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# Design and Implementation of Autonomous Trolley with E Billing

Original Article

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Shopping became one of the most important tasks that people conduct on a daily basis. A mart is a place where various things can be purchased within a roof. Customers must patiently wait in lengthy lines, especially on weekends, until it is their turn. Due to people's busy schedules, this is a time-consuming process that leaves them exhausted and dissatisfied with the services provided at the checkout counters. We proposed and implemented an autonomous trolley with an electronic billing system. The proposed and developed system is separated into two sections, the first section consists of RFID tags and camera-based product scanning and detection, while the second section consists of bill generation and e-payment. The second output is of a shopping receipt, which was printed using a thermal printer effectively, and smart trolley-based bill detection will be accomplished. This self-billing is a new technology that can present us with numerous advantages. Currently, everyone is familiar with e-payments, and because our system is also based on direct bank transactions. This smart trolley-based bill detection will ultimately be accomplished through the user's bank and Jazz Cash. Automated trolley systems are designed to provide customers with knowledge about their collected items and decision-making abilities based on prior purchase patterns in order to ensure a hassle-free shopping experience.

**Keywords:** Smart trolley, E-billing, RFID, Internet of things, LCD, Internet Banking

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All authors contributed significantly to the study, and all authors agree with the content of the manuscript in IJIST.
**Project details.** NiL

## INTRODUCTION

Shopping has become an everyday activity for everyone in urban cities, especially on weekends and holidays, and it encounters an increasing number of hurried people these days. When there is a special offer or a sale, this adds another aspect to the binding system. A shopping center is a location, such as a supermarket, a superstore, or a general store, where customers may find things that meet their needs and intend to purchase those products [1]. Now, every business provides baskets and trolleys to assist people with their shopping by putting their things into the baskets or trolleys, such as apparel, groceries, machinery, and so on, but they have no way of knowing the whole amount of their purchase and must deal with overbilling [2]. In this smart society, everyone's time is valuable, and no one wants to spend it by standing in line at the pay register and waiting for their purchases to be invoiced [3], [4]. This approach also increased the strain on the cashier because each basket contains more products, and at each counter, there is only one cashier who is responsible for creating the bills, which causes this task to become overly time-consuming, resulting in a long queue [5], [6]. This cashier burden and consumer time waste can be minimized by IoT technology, which has such a large impact on everyone's life nowadays. This IoT technology is a rapidly emerging technology that provides multiple solutions and is involved in many industries, such as data transfer over networks without the need for human intervention, autonomous devices, digital machines, and connecting people to smart things. It can help to minimize labor work and costs while also improving the shopping. experience for everyday consumers by allowing them to complete self-checkout [7], [8].

This article employs the notion of IoT with RFID and camera detection technologies, as well as LCD, electroplated stickers, and toughened tags to highlight an autonomous trolley that provides smart billing solutions. Our proposed system's design will be user-friendly and efficient, allowing customers to self-checkout without wasting time standing in a long line. This self-driving trolley will also allow customers to see their whole purchase, advise their future purchases, and eliminate the need for them to worry about overbilling problems. Simultaneously, this technology will lower the human load, cost, and employment ratio.

### Background

The authors of the paper [1] proposed an IoT-based system based on Smart Cart with automatic billing. The goal of this system is to provide an automated billing system that uses RFID and ZigBee communication. Every product in the store and supermarket will have RFID tags, and every trolley will have a PID (Product Identification Device), which includes a microcontroller, RFID reader, EEPROM, LCD, and ZigBee component. This device will feature a linked database via which clients will receive product recommendations on the LCD screen together with runtime bills to assist them in purchasing other things. The main aim of this method is to eliminate the long line system, save time for consumers, and provide product information and recommendations while preventing theft. The author of paper [5] used Zigbee-experimental analysis to create a sensor-based smart trolley system. This trolley has an RFID reader, a tag, and a battery. The tag is generally placed over each product in superstores and supermarkets to allow customers to self-checkout. The goal of this trolley is to let consumers see their total purchase and avoid overbilling, as well as save time by not standing over the cash register and waiting for their turn to have their purchases billed.

