

IoT-Based Intelligent Shopping Cart to Enhance the Shopping Experience

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Abstract— With the complexity of needs, shopping has become an integral part of human life. Due to their busy lifestyles, people are more inclined toward convenient and efficient shopping methods. The shopping cart is an essential tool for shopping in a supermarket. With the rapid development of technology, primarily foreign supermarkets use intelligent shopping carts. The problems that are included in traditional shopping are as follows: customers will receive a receipt after they pay, but it is more likely to disappear in a few days than a physical receipt. Some customers are embarrassed in front of the cashier because the total is higher than they expected. Customers have to take a longer period to shop due to finding products at the supermarket, and it is difficult to push the cart with a heavy load. The newly introduced automated smart shopping cart is a hybrid of a line-following Raspberry Pi-based robotic cart and an Android mobile application built on the Flutter platform and powered by a Firebase cloud database. This novel solution entails making the shopping experience more convenient for customers, particularly those who are accustomed to shopping malls.

Keywords— Smart cart, Mobile application, Bar-code scanner, Raspberry Pi

I. INTRODUCTION

Shopping has become a day-to-day activity for many people in the world. There are a few different reasons for this. Most people shop to buy their daily requirements. There are a few different ways to shop, each with its advantages and disadvantages. Online shopping has

become more popular than ever. There are several reasons for this, but one of the main reasons is that online shopping is convenient. You can shop from anywhere in the world, and you don't have to worry about finding an open store. Online shopping also has a number of benefits over traditional shopping. Although online shopping is effortless, some people are reluctant to do so because they may have some potential not to get the exact right product. In addition, many of the items needed in daily life cannot be brought online. They should be inspected and purchased. With the busy lifestyle of people, they tend to buy everything in one place, and they go to supermarkets because they can buy everything, they need from food to household items without having to go to multiple stores. Supermarket management also identified this opportunity, and they have taken various steps to make the shopping process streamlined and efficient.

Previous research in this field have already implemented systems only focusing on displaying the products and their prices, which are added to the cart on a digital screen built in the shopping cart. Through these systems, what buyers can only know is their product prices and final amount. But it is not the only problem buyers face inside the supermarket. Most of the time, buyers go here and there inside the supermarket searching exact products they need. And also, in peak times, long queues can be seen at the cashier to pay the bill. Also, it is difficult for older people and pregnant women to push the shopping cart. Also, it is good if there is a method that buyers can prepare a shopping list and buyers can view their previous bills at home. The proposed system gives solutions to all of the problems mentioned above that customers face inside the supermarket, and also this system centralizes the purchasing process.

The developed system gives solutions to all of the problems mentioned above that customers face inside the supermarket, and also this system centralizes the purchasing process. The entire product gives the solution such as no need to push a cart, no worries about the payment, receive a digital online receipt as well as no more fraud may happen during the shopping. This model mainly contains a modified shopping cart and a mobile app. Customers can connect their mobile phone to the shopping cart, and the mobile phone act as a digital screen. The shopping cart has a built-in bar-code reader and weight scale. Also, the cart has the functionality to navigate inside the supermarket automatically. This model solve most of the problems customers face inside the supermarket.

This model solves most of the problems customers face inside the supermarket. This research paper contains our background study, which we did to find the research gap. Then the research paper includes methodology which is detailed description of our proposed model and four main components of the research. Next, obtained results until now and discussions. After that, the research paper contains the conclusion, acknowledgment, and references. Within this paper we discussed about background, the methodology and the results of the research area.

II. RELATED WORK

The concept of smart shopping, which originated in the United States, has spread across western Europe [1] and has become a system that is needed all over the world in today and consumers want to make their shopping experience easier through the smart technology and more accessible in one place. Then the smart owners of the shopping malls should be responsible to supply a comfortable and hopeful shopping way to all types of smart shoppers [1]. It is seen that many smart systems have been created which are a challenge to the existing traditional shopping. The majority of existing smart cart is based on IOT technology [7], RFID, Raspberry pi and Arduino.

Within some existing systems created in this way. Most of the currently operating smart systems are based on RFID technology [2]. In most cases, an RFID tag is attached to the product and all the data related to the product is programmed there and the bill must be calculated after reading it [5]. And this RFID card is given to the customer, and it is interpreted as a membership card, thereby representing the shopping trolley as smart [9]. In all these cases, the scanner procedure is obtained by the RFID reader attached to the cart [2]. Although its convenience is somewhat high, it is costly to implement and may experience some errors in its implementation. Thus, when comparing the barcode and the RFID technology, it can be recognized that the barcode reader is very convenient and inexpensive device that can be used simply and smartly. You can read the default barcode of each product and calculate the relevant bills very easily [6]. And in some of

the existing articles, instead of the barcode reader, a scanning procedure has been introduced using the mobile phone [9].

