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Development of an Improve Automated Shopping Trolley Payment System Using A Barcode Scanner and Weight Sensor

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Abstract: Despite the presence of E-commerce people prefer to buy many items only in shopping centers for the sake of their own satisfaction. Among the problems faced by the customers one difficulty is waiting on a bill counter after shopping. Though their intent is just to buy one or two items, waiting to bill items results in long ques and consumes time. The shopping environment are ready to welcome any smart machines that can automate the billing process to reduce manpower and time spent for that process. This research developed a system placed on the shopping trolley, which is to complete the billing process in the trolley rather than waiting in long queues. To achieve this all items in the mall should have barcodes printed on them and all shopping trolleys should be equipped with a barcode scanner, weight sensor and LCD screen. When a customer scans any item it its code will be detected automatically, the item weight, cost and name will be displayed on the LCD, thereby the cost gets added to the total bill. If a customer wishes to remove an item trolley, the customer just presses a push button and rescan the item, the amount and weight of that item gets deducted from the total amount. Hence billing can be done in the trolley itself, thereby saving a lot of time and energy for customers or users. The study show that the Barcode has a response time of 2.6 seconds ,with an accuracy of mean square average of 4.46

Keywords: E-Commerce, Cash Point, shopping Mall, Arduino, Barcode, LCD,Scanner

INTRODUCTION

Shopping is an activity in which a customer browses the available goods or services presented by one or more retailer with the potential intent to purchase a suitable selection of them. Shopping centres like shopping Malls are spots where individuals get their everyday necessities running from sustenance items, garment, electrical appliances and so forth (Megana, 2018). Customer's shopping experience may differ. They are based on variety of factors including how the customer is treated, convenience, the type of items being purchased, and mood. Some of the clients have issues some of the time as a result of inadequate data about an item and time wastage at the billing counter. The shopping trolley is an essential part of the supermarket shopping experience. For all shopping centres, the shopping trolley means convenience for the customer and increased sales for the shops. It allows them explore the supermarket and all its product comfortably. The shopping cart has a vital role in shopping, an improvement to make it more efficient and better will be helpful to people around the world.

Nearly every type of industry is using barcode technology to replace keyboard data entry because bar coding is much faster and more accurate than keyboard data entry (Singh and Sharma, 2016). Barcodes can streamline the inventory management process speeding up data entry, supporting traceability and enabling real time inventory control (Chan, 2017). The load cell, weight sensor is a transducer that transforms force or pressure into electrical output. The magnitude of this electrical output is directly proportional to the force being applied. Load cells have a strain gauge, which deforms when pressure is applied to it. And then strain gauge generates an electrical signal on deformation as its effective resistance changes on deformation. (Saddam, 2017)

Shopping in-individual is easy and satisfactory, people tend to purchase items only in shopping centres despite the presence of e-commerce, nowadays shopping is an easy thing, but waiting in line at a store is not (Deepa *et al*, 2021). A customer wait time analysis has conclusively shown that people won't wait very long before leaving your store for good. In fact, customers are willing to wait only 14 minutes before being served (Kirill, 2020). Customers encounter problems some of the time due to inadequate or unspecific data about an item thereby worrying about the money they have brought would be sufficient enough for all the item purchased. One of the biggest security threats facing shopping centres is the issue of theft. Without proper security precautions, shoplifters can become a major problem in shopping centre. Theft cases or customers unknowingly taking an item without paying is also a serious issue encountered in shopping malls (Ajao *et al*, 2021). Several works have been done to solve the issues encountered in the shopping centers over the years. Defect to the current solutions available include control mechanism, security, cost, the trolley is not fully automated and user friendly. The aim of this proposed system is to Develop an Automated Shopping trolley using Bar Code Scanner and weight sensor.

The research objectives are stated as follows:

1. To interface a barcode scanner with Arduino Uno for reading barcodes
2. To interface a weight sensor and load cell with Arduino Uno
3. To integrate objective one (1) and two (2)
4. To evaluate the system performance using accuracy, sensitivity and response time

RFID enabled smart billing system by (Vanitha and Brindha, 2015) designed a concept model consists of RFID tags, readers and ZigBee which transmits generated bill to the server and then the bill is collected by the worker in the bill counter by identifying customers. But this approach will lead to queue for billing since only bill generation is alone automated by scanning using RFID (Mayur *et al*, 2016) designed an intelligent shopping cart with goods management using sensors. Their aim was to develop a system placed on the trolley that can be used in shopping centers, the system comprised of RFID readers and tags. Electronic Shopping Using Barcode Scanner developed by (Megha *et al*, 2016) exploited barcode for billing of products, where customer scans the product using barcode technology. The bill details are sent to the shop's server and the customer has to pay just the amount and leave. No necessary steps have been taken for the products that are accidentally dropped into the trolley by the customer.

