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IT Applications for Sustainable Living

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Smart Home Door Lock Alarm System

Ahamad Zaki Mohamed Noor, Farhan Raeed Mohd Azri, Mohd Fahmi Anuar, Dona Emira Heinko Dona, Aiman Azim Azmi, Mohammad Azim Hamzah, and Fairul Azni Jaafar

Abstract The future is the Internet of things (IoT) that will transform the real-world objects into intelligent virtual objects. The Internet of things (IoT) aims to gather everything under a common infrastructure, giving us to manage and control things around us and keeping us informed of the state of the things. The main objective of this paper is to provide an overview of the Internet of things based on the example of a smart door. A smart door lock is a combination of a traditional door lock and the futuristic technology of the IoT system. With the help of the IoT system, the door lock can be controlled from anywhere with many features such as voice command, heat sensor, ultrasonic, humidity, push and email notification and alarms. This smart door lock with IoT offers mobile application that allows the user to lock and unlock the doors by clicking an icon.

Keywords Smart home · IoT · Blynk · NodeMCU

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1 Introduction

Malaysia has been experiencing accelerated urbanization which is often associated with increasing crimes in cities. Crime in housing area has become a trend; according to the statistics, the crime index in Malaysia showed an increase and which about 90% of crimes in Malaysia are property crimes, which mainly occur around the housing areas. To prevent the house crimes from skyrocketing, the usage of IoT systems to improve the house security with the assistance of smart home systems is suggested (Soh 2012).

In early 2000, most of the international airports around the world have implemented the IoT system to invent the smart gate by recognizing the people faces, ages and gender to avoid illegal immigrants. Besides, in 2016, a RFID system has been introduced in the most highway's toll system in Malaysia (Lieshout et al. 2007).

So, by using this idea concept, the system of IoT can be implemented in residential areas for every house to avoid gate breaches. The idea is that the house owner will get a notification by a specific application in the smartphone using Blynk application even wherever they are when someone tries to open the gate or door without the permission of the owner. As for design, the circuit was set up using specific component. The simulation was set up according to the controller that was used to run the coding and circuit. Once the circuit has been designed on the breadboard, the code programming that has been created needs to be running using Blynk and the program was performed (Media's et al. 2019).

The main problems that this project attempts to solve are to get a notification for an open door. There must be a reliable system to help users especially a house or a building owner to get notified for an open door. Even if they are away from home or building, the system will automatically send a notification to the phone. Most people are usually very busy, especially with routine jobs. So, they are very difficult to monitor house surveillance and the safety.

The main objective of this project is to study and develop a security monitoring notification system that is used for security and notification systems. The purpose of this system is to increase security by designing a system which is efficient, low cost and can be implemented in home and office security systems. Furthermore, developing a security system gives security in home and office persistently (Anitha 2017).

2 Literature

The Internet of things (IoT) technology has become an evolution in the technology industry which gives a lot of potential benefits toward the community. The basic idea of the IoT was to connect any device with physical substance to the Internet. Then, the Web of things (WoT) is able to connect sensors with the Web and translate it into useful data and information (Theekakul et al. 2010).

The authors proposed a smart home using the IoT application that has combinations of the systems which were related to a portable electronic device. For instance, cloud computing and wireless sensor nodes are used and give an authority to the user to control home appliances such as door locks.

Furthermore, the IoT communication protocol is suitable for any application (Fauadi et al. 2020). The IoT application in a smart home system needs to be low cost since it uses Android application to transmit the information to the cloud. This system removes the use of personal computer (PC) which give such a big impact to the public since nowadays people preference change as technology grows. People prefer portable technology, especially youngsters. This proves that the uses of the IoT can give effectiveness toward the smart home system.

According to Mittal et al. (2017), the procedure of smart home system is using Bluetooth and Ethernet. The Bluetooth connection between the Arduino software and a smartphone has increased the possibility of short-range wireless communication that is commonly used in indoor environments while the Ethernet module is applied to the Arduino board or NodeMCU.

Besides, Media's et al. (2019) had designed a system based on the Blynk software which can be controlled and monitored by any portable device such as smartphones using Wi-Fi. All the sensors were connected to the Internet via NodeMCU.

Plus, Mahindar et al. (2018) state that the application of the Blynk app helps their project of a smart home system and increases the security level with the help of Wi-Fi which connects NodeMCU to the Blynk app. Then, the Blynk app translates the data from the sensors. This gives benefits such as detection of any unfavorable incident so that people can take early precautions.

3 Methodology

The circuit was designed according to a schematic diagram that was created. The ESP8266 Wi-Fi module and all the electronic components were attached to the breadboard.

The piezo buzzer (see Fig. 1) was connected to D5 and D2 on the ESP8266. It is used to generate basic beeps and tones when the door is opened by someone else and will be notified to the owner.

The push button as shown in Fig. 2 was connected to the piezo buzzer pin D5 and ESP8266 D2 from pin 3V3. It is for the open-closed system for the door when it is been pressed or depressed to open or close by someone that used the door.

The resistor as shown in see Fig. 3 was connected to the ground (GND). It is to delimit the electric current, voltage division, heat generation, matching and loading circuits, control gain and fix time constants.

Fig. 1 Piezo buzzer

Fig. 2 Push button

Fig. 3 Resistor

4 Process Flow

The sensor detects an opened or closed door. Next, the sensor sends data to the processing unit ESP8266. The ESP8266 interprets the data and sends data to Blynk. The user receives a notification on the smartphone informing that the door is closed or opened. Figure 4 shows the process flow.

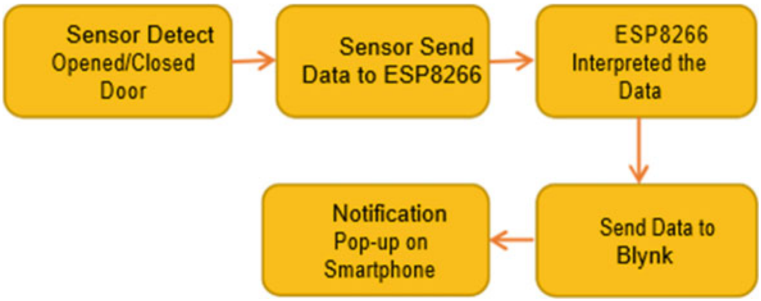

Fig. 4 Process flow

5 Result and Discussion

The system will be implemented at the main door where the user is notified every time the door is opened via an app on the user's smartphone. The system works when the door is closed and the button, which is embedded in the door frame, is pressed. When the door is opened, the piezo buzzer will also sound to inform the potential intruder that the owner of the premises has been alerted and provided thus acting as a deterrent for the intruder. Figure 5 shows the location of push button switch was placed.

When the door is opened, the button is depressed thus sending the user a notification through an app that informs the user that the door is opened. Figure 6 shows the condition of push button when the door closes, and Fig. 7 is the push button condition when the door opened.

5.1 Prototype of the Project

In this section, the information on the prototype of the door operation embedded with sensors and circuit is shared. Figure 8 shows a prototype when the door is closed. The sensor shown in Fig. 9 is for the configuration when the door is opened. Figure 10 shows circuit connection of the prototype door. A buzzer is attached so that the people staying in the house not just get a notification from the phone but also hear an alarm from the buzzer.

Fig. 5 Example on placing/locating push button to door

Fig. 6 Button when the door is closed

Fig. 7 Button when the door is opened

Fig. 8 Prototype of a closed door

Fig. 9 Prototype of an opened door

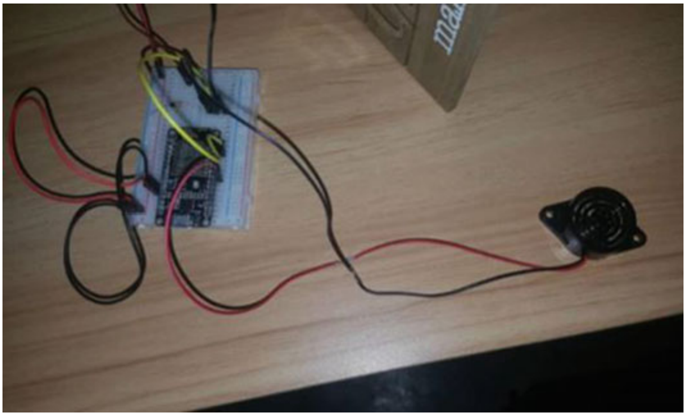

Fig. 10 Circuit assembly using ESP8266

5.2 System Circuit

This section shares the simple connection of developing a smart home door lock system. A push button was connected to the ESP8266. This push button acts as input for the system. The information from the push button will be sent to the processing unit. The output of this circuit is the piezo buzzer. The buzzer will be triggered when the push button is released signaling that there is a breach from the main door. Figure 11 shows the complete circuit for the door lock system.

5.3 Output from Arduino and Blynk

The result from the assembly to the prototype can be observed from two applications or software. The first software used to validate the accuracy of the smart home door lock system is the Arduino software. From Fig. 12, the reading in serial monitor display as “1,” which signify that the door is closed. When the door is opened, number “0” and “Door Opened!!!” will be displayed on the Arduino’s serial monitor.

The next output which was used to validate the functionality of the smart home door lock system is explained in the following. Two icons were placed in the Blynk application as shown in Fig. 13. When the door was opened, a notification was received from the smartphones.

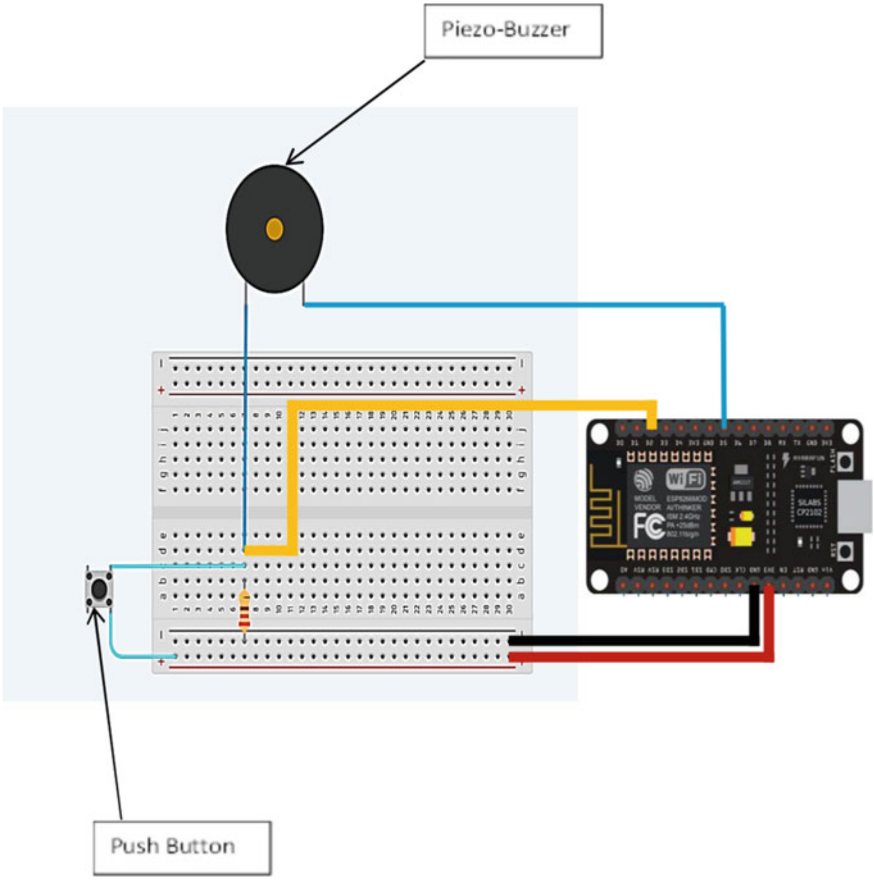

Fig. 11 System circuit

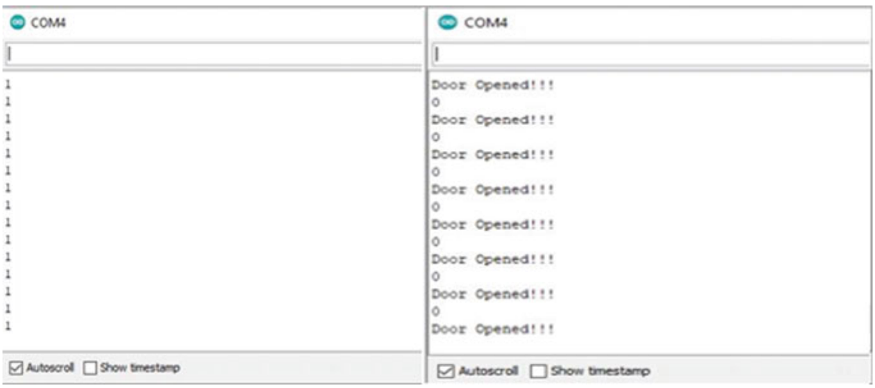

Fig. 12 Serial monitor reading

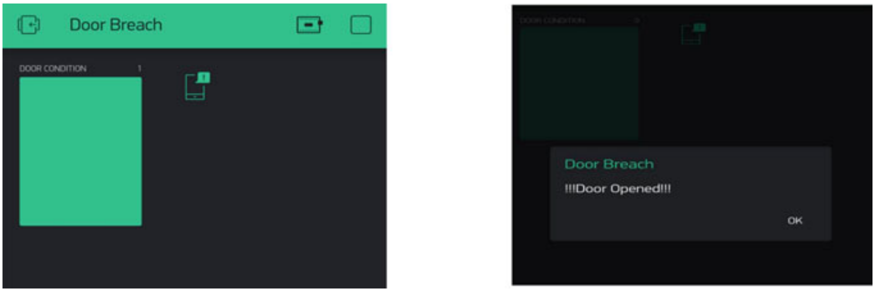

Fig. 13 Blynk interface output

6 Conclusions

In summary, the Internet of things is a revolution in technology which gives a huge impact to the industries and affects every field of life since things that seemed impossible in the past are now available. The smart door alarm project is the implementation of the IoT. This project of the smart door alarm focuses on developing a good security monitoring notification system, and it is purposely designed to increase the security. This project of the smart door alarm is mainly based on the idea of trivial issue faced by the society when a person has some obstacles to keep proper maintenance of a house specifically on the door lock and it could lead to serious consequences because of that particular action.

This innovation connects any tangible or physical possible objects (which in this case is the door) to the Internet to make the door system being controlled using portable electronic devices such as a smartphone. The smart door alarm was designed with a secured accessibility because it has safety measures on database control to prevent any unauthorized person to access the door system since the notification that pops up on phone screen helps in overall safety such as identification of a person and authority checked-up.

Plus, throughout this project, we have learnt the uses of the IoT in real-life scenarios. In addition, the study of topics that have been taught which is combination of basic components has been implied for this related project to testing out whether these project outcomes align with our objective. This innovation also uses the Blynk software to get the notification that occurs on the screen as the results and program coding are shown above.

The smart door alarm brings a lot of benefits to the user after taking everything into account. For instance, a person could take an action faster if there is a suspicious unlocked door. The costs also would not override the benefits. It makes life easier and simple as our standard of living increases day by day.

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Development of an IoT-Smart Parking Mall Sensor Using Blynk and ThingSpeak

Ahamad Zaki Mohamed Noor, Muhammad Zahid Mohd Kamil, Nor Hanis Najeeha Mohd Hisban, Nurul Najwa Mohd Anuar, Siti Nurlina Mohd Khairudin, and Fairul Azni Jafar

Abstract In almost all of Malaysia's malls, maintaining the parking system has become a major problem. Most malls in Malaysia have trouble designing a strategy that allows their parking slots to be optimized. Through the paid parking scheme, some malls earn more profit, sadly the system disappointed the clients. The conventional parking system often faces similar issues as it causes problems for customers, such as finding vacant space to park their car and wasting a lot of time. The aim of this analysis is to propose a parking mall sensor, through the use of the Internet of things (IoT). The paper applies the parking mall's sensor system that helps visitors to access a parking space without wasting their time, and the existence of this sensor also allows the mall's management to collect data on how many cars are parked and how long each slot is parked. The purpose of this research is to improve the current system for parking management designed by the IoT, with the intention of being used as a reference for parking management in a shopping complex.

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Keywords Smart parking system (SPS) · Parking lot · Parking meter (PM) · Internet of things (IoT) · E-parking

1 Introduction

In large cities, such as Kuala Lumpur, shopping complexes and malls have been the favorite place for urban society to go. It has already become part of their lifestyle to visit shopping malls. Not unexpectedly, in shopping malls, they can find almost anything. Mall management has equipped its clients with different services to make customers feel better on their visit to the shopping centers, one of which is parking spaces.

The parking management dilemma can be viewed from many angles in recent studies in urban cities. This leads in an irritating challenge for drivers to park their because it is very difficult to locate a parking slot. To find parking space, they usually waste their time and effort and end up parking their vehicles to find a space on the streets. Worst of all, people, especially during festive seasons and peak hours, fail to find any parking space. Therefore, with the introduced smart management system, parking by using sensors to identify available slots and direct users to the location in some malls in Malaysia can be one of the solutions to this issue (Olanrewaju and Arman 2019).

The Internet of things (IoT) is a well-known communication protocol suitable for any applications (Hafidz et al. 2020). Smart parking is a very simple example for an everyday citizen on how the IoT can be used quickly and efficiently to provide various services to different people. The proposed application is user-friendly and can be used by even non-technical individuals via mobile devices. Users can check for a free parking spot from anywhere in the world using this application. The proposed framework offers well-organized control of car parking by independent localization of parking spaces. The traditional reservation-based system of car parking has a room and time limit. The proposed smart parking solution offers accessible free parking space that saves time and fuel and decreases urban air emissions and congestion. The new IoT-based parking platform allows data collected from sensors to be linked, processed, automated, and implemented effectively, making smart parking possible (Vakula and Kolli 2018).

To give user updates to users about the availability of online parking, the PaaS Blynk Android app is used. A resource management approach is proposed based on real-time sensor data. A complex parking tariff and load-handling plan for parking spaces in parking malls would benefit from this optimization process (Mishra et al. 2019).

In the cloud model, ThingSpeak is used as a medium for transmitting sensor data and visualizing data. Data such as how many vehicles have been stored and how long the car has been parked in each slot could be preserved (Bharadwaj et al. 2020).

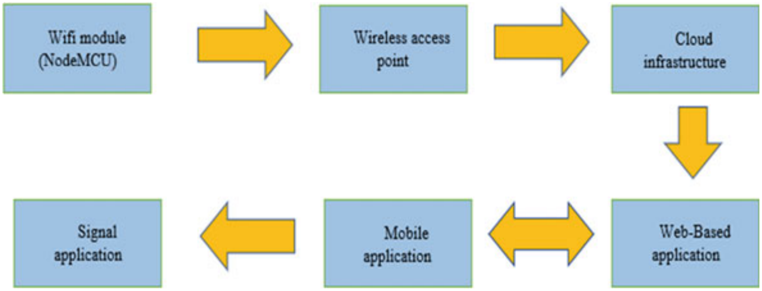

Fig. 1 Flow of application

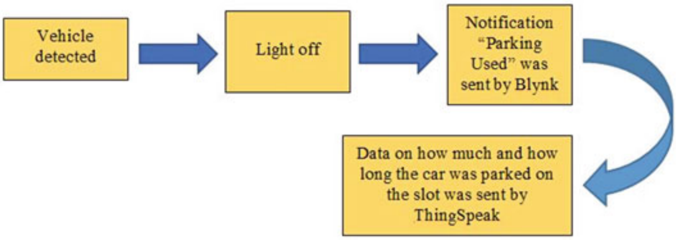

Fig. 2 Flow of parking mall sensor

2 Methodology

For this smart parking sensor, the two important tools needed are Wi-Fi Module named NodeMCU and a wireless access point. These tools will activate the cloud infrastructure, web application, and mobile application. The end user will receive a signal regarding the vacancy of the parking spot. Figure 1 shows the flow application.

More details on the operation are shown in Fig. 2. A sensor will detect the vehicle; hence, a light at the parking spot will turn on if there is a vacant place. If there is no vacancy at the parking spot, then the light is turned off. The user mobile receives notification on vacant and parking in use. For cloud application, the information on the frequency of parking spot used and duration for each parking was stored.

3 Result and Discussion

For this project, we used four components and two applications. NodeMCU is an open-source firmware and development kit that permits one to prototype or build IoT computers. NodeMCU is used to connect the program and computer to the Blynk app. Blynk is a framework that helps us to easily create iOS and Android software interfaces for managing and tracking our hardware projects. Blynk is used when the sensor is sensed to receive notification from the NodeMCU. ThingSpeak is an open-source Internet of things platform and API for storing and retrieving data from things over the Internet or over a local area network using the HTTP and MQTT protocols. The creation of sensor monitoring applications, location control applications, and a social network of status update items is supported by ThingSpeak. Resistors are used to reduce the current flow. LDR is used as an input to detect the vehicle. LEDs are used as an output when the sensor is active. Figure 3 shows the initial prototype of parking space with circuit assembly at the back.

Figure 4 shows the before and after a vehicle park in a parking space. Observe parking space D2 where the LED light turns on when the parking space is vacant. Once the vehicle moves into the parking space, the green LED turns off. When the parking is empty, the LED will turn on to notice other drivers. This is because the sensor is not detecting any vehicle. It means the sensor is not active.

The next phase of result is to observe the output from the ThingSpeak and Blynk application. For ThingSpeak, there are two conditions. When the parking is available, the line graph increases according to the LED ignition. The next condition for ThingSpeak is when the parking space is used. The line graph decreases to signify

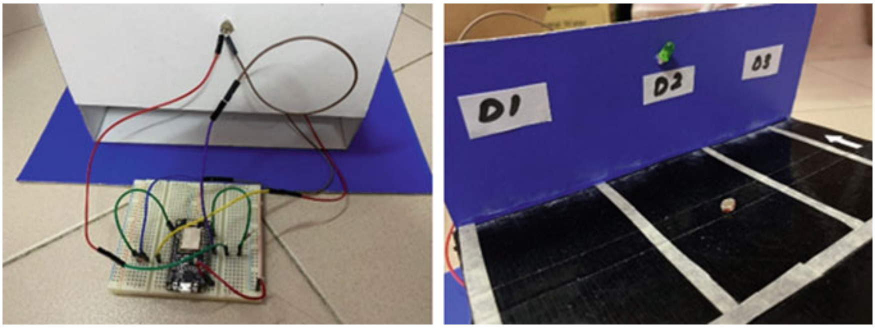

Fig. 3 Prototype of parking space and circuit assembly

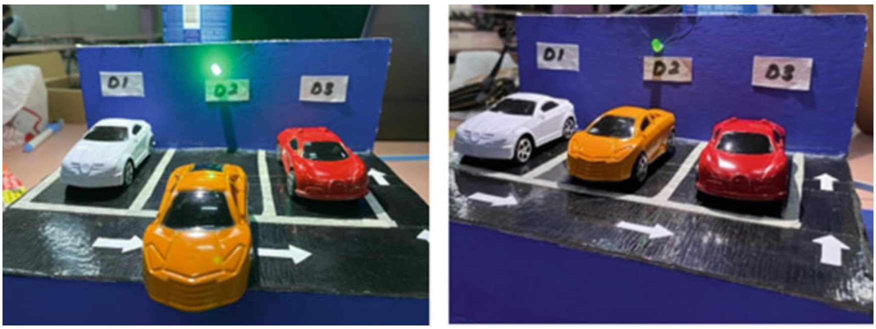

Fig. 4 Before and after vehicle park

Fig. 5 ThingSpeak and Blynk result

that the LED is off. The Blynk application gives notification to smartphones that the parking spot is used.

When the parking was used, the LED will turn off. This is because the sensor is active and detecting a vehicle. Then, the NodeMCU will send data to the Blynk app to pop up the notification "Parking Occupied." ThingSpeak will receive data when the program is running. When the parking is available, the graph will reach to 1025. This is because the sensor is not detecting any vehicle.

After that, when the parking is used, the graph will drop to 980. This is because the sensor detects a vehicle. Figure 5 shows the results of both ThingSpeak and Blynk.

From Fig. 3, it can be seen that this system used an analog input and a digital output. LDR is connected via a wire to the NodeMCU ESP8266. The 3-V supply comes through a resistor with 220 Ω and goes to the first leg of the LDR. Then it goes to the analog pin A0. The second leg goes to ground. We connect to analog pin because LDR is an analog input. LED is connected via a wire to the NodeMCU ESP8266. The connected digital pin D1 reads the LED's state from the first leg of the resistor with 220 Ω. The second leg resistor goes to anode (+) LED to receive supply. Lastly, the other LED leg which is cathode (−) goes to ground. A graph chart from the ThingSpeak is generated to record the data of how many and how long the cars used the parking. The Blynk application sends a pop-up notification to the parking owner/screen monitor for giving alert that the parking is in use.

4 Conclusions

The paper suggests a smart parking solution integrated with the IoT to address the typical challenges faced by the construction management. The concept of the article was applied in many malls in Malaysia, albeit still at an early stage. It is expected that the introduction of the parking mall sensor would assist tenants, parking personnel, and the management of shopping malls. Through this sensor, shoppers can find it easier to park a vehicle in a shopping center.

