Evolution in Electrical and Electronic Engineering Vol. 4 No. 1 (2023) 146-154

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

IoT-Based Automatic Wire Cutting and Stripping Machine for Small-Scale Engineering Industry

Muhammad Zarul Zafran Zahran [1], Jais Lias[1]*

[1]Faculty of Electrical and Electronic Engineering.
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2023.04.01.017
Received 15 January 2023; Accepted 12 March 2023; Available online 30 April 2023

Abstract: In this modern era, there are a lot of technological improvements in wire cutting and stripping. The world is moving rapidly towards an automated or smart mechanism. Although there are many systems, but there are some disadvantages in wire cutting and stripping which could operate on their own with a human interface. The conventional method of wire cutting and stripping may not work efficiently in terms of human error, poor performance and accuracy. When the wire is being cut and stripped manually, the worker tends to make mistakes when measuring the wire as it may not be accurate. The continuous process of cutting and stripping will hurt the worker's wrist and might lead to a minor injury. In this project, an IoT-based automatic wire cutter and stripper machine was developed to increase the wire cutting and stripping performance. The machine is compared to the conventional method of wire cutting and stripping on accuracy of measurement and time taken to finish all the processes. Without a human interface, this machine only needs the input of wire length and quantity from the IoT application to operate. The process of wire cutting and stripping will be done automatically and accurately. The machine has shown the more accurate measurement of wire and faster speed of cutting and stripping process compared to conventional method by the subjects. The machine will certainly be helpful for small-scale engineering industry that does not have enough budget or big production of wire. This means that this machine is portable, convenient and easy to use.

Keywords: Wire Cutting and Stripping Machine, Automatic Process, Remote Control

1. Introduction

Nowadays, manual labour in underdeveloped small-scale engineering industries may become a significant problem for these industries. This may affect many companies resulting in performance degradation and loss in efficiency [1]. The company owners also have to bear losses thus unable to reach their desired profit and goals. The implementation of automation can solve this problem

Corresponding author: jaisl@uthm.edu.my

effectively. The manufacturing of automation equipment is advancing at a rapid speed. Automation has transformed the way manufacturers do business, from the introduction of automation in factories to the automation of new processes [2]. Robotics and automated systems have the potential to revolutionize the construction industry and give numerous benefits to the Architecture, Engineering, and Construction (AEC) sector as a whole [3]. Due to the adoption of Industry 4.0, design and production technologies have fundamentally changed. The use of sensors and the automation of technical processes to integrate and automate industries and production plants is also changing the role of computers in automating industries and production plants [4]. IoT uses smart devices and the internet to provide innovative solutions to various challenges and issues [5]. It also has brought about several new innovations that have made it more efficient, comfortable, and dependable [6]. An IoT-based automatic wire cutting and stripping machine has been discussed to achieve low cost-cutting and increase the efficiency [7] as well as the speed of the process.

2. Materials and Methods

This section will present the methodology used to develop the proposed IoT-based automatic wire cutting and stripping machine. The first subsection will present the overall block diagram of the machine, followed by the flow chart of the process and finally the details of the setup.

2.1 Block Diagram

The main criteria in most of the projects are inputs, control unit and outputs. The input of this project is the value in the Blynk application. The control unit is NodeMCU ESP32 and the output are LCD display, stepper motor and servo motors. Figure 1 shows the block diagram of this project.