Automated smart trolley with smart billing using Arduino by (Suganya, 2016), developed a model of automatic shopping with the use of Arduino and an android application which requires network to be connected always. Android operated mobiles may or may not be present with every customer. Network instability leads to delay in the billing and cost extra money. Murugesan *et al.* (2021) developed a smart motorized trolley using RFID reader. The system also provided suggestions for items to buy based on user purchase history from a centralized system. Table-1 shows me ta-analysis of related studies.

Table-1 Meta-analysis showing relate d works

S/N	Authors Name	Year of Publication	Title	Strengths	Weakness
1.	Manikandan *et al.*	2017	RFID based Advanced Shopping Trolley for Super Market	This system tackles issues related to theft by using DC motors and infrared sensors	The system is not user friendly due to the sliding doors on trolley
2.	Sonakshi *et al.*	2017	Intelligent Sensing Follower Cart automatic shopping trolley	This reduce manpower and money spent on them	This system has limited coordination
3.	Sudipta *et al.*	2019	Intelligent Shopping Cart with Automatic Product Detection and Secure Payment System	This system authenticates the user through a Unique Identification Number (UID) and biometric fingerprint and allows a secure payment of the total amount either through in the cart itself.	Having different hardware components to authenticate user could lead to many distorting factors as the authentication of user might not be accurate
4.	Alfiya *et al.*	2020	IOT based intelligent trolley for shopping mall.	This system makes use of GSM module to send SMS notification	This system can have some limitations as a result of network connectivity
5.	Mahesh *et al*	2020	smart shopping trolley	This system helps user shop within budget using a buzzer as a reminder	The system is not secure as no means of ensuring all items were scanned
6.	Shivika *et al*	2020	IoT based Human Guided Smart Shopping Cart System for Shopping Center	This system uses RFID tags and load cell for decision making against	This system is not cost effective, RFID tags are placed on all items

MATERIALS AND METHODS

2.1 System Development Methodology

This work is aimed at developing a solution to improve shopping experience for customers and shop owners. The proposed methodology is the automated billing for a customer during shopping primarily based on bar code technology supported with other simple technologies. In shopping malls or supermarkets, the products are provided with barcodes instead of RFID tags. The shopping trolleys include the setup containing Barcode scanner and a consistent Wi-Fi connection with the shop's server, Weight sensor, load cell, key pad, LED, LCD and the system will be interface using the Arduino board platform. (Agajo *et al*, 2020).

2.2 Hardware Requirement

Hardware is a physical component that is directed by the software to execute any command or instruction and can be touched and felt, which is used in the course of the research to actualize the aim of the research. The following shows hardware components that is going to be use in the development of a prototype of different modules that will contain in the system. This includes:

i. Microcontroller Board (Arduino Uno)
ii. Barcode scanner
iii. Display Unit (16 x 2 LCD)
iv. Sensory Unit
v. Power Supply Unit

2.3 Working Principle

This system works as on customer gets into the mall she/he first takes a trolley. Every trolley is connected with a Barcode scanner, a weight sensor or load cell, a microcontroller, push button and LCD screen. The items in the shopping centre were provided with barcodes which contains unique id. This Id's are fed in a local memory assigned to the corresponding products., the first step is the customer will put an item in the trolley after a short scan which would be detected by the bar code scanner and will display on LCD the price, name and weight of the item. The weight sensor will detect any change within the physical stimulus like weight, whenever the customer adds an item and produces an output on the LCD that is comparative to the physical stimulus, this will help in cross verification of the weight of items scanned and the weight of the items in the trolley. If the weight of scanned items and items in trolley does not match, and the LCD will display a mismatch message until the item added is removed. In case if customer changes his/her mind and does not want any item added in the trolley, he/she can remove it by using a push button which when pressed initiates remove operation such that item is removed by rescanning satisfying the condition that the scanned item data should be already present in the purchased list. During this remove process, the weight and cost of that particular item will be subtracted from the total amount and weight instantaneously LCD displays the updated cost. At the same time billing information is also updated. These steps are repeated until the end of shopping, button is pressed. Once the push button is pressed the total amount is display on LCD. The customer has to pay just the amount and leave and all the shopped items will be transferred from the trolley to their bags. Fig. 1 shows the flowchart diagram of the proposed system and Fig. 2 shows a circuit diagram of the in a simulation environment. The barcode Scanner and other set up will be placed in the high position on the upper part of the trolley, load cell is placed in the mid position on the bottom/base of the trolley.

