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Development of Self-Checkout in A Shop with Fraud Detection by Using Weight Comparison

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Abstract: The development of self-checkout in a shop with fraud detection by using weight comparison was introduced which to ensure the GDP is less affected according to COVID-19 and minimize standard operation procedures to avoid fraudulent activity who used the self-checkout. The main objective was to develop an auto payment machine with weight comparison as fraud detection and the scope of the study was to design the practical tools by using the exact hardware for conventional usage. The method of development had three parts electronic and electrical design, mechanical design and software design. The entire body conveyor was built 44.8cm long, 23.3cm in width and 28.3cm in height with the electronic attachment that control by the microcontroller, Arduino Uno and NodeMCU to serial communication with the transaction shown on the website. Throughout the development process, the main objective had been successfully achieved and a recommendation for future work was weight comparison can detect even the multiple scan barcode groceries on the conveyor with an indicator to detect fraudulent activities.

Keywords: GDP, Fraudulent, Arduino Uno, Nodemcu, Website

1. Introduction

In Malaysia, the first case was reported on 25 January 2020 [1] and then the lockdown or Movement Control Order (MCO) operated for two weeks from 18 March until 30 March 2020 for the first phase of MCO [2]. Coronavirus gave an impact to the Gross Domestic Product (GDP) of Malaysia. As comparison GDP for the fourth quarter 2019 was 3.6% and GDP for first, second, third and fourth quarter for 2020 were 0.7%, -17.1%, - 2.7% and -3.4% [3]-[7]. GDP can be categorized into two elements which were production and expenditure. Based on the two elements, expenditure was selected because private final consumption expenditures such as food, non-alcoholic beverages and communication were necessities for a human to do their daily grocery shopping. Being focused on that, supermarkets and grocery stores became the places for a citizen to buy their needs such as food, water, snacks and so on.

The cashier section can be classified into two sections which were conventional cashier and self-checkout. It became the company's main prospect for the transaction between customers and cashiers.

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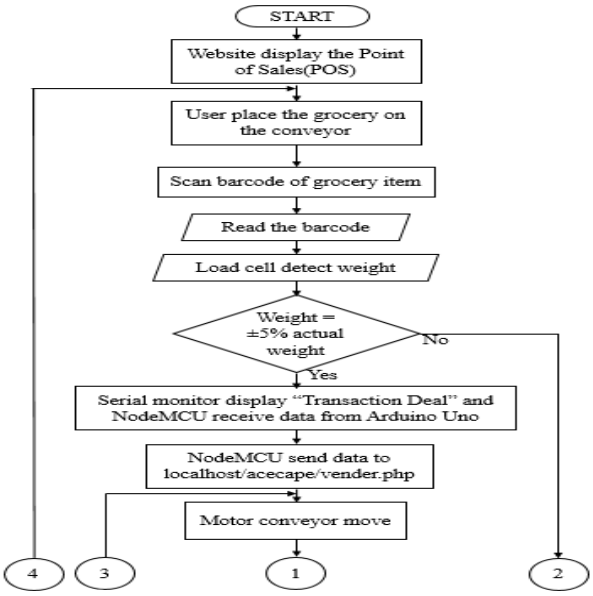
Self-checkout was not a new technology, the first was invented in 1965 and that time was called the automated teller machine. In 1990, self-service became popular after being reinvented in 1984 by David R Humble when he got inspired in South Florida when standing in a long queue at a grocery checkout [8]. Self-checkout has two methods of payment which with cash or cashless. Due to the pandemic worldwide, cashless become the first option when doing transactions or payments as a method. There were many types of cashless such as debit or credit cards and e-wallets, which only scan the QR code, put in the amount that one wants to pay and do the transaction. 65 percent of Malaysians supported using a cashless and Malaysia was behind India which was number one with 79 percent supported [9].

According to the organized retail crime (ORC) activity, an average of 719 548 United States Dollars (USD) per one billion burned [10] and in Westerly, the modus operandi for the theft had a similar pattern in which the individual or individuals either paid for a small portion of their carriage before leave or simply scanned items and left without paying at Westerly Walmart's self-checkout [11]. Next, "the banana trick" was the dark art of stealing for the self-checkout payment section. The trick has two terms for example "the pass around", this term used when the items leave the conveyor belt without being scanned and the second term "the switcheroo", this term used when placing a sticker from a low-cost item over the bar code of a more expensive item [12].