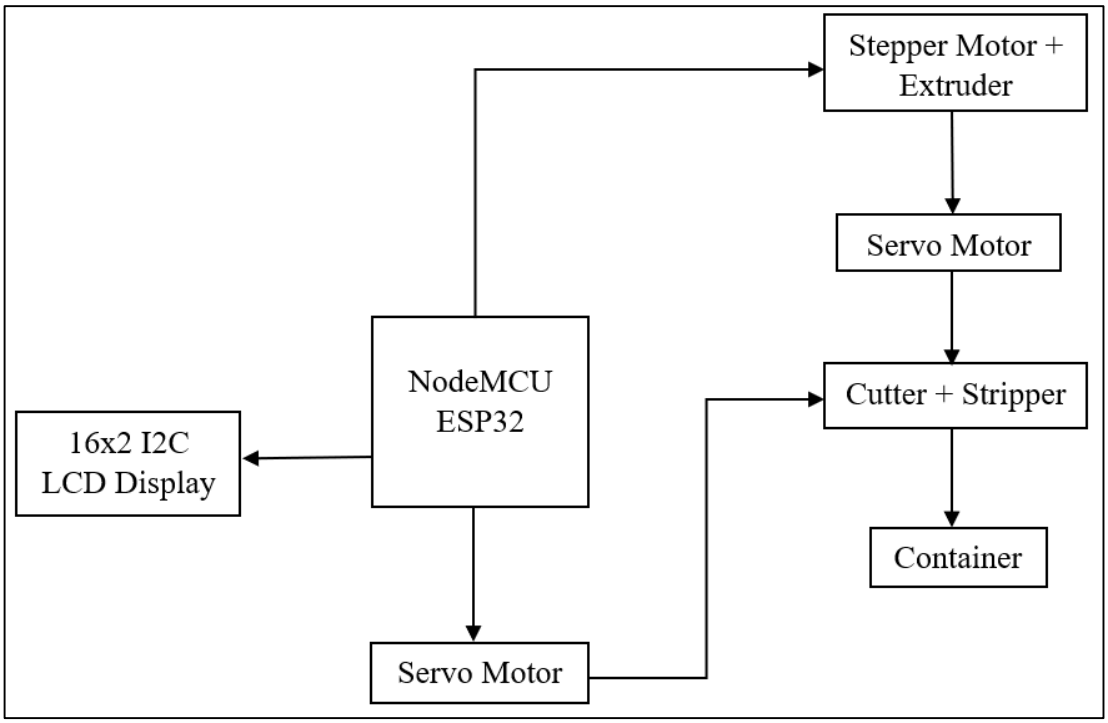

Figure 1: Block diagram of IoT-based wire cutting and stripping machine

2.2 Process Flow Chart

In this project, the flowchart will give an overview of the steps in the process of automatic wire cutting and stripping. The flowchart for process flow is illustrated in Figure 2.

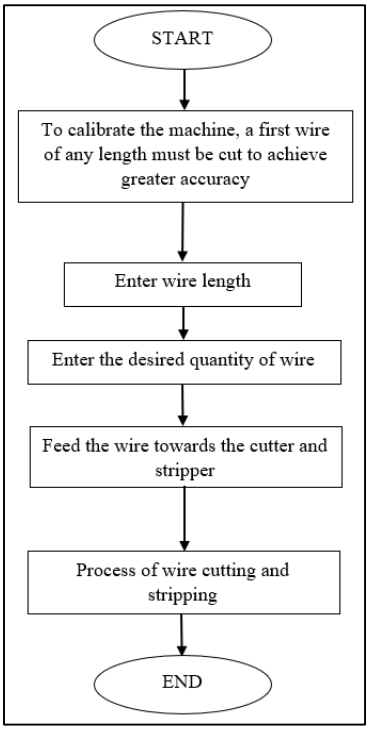

Figure 2: Process flow chart of the machine

2.3 Overall Machine Setup

All the component's connections are combined in this setup. Figure 3 shows the machine setup of this project. The components include I2C 16x2 LCD display, stepper motor, 2 servo motors, metal extruder, NodeMCU ESP32 and motor driver A4988. Plywood is used as a base for the device to sit on. Plywood is cheap, strong enough to hold the device and easy to use. A handheld cutter is used to cut and strip the wire. The spool is used to store the wire, which will be inserted into the metal extruder. 3D-printed parts are used to hold the motors and cutter.