In the parking mall, this sensor makes it easy to limit the traffic in and out of the shopping center and to maximize the parking area. In the context of simple parking control and allocation, parking workers also benefit from this. We understand that parking slots have not only been a problem for Malaysia in shopping centers, but in other areas also such as parks, tourist destinations, conventional markets, restaurants. As a result, the author hopes that this paper will be helpful in other locations or potential studies for parking issues.

The smart parking sensor promotes sustainable living, travel accessibility, and environmental sustainability issues. The smart parking technology is used to boost levels of efficiency and levels of service in operations. It also benefits from reducing running expenses and raising sales and the valuation of the facility. From conventional support platforms including tollbooth and parking attendants, the proposed system has changed. This includes the use of the Arduino Uno, ESP8266-01 Wi-Fi board, ThingSpeak, and Blynk ultrasonic sensors. Hardware, applications, and network networking are built into the Internet of things, allowing objects to be detected and managed directly through existing networks. This integration enables users to track accessible and inaccessible parking spaces, resulting in increased performance, precision, and economic benefits.

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Development of a Smart Travelator Using Blynk and ThingSpeak for Monitoring Customer's Temperature

Ahamad Zaki Mohamed Noor, Herroney Ryan Herman, Khairi Juwaidi Mansor, Anis Sofi Ahamad Salleh, Nur Syakinah Muhamad Fauzi, and Fairul Azni Jafar

Abstract Currently, the whole world is experiencing COVID-19 pandemic. The symptoms are sometimes hard to be traced. Hence, a system was developed in this research to isolate people with COVID-19 symptoms from entering any premises. This research was carried out to develop a prototype travelator with smart monitoring system integrated. The monitoring system was developed by placing a sensor to detect temperature of the people entering premises. When the temperature showed less than 37 °C, a gate will open and travelator will operate. Notifications will be sent via an app named Blynk and ThingSpeak for monitoring and data storage.

Keywords IoT · ThingSpeak · Blynk · Arduino · Travelator

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1 Introduction

Nowadays, people around the world tend to take a route even though some of them are having fever. This could lead to transmission of fever where healthy people would be infected by people that have fever (Gul et al. 2021).

Therefore, a system of a travelator is designed where it functions as a safe security system. A travelator can be used to bring one person from its starting point to the ending point of the track. However, on the middle of the track of the travelator, there would be a thermometer that will scan the user, and if the user possesses a temperature less than 37 °C, the travelator's door would be opened, but if the user possesses a temperature more than 37 °C, the user would be led to another track of the travelator thus do not give a permission to the user to reach the ending point of the specific track.

The idea of this project is conducted based on the COVID pandemic that happens nowadays. The purpose of this technical paper is to evaluate the performance of the project by developing a low-cost travelator in the form of the Internet of things (IoT). Sufficient preparation or not-so-complex illustration is needed to analyze the outcome of the travelator system.

The travelator system requires ThingSpeak and Blynk applications to assist the performance. These applications were widely used in a communication protocol namely the Internet of thing (Hafidz et al. 2020). ThingSpeak is used to visualize, aggregate and analyze live data streams in the cloud. Then, Blynk is applied to create the human–machine interface (HMI) or a graphical interface by providing and compiling the address that is appropriate on the available widgets (Chan 2021).

Finally, a DHT11 sensor is used to measure the atmospheric temperature that surrounds the area (Aafreen et al. 2019).

2 Methodology

This section discusses the tools and equipment used, application and how the whole process happened. Each process will be explained in detail in every section under the methodology section.

2.1 Travelator Process

The sensor of the travelator functions if the user steps on the track. The DHT11 that acts as the temperature sensor will read the temperature of the user at the middle of the track. The signal of the temperature sensor is connected to the module of the Wi-Fi. Blynk and ThingSpeak are being used to obtain the result of the sensor. If the temperature of the user is below 37 °C, then the door of the travelator toward the ending point would be opened immediately or else the user will be led to another track that will not reach the specific end point if the temperature is 37 °C or more. Figure 1 shows the circuit of the smart travelator.

This circuit needs to be built inside the smart travelator. There will be a gate that stops the customer from entering the premise. There will be a temperature scanning. If the customer's temperature is below 37 °C, the gate opens and customer may enter the premise. For customer with temperature exceeding 37 °C, the customer will be rerouted to a different path. Figure 2 shows the sample design on the travelator illustration.

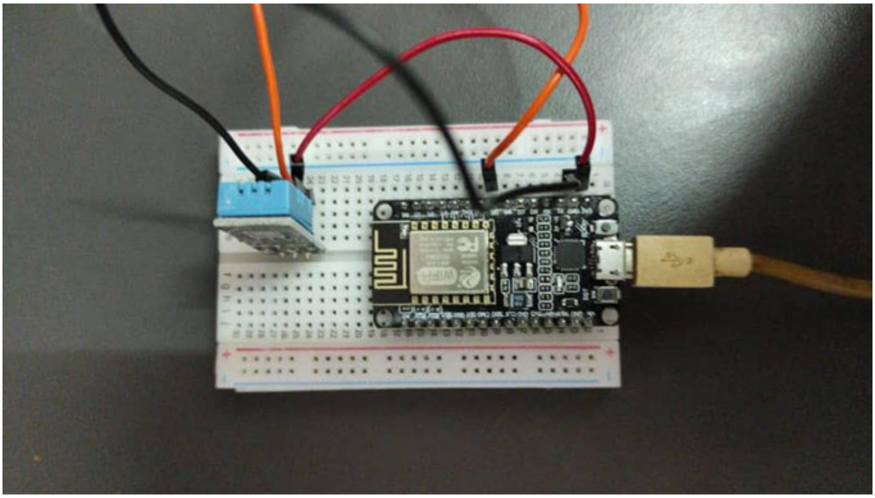
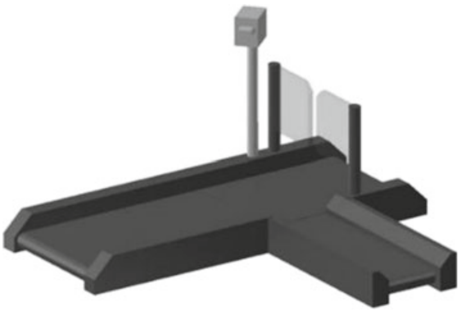


Fig. 1 Circuit of the smart travelator

Fig. 2 Design of the smart travelator



2.2 ThingSpeak Process

ThingSpeak is registered at the corresponding website. A new account is produced and a new channel with temperature as one field is created after ThingSpeak is already registered. Two API keys would be generated once a new channel is created which reads the API key and writes the API key. Writing the API key would be provided by ThingSpeak as stated below: Name of the host and password are substituted with name and password of the Wi-Fi, respectively, in the program. The program is verified with the Wi-Fi setup, while the DHT library is being used by downloading the link of the DHT. DHT library is imported in the Arduino IDE. The program or the sketch is compiled and uploaded to the Arduino MCU through Arduino IDE, and it is compulsory for the Wi-Fi modem and the Internet connection of the PC to work properly. Temperature values are uploaded on the ThingSpeak once the sketch is already uploaded, and it would be graphically viewed in the private view window.

2.3 Blynk Process

The Blynk app that can be found from Google Play Store is installed and then signed in immediately. "Travelator" is named or stated when starting the new project of Blynk. Then select the board as ESP8266 and the authentication token number is provided. The Wi-Fi of the ESP8266 is connected to the PC. Arduino IDE is opened. The com port and the correct board (NodeMCU 1.0) are selected from the tools. The Blynk application is opened in the phone after the programming of the travelator system is uploaded to the Arduino and after ensuring that the Internet is connected. Figure 3 shows the Blynk interface with a notification icon introduced.

3 Result and Discussion

This section discusses the functionality of both ThingSpeak and Blynk in the smart travelator application. The result will be separated according to the type of software.

3.1 Result for Blynk

Based on Fig. 4, the programming is successfully executed by using the Arduino. It shows that the smart travelator is functioning when linked together with Blynk. The play button that can be found on the top at the rightest corner of the application is pressed, and the notification of "Gate Open, Travelator Moving" is shown in Fig. 5.

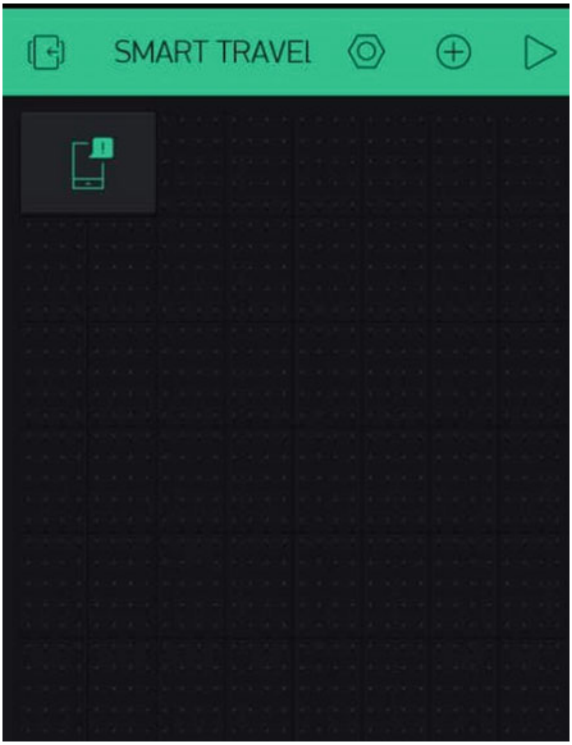


Fig. 3 Interface of the Blynk application

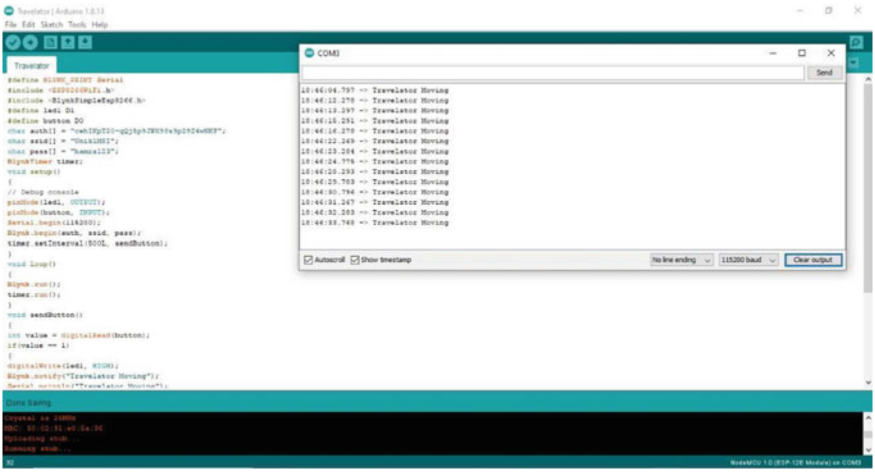


Fig. 4 Arduino interface when the program is successfully executed

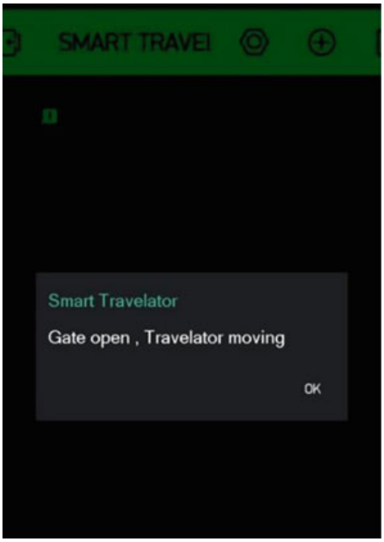


Fig. 5 Notification from Blynk application

The circuit structure is illustrated as the travelator. In real life, the travelator would have functioned if someone steps on it as it detects the weight of a person. It sends the user from the starting point of the location that has been decided and stopped after the person has already reached the end point.

For the case of the circuit, when the push button is switched on by pressing the button with a force that is exerted by a finger, the LED lights up which shows that there is a weight that triggers the button. The LED lights off if the finger is lifted from the push button. This is because the push button is not detecting any force anymore. The travelator is functioning with the existence of weight and stops when there is no weight that triggers the sensor.

3.2 Result for ThingSpeak

There are two conditions whereby ThingSpeak will store information in the cloud. Figure 6 shows the condition when travelator moves in case the temperature detected is 36 °C. Any temperature below 37 °C will ensure the travelator to operate. Figure 6 shows the travelator reading in ThingSpeak.

The programming that is executed is considered failed. However, the interface of the ThingSpeak still measures the temperature of the surrounding. This means that ThingSpeak is functioning when it is connected to the Arduino apps with the presence of Write API keys and ID channel. Furthermore, the DHT 11 proves that it can detect the temperature around its area. The experiment failed due to not accurate coding and probably some dysfunctional equipment. The circuit structure is illustrated as

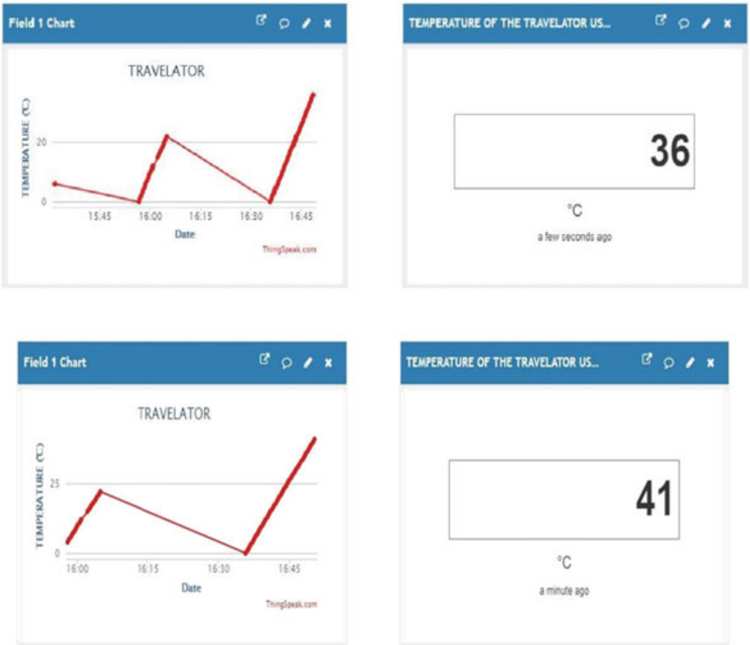


Fig. 6 Travelator temperature reading in ThingSpeak

the travelator. In real life, the travelator would function if someone steps on it as it detects the temperature of a person.

After that, the circuit has been designed according to the specification required to complete the task. ThingSpeak is used to collect and analyze the data in graph form. The data will show the different gap of values. Thus, the notification will appear on the computer screen providing information about the temperature that the results of DTH11 sensor sensed.

4 Conclusions

To conclude, this concept idea will solve by tracing the people with COVID symptoms and eventually reduce the close contact among other premises visitors. By utilizing Blynk and ThingSpeak applications, the ordinary travelator changes into smart travelator.

Future planning is to develop a prototype of this concept idea and introduce it as a common facility which can be utilized throughout the world. Recommended to improve the gate height in order for the user to not simply cross over the gate and enter the premise. Overall, this smart travelator will isolate the COVID-19 symptoms people from others and eventually stop the spreading of COVID cases.

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Development of Smart Agriculture (Smart Hydroponic) to Monitor Soil Humidity Level

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Abstract Recently, the world is evolving along the 4.0 industrial revolution. One of the major developments which come along through this development is a smart cultivation. This kind of industry will help thousands of farmers and agricultural industries that are immersed and utilizing the use of technology like the Arduino. A real-time environment monitoring can provide a visualization of the data and condition of the agriculture. An integration of software and a hardware system which is equipped with a humidity sensor, temperature sensor and water level sensor will lead to the advancement of agriculture among us. We decided to do smart hydroponics as our project. Smart hydroponic system helps to maintain the quality of the crops from far. This system could help our farmers to maintain their crops with less effort because this system requires ThingSpeak and Blynk applications. We could get a notification on the Blynk apps about the information of our crops which is received from ThingSpeak where the data can be monitored by us. This system can help us monitor our crops and can help us prevent something that can cause a major loss towards our crops. The agricultural industry has been pushed by crucial factors such

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as rapid population growth, food security and climate change to explore more creative measures to improve productivity and crop yield. As a result, by offering end-to-end visibility in the agricultural processes, the Internet of things has emerged as a saviour for the farming industry.

Keywords Sensor technology · Smart agriculture · Hydroponics · Internet of things

1 Introduction

As the agriculture is one of the basics of life which provides the most crucial sources, the food industry is started by cultivating and providing jobs for humans. The food industry is also one of the pillars and strengths of the financial condition in country's economy (Da Silva et al. 2009).

Unfortunately, we still could find that many farmers are not exposed to utilizing the technology towards the agriculture activities. Thus, a modern method must replace the traditional method to fill the gap and activates towards the fast phase of farming industry. We decided to extend the framework in this mini-project by adding the water sensor and the DHT sensor (Lakhiar et al. 2018).

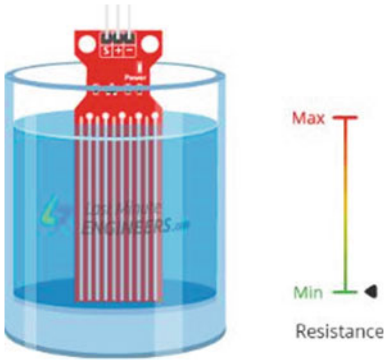
The visualized notification can be easily identified in our system by the present LED. LEDs are mounted here and light up as the sensor senses low soil humidity. By using a NodeMCU, we decided to collect the reading of data. Data is sent to the Blynk application in the form of a notification (Verma et al. 2016).

Our strategies can be quickly and effectively implemented in current facilities in a cost-effective way. In comparison with the traditional technique used, farmers must monitor the plant manually to provide sufficient humidity for soil. Instead of manual control, a smart farm system must be designed to help the farmer keep growing.

2 Literature

The Arduino used in the smart hydroponic system is one of the innovative technologies that is gaining more and more interest nowadays. Automated hydroponic systems have been investigated in the literature for the long run. This is because the automated systems have the advantage of providing huge throughput, high efficiency and need no specialized manpower. To integrate the hydroponic system, a communication protocol namely the Internet of things (IoT) needs to be embedded since it is suitable for many applications (Hafidz et al. 2020). Furthermore, the automation of hydroponics is not beyond reach since the tasks administered during a hydroponic system can easily be automated. Also, computers have the capacity to try to do it better, due to their high availability compared to humans (Lakhiar et al. 2018).

Fig. 1 Water level sensor



2.1 Arduino Uno

The Arduino is a single-board microcontroller intended to allow the programmed more access to interactive objects and their world. The hardware is based on an 8-bit Atmel AVR microcontroller or an open-source hardware board with a 32-bit Atmel ARM. The current models consist of a USB interface, 6 analogue input pins and 14 digital I/O pins that allow multiple extension boards to be connected to the user.

They are simply linked to a device with a USB cable or with an AC-to-DC adapter or battery to get started. Android mobile phone sends instruction to the Arduino board via Wi-Fi module and Arduino will process them in order to control all the inputs and outputs (Mahindar et al. 2018).

2.2 Type of Sensors

2.2.1 Water Level Sensor

Water level sensors are basically used to track and determine the water level in a container. This sensor also can be used to determine the level of solids too for example powder. The set of parallel conductors were exposed whose resistance adjustment corresponds to the distance from the top of the sensor to the water's surface as shown in Fig. 1. According to the resistance, the sensor generates an output voltage that we can be used as water level measurement (Kilmer 2010).

2.2.2 Humidity and Temperature Sensor (DHT11)

Since the beginning of taking care of the crops is highly needed to take care of the humidity, DHT 11 which is shown in Fig. 2 will monitor the humidity of the surrounding air. The normal temperature and humidity of the normally grown crops

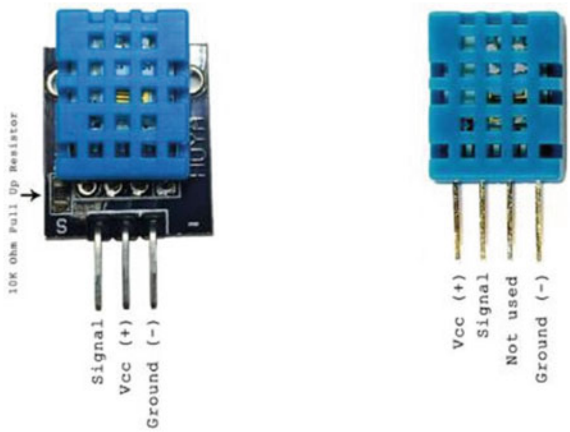


Fig. 2 DHT11

are different. This system is set to take care of the first two months of the normal crops. Spray mist will be triggered based on the reading from the DHT 11. This component will read the level of water to be used for spraying the surroundings (Lakhiar et al. 2018).

2.2.3 Soil Moisture Sensor

A soil hygrometer or soil moisture sensor as shown in Fig. 3 is the best choice of sensor which is able read the soil moisture. Soil moisture is needed to be read for maintaining the water needed for the crops. In the early stages of the seeds, this is everything needed to be taken care of. Since the type of soil is hard to absorb the water, we delayed the detection reading to be read. The system also reduces the amount of moisture reading (Ding and Chandra 2019).

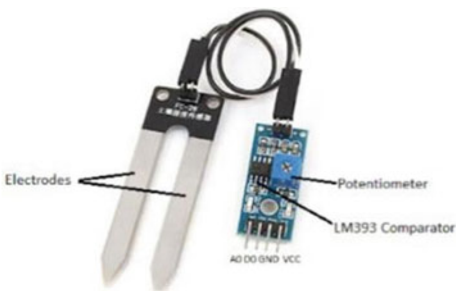


Fig. 3 Soil moisture sensor

2.3 Cloud Platform

ThingSpeak and Blynk apps will be used as monitor and data storage. These platforms help in accomplishing the smart hydroponic system. These are the platforms that are widely used for small project to be expanded to industrial usage (Waworundeng et al. 2019).

ThingSpeak is the platform where all the data will be stored in the cloud. This kind of platform is mainly used as a data cloud storage. The system will collect data from each component that will be sent from the NodeMCU (Ray 2016).

As for the Blynk app, user can monitor the live data directly from their phones. Blynk app is the platform that is widely used as the software that will help the user communicate directly to the system (Aafreen et al. 2019).

This will help on improving the way of taking care of the crops. This platform is the base of the system that helps on improving the way of growing crops. It is also easy to do a maintenance for maintaining the component lifetime.

3 Methodology

The system works at several levels. In the system, there will be three LEDs which indicate the available water level in the tank system, soil and air humidity. The main objectives of the system are to monitor the water and humidity level which is suitable for plant cultivation.

The first LED is to detect the water level at certain height in the water tank. In this program, the LED is switched on as the water level is at the optimum water level. This LED is connected to the water level sensor. This sensor will provide the signal to the system. The LED will be switched on or blinking. The LED will start blinking as soon as the water level reaches the minimum water level. However, the LED is always switched on to indicate the water level is an optimum height. This will help the farmer to obtain information on the water level inside the water tank.

Further to the working system, the system is divided into two sections. The first layout is to control the humidity of soil. Then, the second layout is to monitor the humidity and the temperature of the air surrounding for cultivation activities.

The first layout of the system will monitor the humidity of soil using the soil hygrometer sensor. The measurement is taken using the soil hygrometer sensor to check the suitable level of humidity of soil. Farmers will receive the notification through the Blynk application as the LED two is switched on. This indicated that the level of humidity of soil is low. Therefore, precise information can be analysed using ThingSpeak. Furthermore, the LED two is switched on, and the water sprinkle will be activated as soon as it receives a signal indicating that the soil is insufficient of humidity. This device will provide enough water until reaching the optimum percentages of soil humidity.

The second layout is the system that helps to detect the level of humidity and temperature of the air. The measurement is taken using the DHT sensor to check the suitable level of humidity and temperature of air. This measurement is taken into percentage form to indicate the suitable percentage for plant growth. The indicator for this sensor can be visualized by the farmers using the LED indicator which is LED three. This result of percentage can be monitored from the ThingSpeak. Here, we decided to code the program by making the LEDs switched on when the humidity of air is at low percentage. Therefore, farmers are well informed that the air humidity is low; thus, the system will send data to the mist spray. The mist spray will turn on as they receive the signal. This device will provide enough water until reaching the optimum percentages of air humidity and temperature. Farmers can receive the notification through the Blynk application. The water level inside the tank is referring to the first LED as mentioned before.

Lastly, to ensure that there is no water wastage during the farming process, the soil hygrometer and DHT sensor will provide the data. If both soil and air are at right percentages of humidity, the LED will be turned off. Therefore, the water sprinkler and mist spray will be turned off as no water is required during the condition.

From the flow chart in Fig. 4, the presence of water is important to start the system. This shows that the presence of water will activate other components. As the objectives of this system are to control the humidity of air and soil, all the data will be kept in ThingSpeak and can be monitored through the Blynk application.