The authors of [3] introduced a system for shopping malls and supermarkets that consists of a modern barcode scanner for current shopping situations, a rating process that provides weight and images of the product so that variation can be eliminated, and a centralized system and an installed system used to integrate all of these components. This technology allows the customer to place and removes their purchases while simultaneously updating the overall bill. This system includes utility records to make it easier for the holder to manage their tasks, as well as a trolley module to help customers with well-organized shopping.

In paper [2], the author designed an automatic motion trolley along with an intelligent purchasing device after explaining the need for a shopping trolley during the time of shopping. Usually, the simple trolley used by the customer for carrying their goods will have gone to purchase them, and then they will have gone to the cash counter along with their trolleys for their products to be billed, but this entire procedure is too time-consuming and time-wasting for their automatic motion trolley. This system's design is primarily based on hardware and software, with an IOIO microcontroller and Android phones serving as sensors and controllers, sending signals to the robot to control it, and an IOIO microcontroller linked to the robot's actuator to detect the condition via the smartphone camera. They also utilized the smartphone compass to help the robot read maps. This system also uses Navisens to determine the customer's location, which is based on the smartphone's gyroscope and acceleration sensor.

The authors of the paper [4] created an automated shopping cart system utilizing a Raspberry Pi and an ultrasonic sensor. This system was designed for shopping malls and supermarkets to reduce the employment ratio and burden of the cashier while maintaining the entire checkout procedure from the buyers' and cashier's perspectives. The goal of developing this system is to allow customers to self-check out instead of standing in a long line and waiting for their purchases to be billed. This system also allows the customer to enter and delete things by detecting them and adding them to the consumer's cart; this design is extremely effective on both the consumer's and seller's end. After all of the shopping is completed, if any of the customers leaves the cart with any of the products remaining in it, the amount of that specific product will be charged to their bank account that is linked to the system. Who enters and exits the business will be identified by the face detection system known as Kairos. All information is uploaded and updated in real time by connecting to a backend database, which in this case is Google's Firebase. According to the authors, all of their system modules are experimental and implemented.

In paper [7], authors presented a system that gives the listed things that are available on the customer's closest route, as well as cart-to-cart talking functionality, so that consumers may engage with each other and exchange their purchasing records. With this feature, the system saves time and effort for all individual consumers. This system is also intended for management so that they can quickly assess their overall sales, make their product supplies available to customers, and set up a monitoring system for theft detection to avoid product loss. This technique significantly minimizes the time spent standing in line and improves the shopping experience for both customers and management.

In paper [7], the author highlights the problems that, while self-checkout is now available in 90 percent of superstores worldwide, there is no technique or device available to provide information about products to customers during their shopping, and there is no way to detect theft and save superstores from loss. Standing in the check-out queue is often a stressful experience for any customer. The authors of [7] propose a Cloud-Based Inventory