The main issue filed from that problem statement above was staff assault in the process of robbery, shoplifting, and internal theft are all vulnerabilities to retail establishments. Fraudulent activity and shoplifting cost the retail store huge amounts of money annually. The development of self-checkout was the alternative option and focus study in design to improve the conventional self-checkout with implement the fraud detection system by using weight comparison as an additional safety layer in a commercial retail store. The objectives for development were to develop an auto payment machine with weight comparison as fraud detection and to apply a communication connection between the fraud detection system and website included to make the graphical user interface (GUI) website user-friendly.

2. Methodology

The main control element of this system was the microcontroller, Arduino Uno. It controls the conveyor belt system included to read barcodes from the groceries. The power supply was needed to run the conveyor belt system to move the conveyor motor. The 12V / 5Ah battery was required to supply power DC motor, supply for NodeMCU by connecting VIN Arduino Uno to VIN NodeMCU and 4 × AA batteries with an on/off switch as a power supply for Arduino Uno while for the barcode scan were used power supply from Arduino Host Shield that was connected to Arduino Uno. Figure 1 shows the flowchart for the development of self-checkout with fraud detection by using weight comparison.



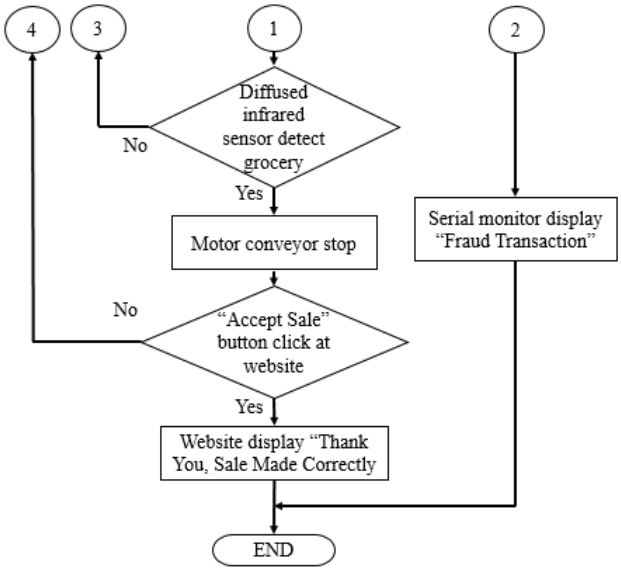


Figure 1: Flowchart of project development

2.1 Mechanical Design

Figure 2 shows the dimension of the conveyor belt with the specification was 70cm × 37cm × 15cm and 9cm for the diameter of rollers. That was the illustration to create the final prototype work as a guideline for designing. All the dimensions were chosen because the reference size was a 10kg rice pack, so extended a little bit in length and width to build this prototype. The material for the case and roller was steel while the conveyor belt was made of rubber.

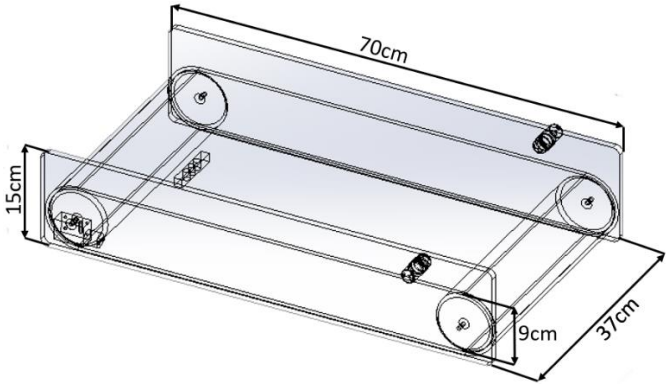


Figure 2: Detail of conveyor belt design

2.2 Electronic and Electrical Design

Figure 3 explained the electronic and electrical design that is used for four sub-systems to work as one system in a block diagram. The first sub-system was in the barcode scanner section and the second to fourth sub-system was located in the conveyor belt section which are the motor conveyor, detection sensor and load cell sensor.