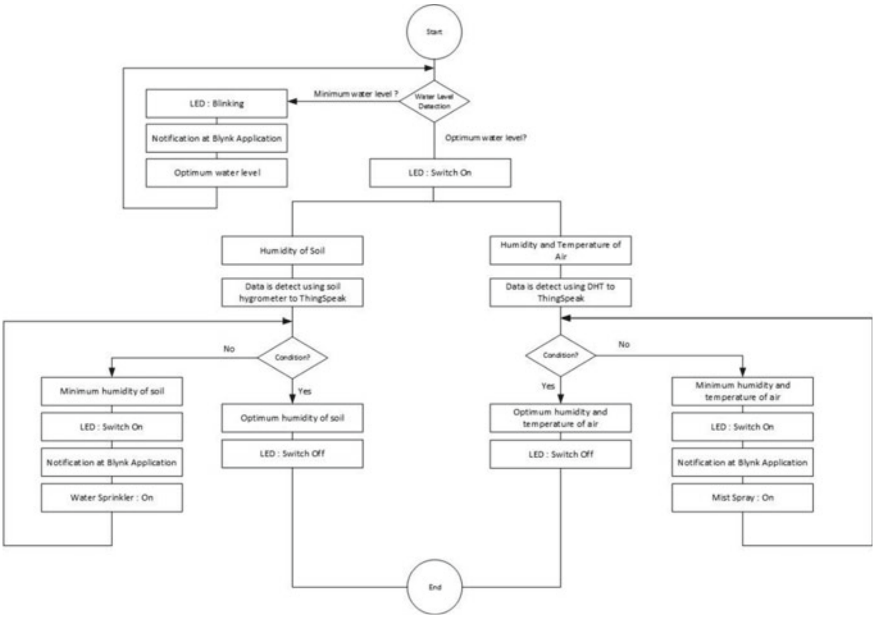


Fig. 4 System flow chart

The component of the soil hygrometer is used to read the humidity of the soil and also to trigger the sprinkler to water the plants or crops. Without the presence of water, the sprinkler will not be activated for watering. The information of humidity of the crops can be monitored through the Blynk app. Blynk is used to monitor live information about the humidity of the soil.

While the DHT11 component is used to detect the humidity and temperature in the surroundings. Surrounding humidity is important at the early stage of growing crops to maintain their quality from the beginning of the plantation. ThingSpeak is used to capture and store data for history usage. From the ThingSpeak, there are two types of data presence which are in gauge and timeline graph.

An Arduino R3 is used to collect data from the components, and NodeMCU will act as a platform to send data to ThingSpeak and Blynk. Arduino and NodeMCU will be generally known as a receiver and transmitter. So, the LED lights up as a command from the NodeMCU is received. The flow chart is shown in Fig. 4.

4 Result and Discussion

Before obtaining the results, all the components were assembled in order to detect the soil humidity level. The components that were assembled are the Arduino Uno, ESP8266, water level sensor, DHT11 and soil moisture sensor. The result obtained is from the ThingSpeak and Blynk applications. Each result is displayed in this section to analyse the functionality. Figure 5 shows the complete circuit assembly.

Fig. 5 Complete circuit assembly

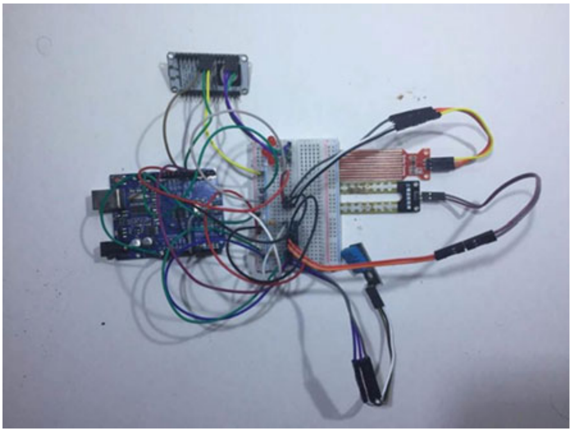


Fig. 6 Result from ThingSpeak

4.1 Result from ThingSpeak

From the ThingSpeak application, four channels were created. Channels 1 and 2 display the temperature and humidity, respectively, from the data input through the DHT11. Channel 3 measures the water level from the embedded water level sensor. For channel 4, soil moisture sensor was used to determine the soil humidity. Figure 6 shows the result obtained from ThingSpeak.

4.2 Result from Blynk

This section discusses the result obtained from the Blynk application. This display shares information on the temperature, humidity level, water level and soil hygrometer. Figure 7 shows the display from the Blynk application.

5 Conclusions

In conclusion, the application of the IoT is applied in our daily life to improve the development of technology in our country. This smart hydroponic system is one of the innovation technologies that will be widely used in future. This project also will improve our structure and mentality of agriculture industries, especially in Malaysia. We learn to integrate the key components of the prior project during the project to

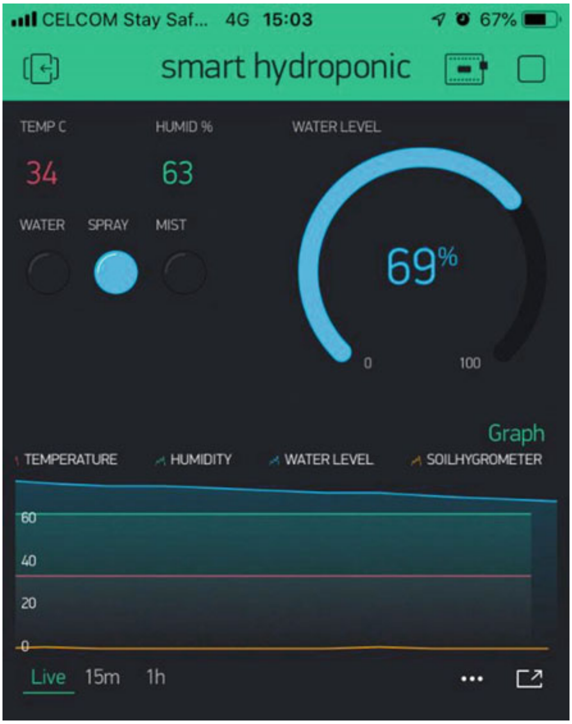


Fig. 7 Display from the Blynk app

create a device that is specific to our case study. In comparison, we demonstrate that the types of precision farming systems implemented rely on the use of software for business management. Control systems manage sensor data and provide remote input for supply and decision support, as well as computer and equipment automation to respond to emerging challenges and performance support.

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Earthquake Monitoring and Detection Using the Internet of Things as Communication Protocol

Ahamad Zaki Mohamed Noor, Muhammad Helmi Jasni, Mohamad Khairul Amirin Mohd Yusoff, Mimiyana Mohd Ghazali, Alya Athirah Mohd Fadzil, Nurul Hazwani Izzati Abdul Nasir, and Muhammad Hafidz Fazli Md Fauadi

Abstract Earthquake monitoring and notification by using smartphones or the Internet of things (IoT) expedients in real time is a difficult and inspiring project, not only because it is forced with the hard real-time issue but also due to the parallel task of earthquake and the non-earthquake notification. Earthquake event monitoring, nevertheless, is a challenge due to a deficiency of high-loyalty sense and sort proficiency. This project plans to use a NodeMCU with a SW-420 vibration sensor, an IoT sensor for smart earthquake monitoring. Earthquake monitoring includes some main measures, detected by using the SW-420 vibration sensor connected with NodeMCU and gets notification through the Blynk app to get data from ThingSpeak. The developed vibration is then detected by earthquake monitoring system from vibration

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sensor using time and regularity province inquiry. About monitoring of an earthquake, the earthquake inspiration transmissions are using the projected data into the Blynk from the smartphone for well-organized notification and conception. The recital of the projected system is assessed through mathematical simulations and a set of tests using trembling table tests.

Keywords Earthquake early warning system · Landslide · Wireless sensor network

1 Introduction

There are a lot of earthquakes that occur worldwide in a year. Although it does not give a big threat to human society, it still frightens us. However, those earthquakes are always famous for their devastating effects and are hardly to be ignored. This is because victim's number is numerous if this phenomenon really happened. To prevent these drastic consequences, a lot of researchers from different fields set an aim to determine an efficient way of predicting earthquakes. Regardless of their efforts, to obtain high accuracy of earthquake values is impossible, such as the time and date of this seismic phenomenon takes place (Wang et al. 2020).

Predicting earthquake methods are noticeable based on data about earthquakes that ever occurred before. The probability to have high prediction accuracy is by collecting more data. Every year a few methods of monitoring are being developed to trace, and it is called earthquake detection (Saad et al. 2017).

Today, developed high-technology devices are among the indispensable values of modern societies. These technologies that we use for many of our daily needs make our life quite easy. Most of these devices operate independently of each other. It is intended for all devices we use in our daily life to communicate with each other and generate a smart communication ecosystem with the Internet of things (IoT) technology and also with other applications (Hafidz et al. 2020). Furthermore, sensor prices decrease with the advancing and spreading technology, data transmission rates and capacities (Lieshout et al. 2007).

Increase with new generation communication systems and Internet of things technology begins to enter the daily life more and more. Internet of things gives the physical things the ability to see each other, hear each other, think and come together "to talk" for them to share information and make a collective decision. IoT is the transformation of basic technologies such as embedded devices, communication protocols, sensor networks, Internet protocol and applications from conventional to smart ones (Verma et al. 2016).

2 Literature

The purpose of this mini project is to develop a low-cost IoT-based earthquake detection system and evaluate it. In line with this purpose, an earthquake system was developed and evaluated using the NodeMCU ESP8266, Wi-Fi module, vibration sensors and Blynk application (Saad et al. 2017).

The IoT technology has produced useful smart systems to find out and monitor several real-time systems. Here, we would like to show the effectiveness of an IoT device which can sense vibrations caused by an earthquake to channel the fitting warning message in line with the force of the tremor (Madakam et al. 2015).

The IoT-based earthquake monitoring technology system is an advanced and innovative system that will inform the users about the vibration that has been detected. This study uses the Wi-Fi module, vibration sensor and Blynk application to monitor the vibration. We placed the vibration sensor to a wall and a ceiling of a structure or ground to detect the vibration. Then the vibration sensor turns the data into electric waves. Meanwhile, the Wi-Fi modem is used to send the data, and it will display it on the Blynk app that has been linked to the system. Thus, this proposed technique helps to inform the user that an earthquake is going to happen, and it will help users to take the next actions (Saad et al. 2017).

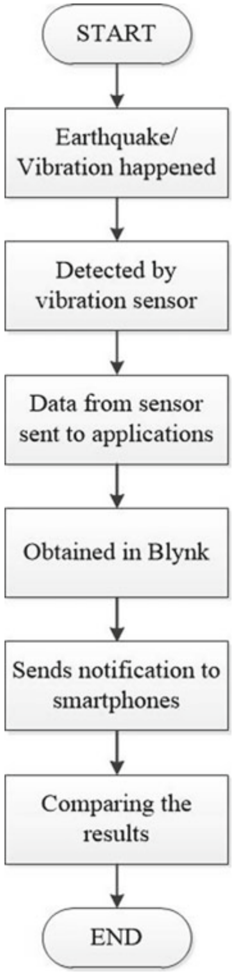
We tested our earthquake detection process by using Blynk and an earthquake dataset (the data have been recorded when we did a wobble table test) to extra assess the effectiveness of our system (Sruthy et al. 2020).

3 Methodology

For the development of the earthquake warning system, two forms are used which are the hardware and software. In the form of hardware, a circuit is made by using the vibration sensor and Wi-Fi module. The software section includes reading data from the vibration sensor and sends to the Blynk app via the wireless connection. At the same time, it can be monitored through the cloud by users and explored in the mobile apps, thus giving alerts to the users regarding the earthquake. Figure 1 shows the overall procedure to create a prototype of earthquake detection.

Firstly, the electronic design of the developed earthquake warning system was made. The vibration sensor was connected to the microcontroller to detect the earthquake. This sensor was tested. Then, the sensor was connected to the Wi-Fi module. Finally, its programming to Blynk was done to implement the desired functions, and extensive testing has been done. The circuit of the designed system is shown in Fig. 2.

Fig. 1 Overall flowchart



3.1 Electronic Components Used in This System

3.1.1 Vibration Sensor

The vibration sensor is the sensor used for measuring, displaying and analyzing linear velocity, displacement and proximity, or acceleration. It is also known as piezoelectric sensor. In this project, the vibration sensor is used to detect the vibration of the earthquake (see Fig. 3).

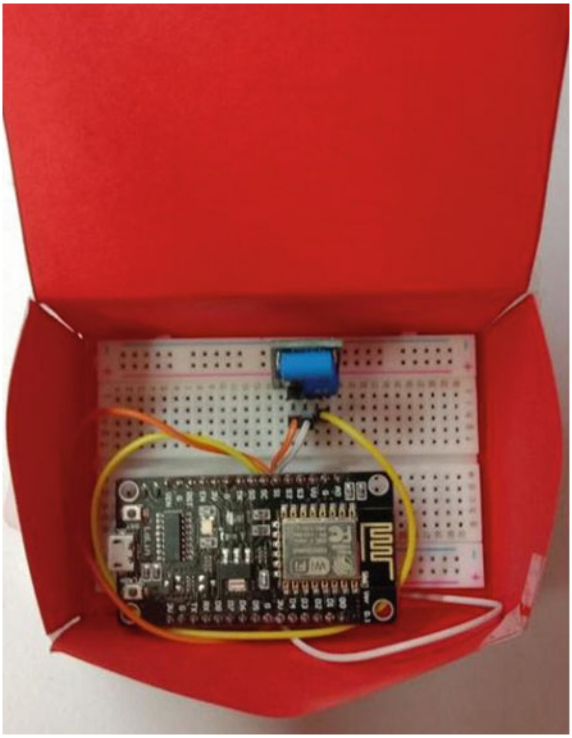


Fig. 2 Circuit of earthquake detection

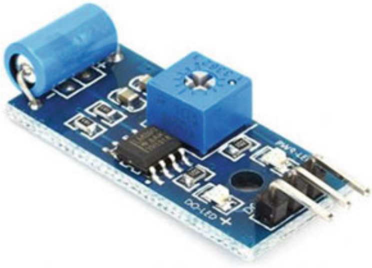


Fig. 3 SW-420 vibration sensor

3.1.2 NodeMCU Wi-Fi Module

This module is used to upload data to the Internet or download data. A Wi-Fi module is used to connect to the Wi-Fi network. The ESP8266 Wi-Fi module is used in this study (see Fig. 4). This is one of the most capable modules for connecting to the Internet. It can also operate independently without being connected to any microcontroller or microprocessor.

Fig. 4 NodeMCU8266

4 Result and Discussion

This section discusses the functionality of the prototype of the earthquake monitoring and detection system. The code was set to provide notification on smartphones whenever the reading goes more than 7200. Figure 5 shows the reading of vibration and demonstration of earthquake detection.

An earthquake is a natural disaster that usually happens and can cause a lot of damage and loss of life. There are a few types of earthquake which are first-induced earthquakes that are caused by human activity such as tunnel construction, filling reservoir and implementing geothermal activities. Secondly is volcanic earthquake caused by active volcanic usually a natural thing and lastly is the collapse earthquake. We try to figure out something useful by creating this project to detect vibrations by earthquakes so that we can prepare ourselves when this disaster happened. A second

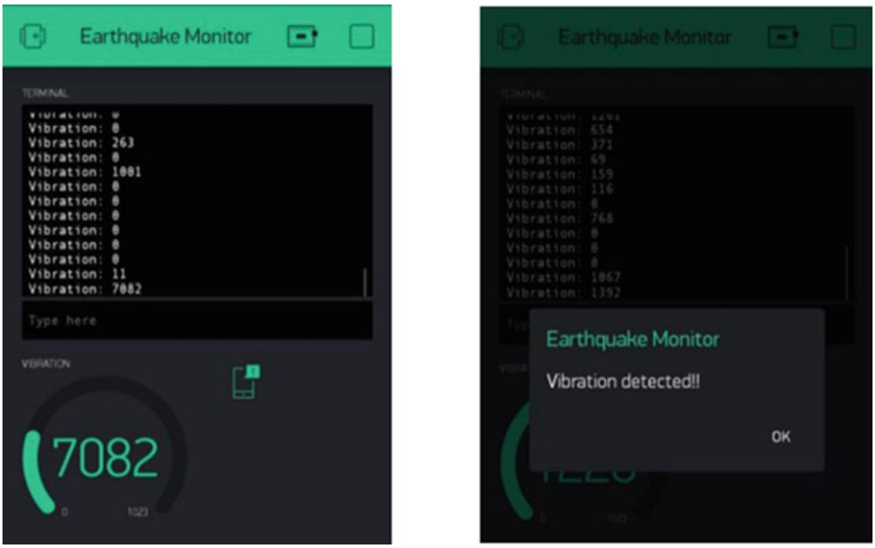


Fig. 5 Blynk interface for earthquake monitoring and detection

action can save a lot of life and important things. Based on the project carried out, this innovation is basically a prototype. Hence, a lot of aspect needs to be studied in order to develop proper earthquake monitoring and detection system.

5 Conclusions

The objective of this paper is to detect the unusual vibrations and generate the alert to the users. This system can be used for emergency response planning. The implementation of this system is in the form of hardware and software by using a vibration sensor. A software system is used to alert the users by smart phone application. System design and architecture are discussed, thus being a flexible, cost-effective and simple strategy to detect the earthquake, especially in the most frequent country with earthquakes. Future work is to plan some improvement later by merging the coding of ThingSpeak and Blynk in one code so we can get the correct data instead of using two separate codes.

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Development of a Malaysian Plate Number Recognition System for Parking Violation

Mohd Fauzi Alias, Fahmi Fitri Abdul Rahim, Mohamad Rosyidi Ahmad, Mohamed Yusof Radzak, Mohd Suyerdi Omar, and Muhamad Husaini Abu Bakar

Abstract Malaysian plate number recognition (MPNR) systems have a wide range of uses, including traffic law enforcement and parking system administration. The MPNR system is non-intrusive and only requires plate number of a vehicle without any additional identification needed. The goal of this work is to create MPNR software that can be used offline. With an average rate of more than 80, the software should be able to recognize the location and read the number plate. The proposed MPNR algorithm was created to respond to the Malaysian traffic conditions. Several pre- and post-processing techniques, including plate's location, character extraction, segmentation, and recognition were used in the creation of the MPNR algorithm. The developed MPNR algorithm was put through its paces in order to assess its performance and capabilities. According to the findings, the system is dependable and strong, and its capacity to distinguish a number plate for a parking infringement indicates that it has a lot of promise for traffic and transportation research.

Keywords MPNR · Localization · Extraction · Character segmentation and recognition · Parking violation

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1 Introduction

A car plate recognition system helps people efficiently read car plate numbers, saving time and energy. Before the computer-based car identification, the number of the car plate was recorded manually with the use of a pen and paper until the great photo-enforcement technology was introduced after the cold war. In 1993, it successfully moved from the research center to the business market. More recently, a growing number of suppliers from all over the world have been finding their way to more solutions-oriented systems.

The technology of the imaging processing is a technique used for the treatment of the image as a two-dimensional signal and for standard signals. This technique is a critical technique to read the car plate number from the car picture in the car plate recognition system. There are many ways in which different suppliers design a car plate recognition system such as an automatic number plate recognition, automatic identification of vehicles, car plate detection, auto plate reader, or optical plate numbers, and character recognition of vehicles also known as automation plate recognition technology. Car plate recognition has various applications since the vehicle license plate is the most important, widely accepted and legible person, obligatory motor vehicle identification. This system has been used by many to identify stolen cars throughout the world based on an up-to-date blacklist. Other useful applications include the control of vehicle access, automatic collection of charges, real-time monitoring and security, and management of the parking area.

2 Literature Review

2.1 Automatic Plate Number Recognition

Vehicle license plate recognition (LPR) has been used in a variety of applications, including entrance admittance, parking control, traffic control, security, and speed control, according to the project's article. They are, however, ineffective when the vehicle image is presented in a variety of formats and styles. Furthermore, much of this software assumes that the camera's position and distance from autos are limited (Kamat and Ganesan 1995). In recent years, automatic plate number recognition (APNR) has proven to be a useful technique for vehicle monitoring. The APNR has three steps, namely number plate localization (NPL), character segmentation, and optical character recognition (OCR). Vehicle license plate recognition (LPR) has been used in a variety of applications, including entrance admittance, parking control, traffic control, security, and speed control, according to the project's article. They are, however, ineffective when the vehicle image is presented in a variety of styles and formats. In addition, most of these software assumes some limits on the camera's position and distance from cars (Kamat and Ganesan 1995). Typically, an APNR system consists of three main stages, namely number plate localization

(NPL), character segmentation, and optical character recognition (OCR). The number plate is detected at the NPL stage. In the OCR stage, characters are segmented and recognized from the plate number (Xu et al. 2006). Based on some research that has been made, there are three main stages in the most common methods used in order to complete the APNR system.

2.2 Existing Methodology *for Automatic Plate Number Recognition*

Based on the APNR research, computer vision, and license plate recognition, character algorithms are important in video image numerical picture analysis. The key modules in an APNR system are therefore formed. The automatic car license plate recognition system includes a camera, a computer, frame reception, and a custom software for the analysis of the image and video processing. There are four stages in an APNR system that extracts a license plate number from a specific image (Sarfraz et al. 2003). Camera parameters such as size and resolution have to be considered. The plate is then removed from the image in the next stage depending on several parameters such as the color's boundary or the presence of letters. In the third stage, the segmentation process is applied to the license plate. The characters and numbers are extracted using their color data, label, or model matching. Finally, the retrieved characters must be recognised by matching templates or decision makers such as neural networks and fuzzy techniques. An APNR system's performance is based on the robustness of each stage.

2.2.1 Plate Number Extraction

The plate number extraction stage has an impact on the accuracy of any system. This stage takes a car image as input and outputs an area of the potential plate number. The plate numbers and characters can be seen in the whole image. Instead of analyzing each pixel in the image, which would take longer, the system can distinguish the plate based on its attributes, and only those pixels with these characteristics are processed. The characteristics are determined by the license plate's format and characters.

All possible rectangles in the image can be recovered because the license plate has a rectangular shape with a specified aspect ratio. Edge detection algorithms are widely utilized for these rectangles (Sarfraz et al. 2003; Bai and Liu 2004; Zheng et al. 2005; Wang and Lee 2003; Faradji et al. 2007). For the detection of edges, a Sobel filter is used in Sarfraz et al. (2003), Zheng et al. (2005), Kanayama et al. (1991), Kamat and Ganesan (1995), Busch et al. (1998), Zhang et al. (2004). The boundary of the plate can be seen by the transition of intensity between the plate and the body of car. During edge detection process, the edges can be seen as two different lines representing different intensity of colors. In Nelson et al. (2008), the rectangle plate is detected by the geometric parameters used to locate rectangular lines. Some research applied the matching edges to locate the regions (Sarfraz et al. 2003; Zheng et al. 2005; Kanayama et al. 1991; Ahmed et al. 2003). A robust extraction feature is the magnitude of the edges on the plate (Wang and Lee 2003). In Sarfraz et al. (2003), some candidate rectangles are matched to the vertical edges. Applicants are considered rectangles with the same ratio as the license plate. Based on different conditions, this method yielded a result of 96.2% on images. According to Zheng et al. (2005), the plate area can be easily extracted from the edge image if the vertical edges are removed and the background edges are removed. In 1165 images, the detection rate was around 100%. The total processing time of one picture was 47.9 ms.

2.2.2 Plate Number Segmentation

Then the separate plate is segmented to remove the identification characters. In a pre-processing, the segmentation algorithms should overcome tilt and non-uniform problems. The bilinear transformation is used in Lee et al. (1994) and Xu et al. (2006) to map a straight rectangle of the tilted extracted license plate. In Pan et al. (2008), in the license plate images, a minimum square approach is used to handle horizontal tilt and vertical tilt. In Pan et al. (2009), the character coordinates are arranged in a two-dimensional covariance matrix according to the Karhunen–Loeve transform. The correction of the horizontal tilt picture is completed by calculating the eigenvector and the α rotation angle. For vertical tilt correction, line fitting based on the clustering of K-means and minimal squares has been applied purposely to measure the tilt angle. In Deb et al. (2010), a line fitting method was introduced based on the least square fitting with perpendicular offsets to correct a horizontal tilt of the license plate.

Some of the characters are difficult to segment especially when an inappropriate threshold is selected to binarize the two separated characters in the combined process. Some characters may be attached to the frame after binarization, making it difficult to segment with a surrounding frame (Comelli et al. 1995). Improving image quality prior to binarization allows for picking the correct threshold (Comelli et al. 1995). Several techniques commonly applied to enhance the image are the noise removal, histograms equalization, and contrast. In Comelli et al. (1995), a system was proposed to conduct gradient analysis over the entire image to detect the license plate and then gray-level transformation enhances the license plate detected. A strategy was suggested in Zhang and Zhang (2013) to improve only the characters and reduce the noise.