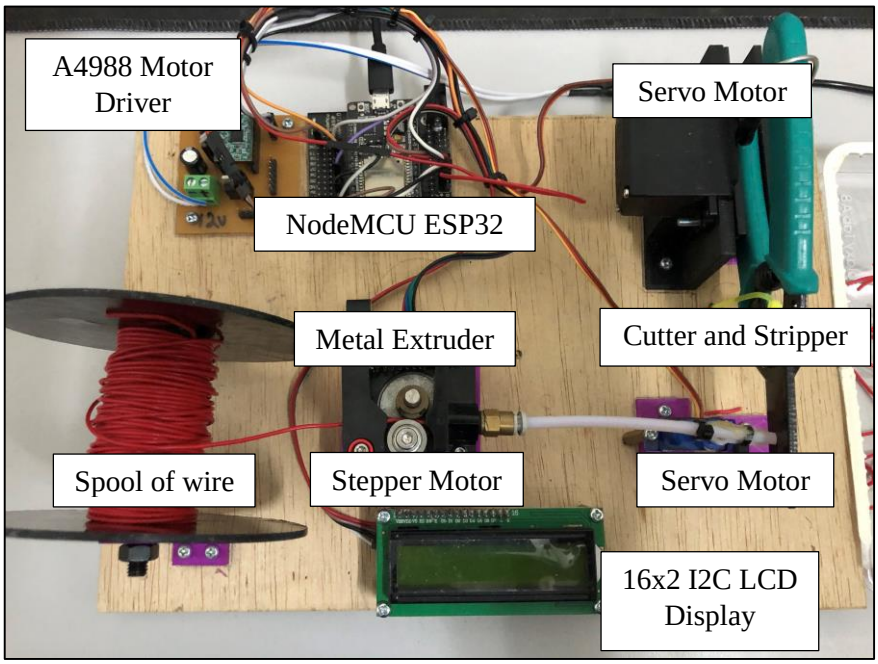

Figure 3: Machine setup

3. Results and Discussion

3.1 Operation of the machine

This machine can take the input from the user using the IoT system and then automatically measure, cut and strip the wire accordingly. After completion, the hardware and system have been tested to ensure that all parts are connected correctly and functioning properly. If there are any problems identified during the testing, troubleshooting needs to be done. The operation of the machine starts when the user inputs the value of 'Wire length' in mm and the 'Quantity' of the wire needed. This process is done by using the Blynk application. The stepper motor connected to the extruder will then feed the wire towards the tip of the cutter. The servo motor holding and feeding the wire will change the angle accordingly to either strip or cut the wire. Finally, the servo motor connected to the cutter will cut and strip the wire. The LCD is also able to display the operation from the Blynk. The operation displayed are the 'Length of wire', 'Quantity of wire', the time required to finish all the processes and the confirmation to start cutting and stripping. This machine will run based on the values which are 5 pieces of wire with a length of 100mm and with a strip of 0.5mm at both ends.

When the connection has been established, the machine can be controlled through Blynk. As shown in Figure 4, the user has to press the 'RIGHT' button to perform the 'NEXT' instruction.

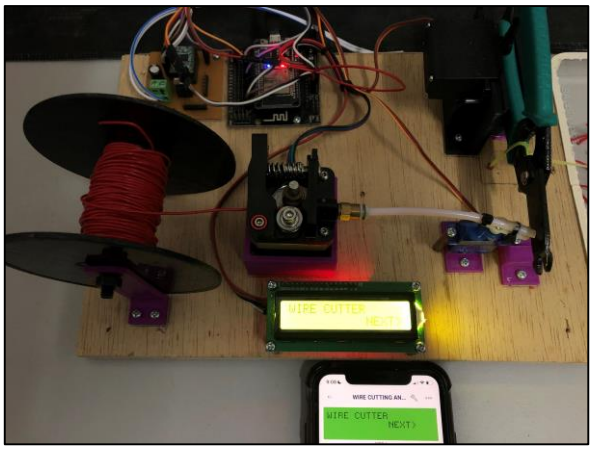

Figure 4: The machine started with the Blynk application

In Figure 5, the user has to put in the value of the desired wire length. The unit of length is in millimeter/mm. The user can press the 'UP' button to increase the length and the 'DOWN' button to decrease the length. In this case, 100mm is the input length. After that, the user can press the 'RIGHT' button to go to the 'NEXT' instruction. Figure 6 shows the process on LCD.