Management System using a Smart Trolley for Automated Billing and Theft Detection as a solution to all of these issues. The goal of this system is to protect against theft by monitoring them, lowering labor costs, providing smart checkout solutions, and decreasing standing time. In the paper [8], the authors create a smart trolley based on a Raspberry Pi. This trolley has a barcode scanner to detect the merchandise and an LCD to display the products and the total bill. When products are added to the cart, the barcode scanner automatically detects the barcode on the product and adds the price of that product to the total calculation, as well as displaying all of the product's details and prices on the LCD. The author created this technique to decrease long lines in the checkout line and to allow all individual users to self-checkout and save valuable time. The author of [9] represents the problems of individuals who are more likely to purchase grocery items from supermarkets and grocery stores in the current environment. Finding a customer's basic needs in a supermarket in such a situation takes extra time, and once located, the consumer must wait in the billing line to finish the payment process for the chosen goods. Author also raises the Covid'19 SOP problems that cannot be followed in this rush system. In the paper [9] the author implements the IoT-based smart trolley with an advanced billing solution for all of these problems. In the paper [10], authors have proposed an advanced retail system with the use of RFID-enabled smart carts and an automated invoicing system. While placing the goods in the trolley and removing it from the trolley, RFID scanners are employed to read the product tag. A reader transmits the microcontroller the relevant product ID, quantity, and price when the item is placed in the cart. Similarly, when any of the products are removed from the cart, its ID is automatically removed from the bill and updates the product stock. This system has a smart stick based on RFID technology for blind people. An automatic payment system with stock monitoring was proposed by the author [11]. This system also enables admins to check stock information in addition to this transaction capability. Without any additional human work, the stock of each product may be tracked and planned properly. The authors of [12] introduces the smart trolley for the enhancement in the superstores, which require membership cards, image recognition-based recommendation, virtual assistants, customer counting, and transaction completion notification. Every customer has a membership card that serves as both identification and a key to the trolley. The camera and load cell in the smart trolley allow it to scan products, measure them, and show the product information on screen. In order to draw customers and assist them in making decisions about what to buy, product recommendation systems analyze customer demands and give the best information about products to both current and potential customers. The necessity for a shopkeeper in the supermarket will be reduced as voice assistants enable customers to ask questions about locations, discounts, deals, and prices. In [13] authors proposes a smart cart that can generate payment by employing IoT and a mobile cart application. Consumer can quickly to their payment by using their smartphone app and trolley. The consumer can also log in using the smartphone application, which will show a list of all the listed products together with their quantities, in addition to this. Once finished, the consumer can use the smartphone app to make a payment. In the [14] authors created the smart cart based Infrared sensors, RFID tags for product identification, ZigBee for wireless communication with the server, and an integrated system with a show for questioning and inventory management. The technology known as RFID (Radio-Frequency Identification) has the potential to develop quickly. Currently, barcode technology is adopted and operational in a number of supermarkets. Barcodes are the continuous, vertical black bars that provide information about an object. There is a smart cart in which ultrasonic sensors enable the user to self-scan each item. Product identifiers are contained in barcodes that are linked to backend databases [15]. However, several technologies are used for the smart trolley, which is initiated possible by the Internet of Things (IoT). Table-1 shows some of these in more detail.

Table-1 Comparison between Existing IoT Based Smart Trolley Devices

| Reference | Years | IoT Devices | Technologies |
|---|---|---|---|
| [1] | 2016 | Smart Communication | ZigBee module |
| [2] | 2020 | Product scanner and detector | RFID module |
| [3] | 2018 | Product detector | Electronics BSC101 Barcode scanner |
| [4] | 2019 | Wheel rotator | DC motors ZGB37RH |
| [5] | 2019 | Distance Monitor | Ultrasonic sensors |
| [6] | 2018 | Product identification and detection | Barcode scanner and camera detector |
| [7] | 2019 | Anti-Theft detector | Infrared sensors |
| [8] | 2018 | Weight detector | Load cell CZL601 |

## Material and Methods

The goal is to design an autonomous trolley with e-billing system, and a considerable user interface in the form of an LCD to interact with this trolley to decrease the check-out line and enable customers to self-checkout and improve their shopping experience. This trolley's fundamental technical notion is as mentioned below.

## Convolutional Neural Network

A Convolutional Neural Network (CNN) is a deep neural network technique and deep learning technology used to investigate image visualization. It takes a picture as input and assigns the important values of several dimensions within the picture, as well as distinguishes them from one another. It employs a one-of-a-kind mechanism known as "convolution," which is a linear combination of two components that results in a neural network system that defines how well the form of one is modified by another. When compared to other existing classification algorithms, the convolution appears to utilize substantially less pre-processing. Whereas traditional techniques necessitate the hand-engineering of filtration systems, convolutional networks can learn such extensions with extensive retraining.

## Region-Based Convolutional Neural Network

Many pioneering efforts to apply deep learning to object recognition include region-based CNNs or regions with CNN features (R-CNNs). In this section, we will go over the R-CNN and its various upgrades, including its selective search technique. It takes an image as an input and applies a selective search over the similar or neighbour pixels that are present in the image after dividing them into 2000 regions. This region of interest will be represented as the boundaries of the rectangle, and a Convolutional Neural Network (CNN) will be applied to each of these regions individually in order to get features, and the Support Vector Machine (SVM) classifier will also be used to classify the objects that are shown inside these regions.