Further a digital screen attached to the cart of many existing articles has been introduced to display it to the customer after scanning using various methods. The location of the items required by the customer, bill calculations, etc. are all shown on this screen, but installing it on each cart is quite a costly task [8]. Because of this, as introduced in this research paper, the customer's mobile phone is used instead. By installing the mobile application, he can perform any role he wants. Amazon fresh grocery stores and Alibaba's Hema groceries have introduced smart shopping carts with various facilities. Even in Sri Lanka, we can see smart shopping cart technology called scan & go in Keels supermarkets.[3] In addition, Self-Checkout Systems, pay from a mobile application are introduced under the IOT environment.

In 2020, research was carried out on the design of a smart cart app for automated shopping in supermarkets by Aida Arvidsson and Lina Hassani to design the application prototype (user interfaces) to give a good user experience to customers based on Human-Computer Interaction (HCI) [14]. This research has mainly focused on the self-checkout process to suit Swedish supermarkets to reduce the queue in front of cashiers. They have used IoT technology in giving an RFID card to every supermarket user, and the rest of all things like scanning the barcode had been put into action using a mobile phone camera.

Ankush Yewatkara , Faiz Inamdarb , Raj Singh , Ayushyad , Amol Brendale have been carried out a research to create a Smart Cart with Automatic Billing, Product Information, Product Recommendation Using RFID & Zigbee with Anti-Theft [15]. This research aims to reduce the long queues in the supermarkets, reduce the labor cost, give a complete idea about the product to customers, and attract customers to the supermarket.

The paper published in 2020 by Anitha, Dr.Subburam, Keerthana, K.H.Yoganandarajurs in the domain of smart trolley billing systems, they have mainly used IoT technology [16]. The solution they have given is not connected with a mobile app. They are tempted to install an LCD screen and RFID scanner in the shopping cart. To increase the system's security, they have used RFID technology instead of a barcode reader.

Another smart cart research was carried out by the International Journal Research Culture Society in 2018 on Automated Shopping Trolley System Using Raspberry Pi Device [17]. Their main objective in this research is to provide an efficient customer service by reducing the rush and queues inside the shopping mall. They have used raspberry pi technology with LCD and barcode scanner.

In the 2016 Hsin-Han Chiang, Yu-Te Liao, and Yen-Lin Chen published research on the Development of Smart Shopping Carts with Customer-Oriented Service [18]. The main aim of this research is to reduce the manpower inside the shopping mall and increase customers' shopping experience. To achieve the target, they have added many new features to the existing shopping cart like recognizing the face of the customer by the shopping cart, according to previous bills, suggesting products, attaching an RFID scanner to the shopping cart to scan and add products, attach an LCD screen to shopping cart to view final amount, automatic navigation system inside the supermarket and automatic billing system. They have used local binary patterns histograms (LBPH) algorithm to do face recognition, and they have attached RFID tags to each product for product identification. However, the RFID card approach is more secure than a barcode reader, and it will have to cost more. Compared with existing articles, can be able to find out how unique the smart cart procedure that introducing in here.

III. METHODOLOGY

A. Development of Line Following Smart Cart

After referring to mobile application-related surveys, two open-source frameworks were identified to overcome these system requirements and develop the mobile application. Flutter and react native are both cross-platform frameworks that support using the same code base for IOS as well as android applications. These cross-platform frameworks are most effective because they give code reusability, reduce cost, provide excellent product maintenance, and hassle-free rapid development. Out of these two platforms, flutter is chosen to develop the mobile application because it is more adaptive to system updates. When selecting the database, No-SQL databases was identified as the best solution, and it should also be hosted in a cloud. Considering these facts, Firebase Firestore was selected as the best solution to go with. The database table is including with Product Category, Product name, Weight, Price, Quantity and Barcode number.

Under this android mobile application, user login, Shopping list, display current payment, searching needed products, add products to the database, remove option and collect removed data by the database can be introduced. Two open-source, cross-platform frameworks can be identified throughout the literature survey and analysis to develop the application. They were Flutter and react native. Cross-platform frameworks are most effective because they support using the same code base for the Android and IOS applications, give code reusability, reduce cost, provide great product maintenance, and hassle-free rapid development. When it comes to flutter and react native, Flutter is more adaptive to system updates. According to the above points, Flutter was the best option to go. When selecting the database, NoSQL databases were

identified as the best solution, and the database should also be hosted in the cloud. Considering these facts, firebase firestore was selected as the best solution. For this implementation, the mobile application develops only for android users. Supermarket administration adds all the product details to the database, including product name, category, weight, price, quantity available, barcode number, and product location (rack number).