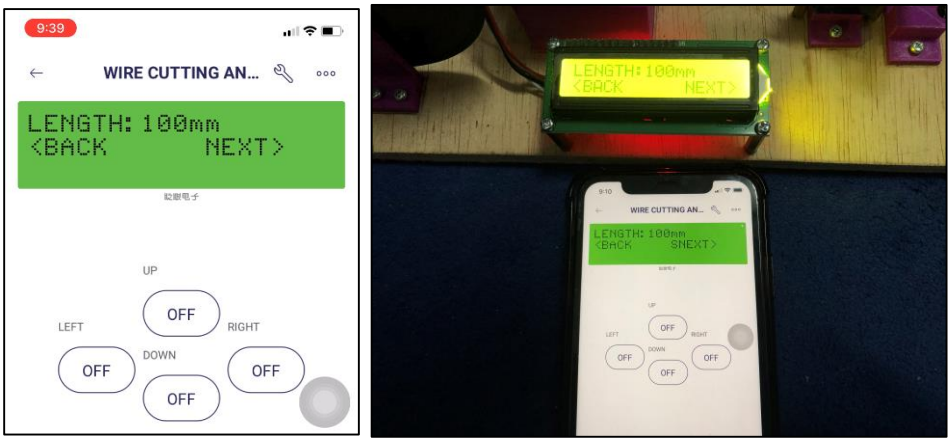

Figure 5: Interface for 'LENGTH' input on the Blynk application

Figure 6: Length input process

For the next process, the user needs to input the quantity of the wire desired to be cut, as shown in Figure 7. Same as the previous process, the 'UP' button is pressed to increase the quantity while the 'DOWN' button will decrease the quantity of the wire. The 'RIGHT' button is pressed after the user inputs the desired quantity to proceed to the next step.

Figure 7: Interface for confirmation of length and quantity of the wire on the Blynk application

In Figure 8, as the user has input the value for the length of wire and quantity desired, this interface is the final confirmation before the process of wire cutting and stripping starts. If the values are correct, the 'RIGHT' button is pressed to start the process of cutting and stripping. All of the process, from the start in the Blynk application, is also simultaneously shown on the LCD.

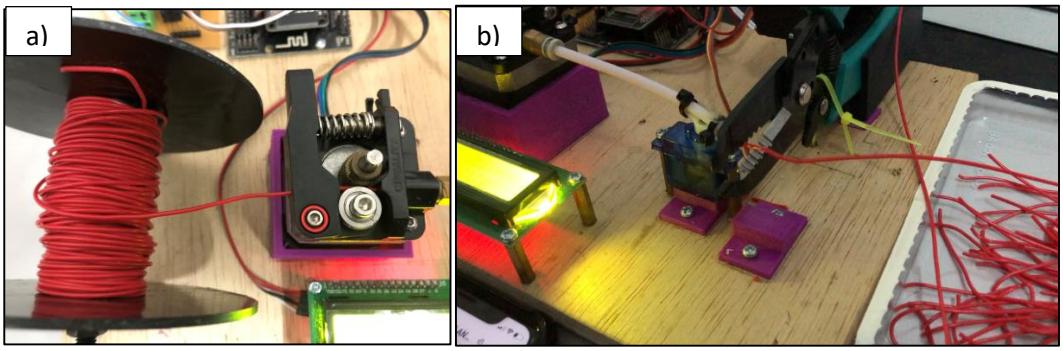

Figure 8: (a) Spool of wire connected to the extruder, (b) Process of cutting and stripping

As the user starts the operation, the spool of wire is then moved by the extruder, which is connected to the stepper motor, as shown in Figure 8(a). It will feed the wire towards the teeth of the cutter whether to cut or strip. In Figure 8(b), the cutter, which is connected to the servo motor, will rotate 90° to move the handle of the cutter which will cut or strip the wire. The machine took a total of 38s to complete all the processes. The result of each wire is shown in Table 1 and Figure 9 shows the wires that have been cut.

Table 1: Measurement of each wire

Wire no.	Measurement, cm	Average. cm
1	10.1	
2	10.3	
3	10.1	10.14
4	10.3	
5	9.9	

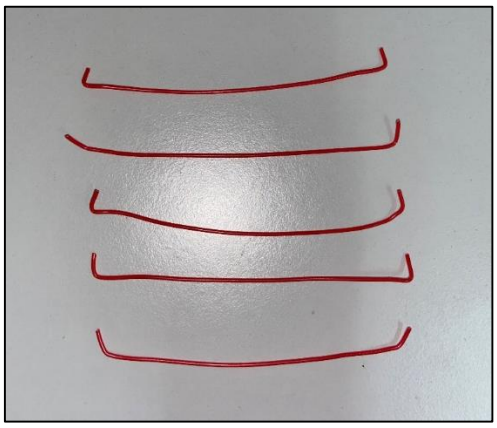

Figure 9: Result of the cutting and stripping of the wire

3.2 Comparison between the machine and manual method

In order to test the machine's efficiency, the machine is tested against the manual method of cutting and stripping the wire. For the comparison, four UTHM's engineering students have been selected as the test subjects. The parameters that will be compared are the time taken to complete the process and the measurement. The students were given a ruler and a cutter to strip and cut the wire. The specification followed as the machine above. The results are shown in Table 2 for comparison against the manual method.