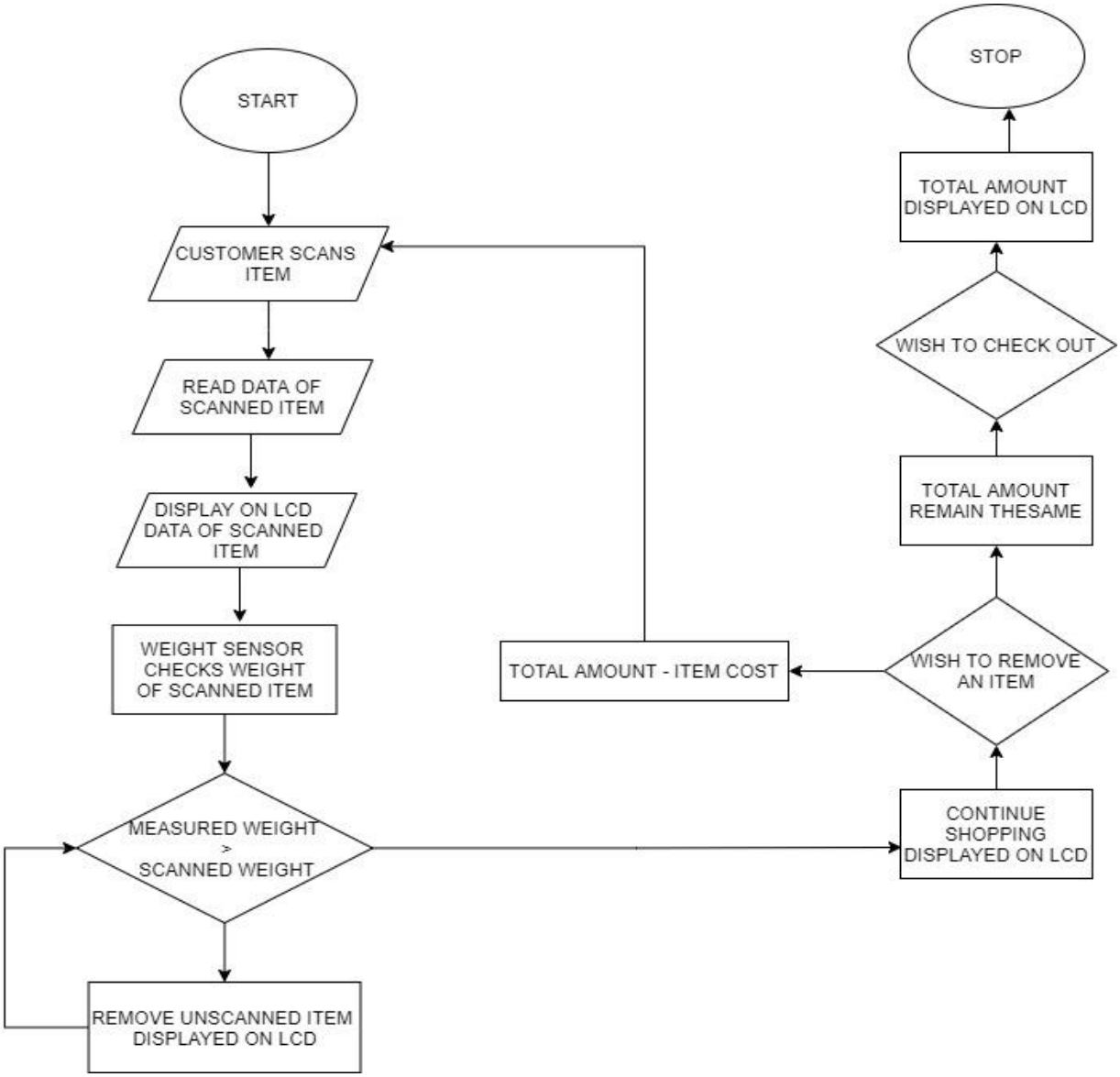

Fig. 1 Flow chart of the developed system

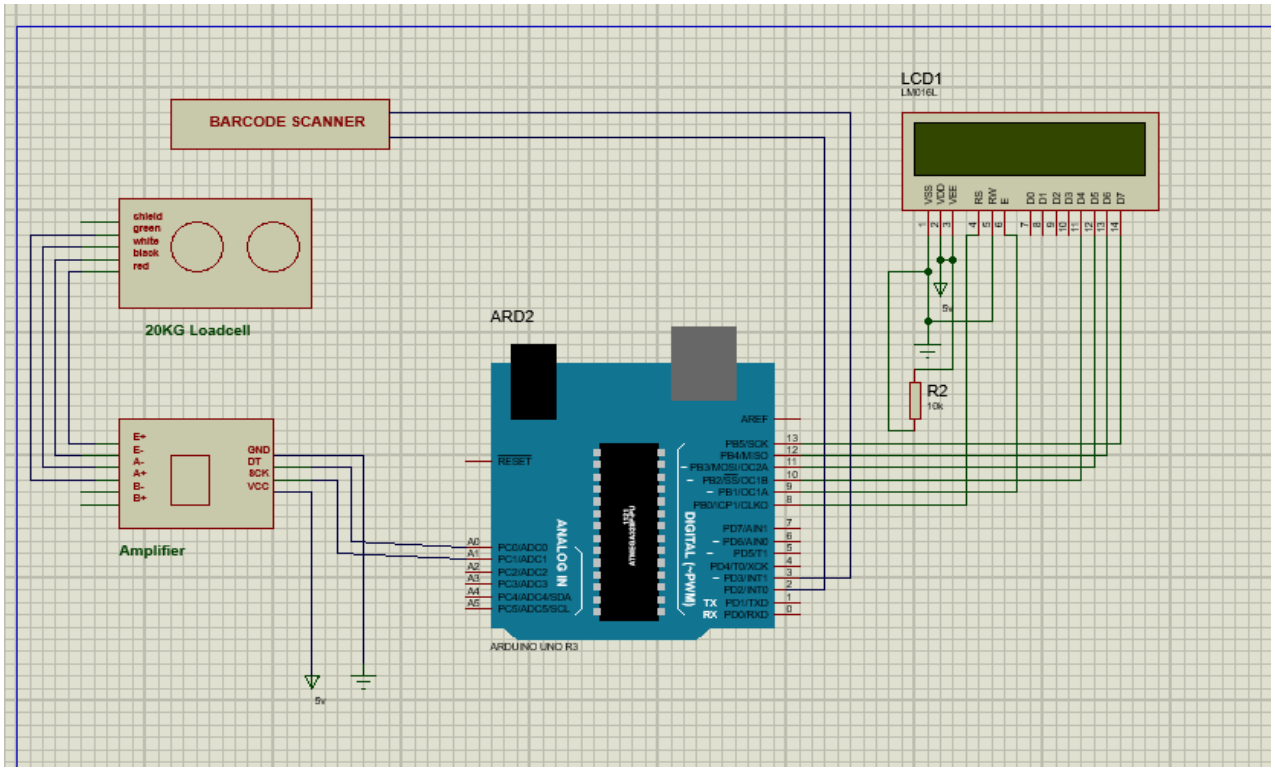

Fig. 2 Circuit diagram of arduino uno connection

RESULTS AND DISCUSSION

This section contains results obtained and discussion based on the result that was obtained in the research. The simulation of the system was done using Arduino IDE, to get results on the implemented system. Also results gotten from the integration of the software and hardware parts of the system are reported and the mean square average gotten is plotted on the number of trials to show the level of accuracy for the implemented system, while the output against the input is used to show the level of sensitivity for the implemented system.

A. Software Simulation Results of Intelligent System

The system was implemented using the C ++ programming language with Arduino IDE version 1.6.8 Fig. 3 shows the results gotten from the serial monitor demonstrating the readings obtained from the weight sensor. The results show the comparison between the measured weight and the actual weight as shown in Fig. 4. The result further shows the two modes (Add mode and Remove mode) as shown in Fig. 5.