## Single Shot Detector

The Single Shot Detector (SSD) is a method for detecting an object from an image with a high rate of precision and in an efficient manner. It just takes one shot to detect various things that appear in a picture using a multi-box and then label them along with multiple classes and dimensions based on their class label. A multi-layered convolution neural network is used in the technique to develop a multi-layered framework that can filter input images into the specified categories. SSD's speed and performance are far superior to Yolo's, allowing us to do detection at numerous levels.

These are the three main algorithms and techniques that we have used to detect the products while using the camera detection feature during the shopping period in order to provide an alternative solution to our consumers in the event that there is any defect in the tags that are placed behind the products or any defaulted chips that are placed over the product that could not be read by the RFID reader and causes the consumer to stop shopping. Their shopping will not be halted, and they will not have to be concerned about their bill computation or total purchase that has been added to their carts and devices. Their billing will continue with the help of our camera detection feature, in which users simply place the product in front of the camera, and these three algorithms will assist the camera in detecting this product image and matching it from the trained dataset, as well as providing relevant information about that specific product, as well as its price, this can be seen on the LCD monitor. This alternative solution is presented to our customers in order to improve their shopping experience and make their shopping more efficient and faster with the assistance of our autonomous trolley with a smart invoicing system.

**Implementation**

The Arduino UNO, Raspberry Pi Model B, version 4, the RC522 RFID Module, and the Rs232 Mini Thermal Printer are the major hardware modules utilised to construct this system. The Arduino UNO, as illustrated in Figure 1, is used to control load cells since it is a low-cost open-source microcontroller board based on the ATmega328P that has 14 digital pins to control servos and LEDs as output by writing code in the Arduino IDE software. The Raspberry Pi, as shown in Figure 2, is utilised to properly run all of the components since it is the light-weight and more powerful Broadcom BCM2711B0 quad-core ARM CPU with a 4K video processor, USB 3.0 and Type-C connectors, and 40 GPIO input/output pins for direct access to external devices. Because it includes an antenna that emits an electromagnetic field with a high frequency to identify objects, the RC522 RFID Module, as illustrated in Figure 3, is used to scan electroplated chips and tempered tags that are put behind the product. Because it employs heat to form images on paper, the Mini Thermal Printer Rs232, as seen in Figure 4, is used to print client receipts.

**Components**

The Raspberry Pi Model B, version 4, is the microprocessor illustrated in Figure 2, which behaves like a mini computer. It has 40 GPIO pins for external device integration and also has an ethernet port for network connection and USB ports for data cable connections. It can be used for complex and multitasking projects.

The Arduino UNO is the microcontroller, as illustrated in Figure 1, it has 20 pins, 14 digital pins for digital configuration, and 6 analog pins for analog configuration. It can be used for small or prototype version projects.

Radio frequency identification is referred to as RFID, as shown in Figure 3. These are small tags that we use to open hotel rooms, automobiles, and other devices. The RFID system is made up of these little chips and an RFID reader. EM waves are used by the RFID reader to receive data from the RFID tag. Tags have a memory capacity of only a few kilobytes. The RFID tag functions similarly to a barcode scanner. A new generation of printers has been adopted by the thermal printer, which is illustrated in Figure 4. Its front panel allows for paper change It can be used to receive and send photos, as well as graphics cards and thermal printers. It is commonly used as thermal copiers and compatible with both thermal printers and ink cartridges.

**Figure 1**: Arduino UNO

**Figure 2:** Raspberry Pi 4 Model B

**Figure 4**: Thermal Printer

**Figure 3**: Radio frequency identification

Above, Figure 5 depicts the flow of our proposed system, which begins with a power supply and continues with the Raspberry Pi and Arduino. With the help of the Raspberry Pi, it scans product tags and chips to see whether they match, and if they do, it determines the product details from memory and displays them on the touch screen LCD. If it does not match, we have a camera detection feature as an alternative solution; the customer simply needs to select this feature, and after doing camera detection, the product data will be checked from memory and then display product relevant information on the touch screen LCD. Whereas Arduino is used here for the purpose of a load cell, which counts the total number of products added to the cart, determines its weight, and displays the all details of the overall product. Following the display of all product-related information, our system calculates the total price of the entire bought product and displays the payment module choice based on the customer's needs. If the customer wishes to make a cash payment, system directs them to the counter; simultaneously, if the customer wishes to make an online or credit payment, system requests additional information about their payment mode. Once the customer has completed their payment, they will leave the store with a paid receipt after completing billing.

