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Development of Water Sound Analyzer for An Automatic Fertilizer System in Agriculture Industry

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Abstract: Fertigation is a modern agriculture process that allows the right amount of nutrients to the plant compared to traditional approaches. However, the fertigation system used manual mixing of the fertilizer compound with water which may affect the precision of the compound and could affect the growth of a plant. This project developed a water sound classification using Edge Impulse by simulation and modeling and its implementation using Arduino Nano BLE 33 and ESP8266 Wi-Fi module with IoT Blynk platform. In Edge Impulse Studio, the model and simulation for the water sound classification are developed. It was observed to the electrical conductivity (EC) value for nutrients consume by the crops. Moreover, the automatic fertilizer system is wirelessly connected so a user can easily monitor the water level of the fertilizer mixer tank. Finally, the system has shown its potential to provide a new alternative way of controlling a fertigation system.

Keywords: Fertigation, Water sound classification, Arduino Nano BLE 33 Sense, Edge Impulse Studio, Ultrasonic sensor.

1. Introduction

In this day and age, the agriculture sector is essential to our country. As a result, agriculture contributes 12 percent to the national GDP and provides employment for 16 percent of the population [1]. However, the Covid-19 world pandemic started in 2019 and resulted in immediate, serious human health issues around the world as well as in Malaysia. Quarantines and other restrictions have been implemented to combat pandemics and these measures are expected to remain in place for many weeks and months causing negative economic effects linked also with the functioning of agriculture systems.

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But, modern agriculture, such as fertilization, can have a positive impact on yield production, apart from increased entrepreneurial income [2]. Smart and intelligent irrigation and fertilization systems are the keys to modern agriculture to control the correct nutrient absorption of plants [3]. This could be an opportunity for farmers to broaden the fertigation technology for their income as well as help to raise Malaysia's economy.

Over the years various methods of fertigation have been introduced and implemented either in manual or automatic ways. Fertilization system upgrades could be one of the factors commercializing the fertigation system in agriculture. The system that was already invented such as the use of timer, water level sensor, and water pressure, it's had its pros and cons in terms of accuracy of the reading, the monitoring part, and the mixing. The automatic system now uses an EC sensor to automatically check the concentration of the mixed nutrient solution. Therefore, this easy-to-use and inexpensive automated system reduce the burden on farmers [4]. Moreover, the water level sensor could be applied in this fertigation system. The water level alert system in industries can notify the user with an alarm when the water level reached is too high or too low; systems may be wired or wireless [5]. With the implementation of sensing the water level, the sound of water can be analyzed. Thus, this system could be improved by using edge impulse despite the previous system. Edge Impulse enables software developers, engineers, and domain experts can solve real problems using machine learning on edge devices without advanced embedded engineering skills [6]. Building up the electric conductivity (EC) in the plant and consequently, the substrate is important in the plant's growth. This demand is controlled by assimilation. The bigger a plant grows the more nutrition it will need. These nutrients are partly locked in the plant and converted into usable amino acids, oils, and fat. Potassium is one of the most important nutritional elements in this process.

Although numerous methods had been done in the previous study, this paper focuses on the use of edge impulse to detect the sample of the sound that is used to determine the function of the system. Thus, the monitoring device concept combines an Internet of Things (IoT) with an Arduino microcontroller based on embedded machine learning.

2. Materials and Methods

The proposed work consists of several stages of development.

2.1 Software development

i. Development Model and simulation for water sound classification in Edge Impulse

The development of the model system for sound classification was implemented in the Edge Impulse Studio. Edge Impulse Studio provides the step before deploying it in the Arduino Nano BLE 33 Sense. Figure 1 shows a block diagram of the following steps in Edge Impulse Studio.

Figure 1: The process of the development model in edge impulse

In the sampling stage, the two (2) types of sounds and 30 seconds for each sound have been collected. The raw sound recorded needs to be processed resulting in the output of the neural network defining the classification and a rating of confidence. In the training step, the model uses the samples collected earlier. the system needs to be trained to observe the accuracy of the model. The model needs to be tested for checking the model performance using live classification before

the deployment to the Arduino Nano BLE 33 Sense. For testing, new live data from different water sound sources and backgrounds were recorded.

2.2 Hardware development

i. Arduino Nano BLE 33 Sense

This controller is chosen because it is equipped with sensors to detect color, proximity, motion, temperature, humidity, and audio. The impressive selection of sensors for audio is the possibility to analyze the water sound classification. The development for the main system of fertigation is executed in the Arduino Nano BLE 33 Sense. the simulation model program from edge impulse was uploaded to Arduino and connected with other components. Figure 2 illustrates the schematic diagram for the Arduino.