The shopping cart needs a path to move inside the supermarket and stop at the exact product. This component's main target is to give the path the shopping cart should follow inside the supermarket. In that case, we have implemented a shopping list function inside the mobile app. All the products, product details, and rack numbers where the product is available are in the database. Customers can create a shopping list at home before coming to the supermarket using our mobile app. When a customer creates a shopping list, products and respective rack numbers are stored in a table called "shopping lists" along with the customer's user id. The cart moving component directly accesses these "shopping lists" table records. We have given a QR code for each shopping cart. Customers can go to the supermarket, scan the QR code and connect to the shopping cart using the mobile app. Then they can shop according to their shopping lists. The below system diagram (figure 1) defines the method of hardware and software implementation for a successful output, which is described in the results section below. The entire procedure describe can identify as a flow using this diagram.

B. Development of the mobile application

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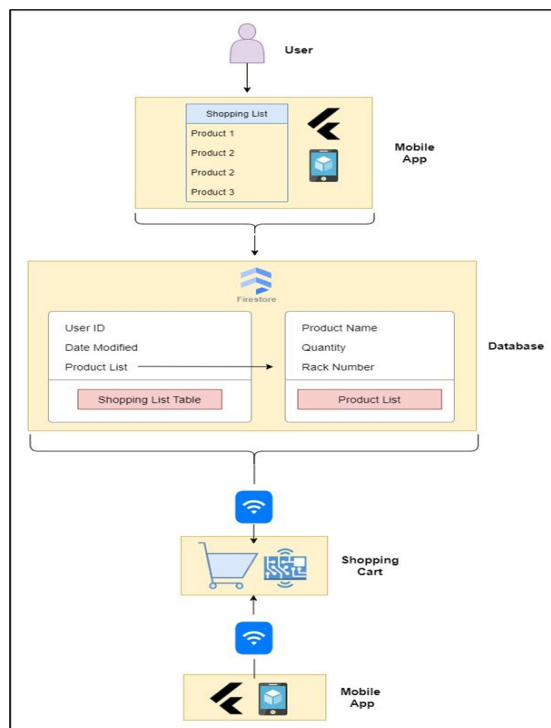


Fig. 1. System Diagram

IV. RESULTS

The results obtained from the development and references of this system are based on survey experiments. The results of the survey encourage us to deliberately deploy these functions to create a smart cart system to improve the traditional supermarket procedure. The following pie chart (fig.2) display the willingness of the customers for a smart shopping system. Most of customers expecting something new looking functions within the physical shopping procedure.

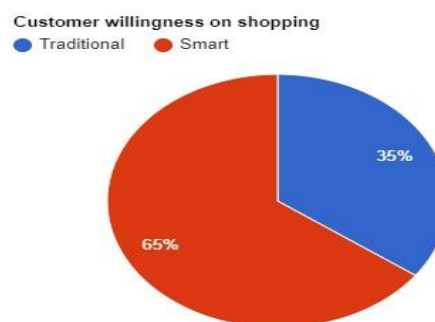


Fig. 2. Customer willingness on shopping

The survey describes another situation: the consumer's willingness to carry goods using a cart or basket (Fig.3). It is a much easier way to express consent. It is easy to multitask, and there is no need to worry about the safety of the goods if the customer uses a cart and needs to push the load.

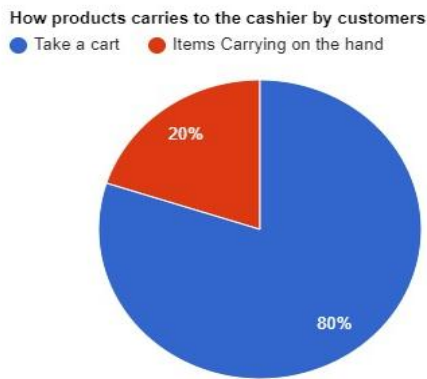


Fig. 3. Willingness of carrying items

The demonstrated production done by Arduino, Raspberry Pi, Flutter, and Firebase output is discussed here. The implemented cart can be able to find relevant needed items by following a specific line at the supermarket. It is possible to take measures to avoid various obstacles encountered by the cart on the way. For that we used ultrasonic sensors, IR sensors and for count distance we used stepper motors.



Fig. 4. Smart cart

Here we introduce an Android mobile application that supports various functions. Before implementing a mobile application, we had to mention the use of smart devices among people. Although this will improve with smart technology, we need to see how much people can use this smart app using their own smart devices. As a result, we can see that the number of people using smart devices is gradually increasing (Fig.5).