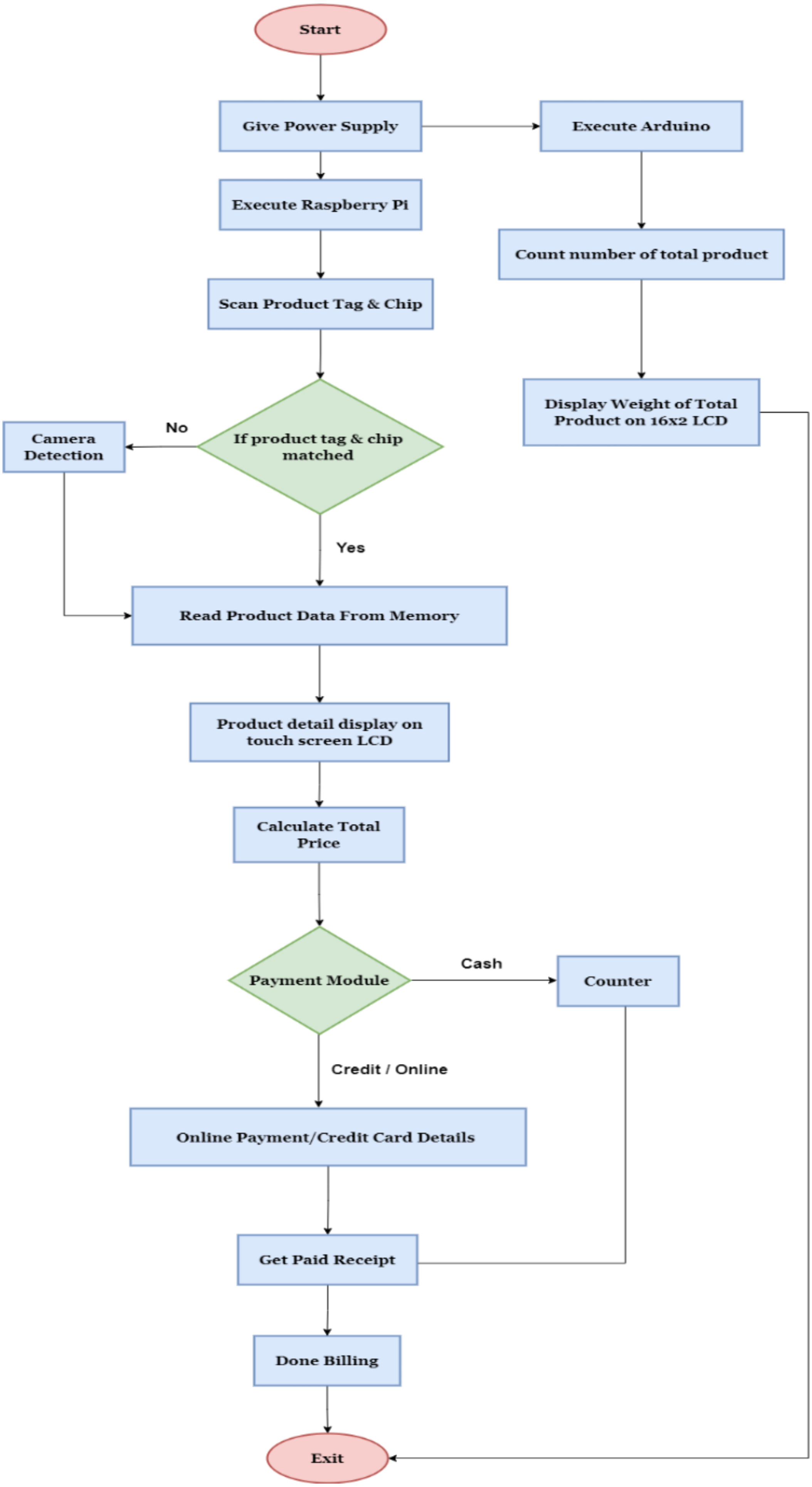


**Figure 5**: System Flow diagram

**Implementation of Smart Trolley with Billing System**

The invention of this innovative technology in the domain of shopping is to make human life easier and to make their shopping experience efficient and fast, so they do not have to stand in the check-out line and waste their time, allowing them to get their product billed by themselves, get their total paid purchase receipt, and complete their shopping efficiently. We used the Raspberry Pi Model B Version 4, RFID Module with Electroplated Chip and Tempered tags, Camera Detection, Payment Module, Touch Screen LCD, Printer, Load Cells, and Power Bank to create this innovative invention. Each trolley is linked to the main equipment. Every individual product has electroplated chips and tempered tags so that when a customer buys that specific product, they will use an RFID module to scan these chips and tags and then add this product to their trolley.

When the product tags and chips are scanned, the RFID reader sends the information to the Raspberry Pi to confirm the product's existence and then displays the product's relevant information as well as its price. They also have a camera detection option, so if any of the products have defaulted tags and electroplate chips, customers can use this to get product details as well as its price, and their shopping will not be hampered or stopped, and they will not have to worry about their entire bill that has been added to the trolley and the device. Their purchasing will be resumed with the assistance of our design system's camera detecting capability. When the product is detected by the camera, the trained model searches for a match in the dataset that was trained on the Raspberry Pi. With the help of Convolutional Neural Network (CNN), Single Shot Detector (SDD), and Region-based Convolutional Neural (R-CNN) algorithms written in Python and C, the camera can detect the products that consumers are about to purchase. After the goods has been scanned by an RFID module or recognized by the camera, the touch screen LCD will display the product details and pertinent information, as well as its pricing. If a consumer wishes to remove or update a product, they can do so manually, and the overall bill will be changed accordingly. The load cells are in charge of sensing each individual product that