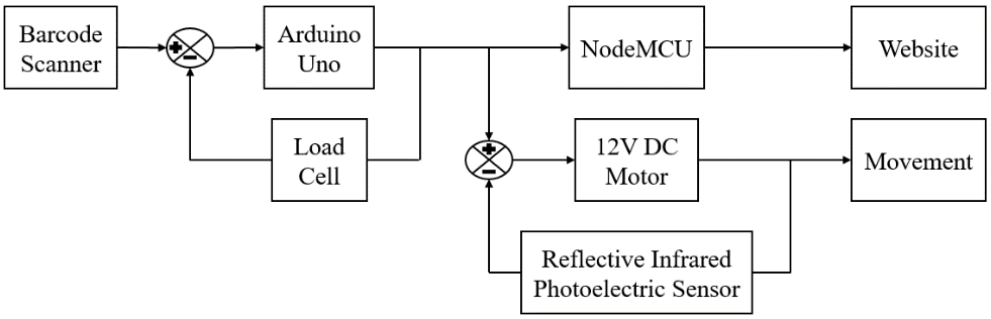


Figure 3: Block diagram for electronic design

2.3 Software Design

Point of Sale (POS) was used for the graphic user interface (GUI) and the platform was used to create the billing system, the software was XAMPP and Sublime Text. This software was free Windows and easy to use and modern with a reliable POS solution. The function of Sublime Text was to create a code for the fully system of POS and XAMPP was needed to get the intellectual property (IP) address to enter the world of Apache with the program run of the written code from Sublime Text.

3. Results and Discussion

The outcomes of hardware in each part of the mechanical prototype, electronic attachment and website development had their own unique results and methodology becomes the guidelines to achieve the result.

3.1 Mechanical Prototype

The entire body conveyor was built as shown in Figure 4 with 44.8cm × 23.3cm × 28.3cm specification measurement compare to the illustration design in Figure 2 with the concept measurement 70cm × 37cm × 15cm. Table 1 shows the materials used to build the entire body with the placement of the load cell and DC motor. Table 2 shows the jointer that needed to join all the parts to ensure strong contact with each component.

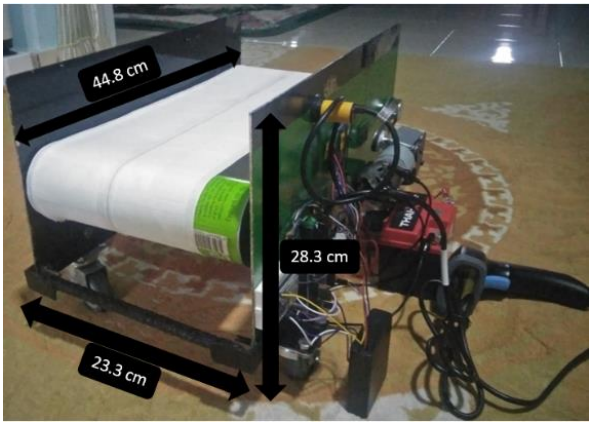


Figure 4: Dimension conveyor setup

Table 1: List of materials for entire body conveyor setup

Materials	Function
A4 Aluminum Plate	Body conveyor
Iron Plate	Pieces to assemble two separate body conveyor
C-Frame	Stability for the body conveyor
Roller	Rotational movement

ZZ608 Bearing	Connect to roller rod for smooth movement
Sponge	Attach to bearing for fix 1 inch hole
Z-Shape	Base for the motor DC placement
Pulley	Move the roller that source from motor DC
L-8 Bracket	Base for the load cell placement
Load Cell Base	Base for load cell detect load
1 Inch Iron Angle	Base for the 2 inches rubber wheels
2 Inches Rubber Wheels	Moveable

Table 2: List of a jointer

Apparatus	Function
Rivet	Joint for two separate aluminum plate
Bolt and Nut	Joint for C-Frame, Z-Shape, L-8 Bracket, 1 Inch Iron Angle, 2 Inches Rubber Wheels
Philip Screw	Joint for DC motor and load cell
Belting	Interconnection between pulley motor and puller roller
Curtain Tape	Interconnection between two rollers
Hot Glue	Joint for bearing with body conveyor
5A Wire Connector	Loop for 5V and GND Arduino Uno supply to components
Cable Tie	Arrange the jumper connection

3.2 Electronic Attachment

The entire electronic connection consists barcode scanner, load cell sensor, diffuse reflective infrared photoelectric sensor and serial communication. Figure 5 shows the full connection and place of electronic components attached to the conveyor system. Table 3 shows the ±5% tolerance weight of grocery from actual weight and Table 4 was analyzed for weight detection by manipulating the value of calibration factor with Eq 1 until Eq 5 was justification in percentage for the effect of minor differential value respect due to load cell base setup.