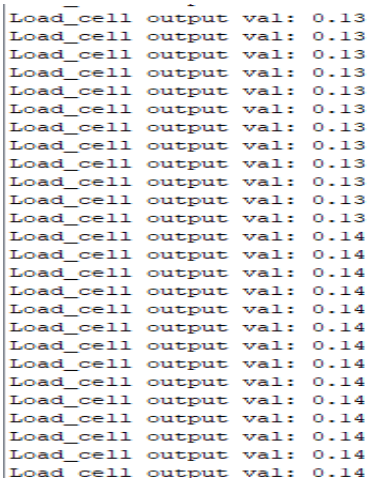

Fig. 3 Showing the load cell readings

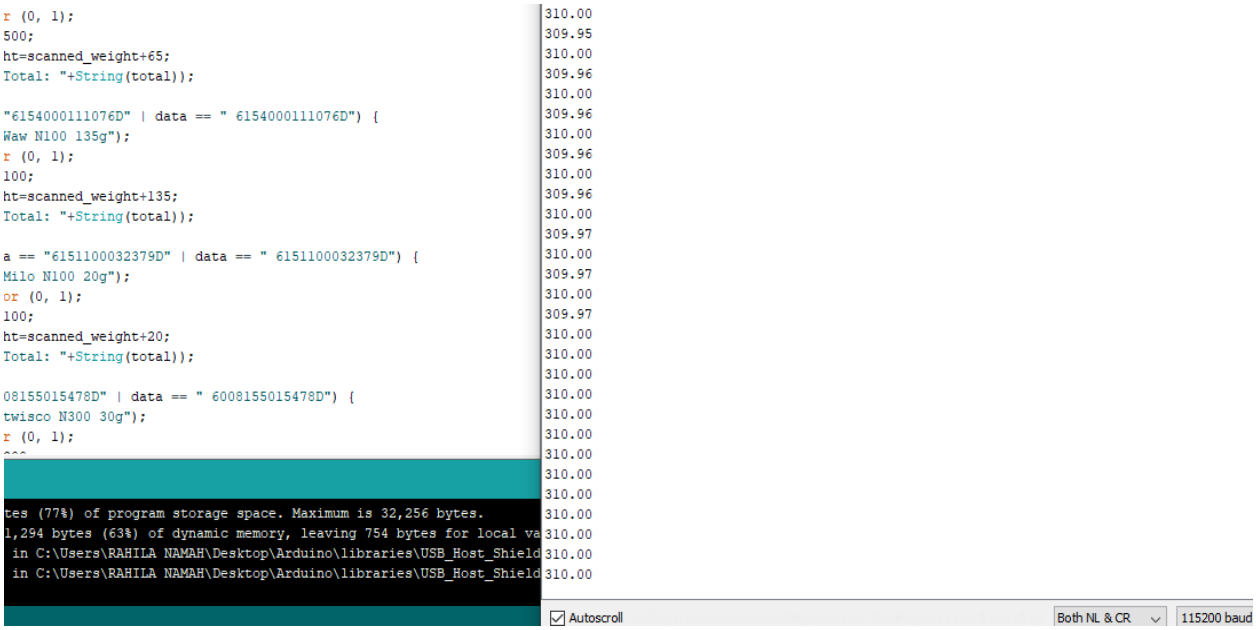

Fig. 4 Showing the comparison between scanned weight and measured weight

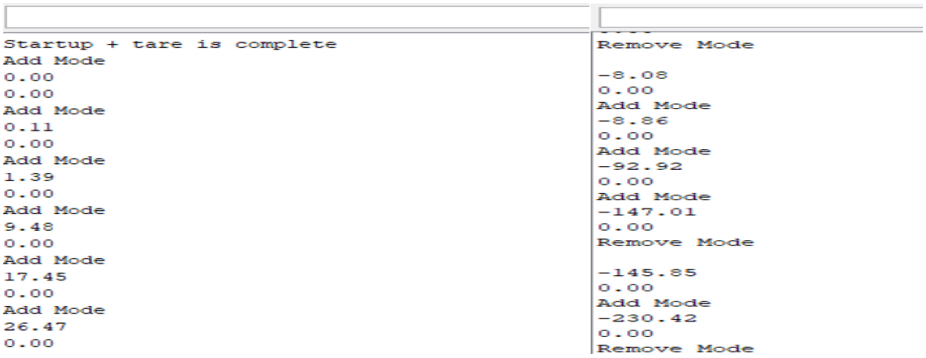

Fig. 5 From left: Add mode and Remove mode

Hardware Implementation Results

The hardware integration includes the following components, the Arduino Uno board, USB host shield, barcode scanner, weight sensor, LCD, push buttons, LEDS and an Amplifier. Item identification is achieved using a barcode scanner and barcodes associated with each item. The Unique data of each barcode is stored with the price, weight and item name in a local data on the Arduino Uno chip. Data read by the barcode scanner displayed on the LCD, total amount adds up as more items were scanned as shown in Fig. 6. A mismatch caution displayed when measured weight is greater than scanned weight is showed in Fig. 6.

Fig. 6 Showing data read by the barcode scanner displayed on the LCD

Performance Evaluation Results

This system was evaluated using different metrics which were as follows:

- Sensitivity which defines various sensitivity levels on the weight sensor on application of various items on the system and how this sensitivity affects the accuracy of the system.
- Average response time, that is the average time it takes for the Barcode scanner to read barcodes and display data.
- Accuracy refers to the quality of being correct or exact. The extent to which a given measurement agrees with the standard value for that measurement.

Sensitivity

In this case, the sensitivity of load cell is the smallest force a pair of load cell can reliably detect. The greater the sensitivity of a load cell the higher the load cell is at detecting changes in tension. It is defined as the small amount of force needed to cause a change in a load cell output which is shown in table2 and both figure 7 and 8.

$$sensitivity = \frac{output}{input}\% \quad (1)$$

$$sensitivity = probability\ of\ weight\ detection\ given\ an\ input\ weight \quad (2)$$

$$output = measured\ weight \quad (3)$$

Output weight value includes the weight of the plain surface it is placed on, therefore the obtain a true output value, the weight of the plain surface which is about 6g is deducted from the measured weight value.

$$Input = item\ weight \quad (4)$$

Table-2 Showing sensitivity at various samples

S/N	Output(g)	Input(g)	Sensitivity (%)
1.	24	25	96
2.	16	20	80
3.	129	130	99.2
4.	64	65	98.4
5.	52	55	94.5