The character's size is estimated to be about 20% of the size of the license plate. The gray-scale rate is normalized to 0–100, so 2.55 is multiplied by a maximum of 20 million pixels. Although noise pixels are minimized, only characters are improved. For each pixel, regional thresholding is used in Llorens et al. (2005). The threshold value is measured by subtracting a constant c in an mxn window mask centered at the pixel from the mean gray point. In Coetzee et al. (1998), the Niblack binarization equation provides the basis for changing the limit over the picture based on the local mean (m) and standard deviation (σ).

Prior character knowledge can help the license plate segmentation. In Busch et al. (1998), a horizontal line scans the binary image to find the character's start and end positions. If the value is lower than this threshold, the character's pixels to background' pixel ratio exceeds the selected threshold and can be considered as the starting position of the characters. In Paliy et al. (2004), the plate extracted is resized to a selected size of the template. In the research, the position of the characters is known. The same locations are removed after resizing to be the characters. This method has a simple advantage. Nevertheless, the abstraction occurs in history rather than characters in the case of any change in the removed license plate.

2.2.3 Plate Number Recognition

As the output, the characters and numbers are extracted and recognized. The extracted numbers and characters produce different sizes and thicknesses due to the zoom factor of a camera (Miyamoto et al. 1991; Comelli et al. 1995). In order to solve the problem, numbers and characters are resized before the recognition process. Extracted and resized characters may be noisy or broken (Miyamoto et al. 1991). It is also possible to tilt the extracted characters (Miyamoto et al. 1991). Template matching in recognition (Sarfraz et al. 2003) is one of the options and straightforward methods. A character's similarity to the templates is measured. The template is known as the goal which is the closest to the character. Many template-matching approaches use binary images instead of gray-scale images. This is due to less intensity values because of the changes of lighting (Pan et al. 2008). Several research has implemented the template-matching techniques after the extracted character has been resized to the template's size (Sarfraz et al. 2003; Kanayama et al. 1991; Miyamoto et al. 1991; Lee et al. 1994; Comelli et al. 1995). In the literature, several similarity measurement techniques are defined.

Recognition of characters in Comelli et al. (1995) uses standard cross-correlation in the matching technique. To measure the normalized cross-correlation, the template scans each number and character column-by-column and determines the highest similarity between them. The normalized output value of each matching process is between 0–1. Template matching is also useful to recognize a single font characters, unbroken, and fixed size. If owing to any font shift, rotation or noise a character is different from the template, the template matching generates inaccurate recognition (Pan et al. 2008). In Naito et al. (2000), recognizing tilted characters can be solved by storing multiple similar character templates with different angles of tilt.

3 Methodology

The purpose of this project is to focus on a MATLAB simulation of the MPNR system image processing method. The images captured should be straightforward to process and should not have any flaws in the number plate, such as missing characters. In Malaysia, there are two types of car plates, black and white plates. White plates use black characters. This type of plate is used by commercial cars such as taxi and limosin. The other plate is white characters in a black plate. This type of plate is used by the passenger car. The block diagram of the method used is shown in Fig. 1.

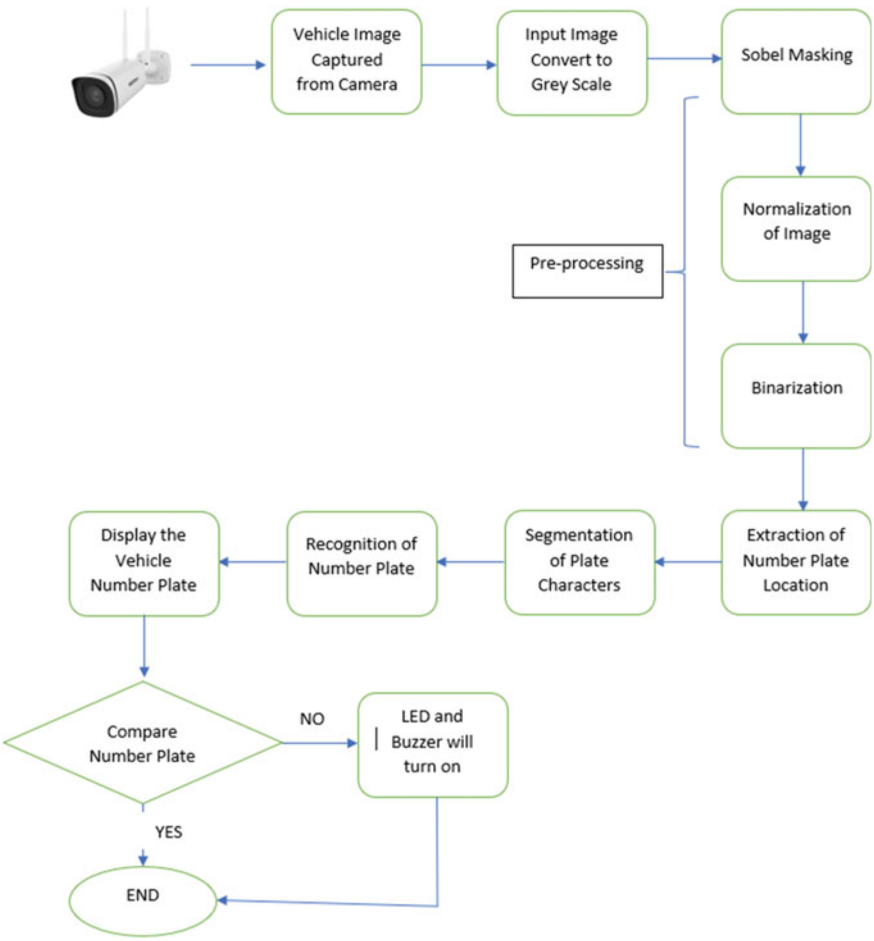

Fig. 1 Flow chart of algorithm

Fig. 2 Input image from camera

3.1 Vehicle Image Captured by Camera

The process of getting an image from a camera is known as image acquisition. The MPNR system's first component is this. The acquisition device sends a static image to the MPNR system for number plate recognition. There are essentially two methods for acquiring an image by using:

- digital or mobile camera
- an analogue or IP (surveillance) camera.

A digital camera or a mobile camera was used to take the images for the MPNR system (Fig. 2).

3.2 Extraction of Number Plate Location

Detecting the plate size is the basic step in recognizing the vehicle number plate. There are generally number plates in a rectangular shape; therefore, the edges of the rectangular plate must be detected. For obtaining the edge of a rectangular plate, plotting the edge histogram makes it easier to choose the plate region. Based on the edge horizontal histogram, use the threshold value of the edge horizontal histogram to find the candidate's plate rows and mask the number plate region using the mask function in MATLAB. This method is used for subtracting all other regions and only focuses on the region of interest. It helps to break down the vehicle's number plate area. Finally, we can find the biggest area of the binary region as late location

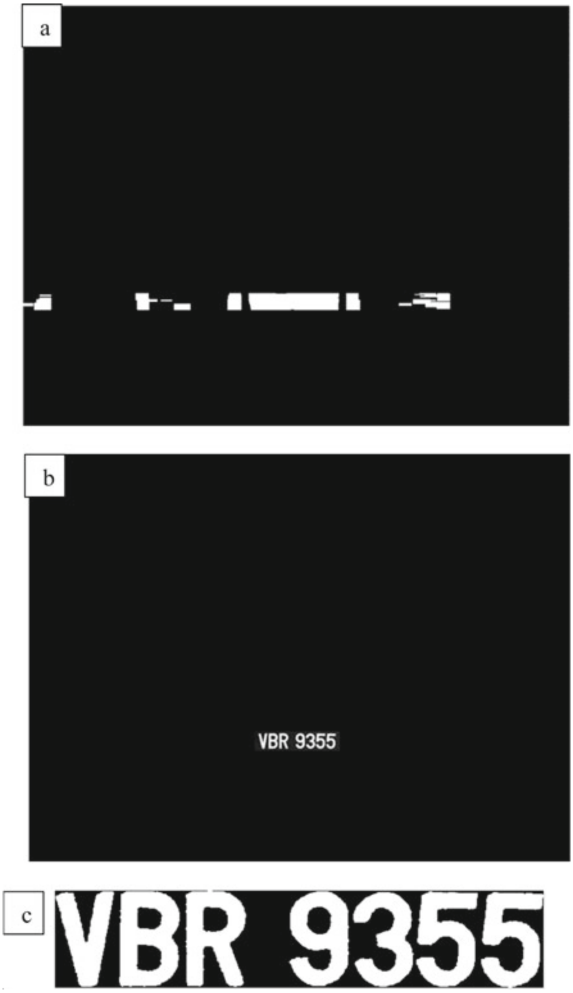

Fig. 3 **a** Masked plate, **b** plate location, **c** number plate extracted

by computing the area of every region and only selecting the biggest binary region using the command in MATLAB. After that, crop the plate location using the imcrop command (Fig. 3).

3.3 Segmentation of Number Plate

Segmentation is one of the most critical processes in the recognition of the number plate. A character may be mis-divided into two or more characters if segmentation fails. The ultimate solution to this problem is to use the connected component technique. So, after cutting the license plate, use im2bw to binarize the image. This is the process of converting gray values in an image to binary values and representing the image as a binary image. Binarization of photographs emphasizes essential pixels while suppressing those in the background. The simplest technique to choose an image binarization threshold value is to classify all pixels with values over the threshold as white (255 Gy value) and all other pixels as black (0 Gy value). The command used in MATLAB is im2bw ("number plate cropped," 0.4). For the second time, use the eroding operation to smooth the edge of characters. After that, we remove all objects containing fewer than 100 pixels.

Then, proceed using the connected component method. The bounding box is used to determine the image region's properties. Once a bounding box has been created over each character and number shown on the number plate, each character and number are separated for number plate recognition.

3.4 Recognition of Plate Characters

In this stage, after segmenting each character from the vehicle's number plate as shown in Fig. 4, we are going to use that segmented character for the translation of text images to characters. Number plate recognition is now used by using template matching to compare each individual character to the entire alphanumeric database. The matching process moves the template image in a larger source image to all possible positions and calculates a numerical index indicating how well the template matches the image in that position. Pixel-by-pixel matching is done. The template size is 42 × 24. Since the template size is fixed, it leads to accurate recognition (Fig. 5).

Fig. 4 Bounding box created

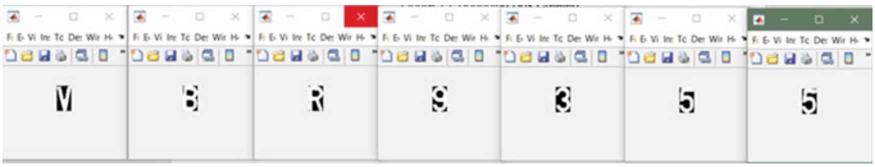

Fig. 5 Each character segmented

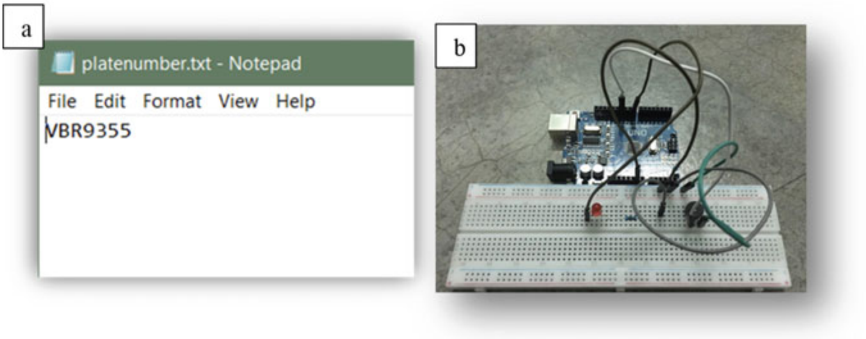

Fig. 6 **a** Number plate shown in notepad, **b** hardware setup for parking violation

3.5 Display Vehicle Number Plate and Alert System

Finally, the recognised number plate of the car is shown in notepad. Figure 14 shows the notepad containing the number plate that has been recognized after notepad has printed the recognized plate number. The comparison between the reserve car's number plate and current recognized car's number plate has been done by using a compare string array for the equality command in MATLAB. When the current car's number plate is not equal to the reserve number plate, output has been sent to Arduino Uno to activate a LED and piezo buzzer, alerting someone in charge to act on parking violation. Figure 6 shows the hardware setup of an alert system for the parking violation.

4 Results and Discussions

The MPNR tests were conducted to determine the ability of the MPNR code to detect the number plate position and to read the numbers. The MPNR code has been tested on a laptop with the following configurations: HP Pavilion 2.71 GHz, 8.00 GB RAM. A total of 50 plates images were used to test the MPNR code in MATLAB R2019a. Table 1 shows the result of the test that has been conducted. The result has been categorized into three groups, namely input images, image pixels and processing time.

Table 1 shows the execution time of the MATLAB software in seconds. The input images are processed through all the steps of the methodology, starting from the pre-processing of the image until the number plate has been printed in notepad. Table 1 shows that the processing time becomes longer when higher pixels input images are being processed.

Table 2, Figs. 7 and 8 show the accuracy and the process of number plate's position extraction, respectively.

Table 1 Processing time of input images

Input images	Image pixels	Processing time (s)
	960 × 1280	16.6186
	3024 × 4032	24.8701
	960 × 1280	17.2546
	3024 × 4032	33.6011
	960 × 1280	17.8871

Table 2 Number plate's position extraction

Total samples	50
Successful number plate's position extracted	45
Unsuccessful number plate's position extracted	5
Accuracy of number plate's position extracted (%)	90

Fig. 7 Number plate correctly extracted

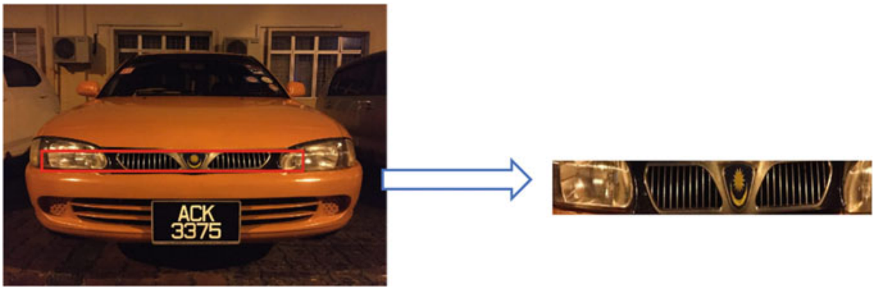

Fig. 8 Number plate incorrectly extracted

There is a certain number of failures in extracting the plate region as shown in Fig. 8. This will lead to incorrect recognition in the last stage of MPNR. From Table 2, the MPNR system has 90% success rate when performing the number plate extraction on the car.

Table 3, Figs. 9 and 10 show the accuracy and the process of the number plate segmentation, respectively. Figures 9 and 10 show the sample of the segmentation process of a single character from the number plate area. The segmentation process accuracy determines the smoothness of the recognition process. Figure 8 shows that the MPNR system is unable to distinguish the body of the car from the plate number, resulting in segment the body of the car is treated as one of the characters. From Table 3, the MPNR system has 70% of success rate when performing the number plate segmentation.

Table 3 Data collected for number plate segmentation

Total samples	50
Successful number plate segmented	35
Unsuccessful number plate segmented	15
Accuracy of number plate segmented (%)	70

Fig. 9 Number plate correctly segmented

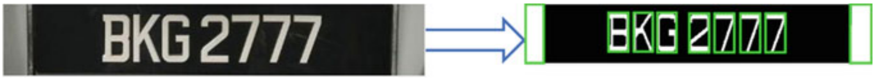

Fig. 10 Number plate incorrectly segmented

Table 4 Data collected for number plate recognition

Total samples	35
Successfully number plate recognized	33
Unsuccessfully number plate recognized	2
Accuracy of number plate recognized (%)	94.29

Table 4, Figs. 11 and 12 show the recognition accuracy and the process of number plate recognition, respectively. Figures 11 and 12 show the sample of the recognition process using MPNR, and all the data has been transferred to the data center using the notepad application. Figure 12 shows the unsuccessful segmentation process will result to the unsuccessful recognition. The recognition process has been successfully done using the correlation method. The 35 samples from the segmented number plate have been selected for the recognition process. Successful segmenting the number plate will make the recognition phase much easier. The accuracy of recognition is 94.29% as shown in Table 4.

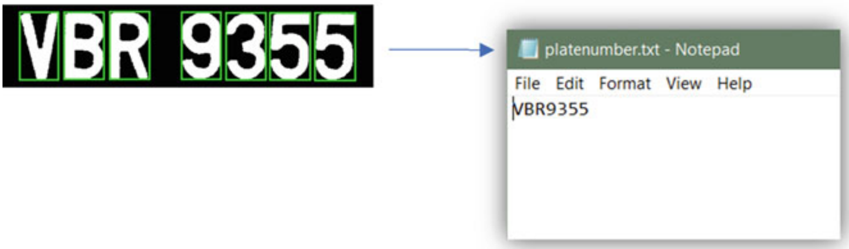

Fig. 11 Correct recognition result

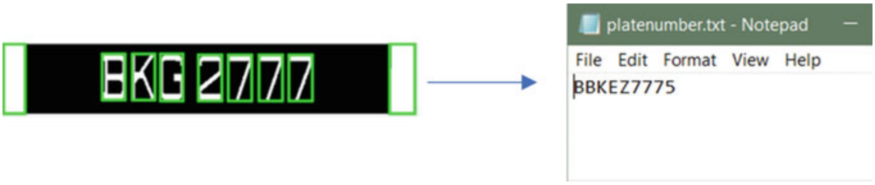

Fig. 12 Incorrect recognition result

5 Conclusions

In conclusion, the project has selected the perfect methods for the plate number recognition process. The Malaysian plate number recognition (MPNR) system has managed to produce high accuracy of plate number recognition detection as high as 94.29%. One of the main contributions to the high percentage was the application of pre-processing methods such as image enhancement and segmentation. The pre-processing methods have been used to minimize the effect of lighting and make the license plate visible in order to deal with the illumination issue. The project has also set some quality comparison rules, such as the process to identify proper license plate extraction, the effective segmentation, and the recognition level of characters. By using the pre-processing methods, the character recognition becomes easier to be successfully detected as all characters on a plate are identified correctly. New sensor systems that are resilient to changing illumination conditions should also be used to improve MPNR performance. For optical character recognition, future research should focus on improving recognition rates for ambiguous characters such as (B-8), (O-0), (I-1), (A-4), (C-G), (D-O), and (K-X) as well as broken characters. To compare the performance of different MPNR systems, a standardized evaluation technique is required.

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Smart Recycle Bin Prototype Using Convolutional Neural Network for Trash Classification

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Abstract This research proposes a smart recycle bin prototype and utilizes a dataset of five different trash types such as cardboard, paper, plastic, metal and glass for trash classification using a convolutional neural network (CNN). Three CNN models were proposed and compared, namely 1-CNN, 2-CNN and 3-CNN to measure the accuracy and the performance of the models. The function of the CNN is to model and predict the characteristic of each of the trash types. The results of experiments indicated that the 3-CNN model has the highest validation accuracy with 93%, followed by the 2-CNN with 92% and the 1-CNN with 91%.

Keywords Smart recycle bin · Trash classification · CNN · Deep learning

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1 Introduction

The aim of the waste policy is the encouragement of the circular economy to preserve the national resources in order to protect health and environment on the other side. Material sorting is part of the management of municipal waste and is necessary for the recycling process. The correct identification of waste, including its hazardous properties, is a decisive interface between whether and how waste is to be handled in compliance with legal requirements in this context (Zetti et al. 2015). In 1998, the government board of Kuala Lumpur City handled as many as 2500 tonnes of municipal solid waste every day for a minimum of 912,500 tonnes (Budhiarta et al. 2012). The management of solid waste is inevitably linked to the planet's environmental impacts and its consequent economic consequences (FCCC 2017).

Many theoretical experiments and some experimental projects have been carried out individually by garbage companies as well. The need for a dataset that correctly covers the problem set is of extreme importance. Recent advances in convolutional neural networks (CNN) have created an incredible environment for learning the image characteristics that lead to image classification, segmentation and detection (Shetty et al. 2020). Another trash-related project was a smartphone framework designed to coarsely segment a pile of garbage in a picture (Yang and Thung 2016). The number of tonnes of trash is keep growing from time to time among all sectors of industries when everyday people keep throwing their trash into the dustbins with different types of materials. Due to various rubbish mixed, the consideration of items that could be recycled again is forgotten. Furthermore, the workers are very exposed to a huge number of bacteria that could affect their health and cleanliness.

The process of manual separation of trash takes a long time to process and requires a lot of manpower to do the job. The manpower capability has its own limit due to getting tired and the need for some break time. As the number of trash increases, the worker might not be able to classify correctly or even missed some valuable items whenever the system conveyors are very fast to be processed at one time. Thus, this study proposed a smart recycle bin prototype that is able to identify and classify the five types of trash which are paper, cardboard, metal, glass and plastic, to enhance the process of sorting the trash.

Deep learning is a machine algorithm class that uses several layers of representation of data and extraction of features. Thus, deep learning in waste segregation includes acquiring camera images with identification, object recognition, prediction and various forms of waste residing on land classification into biodegradable and non-biodegradable categories (Yang and Thung2016; Awe et al. 2017). With 90% test accuracy, the ResNet model in scratch models has achieved the highest classification success (Özkaya and Seyfi 2019; Zhang et al. 2016). CNN hits the spot when the algorithm was used to win the big-scale visual image recognition challenge (ILSVRC) 2012 ImageNet that was proposed in Zhang et al. (2020), Zheng and Gu 2021). Next, AlexNet, efficient success with a high degree of difficulty in the ImageNet competition, has led many researchers to work on CNN structures to solve problems with image classification (Zheng and Gu 2021). The purpose of the application is to allow automatic waste sorting based on a convolutional neural network (CNN) which is able to separate different classes of trash such as plastic, metal, glass, cardboard and paper according to specific categories at the early stage which is at domestic users such as at home and office. In terms of real-time simulation, the CNN performs better (Hossain et al. 2019).

Last but not least, the objective of this research is to propose an appropriate design for a smart recycling bin for automatic sorting of different kinds of trash. Next, the research is to develop a classifier based on a convolutional neural network to separate different kinds of trash according to the characteristic into specific categories. Lastly, the study evaluates the performance of models using several performance matrices.

2 Methodology

2.1 Overview

In this paper, the whole process involves a combination of hardware design and software design. Figure 1 shows the flowchart for the whole process from the mechanical design to the software development.

2.2 Project Mechanical Design

- Container
  The container is designed with five different spaces for the trash, paper, metal, glass and cardboard. Figure 2 shows the design of the smart recycle bin container and microcontroller design that will be implemented to the hardware.
- Microcontroller
  The function of the microcontroller is to interpret the data based on the programming language that has been programmed by using Python to read the input and analyse the characteristic of the trash to be classified into its trash type. The microcontroller is placed in the middle of the container so that the servo motor can easily change the direction 360° around the container. Figure 3 shows the placement of the microcontroller into the smart recycle bin container.
- Lid Container
  The size of the lid is the same as the size of the container where the shape will match perfectly for both sizes of lid and container. Figure 3 shows the lid that was placed on top of the container.
- Solar Lid
  Lastly, the solar lid was inspired by the technology of magnetic wireless charging where when the solar panel receives the energy, the energy will be converted

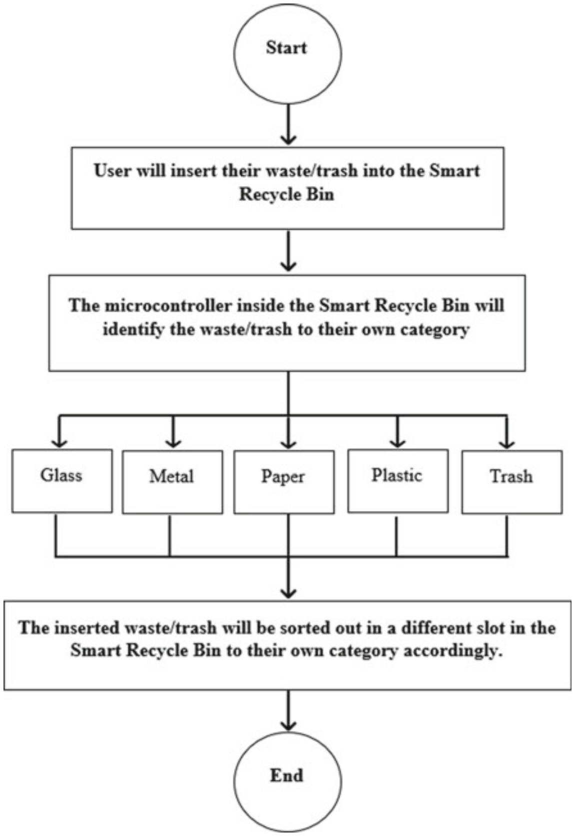


Fig. 1 Flowchart of the smart recycle bin process

into electric energy and transferred by wireless to the microcontroller through the magnet on the lid. Figure 3 shows the view from the top, side and perspective view of the final mechanical design.

2.3 Project Software Design

In this study, the overall work is depicted in Fig. 4, which shows the overall flowchart of the software development.

