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Cost Accounting Issues on Automation: A Case Study on Reducing Start-Up Cost of Automation in Local Factories

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Abstract: The concept of Industry 4.0 has turned out to be important in modern-day industry. Automation is an integral part that builds the concept of Industry 4.0. Automation is viewed as inevitable in manufacturing given rising labor costs and the need to improve the country's productivity. However, it has become difficult for small and medium enterprises (SMEs) in the manufacturing sector to automate without spending a considerable amount of budget to implement automation. For this proposed system, an alternative method to conventional automation equipment has become the focus of the study. The technology fixated on auto-reject detection. Ultimately, an affordable alternative for auto-reject detection technology is produced.

Keywords: Small and Medium enterprises, Industry 4.0, Automation, Manufacturing

1.0 INTRODUCTION

One of the benefits of manufacturing automation is it reduces long long-term by reducing manual labor. However, the high start-up cost is a common problem associated with automation systems. By analyzing the large initial investment when implementing an automated system, several issues are broken down and alternatives are generated to reduce the start-up cost. Auto rejection machine is determined as the automation technology that is crucial in the manufacturing industry. An affordable, alternative to the machine is developed by using cheaper components while maintaining the original functionality. On this basis, more local factories can implement automation systems as more companies can afford the start-up costs [1]-[5].

In the current era, automation technology is already available, but the cost to implement the technology is very expensive. SMEs are not able to accommodate the high costs of said technology. For example, a simple robotic arm that picks parts out of a small injection molding machine may cost around RM10,000 and a fully programmable robotic arm for a big machine can cost up to RM200,000 [6].

Auto rejects detection technology is an important component of manufacturing automation. The auto-reject detection technology helps to ensure the quality control of products and minimizes the labor costs needed to hire workers to manually inspect the product [7]-[12].
This system will also promote automation to the local SMEs as the cost to implement the concept of this system is significantly cheaper than conventional automation technology. By implementing this, the system helps to spread the importance of Industry 4.0 to local industries.

1.1 DEVELOPMENT AND IMPLEMENTATION OF A CONTROL SYSTEM FOR A RETROFITTED CNC MACHINE BY USING ARDUINO

This work explains that the Arduino microcontroller allows for controlling analog and digital devices [13]. This is important as a suitable microcontroller is needed to process and manage the sensor and motor driver, which are analog devices.

The paper also mentioned the low costs of the components allow for the machine to be affordable and capable. Affordability is the main concern in this system as the main objective of this system is to provide a cheaper alternative to SMEs.

1.2 DEVELOPMENT OF POSITION MEASURING SYSTEM USING LINEAR CCD SENSOR AND ULTRASONIC SENSORS

This work explains that a position-measuring system is made using linear CCD sensors and ultrasonic sensors [14]. To produce an accurate position-measuring system, sensors that have high capability in measuring distance are needed. The system in this work makes use of an ultrasonic sensor as one of the main components used in producing the position-measuring system.

Based on this work, it is determined that the ultrasonic sensor is suitable to be used in this system. Measuring distance is a crucial parameter in determining the length of the subject material.

1.3 DEVELOPMENT AND AUTOMATION OF A THERMOELECTRIC CHARACTERIZATION SYSTEM

This work emphasizes developing automation of a system by using the Arduino platform. The development of this automated system serves as proof that the Arduino platform is capable of handling and producing a working automated system [15]-[18].

In this work, the temperature is the key parameter for the automated system. The work has space for improvement by implementing different key parameters such as length and mass. This possible future improvement allows the work to be expanded into wider use cases and this system emphasizes an automated system by using length as the key parameter [19]-[21].

2.0 METHODOLOGY

2.1 OVERALL BLOCK DIAGRAM

Referring to Figure 1, the central part of the system, which is the Arduino Uno microcontroller, is connected to the Ultrasonic Ranging Module HC - SR04 sensor. This sensor detects the distance between the sensor and the targeted object, and this distance is used to determine the length.