Figure 5: Fully attachment of electronic components

Table 3: Weight of groceries ±5% tolerance

Grocery	Weight (gram)		
	Actual	-5%	+5%
250ml Desa Mineral Water	270	256.5	283.5
Snek-Ku Mi-Mi	12	11.4	12.6
Mi Sedaap Perisa Kari	80	76	84

Table 4: Analysis of weight detection

Grocery	Calibration factor		
	97.8	97.9	98.0
250ml Desa Mineral Water	275	270	265
Snek-Ku Mi-Mi	12	12	12
Mi Sedaap Perisa Kari	81	80	79

$$\frac{270-265}{270} \times 100\% = 1.85\% \quad \text{Eq 1}$$

$$\frac{275-270}{270} \times 100\% = 1.85\% \quad \text{Eq 2}$$

$$\frac{12-12}{12} \times 100\% = 0\% \quad \text{Eq 3}$$

$$\frac{80-79}{80} \times 100\% = 1.25\% \quad \text{Eq 4}$$

$$\frac{81-80}{80} \times 100\% = 1.25\% \quad \text{Eq 5}$$

3.3 Website Development

In this part, website development was the Point of Sales (POS) template or graphical user interface (GUI) for the sales transactions. Figure 6 shows an initial template of the website when the consumer wants to do the transaction. NodeMCU will receive the barcode data from Arduino Uno and transmit it to the website for the transaction. Figure 7 shows the transaction accepted and the website will show the comment at upper section, "Thank You, Sale Made Correctly" that shown no fraud activities did.

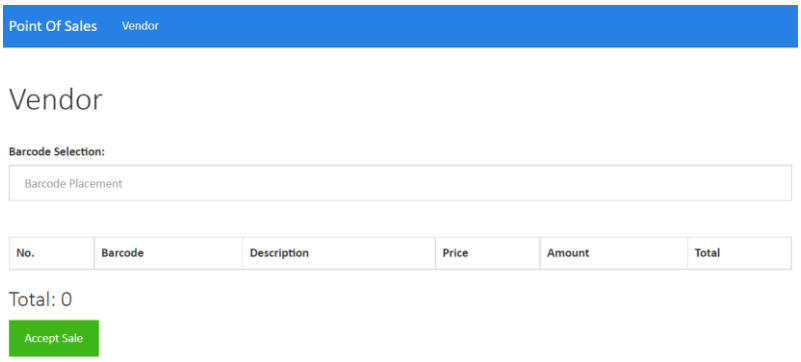


Figure 6: Template of website

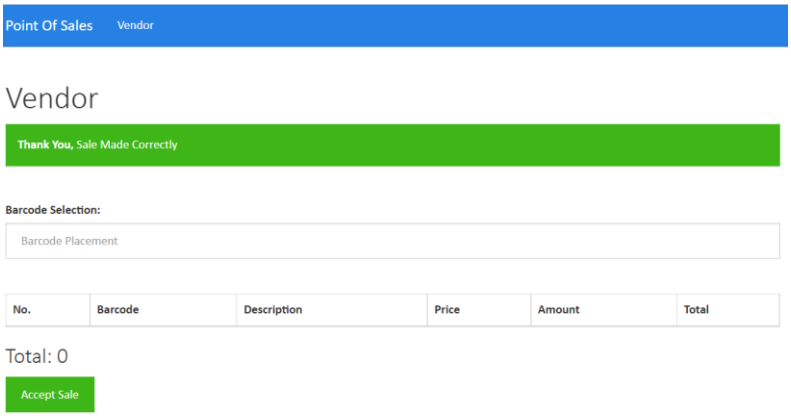


Figure 7: Transaction accept

4. Conclusion

Throughout the development process, all objectives had been successfully achieved. The first objective was to develop an auto payment machine with weight comparison as fraud detection achieved by the connection of all the electrical and electronic components allocated in the Electronic and Electrical Design topic of section 2.2 and the result with analysis as shown in Electronic Attachment topic of section 3.2. Next, the second objective was to apply a communication connection between the fraud detection system and the website in transmitting barcode data with the connection of serial communication refer to Figure 3 of topic section 2.2 which is Electronic and Electrical Design. The third objective was to make the graphical user interface (GUI) website user-friendly as shown in the topic of section 3.3 Website Development successfully operates well. Several difficulties were discovered throughout the prototype's development. The following are a few suggestions were the assemble for the system made in one section as the actual situation of the grocery cashier and for the Point of Sales (POS), make the option for payment method with transaction receipt included so the weight comparison can be detected even the multiple scan barcode groceries on the conveyor and had indicator to detect fraudulent activities.

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