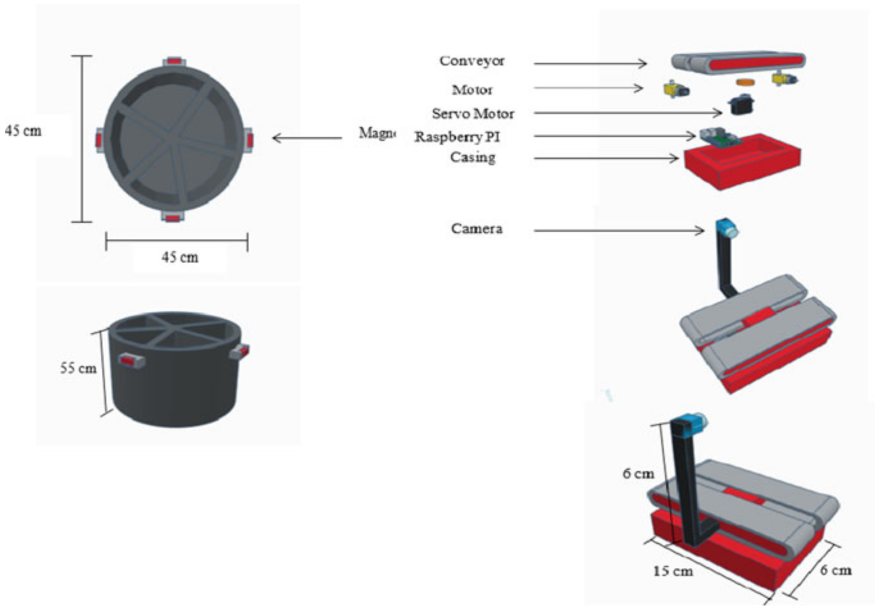


Fig. 2 Design of the smart recycle bin container and microcontroller inside the hardware

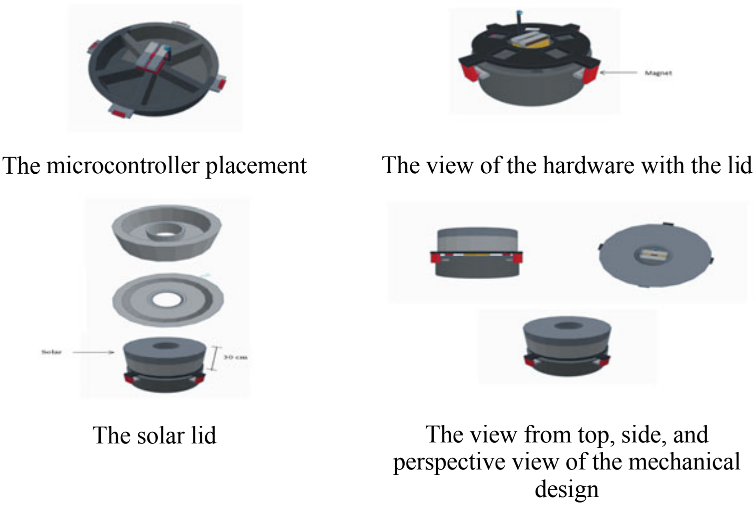


Fig. 3 Microcontroller and lid container, solar lid

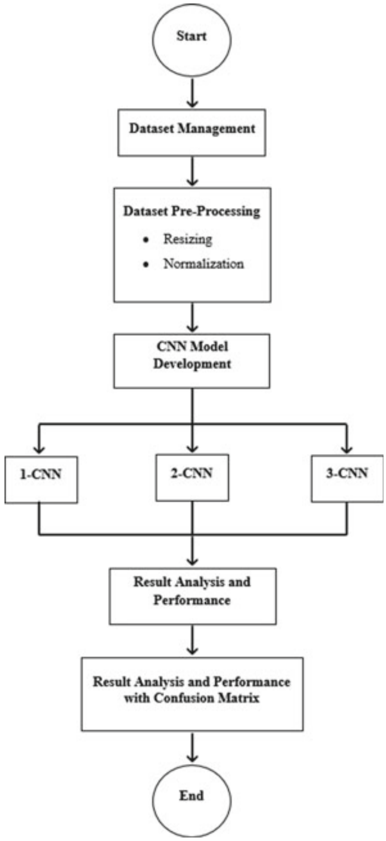


Fig. 4 Flowchart of the software development process

2.4 Dataset Management

The trash dataset was taken from the public dataset consisting of 9980 trash images that can be categorized into glass, metal, paper, plastic and others. Glass contains 2076 images, metal 2092 images, paper 2011 images, plastic 2033 image and trash 1768.

2.5 Data Pre-processing

The microcontroller is placed in the middle of the container so that the servo motor can easily change the direction of 360° around the container. Figure 4 shows the flowchart of data pre-processing. In a convolution neural network, the input must be in the shape of an array; thus, the image has been converted into an array of pixel. Normalization of the dataset is the process to standardize the dataset's values. This

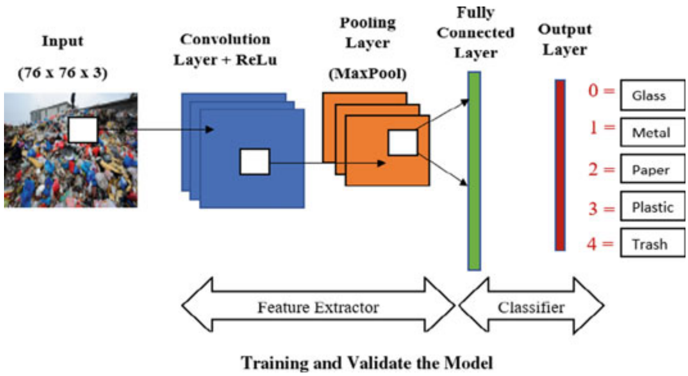


Fig. 5 Convolutional neural network (CNN) basic architecture

is because the value of the image, which is an array, has a variance in the amount of data. The basic architecture of the CNN is depicted in Fig. 5. There were three models of CNN that have been compared. It is 1-CNN, 2-CNN, 3-CNN (Sorokina 2017; Le 2021).

2.6 CNN Performance Evaluation

The performance of each CNN model has been evaluated using the confusion matrix. A confusion matrix is a prediction analysis for a classification problem (Shin 2020).

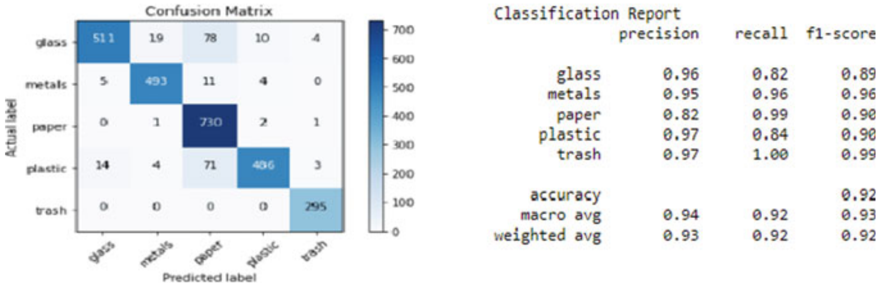
3 Results and Discussion

In this section, the accuracy, loss and confusion matrix results obtained are discussed. There are three different CNN models had been compared on the Jupyter and using the five types of trash dataset as the training and validation. The result of each CNN models had been compared.

1-CNN

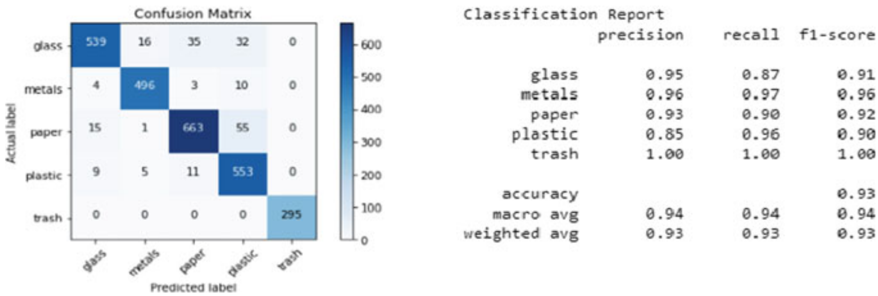
One-layer convolution neural network was the simple trained model with only 1 convolution layer, 1 max-pooling layer, 2 dense layers and 1 dropout layer.

From Fig. 6, the performance of the accuracy, precision, recall and F1-score can be calculated using the algorithm. From the confusion matrix, the accuracy obtained was 0.92 as shown in the classification report in Fig. 6. However, for the recall, glass had reached the lowest which is 0.82 and plastic reached 0.84. The F1-score of the glass is the lowest for the other classes which are 0.89.



	precision	recall	f1-score
glass	0.96	0.82	0.89
metals	0.95	0.96	0.96
paper	0.82	0.99	0.90
plastic	0.97	0.84	0.90
trash	0.97	1.00	0.99
accuracy			0.92
macro avg	0.94	0.92	0.93
weighted avg	0.93	0.92	0.92

Fig. 6 Performance evaluation of 1-CNN model with confusion matrix and classification report



	precision	recall	f1-score
glass	0.95	0.87	0.91
metals	0.96	0.97	0.96
paper	0.93	0.90	0.92
plastic	0.85	0.96	0.90
trash	1.00	1.00	1.00
accuracy			0.93
macro avg	0.94	0.94	0.94
weighted avg	0.93	0.93	0.93

Fig. 7 Performance evaluation of 2-CNN model with confusion matrix and classification report

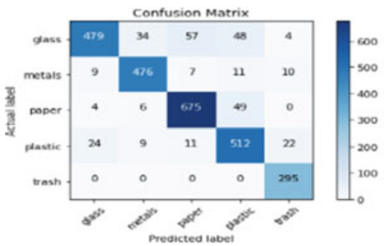
2-CNN

From Fig. 7, the performance of the accuracy, precision, recall and F1-score can be calculated using the algorithm. From the confusion matrix, the accuracy obtained was 0.93 as shown in the classification report in Fig. 7. However, for the recall, glass had reached the lowest which is 0.87 and paper reached 0.90. The F1-score of the plastic is the lowest for all classes which is 0.90.

3-CNN

In the 3-CNN model, the convolutional, pooling layer and dropout have been added with different filter sizes but the same kernel and max-pooling size.

From Fig. 8, the performance of the accuracy, precision, recall and F1-score can be calculated using the algorithm. From the confusion matrix, the accuracy obtained was 0.89 for 50 epochs and 0.82 at 20 epochs as shown in the classification report in Fig. 8. However, for the recall, glass had reached the lowest which is 0.77 and plastic reached 0.89. The F1-score for the glass is the lowest among the other classes with 0.84.




```
Classification Report
              precision    recall  f1-score

       glass       0.93      0.77      0.84
      metals       0.91      0.93      0.92
       paper       0.90      0.92      0.91
     plastic       0.83      0.89      0.85
       trash       0.89      1.00      0.94

    accuracy                           0.89
   macro avg       0.89      0.90      0.89
weighted avg       0.89      0.89      0.89
```

Fig. 8 Performance evaluation of 3-CNN model with confusion matrix and classification report

Table 1 Performance comparison for each model at 20 epochs

CNN model	Training accuracy (%)	Validation accuracy (%)	Training loss (%)	Validation loss (%)
1-CNN	96	92	11	15
2-CNN	93	93	18	12
3-CNN	82	82	50	50

4 Discussion

The performance of each model is compared in Table 1. The best CNN model for image classification from the result obtained was the 2-CNN model with the highest validation accuracy which is 93% and the lowest validation loss which is 12%. The comparison made was at 20 epochs. The lowest validation accuracy and validation loss were for the 3-CNN model. Even after training with 50 epochs, the validation accuracy was only 89% which is still the lowest among the 1-CNN and 2-CNN. However, increasing the number of layers depends on the size of the dataset. A larger dataset usually needs adding more layers to increase the performance (Chen et al. 2020). In an CNN, the architecture is completely dependent on the requirement and the input data. Adding more layers with small size dataset can lead to overfitting that can lead to error in some or the other form like false positives. According to Busyaev (Chen et al. 2020), ADAM is one of the best optimization algorithms for deep learning and its popularity is growing very fast. Hence, the ADAM algorithm has been chosen as the optimizer since it is combining the advantages of two other extensions of stochastic gradient descent which are the adaptive gradient algorithm (AdaGrad) and the root mean square propagation (RMSProp).

5 Conclusion

In conclusion, the sorting of different trash is achieved by using three different training CNN models with the highest validation of accuracy is the 3-CNN with 93%, followed by 2-CNN is 92% and 1-CNN is 91%. This proves that the different kinds of trash are able to be classified into each category with an average percentage of three different training CNN models of above 90%, which presents a good training performance in order to compare the efficiency of the training program. The performance of the training program is observed by the training accuracy and validation accuracy graph for the entire CNN models and confusion matrix for each training program which shows that the sample can be identified into each class, and some of the samples were not correctly predicted into their class. The analysis from the validation accuracy graph for all the CNN models is almost identical to the training accuracy graph which is referred to as the accuracy percentage where the validation is increased when the convolution layer is added.

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On Optimization of Selective Mapping and Clipping Hybrid Scheme Using Firefly Algorithm for PAPR Reduction

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Abstract One of the most widely known wireless communication systems is Orthogonal Frequency Division Multiplexing (OFDM) which is used in many different standards. This popular use of OFDM is because of the advantages given. However, this system has drawbacks, and the main one would be a high Peak to Average Power Ratio (PAPR). High PAPR will lead to nonlinear distortion of the power amplifier. Much research is done to find the right PAPR reduction techniques. SLM and clipping are two of the techniques that are very popular and simple to reduce the PAPR value in OFDM. Filtering is added after the clipping process and reaches spectral radiation requirement. With filtering, another issue rises where peak regrowth reduces the performance of PAPR reduction. In this paper, we proposed using the firefly algorithm (FA) to optimize the performance of PAPR reduction. From this paper, it is proven that PAPR performance can be improved with a lower clipping ratio and the number of subcarriers. A higher number of iterations used can help to improve the system's computational complexity.

Keywords OFDM · PAPR · SLM · Clipping · Firefly algorithm

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1 Introduction

Wireless communication has been progressing since the nineteenth century and has been one of the most important features in our everyday life. Technologies such as 3G, 4G, and 5G depend on Orthogonal Frequency Division Multiplexing (OFDM) as a medium for wireless communication (Vijay Kumar 2021). OFDM is a multicarrier modulation technique (Lavanya et al. 2019; Khosla et al. 2018) where high-rate data is divided into many slow rate data, and these data will be modulated by subcarriers. OFDM has high spectral efficiency which is one of the main reasons why it has been used by a lot of communication standards such as Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), WiMAX, Long-Term Evolution (LTE), and many more. By using Inverse Fast Fourier Transform (IFFT), OFDM could provide a whole lot of advantages such as low complexity, high bandwidth efficiency, high resistance to frequency selective fading, and many more (Lavanya et al. 2019; Murugan and Sivakumar 2015). Unfortunately, OFDM has one main disadvantage which is the high Peak to Average Power Ratio (PAPR) that can cause power amplifiers to work in the nonlinear region by producing signal excursions from the high peak (Kaur 2015; Poonam 2015). Complex Digital to Analog Converter (DAC) together with High Power Amplifier (HPA) can be used to counter-effect the issue, but power consumption and the cost of the system will increase. Intermodulation distortion might occur due to loss of orthogonality. Bit Error Rate and battery life of terminal will face degradation (Lavanya et al. 2019). So, it is crucial to find the right PAPR reduction techniques to avoid all these issues that might arise. Some of the reduction techniques that have been proposed in the past year are clipping, coding scheme, phase optimization, nonlinear companding, tone reservation, tone injection, partial transmit sequence, and selective mapping (SLM) (Murugan and Sivakumar 2015; Kaur 2015). Some of these techniques can lead to the high cost of the system and also don't provide much reduction (Poonam 2015). So, in this paper, we decided to use selective mapping together with clipping to achieve the optimum reduction value.

SLM was first introduced in 1996 and has been popularly used as a PAPR reduction technique. By using this method, the input data will be multiplied with phase sequences to generate new input signals. Then, IFFT will convert these signals into the time domain, and the signal with the lowest PAPR value will be chosen as the output signal (Kaur 2015). One of the setbacks of SLM is it has high computational complexity (Sudha et al. 2015). In this paper, we proposed to further reduce the PAPR value with clipping after SLM. Clipping is one of the simplest and widely used reduction technique with low computational complexity and take place in the domain (Dubey and Shrivastava 2015). The part of the signal that exceeds the threshold will be clipped so the receiver needs to realize the situation while retrieving back the transmitted data which is hard and could cause in-band and out-of-band distortion. These distortions will degrade BER and spectral efficiency. While this issue can be solved by applying filtering, peak regrowth could happen (Murugan and Sivakumar 2015). To optimize the hybrid of these two reduction techniques, we use the firefly algorithm (FA). FA is a metaheuristic algorithm inspired by the behavior of fireflies and their flashing patterns. There are three basic rules that we need to keep on when using this algorithm which is (Zhang et al. 2016):

1. Every firefly has the same sex.
2. Firefly attractiveness increase with their brightness.
3. The brightness of fireflies depends on the objective function.

In the next section, we will discuss OFDM, PAPR, SLM, clipping, and FA mathematically. We will also discuss how we implement the proposed method. Results of the simulation will be stated in Sect. 3 and followed by conclusion in Sect. 4.

2 System Model

Subcarriers in OFDM are overlapping but also orthogonal to each other which increases high data rates and bandwidth efficiency. Orthogonality also helps combat Inter-carrier Interference (ICI) and Inter-symbol Interference (ISI) (Kaur 2015). Flat fading channel generated from frequency selective channel making OFDM robust to multi-path fading. Data is converted from frequency to time domain by IFFT. IFFT is used instead of IDFT due to its computational efficiency. All these processes will be re-versed on the receiver side (Lavanya et al. 2019). Mathematically, a high data rate is divided into N low-rate data with equal subcarrier spacing through serial to parallel converter where (Lavanya et al. 2019; Khosla et al. 2018) $\Delta f = 1/NT$. Every subcarrier is modulated by the modulation technique chosen. The input in the frequency domain can be described as (Lavanya et al. 2019) $A = (A_0, A_1, A_2, \ldots, A_n - 1)T$. After IFFT, the signals can be represented as (Lavanya et al. 2019) $y = (a, a_1, a_2, \ldots, a_n - 1)T$. The orthogonality of the subcarriers needs to satisfy the following condition (Lavanya et al. 2019), $\int_0^T a_1(t)a_2(t)\mathrm{d}t = 0$, where the subcarrier frequency satisfies the following equation (Lavanya et al. 2019):

$$f_n = \frac{n}{T} + f_{RF}, \quad n = 0, 1, 2 \ldots N - 1, \tag{1}$$

where f_{RF} represents multiple radio frequencies. OFDM signal can be represented as (Lavanya et al. 2019)

$$x(t) = \int_{n=0}^{N-1} A_n e^{j\frac{2\pi \Delta f t}{T}}; \quad 0 \leq t \leq NT. \tag{2}$$

When N number of independently modulated signals with sinc waves and non-constant envelopes get added (Kaur 2015), it causes a peak power and create PAPR. This peak power can be very high compared to the other average power and caused high PAPR (Praveen Pawar 2016). PAPR is the ratio of peak power to average power (Poonam 2015) and can be defined as (Lavanya et al. 2019; Dubey and Shrivastava 2015)

$$\text{PAPRdB} = 10 \log 10\left(\frac{P_{\text{peak}}}{P_{\text{avg}}}\right). \tag{3}$$

The performance of PAPR reduction can be analyzed using Complementary Cumulative Distribution Function (CCDF) (Murugan and Sivakumar 2015; Dubey and Shrivastava 2015) to know the probability of PAPR to exceed threshold value (Lata and Thakur 2015) and can be expressed as (Sudha et al. 2015)

$$\text{CCDF} = \Pr(\text{PAPR} > \text{PAPR}_0) = (1 - (1 - e^{-PAPR_0})^N. \tag{4}$$

SLM is part the of symbol scrambling technique (Lata and Thakur 2015), where the input data is divided into M number of sub-blocks, and once the parallel conversion ends, the signals will be multiplied with a phase sequence that can be represented as (Kaur 2015) $P_u = (P_1, P_2, P_3, \ldots P_u)$, where $u = (0, 1, 2 \ldots U)$, to make OFDM data blocks to be phase rotated. OFDM signal with the lowest PAPR value can be represented as (Kumari and Chawla 2017)

$$X^u(t) = \frac{1}{\sqrt{N}} \int_{n=0}^{N-1} X_n P_{u,n} e^{j2\pi f_n t}. \tag{5}$$

The computational complexity faces by this technique is due to the high usage of IFFT operations. SLM also transmits together side information to help receiver recover all the information transmitted. Clipping amplitude can be explained by the following equation (Kumari and Chawla 2017):

$$\begin{aligned} A(X) &= x,\ |x| \le B \\ &B,\ |x| > B, \end{aligned} \tag{6}$$

where B is the clipping level, x is the signal value, and $A(X)$ is the amplitude function. In receiver, to recover all the information back, two parameters need to be considered is size and location of the clip (Kumari and Chawla 2017). B can be calculated as (Tang et al. 2020) $B = \gamma\sqrt{P_{\text{av}}}$, where P_{av} is the average power and γ is the clipping ratio. Only large signals will be limited by the threshold while smaller signals will remain unchanged. As filtering is needed due to out-of-band emission by clipping, it can be defined as (Tang et al. 2020)

$$\begin{aligned} H(k) &= 1,\ 0 \le k \le N-1 \\ &0,\ N \le k \le LN-1. \end{aligned} \tag{7}$$

Two important things in FA are the formulation of light intensity and change of attractiveness. In this simulation, we know that light intensity I changes according to the distance r and light absorption parameter φ. This relationship can be seen from the following equation (Zhang, et al. 2016), $I = I_0 e^{-\varphi r}$, where I_0 is the light intensity when $r = 0$. We also can define light attractive coefficient β the same as light intensity. The distance between two fireflies can be calculated by the following equation (Zhang, et al. 2016) $r_{ij} = \sqrt{\int_{k=1}^{d} (x_{i,k} - x_{j,k})^2}$, where d is the number of dimensions. The amount of movement of firefly also can be calculated as following (Zhang, et al. 2016) $x_i = x_i + \beta_0 e^{-\varphi r}\left(x_j - x_i\right) + \alpha\varepsilon_i$, where the third term is random variables coming from different distributions.

2.1 Proposed Method

Once parameters are initiated, input signals will be modulated using 16-QAM constellation and converted into parallel signals using serial to parallel converter. These signals will be divided into several sub-blocks and multiplied with phase factors and produce new input signals. The signal with the lowest PAPR will be chosen. The amplitude of the signals will represent the population of the fireflies. Light intensity corresponds to the objective function which is to find the signal with the lowest PAPR value. So, firefly that satisfies the requirement will be brighter and attract other fireflies to it, and this movement can be expressed by the following equation (Singh and Patra 2018):

$$b_i = b_i + \beta(r)\left(b_j - b_i\right). \tag{8}$$

This new signal will be compared with randomly chosen amplitude signal. The one with higher amplitude value will be chosen to be clipped. If both signals have the same amplitude value, a random walk step will be applied to randomly choose between the two signals. This process will keep on repeated until maximum iteration reach. Figure 1 shows the flowchart of the implementation process (Table 1).

3 Results

The number of iterations, clipping factor, and sub-blocks used in Table 2 is 100, 0.6, and 44, respectively. For every signal, the value of PAPR increases as the number of subcarriers increases. Also, can be seen that the performance of PAPR get better as a new method added to the algorithm. The proposed method is proven to give the best results out of all the methods used. The value of PAPR manages to be reduced by more than 80% from the original OFDM signal. The increase in value of PAPR proportionally to the number of subcarriers is due to increase in computational complexity and

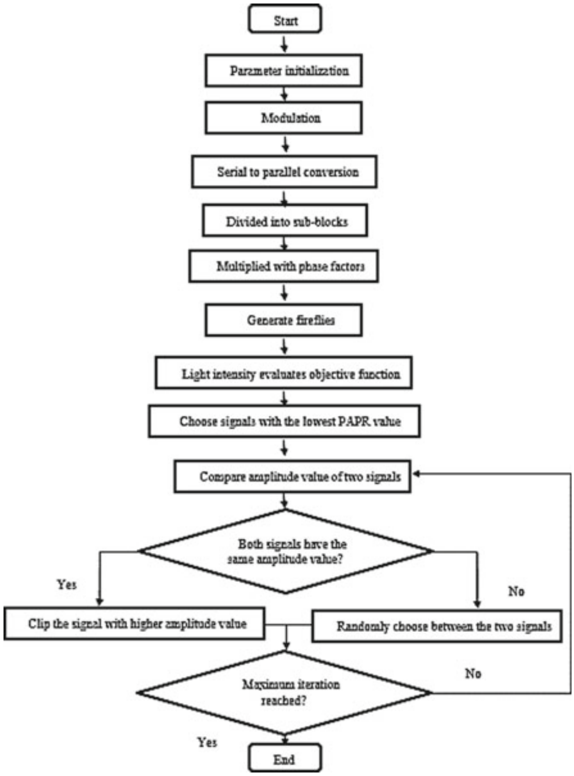

Fig. 1 Flowchart of proposed method

Table 1 Proposed method simulation parameters

Simulation parameter	Value
Clipping factor	0.6, 0.7, 0.8, 0.9, 1.00
Number of subcarriers	64, 128, 256, 512
Number of sub-blocks	4
Number of fireflies	20
Randomness strength	1
Attractiveness constant	1
Absorption coefficient	0.01
Randomness reduction factor	0.97
Number of dimensions	15
Number of iterations	100, 200, 300, 400, 500

Table 2 PAPR performance with different number of subcarriers

Number of subcarriers	OFDM original signal (dB)	SLM (dB)	SLM + Clipping (dB)	SLM + Clipping + FA (dB)
64	18.7980	12.8089	6.8476	2.5520
128	20.8229	14.9057	6.9058	2.8380
256	22.0713	14.8663	6.9797	3.0763
512	22.9578	16.1505	7.0165	3.1924

Table 3 PAPR performance with different number of clipping ratio

Clipping ratio	SLM + Clipping (dB)	SLM + Clipping + FA (dB)
0.6	6.8476	2.5520
0.7	7.9225	3.6273
0.8	9.1622	4.1291
0.9	10.2176	5.4030
1.0	11.4477	6.3202

limited phase weighing factors. Even with high number of subcarriers, the proposed method still can effectively reduce PAPR value.