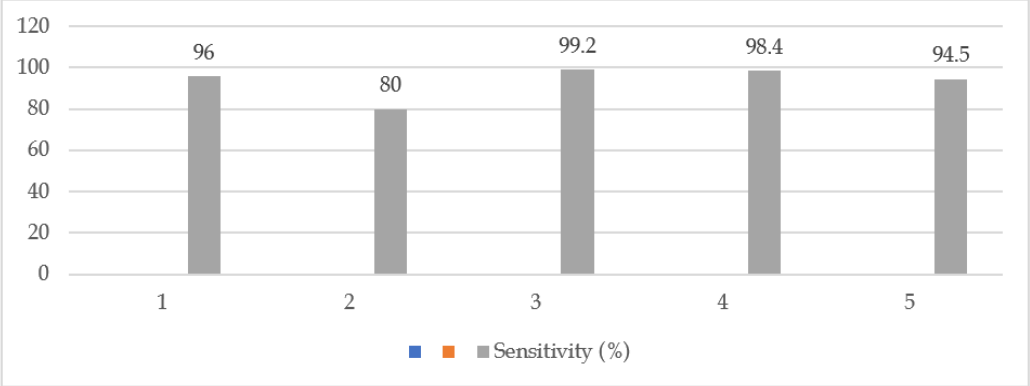

Fig. 7 Sensitivity Bar chart with respect to number of samples

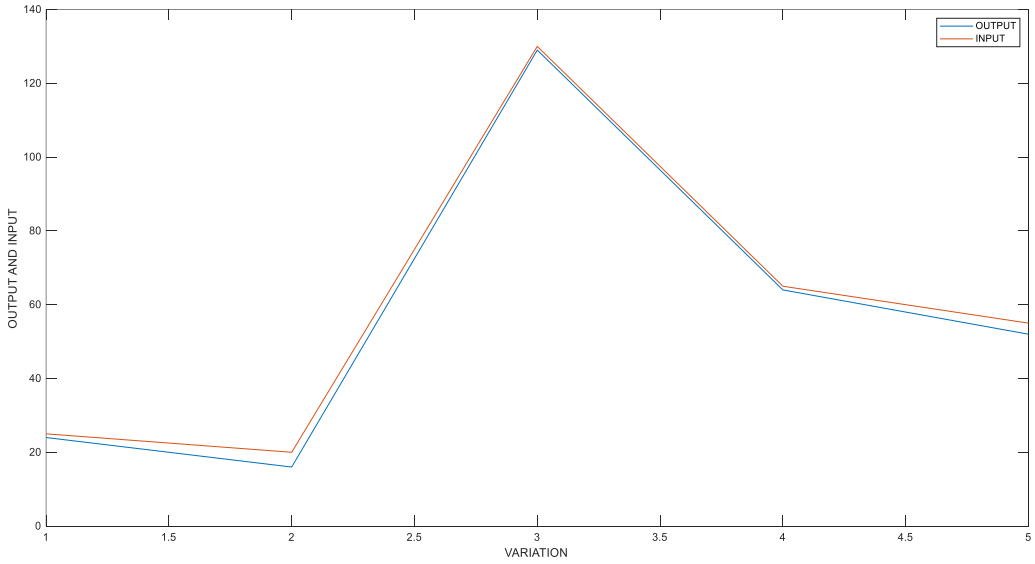

Fig. 8 Sensitivity graph with respect to number of samples

Average Response Time

Response time can be defined as the time elapsed by barcode scanner identification on the system and responds to that identification. It is used as a measure of overall systems' performance, and may refer requests to the various technologies. Therefore, low response times may be important for a successful computation.

In this case the response time is the time elapsed bet ween barcodes read and time data is displayed to the user, this system was evaluated using 10 trials to read barcodes as shown Table-3.

Table-3 Showing response time for Barcode readings

No. of barcodes read	Elapsed Time for barcode reading (seconds)
1	3
1	4
1	2
1	3
1	2
1	5
1	2
1	2
1	3

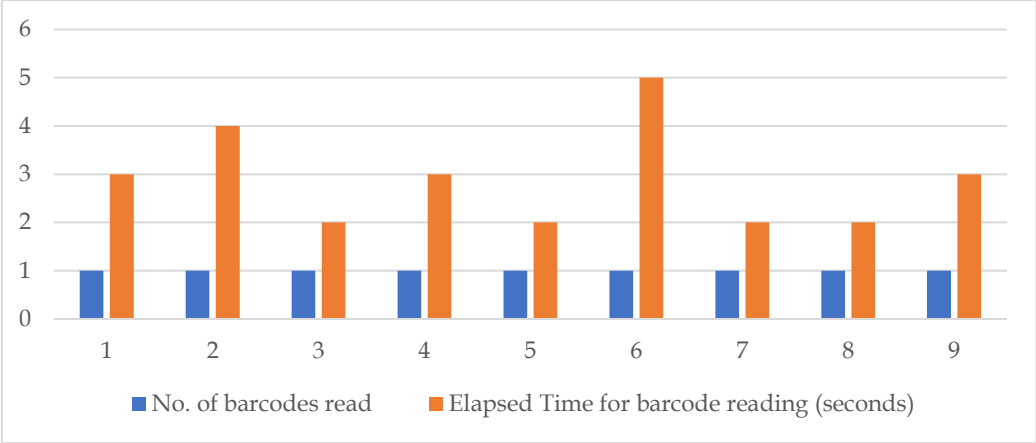

Fig. 9 Response time Bar chart for barcode readings

$$Average\ response\ time = \frac{Total\ number\ of\ Elapsed\ time}{Total\ number\ of\ barcode\ read}$$