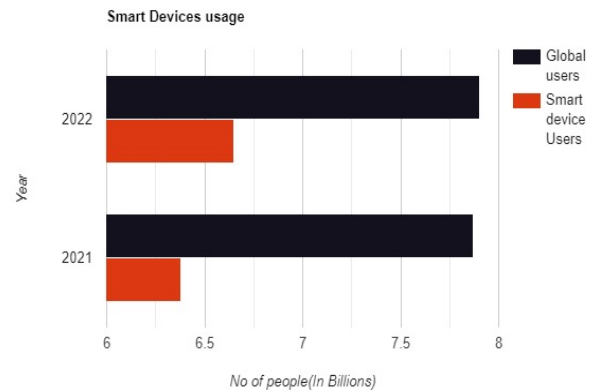


Fig. 5. Smart device usage

In this research area, customers should install and create an account for the mobile application. The front end and backend have been created successfully including the interfaces with home page, Sign-In option, Shopping list page, Calculated bill displaying page, removing options, searching for product options. Customers have traditionally done their shopping using a shopping list they created at home or by purchasing items at random in a shopping mall. The majority of these two types use a shopping list to buy what they need. We have finalized it using survey details (Fig.6).

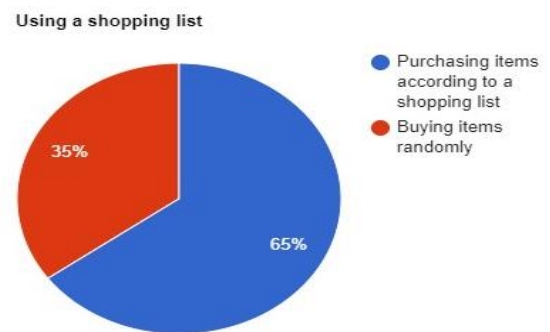


Fig. 6. Shopping list preferences

The mobile app was tested before integrating with the shopping cart and after the integration. Fig.7 shows the interfaces after customers add products to a shopping list. Figure 8 shows the real-time database of the mobile app. There the connection happens between the mobile app and the shopping cart and giving the path for the shopping cart to follow.

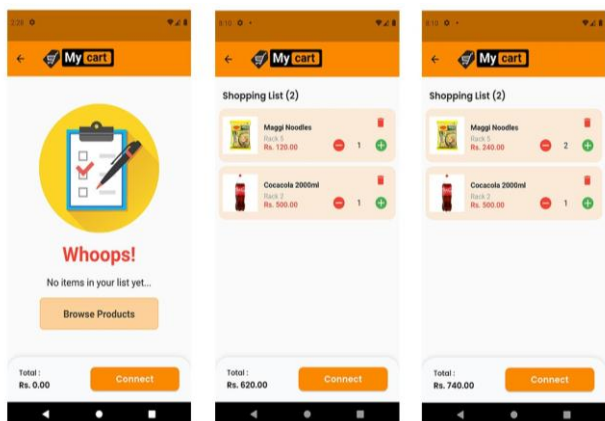


Fig. 7. After Adding products to shopping list



Fig. 8. Real time database

Using the barcode reader, the customer can monitor the purchased products to be aware of the current payment. This barcode reader is programmed to detect the barcode of any item, and it could be able to connect with the database. The interfaces below show (Fig.9) how the current total payment appears after it has been read by the barcode reader. If customers need to return a purchased item, they can use the remove option by swiping from the application. In parallel, the total payment will decrease.

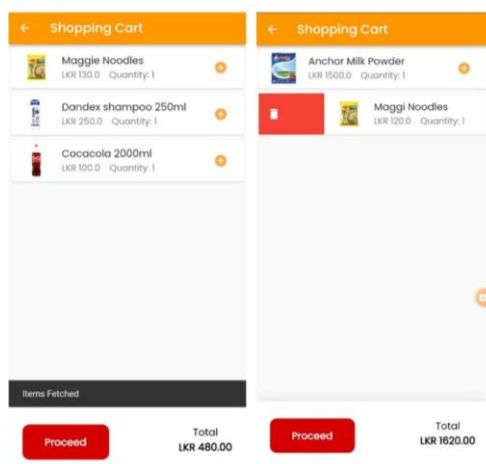


Fig. 9. Display current total amount

CONCLUSION

By means of this paper, the research intends to simplify traditional shopping issues through IOT technology. This will improve the standard of the entire shopping experience. This entire paper depicts the act of combining a smart cart and a mobile application. This is an automatic cart, which can be introduced as a line-following robotic shopping cart. There is no need to push carts through the shopping mall like traditional carts, and there is another advantage: no more waiting in front of the billing queue because the mobile application calculates payment automatically. The shopping list has the significant advantage of allowing the customer to estimate the total amount of the bill at home. This research provides an anti-theft system for avoiding fraud using a weight scale system. The smart power system shows the battery percentage level, and when the level drops below a certain threshold, the bulb turns on. It is beneficial to locate the supermarket helpers in order to locate carts with low battery levels and charge them before the customer uses them. This is a successful implementation of the intelligent shopping cart system using updated smart technologies

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