The number of iteration, subcarriers, and sub-blocks in Table 3 is 100, 64, and 4, respectively. Clipping ratio definitely affects the performance of PAPR. The value of PAPR increases proportionally with the clipping ratio. This is because when using lower clipping ratio, the symbol to error ratio (SER) degradation due to nonlinear distortion counteracted by the saved energy at power amplifier and vice versa. Even so, the proposed method still provides a better performance than the other method. The value of PAPR was able to be reduced by almost half of its original value.

The number of clipping ratio, subcarriers, and sub-blocks in Fig. 2 is 0.6, 64, and 4, respectively. As the number of iterations increase, the value of PAPR decreases, and this is due to computational complexity getting lower. Higher number of iterations increases the processing time and eventually increases the number of function evaluation.

4 Conclusions

There are a lot of research done on finding the right technique to reduce PAPR value in OFDM. In this paper, the combination of SLM, clipping, and FA was proposed due to the effectiveness, simplicity, and efficiency of the techniques. PAPR performance is proven to be improved with lower value of clipping ratio and number of subcarriers, and also higher number iterations. It is also proven that the performance of PAPR by using SLM-clipping-FA is much better than conventional clipping or conventional

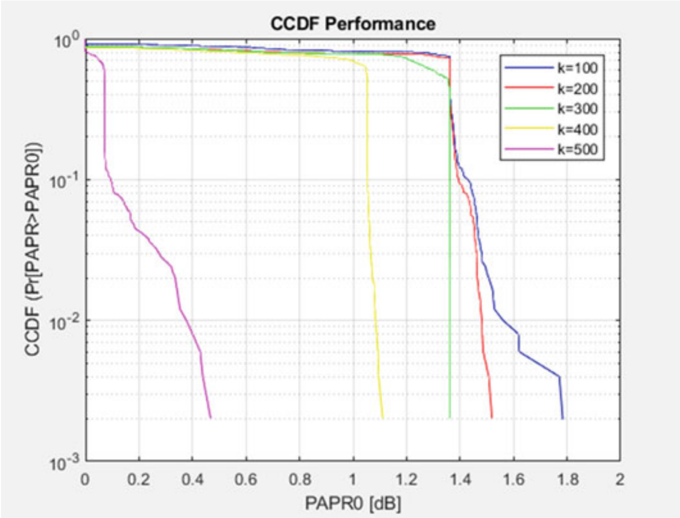

Fig. 2 PAPR performance with different number of iterations

SLM. Computational complexity also has been reduced by applying a higher number of iterations.

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Embedded RFID System: OKU Smart Card Detector

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Abstract Identification technology by radio frequencies contributes in many IoT application scenarios, such as smart system. This paper presents the system that uses the Raspberry Pi microcomputer as a platform for the development of embedded RFID system, which also involves RFID reader and the RFID tags that act as the OKU smart identification card. The system can be used for further enhancement in developing the purpose of RFID technology most of all as a registration platform for valid OKU registrar under JKM since this project is a collaboration with JKM. The data entry can be stored and monitored by JKM's staff through the smart system that is connected with the OKU's unique and smart identification card that can store up to 1 KB of data. The purpose of this system eases JKM in handling and organizing the amounts of OKU data in a long-term process.

Keywords Embedded RFID system · OKU smart card · Person with disabilities

1 Introduction

Radio frequency identification (RFID) technology integrates the use of radio frequency (RF) to peculiarly distinguish object, animal, or person. The RFID system includes antenna and transceiver that are often combined as one reader and a transponder which is the tag. RFID technology differs from barcodes, which can be considered as one of the latest technologies used nowadays that does not even require any line of sight to detect the target. Hence, it makes detecting documents, whether digital or prints, easier and quicker (Makhija and Chugan 2016).

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The RFID reader can read the tag even from a distance, and even right through clothes, wallet, backpack, or purse. The RFID tag is each built of unique identification (UID) where it will be used to identify the user's identity (Nsengumuremyi et al. 2018). People with disabilities, known as 'Orang Kurang Upaya' (OKU), represent a distinct population with elevated needs for short- and long-term healthcare services. They are qualified to have the disabled card, as they are fit to the criteria that give advantages like discounts for public transport, medical facilities, and medicine, and even disability allowance (Mohd Nor et al. 2017).

Up until today, the card provided for registered OKU is a plain card with details printed on the front and back part of the card, but with no built-in chip to store any important data needed. The OKU can still use the card even when they are not valid anymore because if they have the OKU card and sticker, they can still use any OKU public facilities like OKU public toilets and parking spot with their rights as an OKU. The JKM system is generated and run manually by the authorized staff. The issue occurs most of all when they needed to check details of any registered OKU and when they needed to edit any data stored, as these lead to time consumption and failure to search for the specific identity correctly and respectively with possible typing errors.

This paper dedicated of a smart card detector system that specifies the information of OKU and automatically generates the data of OKU from JKM system. To achieve the objectives, this paper focused on the development of hardware and software that are used for writing, reading, and storing the data. It will be performed through embedded RFID system.

2 Literature Review

Registration is very important and necessary for every OKU that are registered under JKM. The RFID card acts as address as well as identity and validity proof. This paper presents a smart card system developed using RFID technique to avoid the time delay and the rush during the registration. This RFID system in fact eliminates the weakness of the current system. In this system, RFID reader radiates a low power RF wave field through its antenna to activate the card to share the information that contains in the chip. The RFID card carries the OKU details, and they need to show the card to the RFID reader. The microcontroller, which is the Raspberry Pi 4, is connected to the RFID reader, will store data, and performs a database search for the details of the user. If the user, which is the OKU registrar, they are found authentic (Navaneeth 2018).

The reader communicates with the card or tag for numerous cause that involves authentication as well as storing and retrieving information. A more commonly used passive card or tag, containing a limited memory space and processing power, which allows information to be locally stored and processed on the card for quick response, requires the reader to initiate communication (Doss et al. 2020).

RFID RC522 reader is used as it is a high frequency RFID module of 13.56 MHz, which has a wide variety of transponders at 13.56 MHz including the complete

MIkron FARE Collection System (MIFARE) kit. RFID proximity passive card is used as it could work in the 125 kHz RF range. The card includes the identity of the user, which in this case is the OKU, along with their data of information details like name, date of birth, type of disability, validity as a registered OKU and UID number of the card. It is activated to write the information and returns the data as required by the reader.

Nevertheless, the RFID system is considered a worthy successor to the barcode system and has significant advantages for monitoring purposed applications. Recent study suggests the use of RFID and Internet of Things (IoT) sensors that can function as a traceability system used to track and trace biodegradable food. The IoT sensors functions for measuring temperature and humidity, while the machine learning models are utilized to detect and identify the direction of passive RFID tags (Alfian et al. 2020).

RFID as an automatic identification technology, also affected by innumerable other factors, such as RF power, the speed of tag, target size, shape, material, and surface structure. Numerous research has been done to annihilate the interference of these factors to improve the read rate like multi-path read range estimation method and dynamic RFID performance test system (Xie et al. 2017).

3 Methodology

For the system development, Raspbian OS is used in designing and developing the embedded RFID system that will store the database of the OKU in the JKM system and be used in the application of the system in the future. The main part of the system includes write, read, and store data of the OKU with their respective smart card. To create a database for a user, the Raspberry Pi is interfaced with the RFID reader and card and connected with a server to store the data.

3.1 System Development

Since Raspberry Pi is used as the microcomputer in this project, NOOBS is needed as the OS install manager that contains Raspbian. The Raspbian OS connects the user and Raspberry Pi, with Python as the programming language. It helps to develop and engineer the programs, which enables the hardware to communicate with the software to generate those interactions.

In this project, the OS is used in designing and developing the embedded RFID system that will store the database of the OKU in the JKM system and be used in the application of the system in the future. The main part of the system in this project includes write, read, and store data of the OKU with their respective smart card. To create a database for a user, the Raspberry Pi is interfaced with the RFID reader and card and connected with a server to store the data.

As every RFID card contains different UID, this will help to distinguish every each and one of the users. In this case, JKM will be the authorized employer that will handle the developed system. The system highlights data collection and analysis which enables the employer to act on the data collected instantly which is an important criterion in deciding if a system is an IoT system. The Raspberry Pi sends its data through the Serial Peripheral Interface (SPI) protocol and operates by generating a 13.56 MHz electromagnetic field to communicate with the RFID tags.

3.2 Project Implementation Flow

The flowchart in Fig. 1 shows the overall process of implementing this project. The project started by creating design specifications by doing research on related topics to gain ideas and knowledge specifically about RFID system, how it operates and how it needs to be programmed, and background of every process involved.

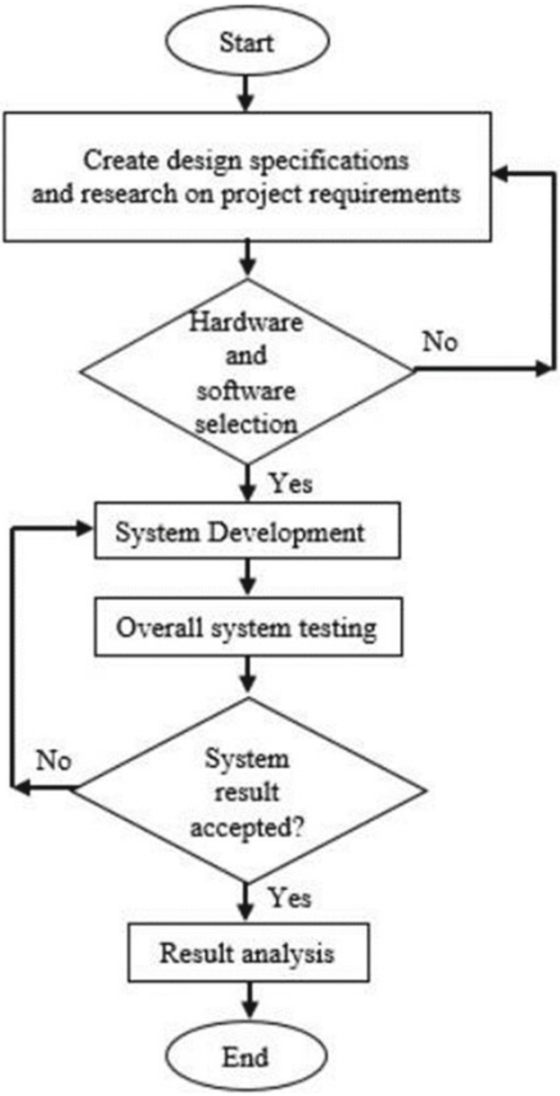
The hardware components and software program required like programming language were chosen based on the research made and the understanding of project concept. Then, the flow continued with the development of the system involving the hardware and the software part and followed by every other process that were discussed in the following subchapters. The project moved on to the overall system testing as soon as the system can fully operate. During the testing, the output of the system was observed and recorded. When there were any problems during the testing, the overall system development and testing were done until the respective problems were solved completely as how the flow goes. Finally, results were analyzed and discussed in result and discussion section.

3.3 Data Collection

Since this project is a collaboration with JKM, proper data of OKU is needed to be used. Once JKM had agreed to accept the research as one of their priorities, they had given me the opportunity to set up a few meetings with their staff and discussed further in details about this project where they had agreed to give me the data of the OKU for every category involved under their supervision.

There are seven categories of disabilities that are involved under JKM, which are Physical Disability, Deaf or Hard of Hearing, Vision Impairment, Intellectual Disability, Mental Health Conditions, Speech and Language Impairment, and Multiple Disorder. The details included are their full name, date of birth as to replace the OKU's identity card number for privacy matter, OKU card's date, category of disability, and their registration number. The card's date and registration number are also important in this project as to validate the OKU's validity as a legitimate OKU from time to time. Table 1 shows some of the data that were given by JKM. From the categories of disabilities given, the categories were divided into two groups, which

Fig. 1 Project implementation flow



consist of Group 1 that is the OKU who is qualified to apply for driving license and Group 2 that is the OKU who is not qualified to apply for driving license. Based on the conditions set by Road Transport Department of Malaysia, only the OKU with Physical Disabilities is qualified for a driving license. Table 1 shows the relationship of the categories of disabilities to the groups of disabilities (Table 2).

Table 1 Data of OKU by JKM

Name	Born date	OKU card date	Categories	OKU registration no
Person 1	06.02.1936	02.01.2018	Physical	PH070018000001
Person 2	19.02.1996	05.09.2016	Hearing	DE070116000017
Person 3	08.05.1946	24.09.2019	Vision	BL070019000017
Person 4	28.03.2014	02.07.2018	Learning	LD070518000056
Person 5	14.07.1961	21.12.2019	Mental	ME070416000016
Person 6	31.01.1987	15.10.2019	Speech	SD070419000002
Person 7	03.12.1972	31.10.2019	Multiple	MD070119000017

Table 2 Groups of disabilities

Categories of disabilities	Groups of disabilities
Physical disability	1
Deaf or hard of hearing	2
Vision impairment	2
Intellectual disability	2
Mental health conditions	2
Speech and language impairment	2
Multiple disorder	2

4 Results and Discussion

The analysis was performed to obtain the perfect results. Based on the flow of project implementation, the performance of the system was analyzed after an overall system testing was successfully conducted. The testing focused on the functionality of a complete interfaced hardware with software program codes, which involved the writing, reading, and storing and retrieving data of OKU. To determine the performance of the system, the outcomes were observed, recorded, and analyzed.

4.1 Study Case Application System

This project was planned to be applied for an OKU smart parking system in the future. In this case, the groups of disabilities would be highlighted and prioritized accordingly because only the OKU with Physical Disabilities is qualified for a driving license as discussed in previous chapters. Hence, the system distinguished the groups by the data written and stored in the system as shown in Fig. 2.

The smart parking system was operated by the verification process from the data of the OKU. The OKU placed their smart card near the RFID reader, but as the reader detected an unauthorized user, which is the OKU from Group 2, the system rejected

Fig. 2 Study case application performance. **a** Group 2, **b** Group 1

the user from using the parking spot. As for Group 1, the barrier of the parking spot was lowered down, and the user can park his vehicle. Meanwhile, the barrier will be moving up to avoid being misused by normal people within three minutes. A waterproof ultrasonic sensor was also used to detect the distance of the vehicle from the barrier. Figure 3 shows the overall connection for the system.

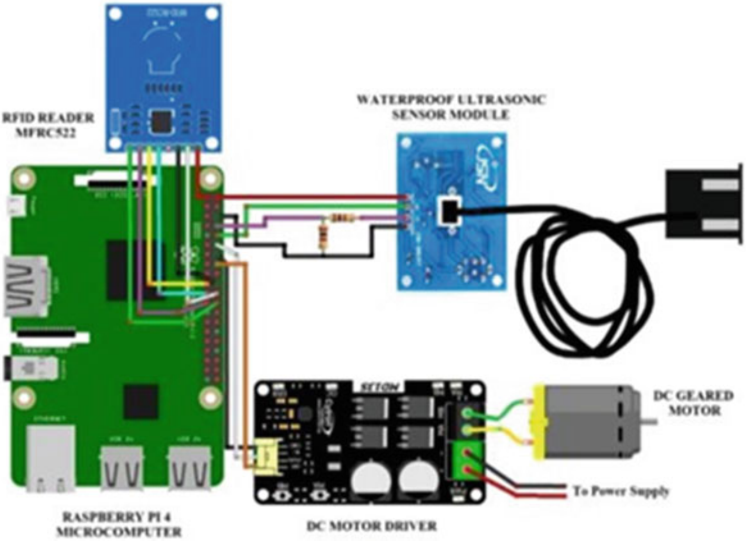


Fig. 3 OKU smart parking system schematic circuit

5 Conclusion

The objectives of this project are proven to be achieved successfully. This project focuses on developing a system that specifies the information of OKU, most of all their categories and groups of disabilities. Even though the authorized staff still needs to manually key in the OKU's information for every first-time registrar, the system is very efficient when it comes to searching for stored data. They can easily place the OKU smart card near the RFID reader, and the data will be automatically retrieved as it involves a real-time data storage. Hence, proving another objective of the project that is a success.

Furthermore, this project could be a contribution for the public handicapped facilities as one of its applications. Since the facilities like the parking spots are often abused by unauthorized users, this system can prevent the violations. Consequently, providing the OKU their rights as the authorized users.

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Quality Improvement of Small Form-Factor Pluggable (SFP) Units Assembly Using Robotic Automated System

Choong Chee Guan, Saw Chun Lin, Robert Kerk Swee Tian, and Nadzri Che Kamis

Abstract Automated mechanization in other word referring to various tasks and jobs done by human is replaced by automated system. In the manufacturing processes, automated conveyor system and automated plant control processes are among the automated system applied to improve the process efficiency. In this study, an automated assembly process using robotic system to replace conventional manual assembly process is investigated. The objective of this study is to improvise the manual bail, latch, and shell assembly processes that causes many defects quality. Thus, a new robotic machine is built to reduce the quality errors of the assembled product and increases efficiency of the assembly process. As the results, the robotic machine increases the productivity by 99%, while the defect rate has been reduced from 10.31% to 0.27%. .

Keywords Industrial Robotics · Quality · Productivity · SFP

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1 Introduction

In the past years, the role of robotics arm replaces the human manpower is picking up the pace as many industries are implementing more automation system. The robotics arms, usually made up of 4–6 joints which can be for several manufacturing applications such as assembly process, welding, and material handling professions (Graetz and Michaels 2015). An industrial robot arm can be defined as a marvel of engineering in that it reacts similarly to our own arms. It closely resembles a human arm with a wrist, forearm, elbow, and shoulder. The use of industrial robots increases the potential of replacing human labor by reducing human interaction in controlled operations (McCutcheon and Pethick 2014). Automation can benefit many businesses. Solar panel, tires, and semiconductors among the industry that implemented robotic system in the production line. Robotics is used when high intelligence is required (Vosniakos and Matsas 2010). Since robots are more precise compared to physical labor, many experts believe cheaper, better robots may replace human labor in the next decade hence lowering labor expenses (Asbeck et al. 2014).

Trending the 4.0 industrial revolution, robotics not only applied in developed countries, while many developing countries is also utilizing the benefit of robotics system in the production (Accenture 2016). Robust machines and robot's core save the most energy and overhead cost since robot can precisely repeating the same task with acceptable accuracy (Asbeck et al. 2014). As technology advances, robotic technology is quickly expanding its operations integrated with vision system to improve the efficiency of manufacturing process by solving complex industrial tasks reliably and consistently (Arntz et al. 2016). Types of vision systems include 1D vision system, 2D vision system, Line scan or Area scans, and 3D vision system depending on the needs of the industrial process (Gregory 2016). Consequently, new specialty robots are design and customize as machine vision system to meet the owner demand to fulfill the efficient automation process (Cowen 2016).

In this paper, a machine vision system was built comprise of three robotic arm, vision system to detect the defect via imaging, and rotary automated system to solve the defect occurred during manual assembly process at labeling department. An investigation was done to collect production data on assembled module and analyze the defect rate of product.

1.1 Problem Statement

The combination of quality defects such as bail scratches, wrong orientation, bail mismatch, loose bail, dented shell surface and color match of SFP units during assembly process has caused product defect of more than 10%; hence, this has reduced the productivity of finished assembling product and added to manufacturing cost. Current manpower of three persons to assemble the SFP units can be eliminated by introducing the robotic machine to do the assembling task of the product.

2 Methodology

The process flow shows how the project is done step by step to achieve the objectives.

Figure 1 shows the research problem which is quality defects in manual assembly process of SFP module which carry out in labeling department was identified. The root cause of the problems was analyzed, then an automated assembly system integrated with vision system was built to solve the problem. There are two robotic arms for pick and place task, a machine vision system to inspect defect and reject the defected units and a main and sub-rotary system to rotate the units during the assembly process. An investigation on daily assembly process took place for manual assembly and automated assembly system. The recorded data collection conducted for one month to obtain the average productivity and quality rate. The purpose of investigation is to evaluate the capability of robotic automated system to carry out the complex tasks given accurately, if the defects become greater than a re-work or re-improvement need to be done. The main role of robotic automated system built is to reduce defect at mechanical gripper, bail robot arm, robotics vison camera, and two pocket latch and bail nest assembly.

2.1 Quality Defect Rate and Productivity

Labeling department was going through some difficulties in achieving the desire production rate in SFP module manual assembly process. The average monthly and daily production rate show that 89.69% while remaining 10.31% contributed to quality defects. Thus, the target is to reduce the quality defect as much as possible to increase the productivity by using the new robotic machine. Hence, the new target was set as below:

- The targeted productivity = 98%
- The targeted quality defects = Less than 2%

2.2 Data Analysis Tool (Bar Charts and Pie Charts)

The bar charts and pie charts were developed to investigate the production rate and quality defects. Comparison on the production rate and defects quality between manual and robotic assembly process is discussed in results section.

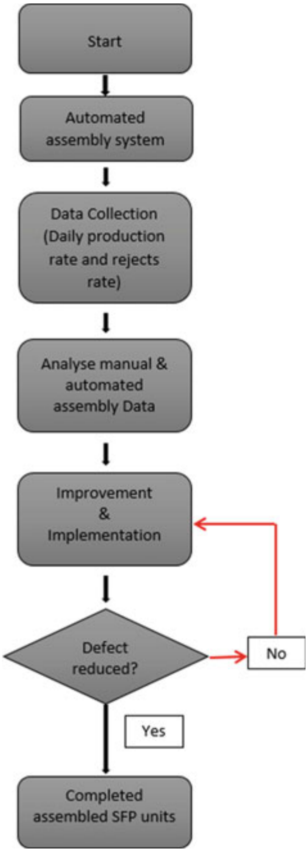

Fig. 1 Process flow

3 Results

3.1 Manual Assembly Process

Table 1 shows the monthly data collected for the manual assembly process from December 1 to 31, 2020. The quality defects in manual assembly process identified as given in Table 1. The quality defects are bail scratches, wrong orientation, bail mismatch, loose bail, dented shell surface, and color match. The total failed units represent the sum of all the six quality defects. The total units per day are the production rate while pass units represent the quality inspection pass units. The average units calculated by dividing total days in the month of December 2020.

Figure 2 shows the daily quality inspection passed units versus failed units. The daily and monthly quality defects are 4042 pieces and 125,303 pieces respectively that contribute 10.31% in total production rate. This led to the monthly production rate achieved only 89.69% as shown in Fig. 3. Figure 4 shows the quality defects

Table 1 Manual assembly production rate and defects rate of SFP module in labeling line

	Total Units per day/month	Passed Units	Bail scratches	Wrong orientation	Bail mismatch	Loose bail	Dented shell surface	Color match	Total Failed Units
Sum (monthly)	1,215,169	1,089,866	91,685	5481	18,176	3108	3242	3611	125,303
Count (day)	31	31	31	31	31	31	31	31	31
Average (daily)	39,199	35,157	2958	177	586	100	105	116	4042
Percentage	100%	89.69%	7.55%	0.45%	1.49%	0.26%	0.27%	0.30%	10.31%

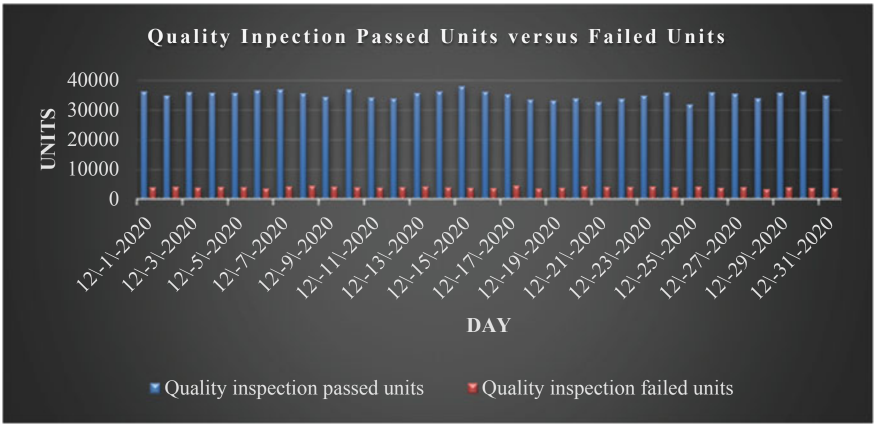

Fig. 2 SFP module daily quality inspection passed units versus failed units

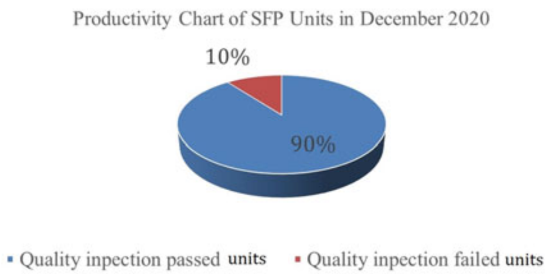

Fig. 3 Productivity chart of SFP units in December 2020

rate as compared to total defect quality rate which showed dented shell surface contributed the highest defects that is 73%. The quality defects are bail scratches, wrong orientation, bail mismatch, loose bail, dented shell surface, and color match. The total failed units of 4042 pieces represent the sum of all the six quality defects. The total units per day are the average production rate while pass units represent the quality inspection pass units.