Table 2: Result of the manual method for each subject

Subjects	Time taken, s	Measurement, cm	Average measurement, cm
Student 1	78	Wire 1: 10.3 Wire 2: 9.6 Wire 3: 9 Wire 4: 10.4 Wire 5: 10.3	9.92
Student 2	127	Wire 1: 9.5 Wire 2: 9.9 Wire 3: 9.6 Wire 4: 8.9 Wire 5: 10	9.58
Student 3	153	Wire 1: 10.1 Wire 2: 9 Wire 3: 9.4 Wire 4: 9.6 Wire 5: 9.3	9.48
Student 4	135	Wire 1: 9.8 Wire 2: 9.4 Wire 3: 9.5 Wire 4: 9.5 Wire 5: 9.8	9.6

3.3 Speed Analysis

Based on the graph in Figure 10, all of the subjects' time taken to complete the process of cutting and stripping is different. The machine took the quickest time, which is 38 s, compared to other subjects. Students 1,2,3 and 4 took different time taken as they all used various methods to measure, cut and strip the wire. By ratio, the machine is 1:3 times quicker than the manual cutting method.

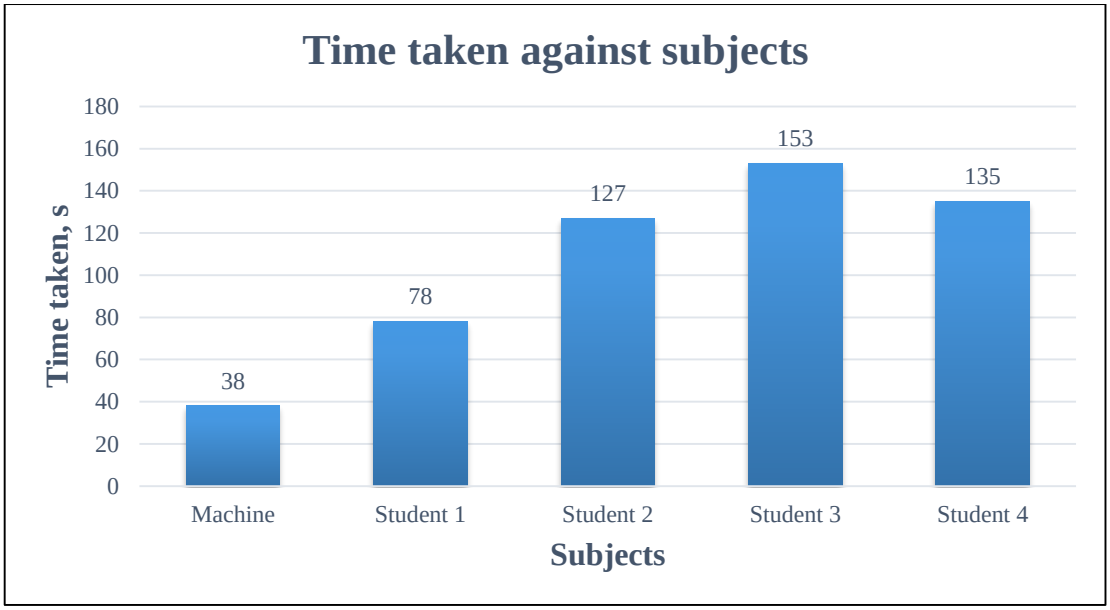

Figure 10: Graph of speed analysis

3.4 Accuracy Analysis

In Figure 11, the threshold of accurate measurement is 10 cm. The machine managed to get an average of 10.14 cm, which is quite close to the threshold value. In contrast, other subjects managed to get an average of under 10 cm, which is not quite enough to achieve the threshold value.