Total number of barcodes read is 10, therefore,

For Barcode readings the Average response time can be calculated as:

$$Averager\ Response\ Time = \frac{26}{10} = 2.6\ seconds$$

Accuracy

Accuracy can be defined as the degree to which the result of a system or specification conforms to the correct value or standard. Mean square average is used to determine the accuracy of this system, and was evaluated using 5 samples as shown Table-3.

$$Mean\ square\ average\ = \frac{\Sigma(y_a - y_e)^2}{Total\ number\ of\ samples}$$

$$Mean\ square\ average\ = \frac{22.3}{5}\ = 4.46$$

$y_a = Actual\ output$

$y_e = estimated\ output$

Table-4 Showing actual and estimated output at various samples

S/N	ya (g)	ye(g)
1.	30	29.95
2.	160	159.98
3.	165	160.07
4.	220	218.05
5.	310	310

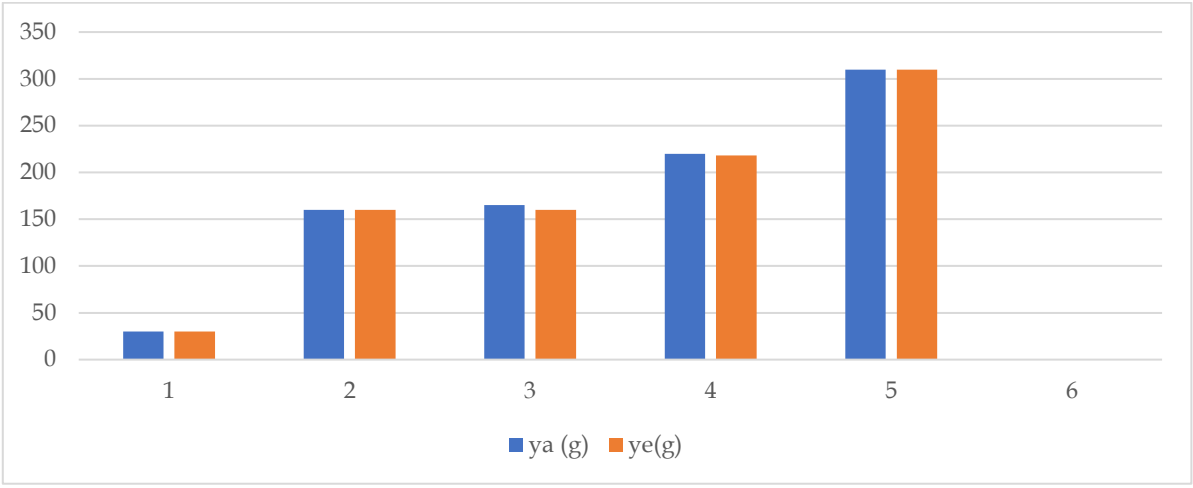

Fig. 10 Showing bar chart for actual output and estimated output

Fig. 10 is a bar plot showing the actual output against the estimated output, the measure for accuracy is made visible in Fig. 11 with an expanded data range in Fig. 12 and Fig. 13.