3.2 *Automated Assembly Process*

Table 2 shows the data collected in the automated assembly process using the robotic machine from March 1 to 31, 2021. Figure 5 shows the daily quality inspection passed units versus failed units. From the figure we can see that daily the quality defects are reduced to 0.27% from 10.31% in total production rate by using robotic machine. This led to the monthly production rate achieved more than 99.73% as shown in Fig. 6. Apart from that, Fig. 7 shows the various types of quality defects in auto assembly process of SFP units, where the major quality issues are due to bail scratches which

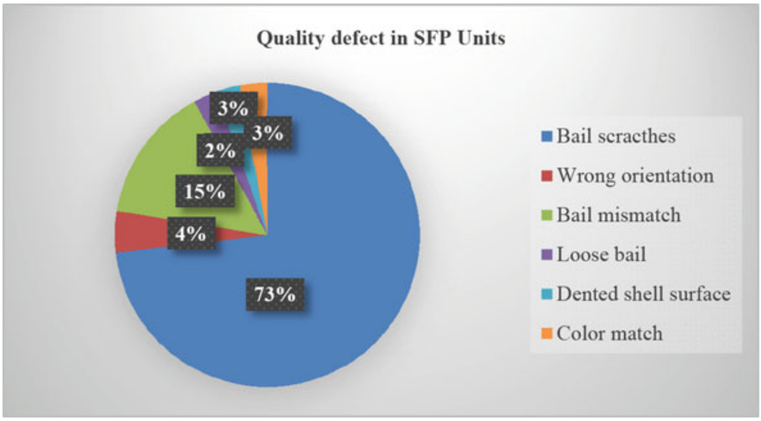

Fig. 4 Quality defects rate which obtained from inspection process

contributed 64% of defects; dented shell surface and loose bail have contributed 22 and 14% to the quality issues. Apart from that, wrong orientation, color match, and bail mismatch have no issues in automation assembly process.

4 Discussion

Table 3 shows the data comparison of both manual and automated assembly processes. The inspection pass unit percentages were 89.69% in manual assembly process, but after the automated assembly process implemented, the production rate has been raised to 99.73%. This showed that the quality defects rate had been reduced from 10.31 to 0.27%. Apart from that, we manage to reduce some of the defects to zero percentage. Wrong orientation, bail mismatch, and color match have no issues in auto assembly process. Furthermore, bail scratches have been reduced from 7.55 to 0.17%. Bail scratches were the major issue which contribute highest percentage among other quality defects. Apart from that, the other two defects were loose bail and dented shell surface which have only very low percentage which is below 0.1%.

Table 2 Manual assembly production rate and defects rate of SFP units in labeling line

	Total units per day	Passed units	Bail scratches	Wrong orientation	Bail mismatch	Loose bail	Dented shell surface	Color match	Total failed units
Sum	1,221,870	1,218,580	2112	0	0	450	728	0	3290
Count (d)	31	31	31	31	31	31	31	31	31
Average	39,415	39,309	68	0	0	15	23	0	106
Percentage	100%	99.73%	0.17%	0%	0%	0.04%	0.06%	0%	0.27%

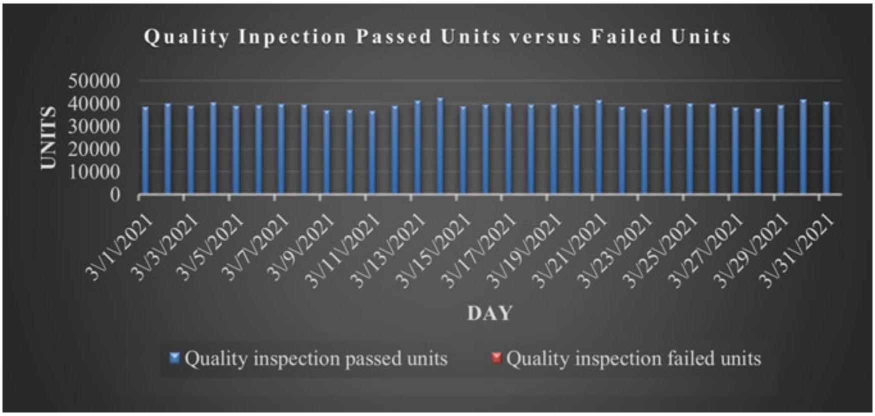

Fig. 5 SFP module daily quality inspection passed units versus failed units

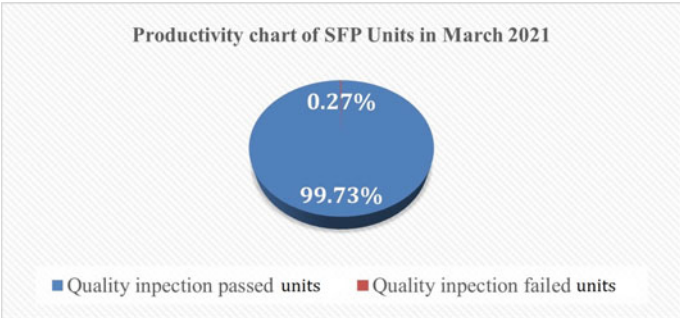

Fig. 6 Productivity chart of SFP units in March 2021

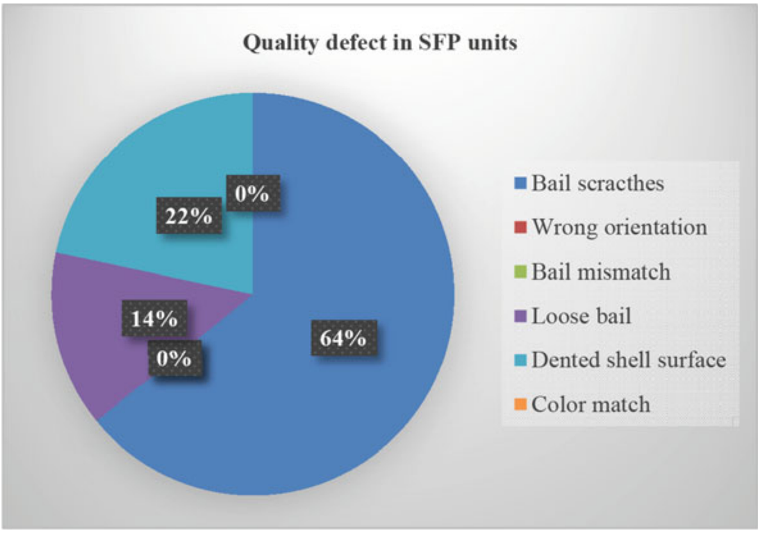

Fig. 7 Quality defects in SFP units after quality inspection

Table 3 Comparison between manual assembly process and automated assembly process

Total units per day	Passed units	Bail scratches	Wrong orientation	Bail mismatch	Loose bail	Dented shell surface	Color match	Total failed units
Manual assembly process								
100%	89.69%	7.55%	0.45%	1.49%	0.26%	0.27%	0.30%	10.31%
Automated assembly process								
100%	99.73%	0.17%	0%	0%	0.04%	0.06	0%	0.27%

5 Conclusion

By implementing the automation assembly process by using robotic machine, all the six (6) quality defects in the manual assembly process have been reduced significantly below 2% with great achievement of only 0.27% total defect quality. This proved that manpower in manual assembly process led to quality defects. As this is a repeated process, humans tend to produce errors while doing the given tasks for long hours. Hence, we can conclude that robotics is specialized in handling sensitive product and component with precise as compared to human manpower. As the results, quality inspection of passed SFP units improved by 10% from 89.69 to 99.73%. This led to achieving 99% of production rate in assembly of SFP units that saw a reduction of 97.4% in total defect quality from 10.31 to 0.27%. Secondly, the major defect of bail scratches is reduced about 97.7% which is a reduction from 7.55 to 0.17%.

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An Energy-Efficient Clustering Protocol for the Lifetime Elongation of Wireless Sensors in IoT Networks

Ali Mohammed Kadhim Abdulzahra and Ali Kadhum M. Al-Qurabat

Abstract The efficient use of energy is a crucial difficulty that must be addressed when constructing a wireless sensor network (WSN)-based Internet of Things. Thousands of battery-powered tiny devices known as sensors make up these networks. Sensors are limited-resource devices with a finite amount of energy. The lifetime of the entire network may be extended significantly by reducing the energy consumption of these nodes. WSN-based IoT clustering is a rapidly growing field of study. The main problems in clustered WSN-based IoT are determining the right number of clusters and then picking a cluster head (CH) node inside every created cluster. In this paper, we introduce a unique clustering approach for WSN-based IoT systems based on fuzzy c-means (FCM). The approach employs a FCM methodology to form the clusters and a decrease in the total energy used on each cluster to identify the optimal cluster head (CH). Instead of changing CHs with dynamic clustering at each period, we aim to apply an energy threshold to postulate CH dynamicity based on current energy levels, therefore extending the sensor network life span.

Keywords IoT · WSN · Clustering · Energy consumption · Fuzzy c-means

1 Introduction

The considerable advancement in the field of the Internet of Things (IoT) in the current modern era has made human existence more evolved (Al-Qurabat and Abdulzahra 2020). It has improved the standard of living for all people. Along with the development of WSNs, the IoT idea was broadened. A WSN is made up of N sensor nodes (SNs) that are scattered at random throughout a geographic region

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(Abdulzahra et al. 2021). These sensors collect information about the surroundings, including humidity, acoustics, light, vibration, and temperature. The data collected is sent to a sink node, which is a base station (BS). A WSN-based IoT application is made up of a collection of self-contained sensors that may collect data from their surroundings in order to create a general overview of the controlled region (Idan Saeedi and Al-Qurabat 2021).

The transmission of data is the most energy-intensive function for SNs in WSNs. As a result, fewer data transfers or lower transmission power are necessary to decrease energy consumption. Furthermore, a number of requirements in the network's architecture and operation must be satisfied in order for WSNs to be employed. Because SNs have a fixed quantity of energy, energy conservation is typically seen as the most important difficulty in maintaining network connectivity and prolonging the SN's life span, especially if the deployment region is harsh or hostile and the battery is not replaceable (Idrees and Al-Qurabat 2021; Saeedi and Al-Qurabat 2022).

Clustering is one viable option for addressing these issues and making the most of available energy. Clustering, which splits the network into clusters and forces SNs in each cluster to transmit data to a cluster head (CH), is responsible for this (Panchal and Singh 2021). Because the sensors are so near to the CHs, they may lower their transmission powers, reducing energy usage and increasing the network's life span. CHs are selected from among the SNs to oversee the collection of data from sensors within their clusters, aggregate it, and transfer it to the BS (Gantassi et al. 2020).

We offer a unique clustering protocol based on fuzzy c-means with distance- and energy-limited termed (FCMDE) for clustering, CH selection, and data transfer to increase the life span of WSN-based IoT. Instead of picking the node closest to the fuzzy c-means centroid as CH, as in earlier research (Panchal and Singh 2021; Qin et al. 2017), FCMDE picks the node closest to the majority of nodes in the network. The proximity criterion ensures that nodes in each cluster remain close to their CH at all times, allowing them to broadcast at much lower power levels. We aim to apply an energy threshold to hypothesis the dynamicity of CH based on current energy levels rather than substituting CHs for dynamic clustering at each period in this investigation. The change in how the CH is chosen has a significant impact on the network's energy consumption.

The remaining portions of the paper are described below. Section 2 includes the related works. Section 3 briefly introduces the network concept and energy consumption model. Section 4 contains a full overview of the suggested protocol. The simulation findings and discussions are presented in Sect. 5. Section 6 outlines the paper's conclusion.

2 Related Works

The sensor nodes in the network may be configured to operate as CH either centrally or distributedly. The first uses a BS to control CH selection, but the second is completely self-contained. Distributed protocols include low-energy adaptive clustering hierarchy (LEACH) (Heinzelman et al. 2000), hybrid energy-efficient distributed clustering (HEED) (Younis and Fahmy 2004), and others. Machine learning is increasingly being utilized to divide the network into clusters, from which CHs are selected depending on predefined criteria. This may be performed using algorithms like k-means (Gantassi et al. 2020; Qin et al. 2017; Cai et al. 2019) and fuzzy c-means (Panchal and Singh 2021; Qin et al. 2017), which are becoming more popular in WSNs, IoT, and crowd-sensing applications.

To deal with the uncertainty in WSNs, (Bhajantri and Sutagundar 2017; Ahamad and Kumar 2017) used clustering methods based on fuzzy logic. The authors in Bhajantri and Sutagundar (2017) introduced data processing and clustering for WSNs based on fuzzy logic. This method takes into account each node's energy level, bandwidth, and connection efficiency. The suggested work aims to increase network performance regarding the lifetime of the network, the number of live nodes, CH selection time, throughput, and energy usage. The authors in Ahamad and Kumar (2017) presented an energy-efficient clustering technique based on the fuzzy logic system to extend the WSN life span in a probabilistic approach model. With the support of an efficient CH selection approach, this effectively tackles the issue of low sensor node residual energy usage. The authors of Usha Kumari and Padma (2019) recommended three protocols: enhanced DEEC (EDEEC), developed DEEC (DDEEC), and DEEC. The rates of CH energy minimization and network longevity were investigated for each clustering strategy. In terms of sensor network longevity, the EDEEC protocol surpasses both the DECC and DDEEC protocols, according to the data.

In Rahimi and Chrysostomou (2019), the authors introduced a load balancing method that works intelligently dependent on a controller of fuzzy logic and the queue of priority to reduce and disseminate energy usage, resulting in an improvement in network life span. In Wang et al. (2018), the authors firstly offer an analytical approach for determining the ideal number of clusters in a WSN. Next, they present a centralized clustering approach dependent on the spectral division method. Following that, they offer a decentralized solution to the clustering technique based on the fuzzy c-means approach. Eventually, they ran extensive simulations, and the findings revealed that the suggested approaches beat the HEED clustering method in regards to energy cost and network longevity. The paper's authors Tarhani et al. (2014) suggest a Scalable Energy-Efficient Clustering Hierarchy (SEECH) for selecting CHs. High-degree SNs are categorized as CHs in this approach, whereas low-degree SNs are used as relays. It employs a distance-based method to assess the homogeneity of CHs for balancing clusters. As compared to the LEACH and TCAC methods, the suggested algorithm shows improved SEECH protocol performance in terms of sensor network life span.

3 Preliminaries

The energy consumption model and the network model are presented in this section.

3.1 Network Model

We provide a standard IoT monitoring environment for WSN-based IoT applications in this section. To assure the system's energy efficiency, we adopt a cluster-based architecture. The BS is at the center of a square sensing field with N randomly dispersed sensor nodes. The nodes continuously monitor the environment and report their results to the CH, which periodically transfers the data gathered to the BS (also known as the gateway). We make the following assumptions for our network model:

- The topology of the network remains static throughout the network operation.
- Sensor nodes based on the IoT are deployed in a uniform pattern but at random.
- The sensor nodes are all homogeneous.
- All sensor nodes are energy-restricted and start with the same amount of energy.
- The BS is supposed to be free of energy, computation, and network coverage limitations.
- Radio interference, as well as any obstruction or signal attenuation caused by the existence of physical objects, are not taken into account.
- We believe that the suggested protocol is extremely secure. This work's security considerations are outside the scope of this paper.

3.2 Energy Model

Sensor nodes need energy for remaining awake, network maintenance, data processing, packet receiving, packet transmission, and sensing, among other things. The amount of energy required to send a packet is proportional to the size of the packet and the distance traveled (Heinzelman et al. 2000; Al-Qurabat et al. 2021; Al-Qurabat 2022). The transmitter demands a quantity of energy to send an $w-$ bit packet across a distance of d, as given:

$$E_{\mathrm{TX}}(w,d) = \begin{cases} E_{\mathrm{elec}} \times w + \epsilon_{\mathrm{fs}} \times w \times d^2 & \text{if } d < d_0 \\ E_{\mathrm{elec}} \times w + \epsilon_{\mathrm{mp}} \times w \times d^4 & \text{if } d \geq d_0 \end{cases} \tag{1}$$

Receiving a $w-$ bit packet consumes the following amount of energy:

$$E_{\mathrm{RX}}(w) = E_{\mathrm{elec}} \times w \tag{2}$$

The energy wasted per bit by the receiver or transmitter circuits is denoted by E_{elec} in (1) and (2). In a free space model and a multi-path fading channel model, we utilize ϵ_{fs} and ϵ_{mp}, respectively, to describe the energy usage of the amplifier per bit. The distance between the receiver and transmitter is indicated by the letter d. The d_0 threshold is formulated as having

$$d_0 = \sqrt{\frac{\epsilon_{\text{fs}}}{\epsilon_{\text{mp}}}} \tag{3}$$

The data aggregation power consumption, which is denoted as E_{da}, is another factor that is considered. We suppose that each cluster member delivers $w-$ bit packet to its CH during each period of data collection, and that the energy spent by a CH during one period of collecting data may be expressed as

$$E_{\text{CH}} = \frac{N}{c} \times E_{\text{elec}} \times w + \frac{N}{c} \times E_{\text{da}} \times w + \epsilon_{\text{mp}} \times w \times d_{\text{BS}}^4 \tag{4}$$

The CH wastes energy by collecting packets from nodes, aggregating them, and transferring the resulting packets to the BS. The number of clusters is given by c, while the average distance between a CH and a BS is given by d_{BS}.

4 The FCMDE Protocol

There are four phases to implementing the FCMDE protocol. The first phase is to decide on the best number of clusters to use. The fuzzy c-means method is used in the second phase to propose a centralized clustering technique. The third phase is CH selection. This phase considers the nodes' remaining energy as well as their cluster's position (with regard to other nodes). Instead of using the sensor node closest to the centroid, FCMDE uses a novel measure in which the sensor node closest to all other nodes is chosen as the CH. Transmitting data between nodes and CHs in the clusters is the last phase.

4.1 The Optimal Number of Clusters

Since the quantity of inter-cluster communication rises with c, determining the ideal number c of clusters is crucial. However, when c is lower, the number of intra-cluster communications increases considerably. Using the silhouette coefficient (SC) or silhouette score approach Younis and Fahmy (2004), we will determine the ideal number of clusters as in the following:

$$\mathrm{SC}(n_i) = \frac{b(n_i) - a(n_i)}{\max\{a(n_i), b(n_i)\}}, \tag{5}$$

where $SC(n_i)$ is the silhouette coefficient of the sensor node n_i; $a(n_i)$ denotes the average intra-cluster distance, that is, the average distance between sensor node n_i and all other sensor nodes in the cluster to which n_i belongs. The minimal average inter-cluster distance between sensor node n_i and all clusters to which n_i does not belong is denoted by $b(n_i)$.

The SC's value ranges from [− 1, 1]. A score of 1 indicates that the sensor node is highly compact inside the cluster to which it belongs and is far distant from the other clusters. The poorest possible value is − 1. Near-zero values indicate overlapping clusters.

4.2 FCM Clustering

To split the network into a fixed optimal number of clusters, we suggest a centralized clustering algorithm based on the fuzzy c-means (Idrees and Al-Qurabat 2021) approach in this section. We presume that the sink node is fully aware of the network architecture. The sink node connects all CHs and separates the sensor nodes into c clusters: $C_1, C_2, \ldots, C_c$. The goal of this protocol's cluster creation is to decrease the following objective function:

$$J_{\min} = \sum_{i=1}^{c} \sum_{j=1}^{N} u_{ij}^m d_{ij}^2, \tag{6}$$

where u_{ij} is the degree of membership to cluster i of sensor node n_j, d_{ij} denotes the distance between sensor node n_j and the cluster i's center point. With the actual parameter $m > 1$, the degree u_{ij} of sensor node n_j with regard to the cluster is determined and fuzzyfied as follows:

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{d_{ij}}{d_{kj}} \right)^{\frac{2}{m-1}}} \tag{7}$$

In addition, the cluster center is being upgraded utilizing:

$$c_j = \frac{\sum_{i=1}^{N} u_{ij}^m n_i}{\sum_{i=1}^{N} u_{ij}^m} \tag{8}$$

The FCM-based clustering algorithm's behavior is determined by the clusters' number c in addition to the sensor nodes' number. Because the number of functioning sensor nodes fluctuates from period to period, clustering occurs at the start of each period. During the clustering phase, the following activities are taken:

1. Set the clusters' number to c.
2. Assign c initial cluster centers at random.
3. Use (7) to compute the matrix of membership.
4. Use (8) to compute the center of the cluster.
5. Steps 3 and 4 should be repeated until equilibrium is achieved (fixed centers).

The FCM algorithm associates the cluster center coordinates with their sensor members; only the sensor node's membership is taken into account by our protocol.

4.3 CH Selection

Clustering is conducted prior to CH selection in this study to decrease the energy consumed in the process of cluster creation. Two factors must be met by the CH selection policy.

4.3.1 *Position Inside the Cluster*

Rather than the node closest to the cluster's center, the CH is chosen based on its proximity to the most other nodes. Because the aim of the proposed protocol is to minimize the energy required by sensors for sending to the CH, rather than to choose the node at the cluster's center, this requirement, which we call the proximity criterion, is more beneficial than closeness of the possible CH to the cluster's center. We develop a cost function, λ, that calculates the Euclidean distance between the selected node and all other in-cluster nodes to discover the sensor that is closest to the most other nodes and costs the least amount of energy to broadcast to inside its cluster.

$$\lambda = \sum_{j=1}^{c} \sum_{n_i \in C_j} d\left(n_i, X_j\right), \tag{9}$$

where n_i denotes the ith node in the network, X_j indicates the centroid of the sensor nodes in a specific cluster, and C_j comprises N_j nodes and the Euclidean distance $d(n_i, X_j)$ is given by

$$d\left(n_i, X_j\right) = \left\|n_i - X_j\right\|^2. \tag{10}$$

4.3.2 The Level of Residual Energy

A node's remaining energy should be over a certain threshold E_{TH} in order for it to be considered for CH selection. This criterion is required to prevent the CH from dying too soon, resulting in the network being disconnected. For every CH selection, we create an energy-related cost function that describes the toenergy usage for all sensor cluster members. When sensor node X_i is designated as CH, the energy-related cost functions $E_{\mathrm{Co}}(\mathrm{CH}_i)$ for each cluster of n_c sensonodes are expressed as the total consumed energy of all sensor nodes.

$$E_{\mathrm{Co}}(\mathrm{CH}_i) = \sum_{j=1, j\neq i}^{n_c} E_{\mathrm{TX}}\big(x_j \to X_i\big) + (n_c - 1) \times E_{\mathrm{RX}}(X_i) + E_{\mathrm{TX}}(X_i \to \mathrm{BS}), \tag{11}$$

where

- $E_{\mathrm{TX}}\big(x_j \to X_i\big)$: The amount of energy expended by sensor node x_j to send a data packet to CH X_i.
- $E_{\mathrm{RX}}(X_i)$: The amount of energy utilized by the CH X_i when it receives a data packet from a sensor node.
- $E_{\mathrm{TX}}(X_i \to \mathrm{BS})$: The amount of energy expended by CH node X_i during the transmission of the aggregated data packet to the BS.

The BS calculates the cost functions relating to energy and closeness for each cluster and chooses the node with the lowest $E_{\mathrm{Co}}(\mathrm{CH})$ and λ as the CH. The BS transmits a packet of information to every node in the network once the CH has elected, which includes the CH ID, and the cluster ID. Following the CH election, the BS changes the state of the nodes in its system (energy levels of nodes).

Following the completion of the initial configuration of the network, the CHs in the next period will compare their energy levels ($E_{\mathrm{CH-Th}}(i)$) to the energy threshold function E_{TH}. The CH can maintain intra-cluster communication with member nodes of a cluster if the present CH remaining energy levels ($E_{\mathrm{CH-Th}}(i)$) are equivalent or higher than the energy threshold level E_{TH}; otherwise, the CH must discontinue and demand the creation of a new cluster. Therefore, the CH could remain without change for consecutive periods until its residual energy falls below the threshold.