has been added to the trolley for the purpose of counting it and keeping customers informed of the trolley's health so that they do not overload it. When the customer's shopping is finished, they are given their total bill. They must first decide whether they want to pay with cash or with a credit card. If they choose to pay with a credit card, they must also choose their card's relevant information before making their payment for their overall purchase and receiving their paid receipt. If they pay with cash, they will be given a counter number where they can make their payment. The power bank provides the Raspberry Pi with the actual amount of power required for all of these modules to function properly. At the same time, we have a Jazz Cash billing option, as shown in Figure 8; jazz Cash allows customers to pay for their purchases in a quick, safe, and convenient manner. We ensure that customers are no longer restricted to conventional payment methods by utilizing a variety of payment channels, including vouchers, mobile accounts, and credit/debit cards. After the transaction, the customer will receive a confirmation SMS following the purchase.

**Trolley Setup**

For the setup of the Autonomous Trolley, an elegant and versatile design will be required to convince customers to utilize the device. To do this, we clad our trolley in glossy blue paper to make it more appealing to customers. The autonomous trolley has been attached with Raspberry pi along with a 10000mah Power bank under the main front shell to operate all the main systems. Then we have attached a touch screen LCD which is placed above the main shelf, as shown in Figure 7, to provide user-friendliness by showing all the scan product details as well as enable users to manually add and delete products and generate their bill and their transaction details. And we have attached the RFID RC522 module and camera detection in the same direction over the main front shelf in order to scan the product easily. For the live trolley weight, we have used Arduino UNO and load cells which is placed under the main front shelf and connected with the power bank, and 16x2 LCD is placed over the main front shelf so that it can be easier for the customer to get live information about the capacity and health of the trolley. All the wires and main cables are placed and covered under the main shelf, as shown in Figure 6.