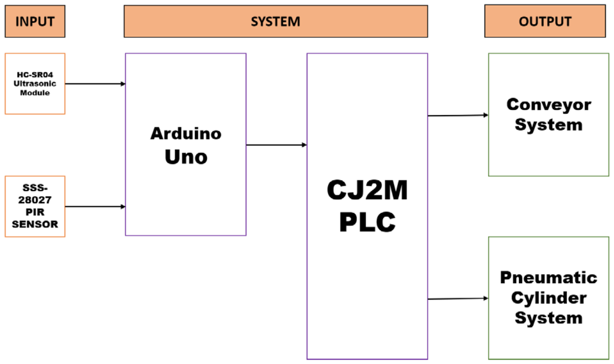

Figure 1: Overall Block Diagram

The Arduino Uno microcontroller will process the input given by the ultrasonic sensor and the PIR sensor will determine whether the program will be executed or not. The executed program will be processed through the CJ2M PLC to time it with the conveyor and pneumatic cylinder system.

2.2 OPERATIONAL FLOW CHART

The operational flow chart for this system is shown in Figure 2**.**

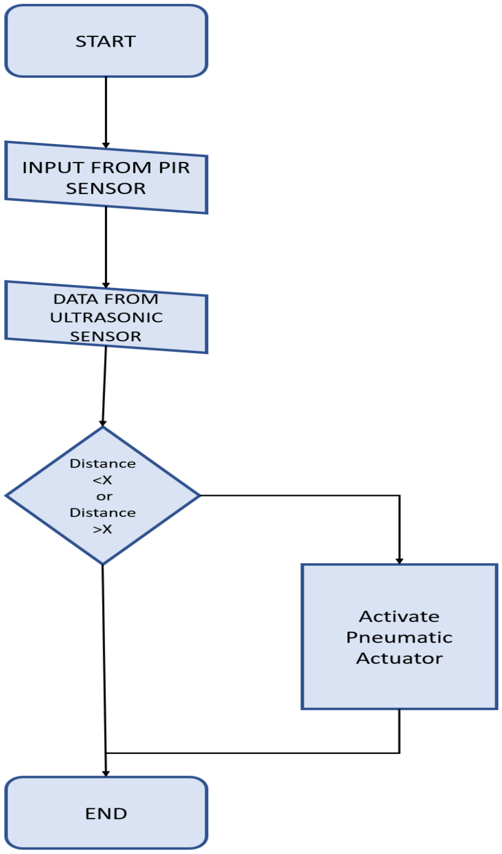

Figure 2: Operational Flow Chart

3.0 RESULTS AND DISCUSSION

3.1 ARDUINO PROGRAM TEST

Based on the system design, the following values have been assigned:
y = 180 cm
z = 300 cm
z = x – y = 120

Referring to Figure 3, the highlighted part of the code is inserted with the 'z' value = 120. Table 1 refers to the three conditions that have been set to be tested for the Arduino program. For the testing, 3 conditions have been determined

```
void loop() {

  time_Measurement();
  distance = (float)duration * (0.0343) / 2;
  error1 = 120 - distance;
  error2 = distance - 120;
  boolean sensorvalue= digitalRead(PIR_In);
  if (sensorvalue == 1){
    check_For_Component();}

  if (distance < 120){
  condition1();
  }

  else if (distance > 130 && distance < 333)
  {condition2();}

  else if (distance >= 120 && distance <=130){
  condition3();}
    else {condition4();}
}
```

Figure 3: Arduino Code

Table 1: Tested 3 Conditions

Condition 1 (cm)	Condition 2 (cm)	Condition 3 (cm)
Distance < 120	Distance > 120	Distance = 120

3.2 TEST AND RESULT: CONDITION 1

Figure 4 shows that the distance is 100.3 cm which is 19.7cm shorter than the z value (120). The LCDs object length is 19.95 cm longer than the desired length of the product. The margin of error can be calculated through

