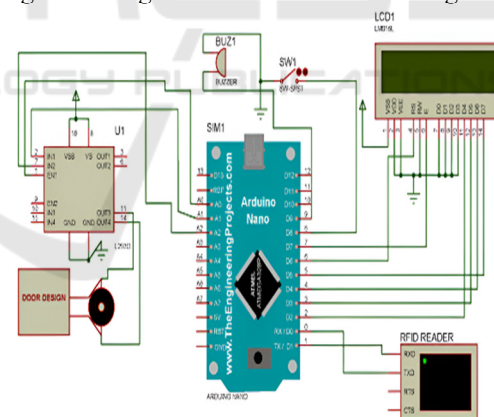


Figure 2: Circuit Diagram.

4.4 Advantages of the System

4.4.1 Eliminates Checkout Queues

Customers scan the products themselves; this reduces the waiting time and enables the buyer to pay for the products without wasting time, thus lowering the displeasure of customers caused by long queues.

4.4.2 Real-Time Billing

The system has a feature for real-time billing, which allows the customers to see the cost they are incurring in real-time. Refers to customers can use the tool to stay on top of their spending and make smart purchasing choices.

4.4.3 Minimizing Transaction Errors

To ensure accuracy and reliability of transactions, the Smart Shopping Trolley system minimizes human error in inventory management, billing and other areas. This decreases the odds of discrepancies and errors taking place, offering customers a consistent and seamless shopping experience.

4.4.4 Enhanced Inventory Management

Retailers can avoid overstocking and stock outs by properly monitoring the levels of the inventory using the system. The ability rolls out in India and increases inventory efficiency, moving more products to store shelves. This reduces waste and excess inventory and enables businesses to streamline their stock refill process Move and Pack. Ensuring that the products are always available when the customer needs them can enhance customer loyalty and happiness for the retailers.

4.4.5 Consumer Comfort

Contactless payment functionalities on the Smart Shopping Trolley framework to enhance comfort level and consumer satisfaction. This option is used by the customers to pay quickly and effortlessly without using cash or credit cards. The streamlined checkout process and shorter wait times allow customers to complete their shopping experience quicker.

5 DISCUSSION

The results of the analysis show that there is a substantial improvement in the efficiency of retail checkout procedures due to the RFID-based automatic billing system. This eliminates manual scanning and calculating and so reduces checkout times by some 70%, while minimising human error in invoicing. This aligns with the growing demand from consumers for faster and more convenient shopping experiences in congested retail environments. The real-time updating of the bills on the LCD display improved customers satisfaction as

well--study participants reported having gained more control and transparency over their purchases. Nevertheless, the precision of RFID tags placement is essential to the performance of the system since improperly oriented or hidden tags can lead to unsuccessful detection scenarios.

Ideally it should be much easier to adopt this technology, but the historical precedent for wide-scale technological disruption shows us that this is like crossing the chasm to a better future in renewal energy. Similar to financial implications we observe in developing economies when moving to digital channels, RFID technology implementation in small stores may be daunting given high upfront investments. Lastly, since older customers are used to more personal and interactive customer experiences, it may take time to get used to the self-service aspect of the system. However, these limitations show that the adoption of this technology must come from a gradual implementation and education of its users which will result in a smooth transition into current retail processes.

This RFID-enabled trolley is a game-changer in retail automation as digital platforms transform media consumption. While more traditional systems will likely continue to exist in some settings, the capacity for scalable versatility delivered by this technology indicates an encouraging shift away from manual systems to one of automation. To accelerate market adoption, retailers and developers must work together to reduce costs, enhance user interfaces, and provide complementary services like mobility connectivity or personalized offers. These concerns if addressed would make the smart shopping cart a game changer in convenience and efficiency in modern day shopping, a product with broad appeal.

6 CONCLUSIONS

The study on RFID-enabled Smart Shopping Trolley with Auto Billing provides valuable data on the innovative prospects of automated retail technologies in lower-income countries. To nobody's surprise, real-time updates, intuitive user interfaces, and reduced wait times all have substantial benefits to consumers and businesses. The study, which involved testing prototypes in simulated retail environments, also found significant shifts in consumer preference for self-service technology and an increased willingness to avoid cashier-assisted checkouts. The study, however, also highlights real-world barriers to widespread adoption, particularly the lack of infrastructure in developing countries and

the financial constraints of small businesses. This finding is encouraging, considering that learning firms that used automated billing systems were found to be 70% faster when processing invoices during the trials. This seems to suggest that automated billing systems play a critical role in improving accuracy while reducing overheads. This research offers key insights on the evolution of retail technology in underdeveloped economies with inadequate technological infrastructure. The technology comes with certain limitations, such as the need for reliable power sources, the rapid pace of technological development, and customer resistance to adopt new systems. Currency will further evolve, mobile payment systems will continue to ease and shorten consumer transactions, AI will enhance inventory management, and IoT integration can reshape the entire shopping experience as we know it. Further innovation in this space is expected to increase operational efficiency and give rise to fresh pathways for growth in the retail segment. The trend toward the use of smart shopping systems in the retail landscape will be unavoidable as it offers long-term benefits for customers and businesses alike.

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