**Figure 6**: Autonomous Trolley with Smart Billing

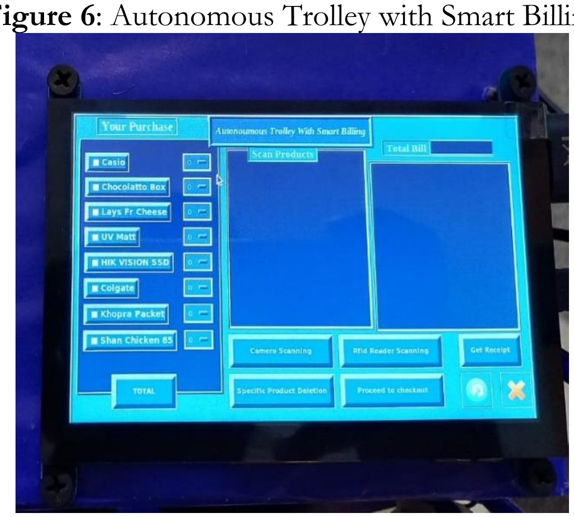


**Figure 7**: Autonomous Trolley Billing Detail with Touch Screen LCD

Figure.8 E-Billing payment through Jazz Cash

## DISCUSSION

The proposed method is subject to catering with an electronic payment system. This trolley is priced at nearly PKR 90,000. This method for cost collection is based on Arduino, Raspberry Pi (V4)-Model B, RFID-RC522, Mini Thermal Printer Rs232, power bank, load cells, LCD, RFID tag and scanner, Camera, and Barcode reader. Considering 500 trolleys, the overall cost would be PKR 45,000,000, and so on for additional trolleys, if we could place these trolleys in any super market. Despite the fact that this system is based on both hardware and software, the hardware components of the project modeled the most danger because the smart shopping cart is a mobile object whose parts are susceptible to damage from random impacts or short circuiting. After evaluating and locating the defective component, it may take some time to repair items.

On the other hand, this is a phenomenal and completely operational system that was designed to make the customers' shopping experiences more pleasant and convenient. Utilize RFID technology due to the effective tracking capabilities it offers as well as the security features it possesses. The system allowed users to set a budget, add and remove products from the shopping cart, receive product recommendations, and add to or subtract from the price of a product depending on whether or not it was already present in the cart. In the event that there are many options available, this trolley provides us with an additional option of product scanning by camera detection in addition to RFID tags. Despite this, this technology will eventually replace manual processes with fully automated ones.

## CONCLUSION

Shopping carts are a familiar occurrence at most supermarkets. Deny the reality that these shopping carts are useful. Our smart shopping cart provides users with access to the price of the product that item which they intend to buy in supermarkets. The placement of the shopping cart and RFID technology allows for easy tracking of objects. This technique is beneficial to preventing customers from standing in long lines queues. We have successfully introduced a technology based on RFID that assists a large number of customers and saves valuable time, also by particularly in billing, which is a tedious process that requires us to wait out our way. We have implemented successfully an RFID-based system that is viable. RFID can scan multiple items sequentially, but every item must be tagged. For this purpose, LCD is utilized to display product information in terms of price and weight, and this screen also helps customers to stay within their budget by displaying the overall price. Smart trolley aims to automate the invoicing process as well by easing the creation of shopping sessions for e-payments. This electronic payment based on banks transaction and particularly Jazz cash, lets businesses in Pakistan accept digital payments from their customers, digitize their supply chain, and move away from using cash. The new set of financial solutions is expected to change Pakistan's payments industry by making it easier for millions of Pakistanis to use digital payments and by making it easier for people who do not have bank accounts to get one.

**Comparison between Author's devised Trolley with already exiting Amazon Trolley**

| Comparison Features | Our Proposed Trolley | Amazon Trolley |
|---|---|---|
| Product Detection based on RFID tag | √ | × |
| Product Detection based on Camera | √ | √ |
| Product and Price details on LCD Screen | √ | √ |
| Product Add, Remove, total price and Items | √ | √ |
| Substitute option for manual product adds, remove | √ | × |
| Payment based on QR code | √ | × |
| Bank Transaction | √ | × |
| Confirmation SMS of payment | √ | × |
| Self-checkout | √ | √ |

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