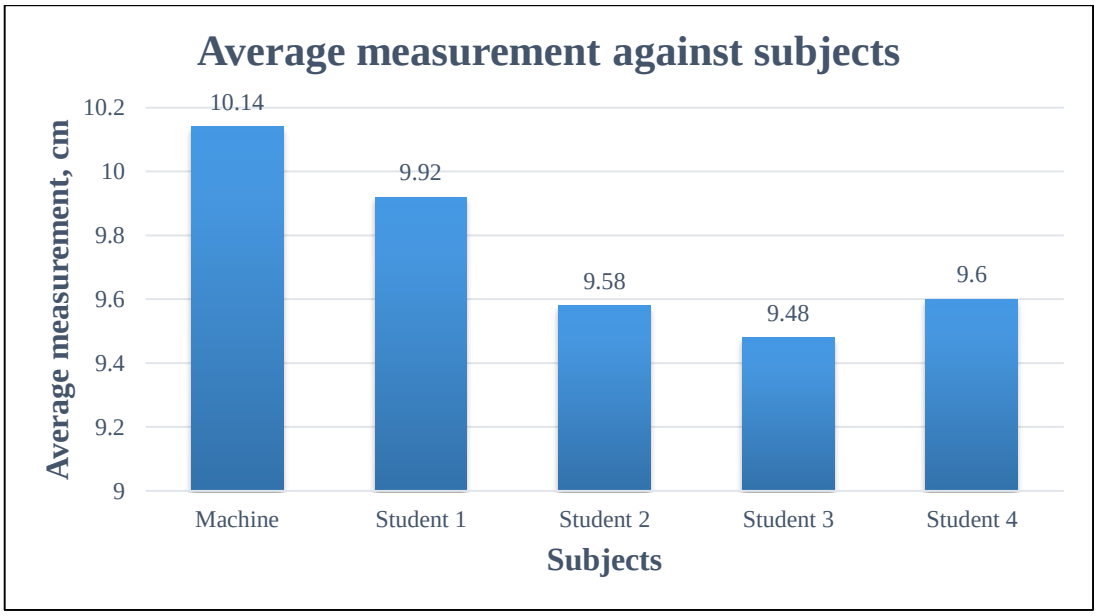

Figure 11: Graph of speed analysis

4. Conclusion

This project enhanced my knowledge of electronic construction, circuit designing and also component connection. During hardware development, the information on software management, circuit designing, components selections and motor functionality has been improved. Theory related to the subject studied can be applied in this project. Plenty of new knowledge can be learned in developing

this project. This project is an IoT-based automatic wire cutting and stripping machine that can be controlled using a smartphone application. The machine will certainly be helpful for small-scale engineering industry that does not have enough budget or big production of wire. As stated in the first objective, it only requires the user input value for the length and the quantity of the wire. All the processes are automated and work efficiency compared to the conventional method. This will reduce human error and increase efficiency and accuracy, which is stated in the second objective. With wireless communication in mind, the user does not even have to stay near or at the machine as they can operate the machine wirelessly. This means that this machine is portable, convenient and easy to use.

Acknowledgement

The authors would also like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] S. Narendra Patil, "Design and development of Automatic Wire Cutting Machine: A case study in small scale industry," International Journal for Research in Applied Science and Engineering Technology, vol. V, no. III, pp. 951–956, 2017.

[2] Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. Industry 4.0: The future of productivity and growth in manufacturing industries. Boston consulting group, 9(1), 54-89, 2015.

[3] J. M. Davila Delgado, L. Oyedele, A. Ajayi, L. Akanbi, O. Akinade, M. Bilal, and H. Owolabi, "Robotics and automated systems in construction: Understanding industry-specific challenges for adoption," Journal of Building Engineering, vol. 26, p. 100868, 2019.

[4] Z. Fatima, M. H. Tanveer, Waseemullah, S. Zardari, L. F. Naz, H. Khadim, N. Ahmed, and M. Tahir, "Production plant and warehouse automation with IOT and industry 5.0," Applied Sciences, vol. 12, no. 4, p. 2053, 2022.

[5] T. Pulainthran and Jais Bin Lias, "IoT Based Smart Pet Cage", EEEE, vol. 3, no. 1, pp. 053–061, Jun. 2022.

[6] S. Kumar, P. Tiwari, and M. Zymbler, "Internet of things is a revolutionary approach for future technology enhancement: A Review," Journal of Big Data, vol. 6, no. 1, 2019.

[7] Pavinraj A/L Chandran and Jais Lias, "Banana Quality Managing System", EEEE, vol. 2, no. 1, pp. 123-130, April. 2021.