[(19.95 – 19.7) / 19.7] x 100 = 1.269%

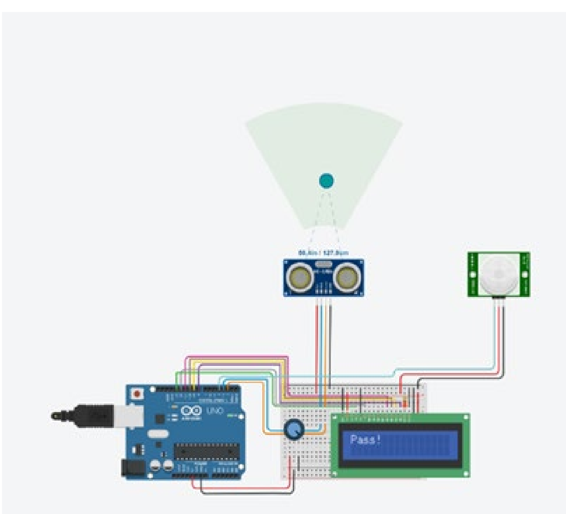

Figure 4: Condition 1 Result

3.3 TEST AND RESULT: CONDITION 2

Figure 5 shows that the distance is 239.7 cm which is 119.7cm longer than the z value (120). The LCDs object length is 118.75 cm shorter than the desired length of the product. The margin of error can be calculated through

[(119.7 – 118.75) / 119.7] x 100 = 0.794%

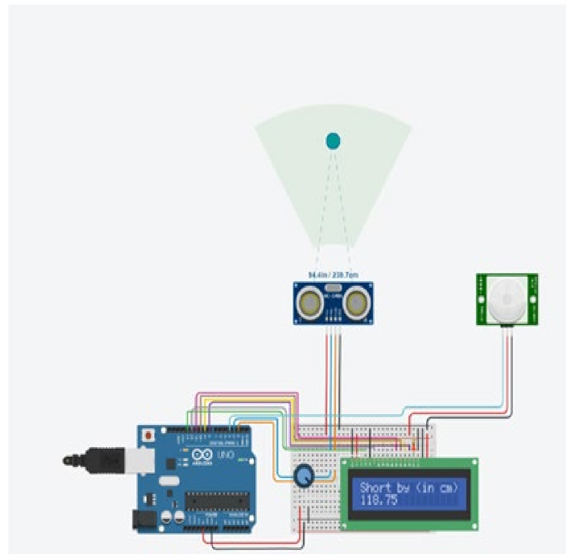

Figure 5: Condition 2 Result

3.4 TEST AND RESULT: CONDITION 3

Figure 6 shows that the distance is 127.9 cm which is close to the z value (120). The LCDs 'Pass'. The margin of error can be calculated through

[(127.9 – 120) / 120] x 100 = 6.58%

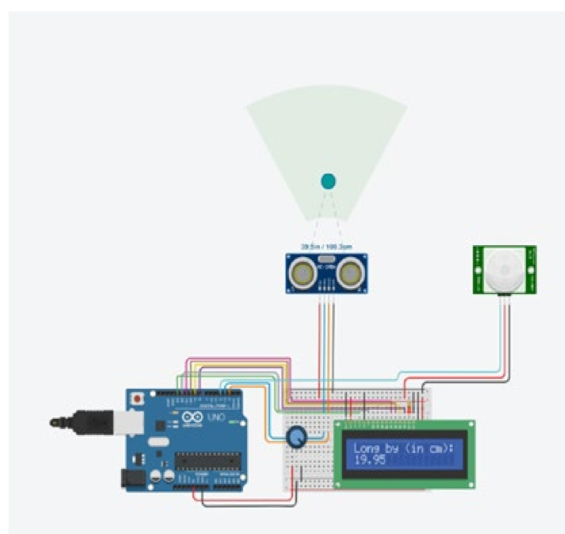

Figure 6: Condition 3 Result

The accuracy of the Arduino program test is illustrated in Table 2.