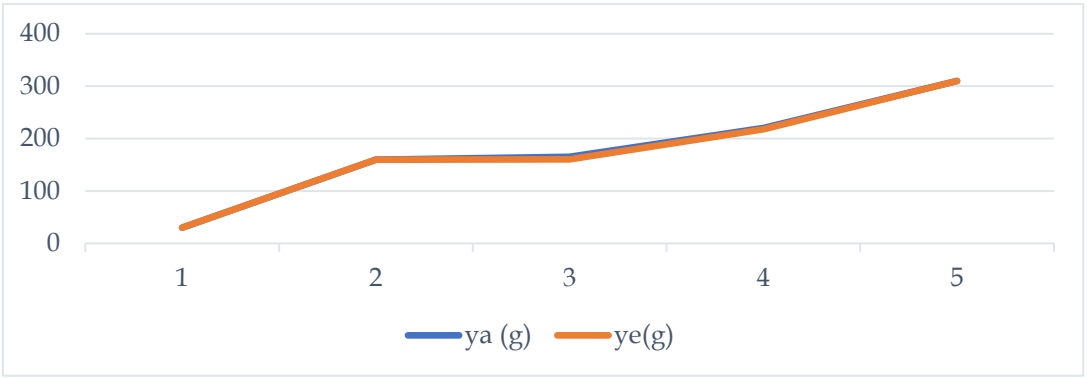

Fig. 11. Accuracy graph with respect to number of samples

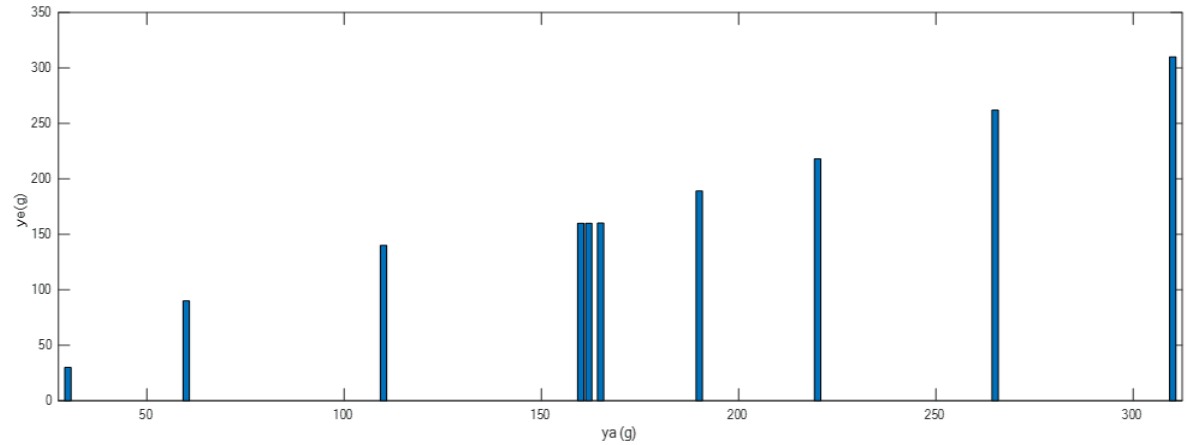

Fig. 12 Bar Chart showing progression of ye against ya

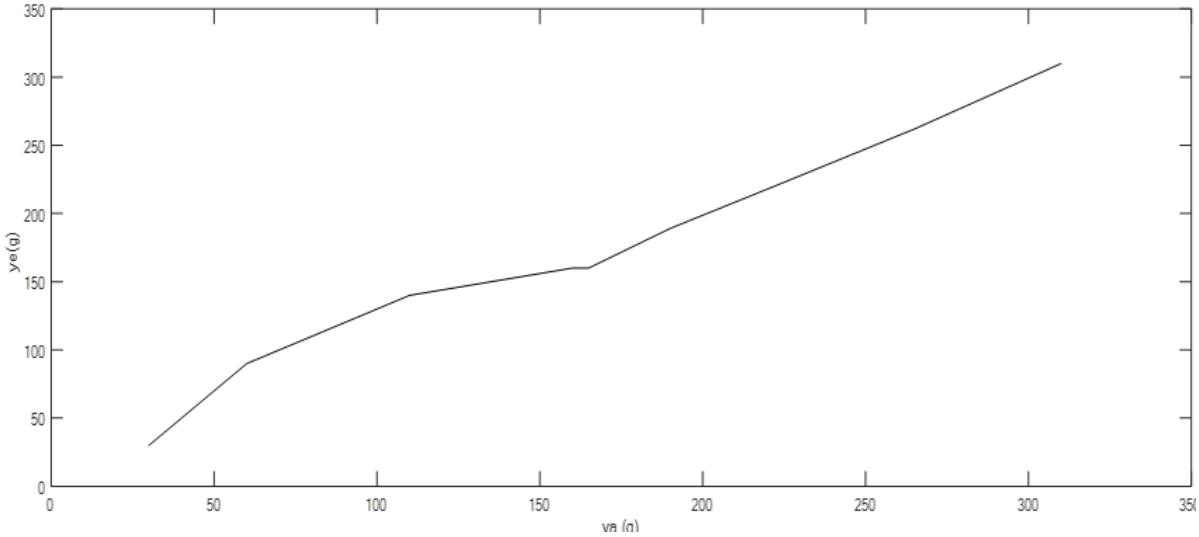

Fig. 13 Graph of expanded Accuracy against respect to number of samples

CONCLUSION

Time and security are a crucial aspect of everybody, both globally and locally time management and security should be given serious concern and attention. Various methods are already in place to tackle the issue of time wastage and security in a shopping environment.

This project tried to improve on an already existing concept of smart shopping trolley system and also applies the ability to monitor weight for authentication, the system also plans to tackle the basic issue of an average Nigerian as to the time wastage when. In other words, the system is providing an easy and fast means of shopping with automatic billing and ensures security. As demonstrated in the discussion, the system design parameters were used to develop an intelligent shopping trolley system using a barcode scanner and a weight sensor, this model was employed in a shopping trolley system to facilitate shopping process and detect any abnormal activities in the trolley.

RECOMMENDATIONS

This system can be improved upon by providing a camera to capture the item scanned in such a way it also performs image detection, this makes the system to be able to distinguish between item scanned and item in trolley to improve system performance and accuracy. Also, this system can be extended to use a 50kg load cell to detect heavier items or goods in a shopping center.

CONFLICT OF INTEREST

There is no conflict of interest for this research work.

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