5 Transmission of Data

The sensor nodes begin transmitting data to the CHs when the CHs are identified. Due to the obvious shortest geographic distance to the CHs attained by the FCM algorithm, the transmitting power of cluster member nodes is enhanced. The CHs perform data aggregation, reducing the quantity of data and then transmit the aggregated data to the BS.

6 Simulation and Performance Evaluation

The simulation findings used to assess our suggested protocol (FCMDE) are presented in this section. The FCMDE supposes that the sensor nodes are deployed in a 1000×1000 m region for building the network model. The sink node is positioned in the center of the network (500, 500). Table 1 lists the factors that were utilized in the simulations. The FCMDE protocol is compared to the DDEEC (Qin et al. 2017) and SEECH (Tarhani et al. 2014) protocols in four aspects: network lifetime, throughput, and energy consumption.

It is critical that all sensor nodes remain operational as long as feasible since the performance of the network suffers when a node dies. As a result, knowing the death time of the first node is critical. The period of time during which the network's first node dies is described as the network's lifetime. First-SN, Half-SN, and Last-SN (periods' number during which the network's first, half, and last node die, respectively) are all being included in the study. Figure 1 shows the comparison of FCMDE with SEECH and DDEEC simulation results.

Table 1 Simulation factors

Factors	Value
WSN size	1000×1000 m
SNs no	100
Initial energy	100 J
E_{da}	5 nJ/bit/signal
ϵ_{fs}	10 pJ/bit/m^2
ϵ_{mp}	0.0013 pJ/bit/m^4
E_{elec}	50 nJ/bit
Packet size	512 bytes

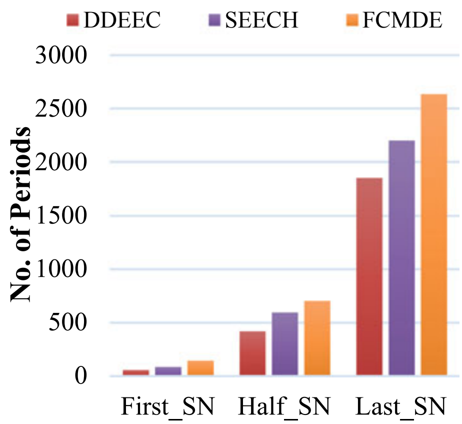

Fig. 1 First-SN, Half-SN, and Last-SN stages of the network

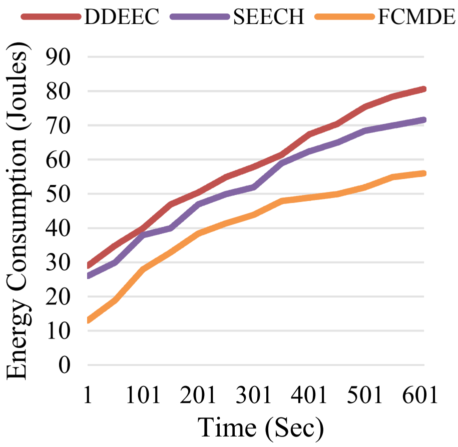

Fig. 2 Energy consumption of the network

It is shown by the results obtained in Fig. 1; the suggested protocol (FCMDE) has a first-SN enhancement of roughly 250% and 168% when compared to DDEEC and SEECH, respectively. The Half-SN and Last-SN are also superior in comparison.

In the next experiment, the FCMDE protocol investigates how much energy is lost on average inside the network. Consumption of energy is among the ultimate important factors to consider when determining WSN's effectiveness. Figure 2 compares the suggested FCMDE protocol to the DDEEC and SEECH strategies in terms of energy usage. Experiment results demonstrate that the energy consumption during every period was already lowered. The FCMDE protocol uses roughly 10 and 18 J throughout the transmission of data, respectively, which is less than the SEECH and DDEEC protocols. The findings demonstrate that the FCMDE protocol performs best and saves more energy in comparison with the other two protocols.

Another simulation experiment was conducted to assess the network's throughput. Throughput is defined as the ratio of the packets that the CH acknowledges to the delay of the communication of packets in the process of transmitting, which defined as

$$\text{Throughput} = \frac{\text{total No. of packets received by CH}}{\text{delay in process of communication}} \tag{12}$$

The analysis of the throughput of the suggested FCMDE protocol compared to SEECH and DDEEC protocols is shown in Fig. 3. When compared to the DDEEC and SEECH protocols, the quantity of packets sent to the CH in the suggested FCMDE protocol is 22% and 13% faster, respectively. As a result, as compared to previous techniques, throughput measuring has grown over time.

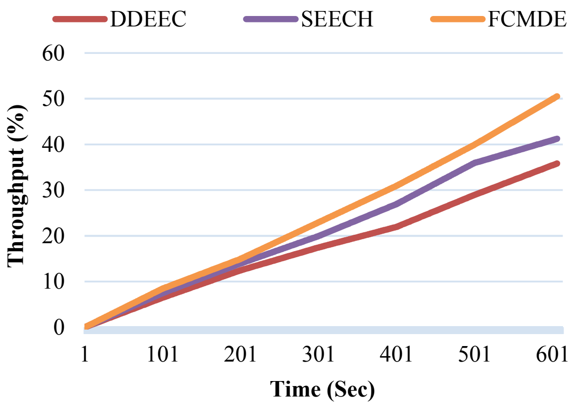

Fig. 3 Throughput of the network

7 Conclusions

In this study, FCMDE was introduced as a clustering protocol for WSN-based IoT. The suggested FCMDE reduces energy drain and increases longevity while minimizing overhead costs. FCDME chooses a CH during clustering by combining fuzzy c-means, node location, and residual power. In an attempt to reduce transmission overhead costs and unnecessary CH changes for every transmission period, FCMDE uses functions of thresholds, namely the threshold of energy and the proximity criterion. The effectiveness of the suggested FCMDE protocol has been demonstrated through thorough simulation using a variety of possible assessment performance indicators. Average energy usage, network longevity, and throughput are all examples of these indicators. A comparison analysis of SEECH and DDEEC procedures was also conducted, demonstrating the superiority of the FCMDE approach.

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Smart Vending Machine for B40 Student

Ahmad Azharudin, Siti Maryam Sharun, Muhammad Firdaus Asyraf Abdul Halim Yap, and Syamimi Mohd Norzeli

Abstract A vending machine is a money operated machine that dispenses goods automatically such as snacks, drinks, and other consumer products. It allows the customers to get what they want by making payment into the machine. The payment systems come in many forms such as cash (coins and notes) and credit or debit cards. The latest technology applied in the vending machine allows payments to be made via smartphone, a key for the transmitter, or something similar. These systems accept payment, determine value, and make a change if necessary. Smart Vending Machine for B40 was a vending machine that provides healthy food such as bread and packed meals for B40 students in Universiti Sultan Zainal Abidin (UniSZA). Smart Vending Machine applies Quick Response (QR) code as the method to access the vending machine whereby specially designed QR code for B40 students of UniSZA was installed in the student's matric or student identification cards and allows them to take the food from the vending machine without having to make any payment.

Keywords Smart · Vending Machine · B40 · QR code · Student

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1 Introduction

The Smart Vending Machine for B40 students will be created to help the student who doesn't have enough money to survive in the University. This can reduce the burden on the student and their family. This project collaborates with Kolej Kediaman UniSZA. This vending machine will be placed at Kolej Kediaman to provide free food and drink for the student who needed, and this vending machine was only use QR code and doesn't use the money and coin collector. QR code only will be provided for the chosen student at Kolej Kediaman who in needed only. The objective of this vending machine was to replace the foodbank. The function of the foodbank was to store the food and give it to the student needed. Foodbank doesn't have the security that guards the food against the food pick up by the wrong group of students. So, this vending machine was created to guard the food and to give the food to the right group of students only (Wetherill et al. 2019).

This vending machine uses the Arduino system. This system will program to allow only provided QR code can use with this vending machine. This system also programs to record the name of the student and the time when the student picks up the food and drink in Google sheet (González-Torre et al. 2017). This can control the taking of food and drink by the student and can provide enough food for a student that is needed. Only one time per student can use the QR code to take the food from this Smart Vending Machine (Lohnes and Wilson 2018).

Most universities in Malaysia today provide wakaf carts that contain various types of foods and beverages such as dried foods, drinks, and even bread (Alkaabneh et al. 2020). The purpose of these wakaf carts was to help students categorized as B40 to get food when they needed it. However, it was found that the food inside the wakaf charts was also taken by other students. Therefore, the primary purpose of assisting B40 students cannot be realized. The concept of a wakaf cart that provides unbalanced food also makes it less suitable to help students' mental and physical development. Foods and beverages offered in school vending machines continue to be high in fat and calories (Rombach et al. 2018).

The project "Smart Vending Machine for B40 Students" encompasses several study scopes (Bodhale and Kulkarni 2017). Firstly, it aims to provide sufficient and nutritious food to the B40 student group. Secondly, it focuses on preventing food access by the wrong students. Lastly, it seeks to alleviate financial burdens on B40 families. The project's objectives include designing a healthy meal vending machine, creating an economical prototype, and programming a smart vending machine. This initiative will benefit financially challenged B40 students, easing their daily food expenses at university and relieving their parents' burdens (Higuchi 2007). Additionally, it aligns with the healthy meal guidelines set by the Ministry of Health Malaysia.

2 Methodology

The purpose of this research was to develop a vending machine that can store the meal, fruit, and water that can control the food intake from the wrong group target. Our research focuses on the B40 group that was studied at University Sultan Zainal Abidin. We choose the B40 group because want to help them to reduce their financial burden. Their emotions and studies will interrupt because of the financial burden. The vending machine is composed of two segments: a mechanical part and a system. For the development and design of the mechanical component, we utilize Autodesk Fusion 360, a tool capable of generating 3D models and technical drawings. These 3D models provide a clear representation of our product in three dimensions, and we can easily bring them to life through 3D printing.

Technical drawing, drafting, or drawing, is the act and discipline of composing drawings that visually communicate how something functions or is constructed. The technical drawing is essential for communicating ideas in industry and engineering. To make the drawings easier to understand, people use familiar symbols, perspectives, units of measurement, notation systems, visual styles, and page layout. Together, such conventions constitute a visual language and help to ensure that the drawing is unambiguous and relatively easy to understand. Many of the symbols and principles of technical drawing are codified in an international standard called ISO 128. The system part of this vending machine is produced using Arduino components and Arduino software. The essential Arduino components, including Arduino Uno, servo motor, Bluetooth module, jumper wire, and belt, enable the movement of the conveyor and elevator within the vending machine. To develop the system, Arduino IDE is utilized, a powerful software capable of coding and controlling the mechanical part's movement in the vending machine.

2.1 Questionnaire

This questionnaire primarily targets the B40 student group, with 37 respondents, the majority of whom belong to the B40 group, providing their answers. Through this approach, a wealth of valuable information has been collected, which can be utilized in this study. Additionally, the insights gained from this questionnaire have contributed to the development of a smart vending machine tailored to the needs of B40 students, ensuring that it meets the required criteria and delivers a satisfactory user experience.

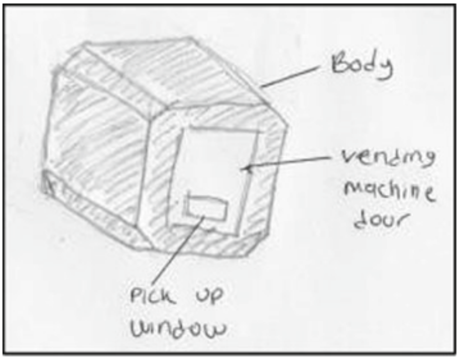


Fig. 1 Idea generation 4

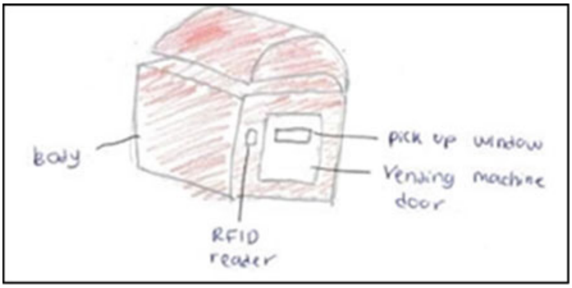


Fig. 2 Idea generation 5

2.2 Design Development

To design the 3D model of this Smart Vending Machine, Autodesk Fusion 360 was used. Before using this software, idea generation must develop first. Figures 1 and 2 show the selected idea generation for this Smart Vending Machine and complete technical drawing of selection idea generation as illustrated in Fig. 3.

2.3 System Development

The vending machine's system control relied on Arduino Uno, acting as the microcontroller responsible for managing the project's system and sensors. Programming this Arduino was conveniently accomplished using Arduino IDE, which utilizes the C++ language known for its user-friendly nature and ease of coding.

For the mobile application development aimed at the smart vending machine catering to B40 students, MIT App Inventor was chosen. This application was created

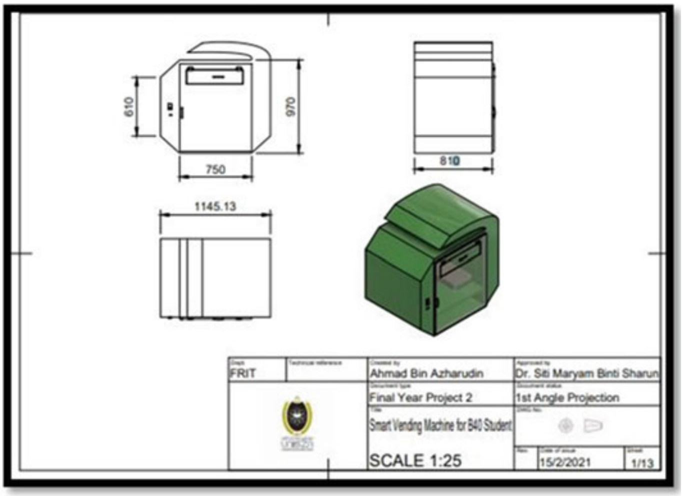


Fig. 3 Technical drawing

free of charge and can be seamlessly connected to a phone or emulator. The flowchart of the smart vending machine system is depicted in Fig. 4.

Moreover, a specially designed student matric card incorporates a vending machine QR code, granting access exclusively to B40 students, as illustrated in Fig. 5. This unique feature ensures a secure and exclusive experience for the intended user group.

Table 1 outlines the electronic components integrated into the smart vending machine designed for B40 students.

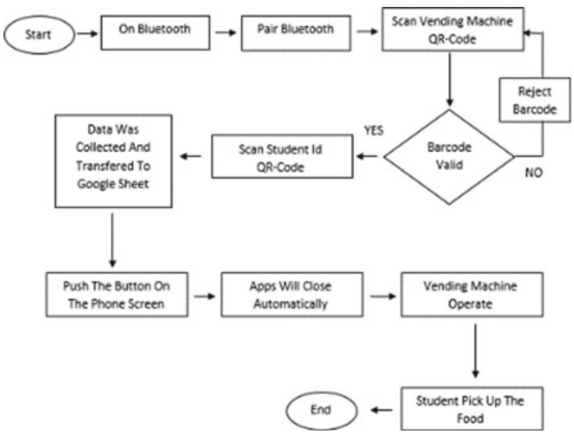


Fig. 4 Smart vending machine for B40 system flowchart

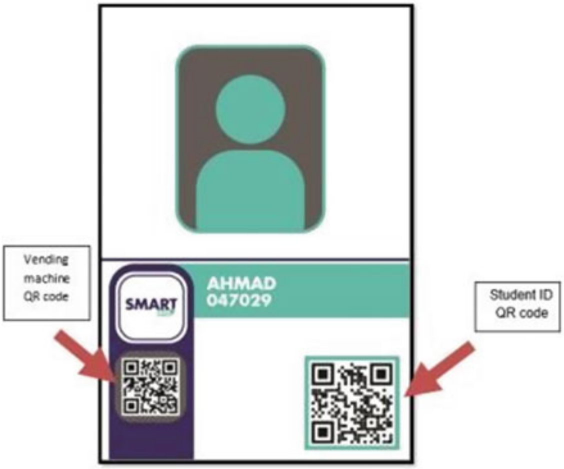


Fig. 5 Smart vending machine for B40 matric card

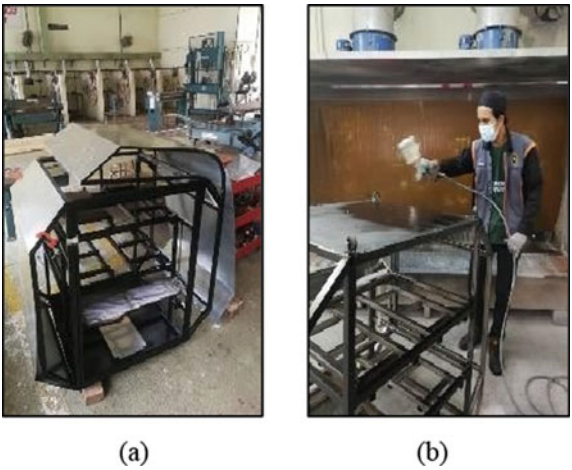
Table 1 Electronic component

Component	Function	Quantity
Arduino Uno 	To control the entire system in the vending machine	3
Stepper Motor Nema 17 	To control conveyor movement and lifting	4
A4988 stepper motor driver 	To control the stepper motor	4
Hc-05 Bluetooth module 	Can control the system remotely	1
Breadboard 	To connect electronic components	3

2.4 Product Development

The fabrication of the smart vending machine's body involved using 1-inch mild steel hollow. The mild steel was accurately marked with the appropriate dimensions using a scriber. Subsequently, it was cut using a cutoff machine, and any sharp edges

Fig. 6 **a** Body fabricate; **b** spray process



were smoothed out with an angle grinder. MIG welding was employed to assemble the mild steel components, creating the frame of the vending machine.

As for the body cover, 0.3-mm-thick sheet metal was utilized. It too was marked with a scriber and then cut using sheet metal cutter scissors. To attach the sheet metal to the frame, a cordless drill and rivets were employed, ensuring a secure and sturdy construction.

Finally, the body fabrication was completed through a spray process. This involved the use of a compressor and spray gun to apply black color to the interior of the vending machine and green color to the outside body, as depicted in Fig. 6.

2.5 Product Testing

This product was test by 15 of B40 student which is this vending machine was placed in the library in UniSZA.

3 Results and Discussion

Smart Vending Machine for B40 student was operated by using electric power only. This vending machine can plug and play anywhere that has electricity. This smart vending machine was controlled by using an application that installs on phone. This vending machine can be operated only for the targeted group of the student only by using the smart vending machine QR code. Without this QR code, the vending machine doesn't function. Student id was recorded in Google Sheet immediately when a student scans their id card. The conveyor and lifting mechanism were operated by the stepper motor. This stepper motor had its own driver that can control the movement and speed of the stepper motor. Lastly, this vending machine had its door security system.

3.1 Mobile Application Testing

Figure 7a shows the main page of this vending machine application. When touching the vending machine logo, the application is required to scan the vending machine QR code. If the QR code wrong, it cannot move to page two of this application that shows in Fig. 7b. Figure 7b shows the page of the application that student needs to scan their id card. When student scans their id card, the data such as date, time, and name of the student will be recorded in Google Sheet. As shown in Fig. 7c, this application must be connected to the vending machine. To connect it, Bluetooth is needed. When the phone and vending machine were connected, the Bluetooth display in this application will turn green as shown in Fig. 7d. The vending machine will operate when the student touches the food logo. Lastly, when students touch the food logo, this application will close automatically.

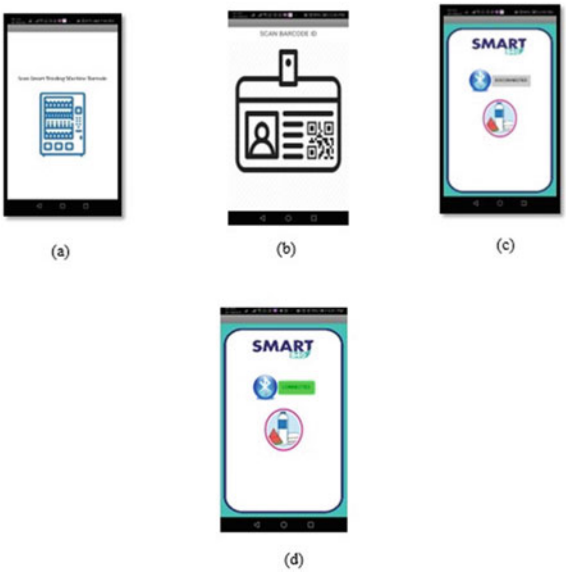


Fig. 7 Mobile application testing

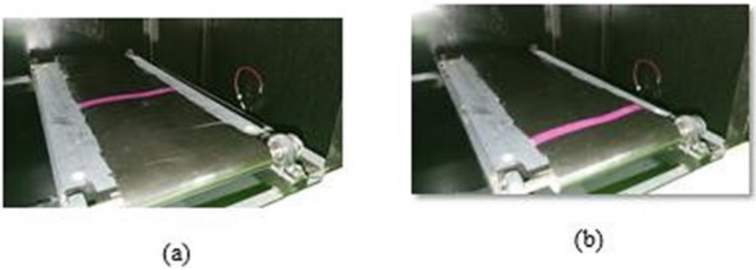


Fig. 8 **a** Original position of conveyor belt; **b** moving conveyor belt with apps

3.2 Conveyor Testing

The conveyor was the most important part of this project. It is used to transfer food and drink to the lifting mechanism. Without a conveyor, this vending machine doesn't function smoothly. This conveyor was used a stepper motor to control its speed rotation and direction. As below, Fig. 8a shows the original position of the conveyor belt in this vending machine. The pink tape was used to mark the position of the original conveyor belt. Figure 8b shows the conveyor belt moves forward when the mobile application of this vending machine was applied.

3.3 Lifting Mechanism Testing

A lifting mechanism was used to lift the food and water from the conveyor to the pickup window of the vending machine. Figure 9a was showed the original position of the lifting mechanism. Figure 9b showed the lifting mechanism was lift until it reaches the pickup window.

3.4 Door Security System

The door security system was used RFID reader to make sure only the right person can open this vending machine. Figure 10a shows the LED was in red because this person was used the wrong card to access this vending machine door. When LED was in red condition, the door of this vending machine cannot be open. When the LED turns in blue color as shown in Fig. 10b, the person has used the right card and the door of this vending machine can open.

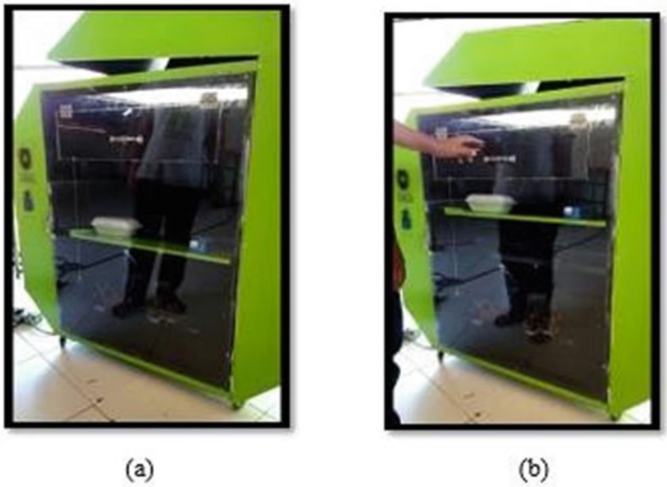


Fig. 9 Lifting mechanism testing

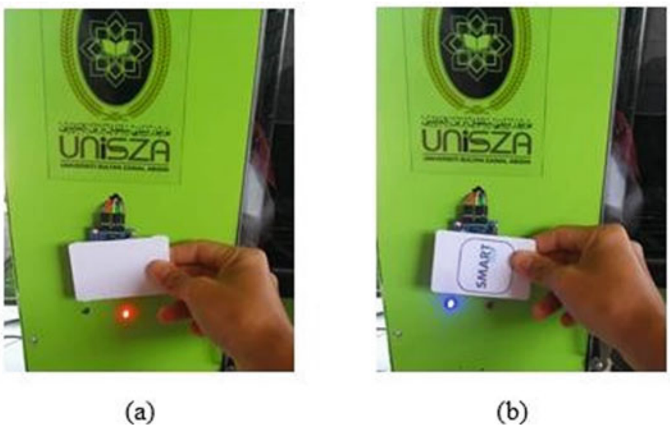


Fig. 10 Door security system testing

4 Conclusion

In conclusion, the smart vending machine designed for B40 students serves as an interactive solution to alleviate their burden. This innovative vending machine eliminates the need for students to insert money or coins since the distributed food and drinks are provided free of charge. It is composed of two parts: the mechanical component and the system component. QR code technology is employed to unlock and access the items, ensuring a secure system that grants access only to the intended user group. Notably, the vending machine does not rely on push buttons for item retrieval; instead, it offers a user-friendly experience through a smartphone interface, allowing students to select their desired food and drinks conveniently.

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