Table 2: Arduino Test Data

Condition	Real Length (cm)	Simulated Length (cm)	Percentage of Error (%)
1	19.70	19.95	1.269
2	119.70	118.75	0.794
3	120	127.90	6.58

3.5 PLC PROGRAM TEST AND RESULT

3.5.1 LOGICAL SEQUENCE TABLE

The 10 steps of the PLC program that has been tested in CX-Programmer to validate the functionality of the PLC program as shown in Table 3.

Table 3: Logical Sequence Table of the PLC system

Input (Address)					→	Output (Address)			
Step	Ultrasonic Sensor (0.04)	PIR Sensor (0.03)	Stop (0.02)	Start Button (0.01)		Step	Pneumatic System (1.03)	Delay (1.02)	Conveyor Belt Motor (1.01)
1	0	0	0	0		1	0	0	0
2	0	0	0	1		2	0	0	1
3	0	0	0	0		3	0	0	1
4	0	1	0	0		4	0	1	0
5	0	1	0	0		5	0	0	1
6	0	0	0	0		6	0	0	1
7	1	0	0	0		7	1	0	0
8	1	0	0	0		8	0	0	1
9	0	0	0	0		9	0	0	1
10	0	0	1	0		10	0	0	0

3.5.2 PLC TEST DATA

The states of input in the PLC program. The intended input state is the state that has been set in the program and the simulated input state is the result obtained from the simulation as shown in Table 4.

x = Intended Input State based on the logical sequence table
y = Simulated Input State

Table 4: Intended Input State and Simulated Input State

Step	0.01 (x)	0.02 (x)	0.03 (x)	0.04 (x)	0.01 (y)	0.02 (y)	0.03 (y)	0.04 (y)
1	0	0	0	0	0	0	0	0
2	1	0	0	0	1	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	1	0	0	0	1	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	1	0	0	0	1
8	0	0	0	1	0	0	0	1
9	0	0	0	0	0	0	0	0
10	0	1	0	0	0	1	0	0

The states of output in the PLC program. The intended output state is the state that has been set in the program and the simulated output state is the result obtained from the simulation as shown in Table 5.

a = Intended Output State based on the logical sequence table
b = Simulated Output State

Table 5: Intended Output State and Simulated Output State

Step	1.01 (a)	1.02 (a)	1.03 (a)	1.01 (b)	1.02 (b)	1.03 (b)
1	0	0	0	0	0	0
2	1	0	0	1	0	0
3	1	0	0	1	0	0
4	0	1	0	0	1	0
5	1	0	0	1	0	0
6	1	0	0	1	0	0
7	0	0	1	0	0	1
8	1	0	0	1	0	0
9	1	0	0	1	0	0
10	0	0	0	0	0	0

4.0 CONCLUSION

In conclusion, the objectives of this system are achieved. Automated material rejection is identified as one of the automation technologies that are important in the manufacturing process. Through this system completion, an affordable alternative option for SMEs is created by using less expensive counterparts compared to the existing machine. Lastly, the reliability of this system is proven through the results by having a small margin of error (10%).

5.0 RECOMMENDATIONS

Following are the recommendations to improve the system in the future**.**

i. Multiple Sensor Implementation

The current system can only detect two parameters, the distance, and motion of an object. To further improve this system, different types of sensors can be implemented such as weight sensors. Weight sensors will increase the reliability of the system by providing more parameters which as weight. Multiple combinations of sensors will provide a variety of use cases which is needed in an industry as large as the manufacturing industry

ii.Data Collection Capability

Data collection is important in the manufacturing process. It helps in keeping a check on the performance and reliability of the whole system by collecting data on the success rate and quantity of products produced. The current system does not have a data collection system. Real-time data collection will massively increase the capability of the system.

iii.Live Testing

As of the time of completion of this system, the Conditional Movement Control Order (CMCO) is in place. The CMCO prevents the system from being live-tested on a real conveyor and pneumatic system. To counter this, the system is tested through simulation programs such as TinkerCAD and CX-Programmer. Live testing will confirm the reliability of the system and significantly boost the marketability of the system

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