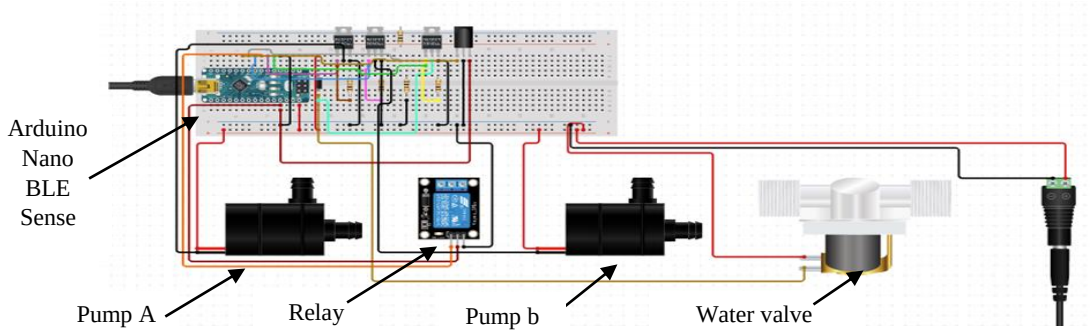

Figure 2: Schematic diagram of Arduino nano BLE 33 senses to the water pump

ii.ESP8266 Wi-Fi Module

As that of an IoT technology system, the system is based on the NodeMCU board. The NodeMCU is connected to the internet via WIFI from the hotspot of the smartphone because the NodeMCU has an ESP8266 circuit to connect to the internet. ESP8266 Wi-Fi module is used to send information from the ultrasonic sensor for the water level in fertigation to the Blynk application and delivery function to the valve for the water sources. As a consequence, the parts were chosen based on their functions and the requirements of this study. The electronic components are essential to this project because they sense, interpret, and transfer information and data for display. The interface displayed the water level in the tank for fertilizer A, fertilizer B and the mixing tank in the Blynk application is quite simple so that the user easily can use it. It showed the percentage of the level by determining it using coding. It is user-friendly because the farmer is easy to understand compounds without specific knowledge. Figure 3 illustrates the schematic diagram of the ESP8266. Blynk is used as the platform for monitoring and controlling the fertigation system with a simple interface.

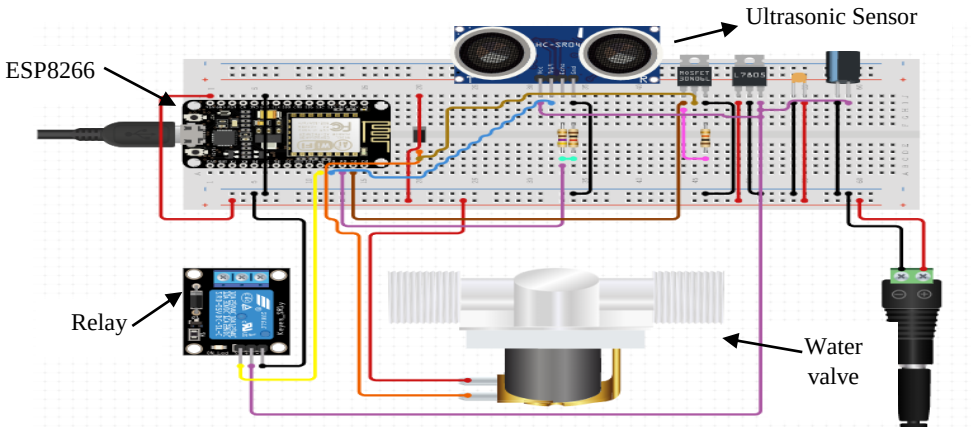

Figure 3: Schematic diagram of the ESP8266 connection

2.3 Operational of the system

The system was developed on a fertilizer system for the fertigation and the water level of the fertigation tank. Figure 4 illustrates the overview of the proposed automatic fertilizer design.

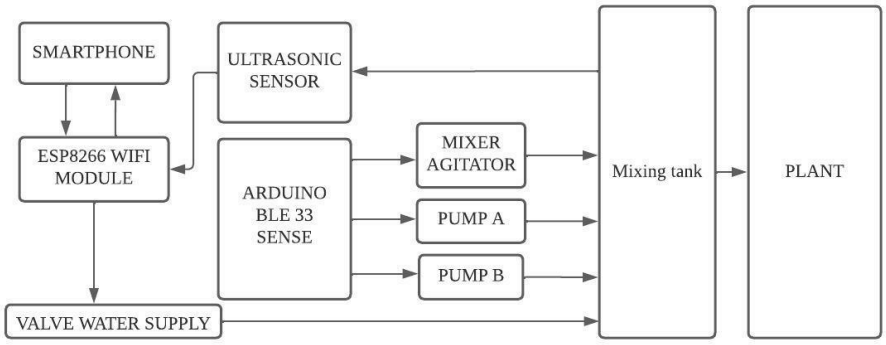

Figure 4: Block diagram of automatic fertilizer flow

The process was started with the flow of water supply in the mixer of the fertilizer tank and the Arduino BLE 33 senses will trigger the sense of water flow. Next, the Arduino triggers the sense of water flow from fertilizers A and B after the water sources was filled. When the water source in the mixer tank reaches 800L in 30 minutes, pumps A and B will release 0.25L in 15 seconds, the pump and valve for water sources are automatically closed and start for the irrigation in the next step. The mixer of water and fertilizer produces fertilizer with an EC concentration of 1.5EC. The ratio is 1:100 to get the 1.5ms/cm of EC concentration [7]. The range is suitable for the growth of all types of crops. Therefore, the design is improved by using the ESP8266 WIFI module to monitor the level of the water level of the tank through the phone. The level of water in the mixer tank will be reduced and will be monitored with the Blynk application through a smartphone. Figure 5 represents the layout of the whole system.

Figure 5: The layout of the automatic fertilizer system

Figure 6 shows the Blynk interface for monitoring the fertilization parameters. There are several icons and displays in the Blynk application that show the level of content for each tank, namely the water level for tanks A, B, and the main tank of the fertilizer and water mixture. In addition, there is a button icon for the user to use to start the fertigation mixture system, which is the "On" button.

Figure 6: Blynk interface

3. Results and Discussion

3.1 Water Sound Classification using Edge Impulse

The sample was taken and trained in the Edge Impulse Studio following the step discussed in the previous section. The model needed to be trained to classify the sound of water and the environment's noise. The setup for training cycles in this model is 100 cycles to get a good result. This specifies the number of times the model is trained. The results were good, with an accuracy of 80.8 percent. The

result shown in Figure 7 is the output training result. The model was tested before it deploys into the device. The test needed to know how well it performs on unseen data. New samples from the water sound and random sound were taken as testing samples. The sample resulted that 65 percent. Figure 8 gives the real test data of the model.

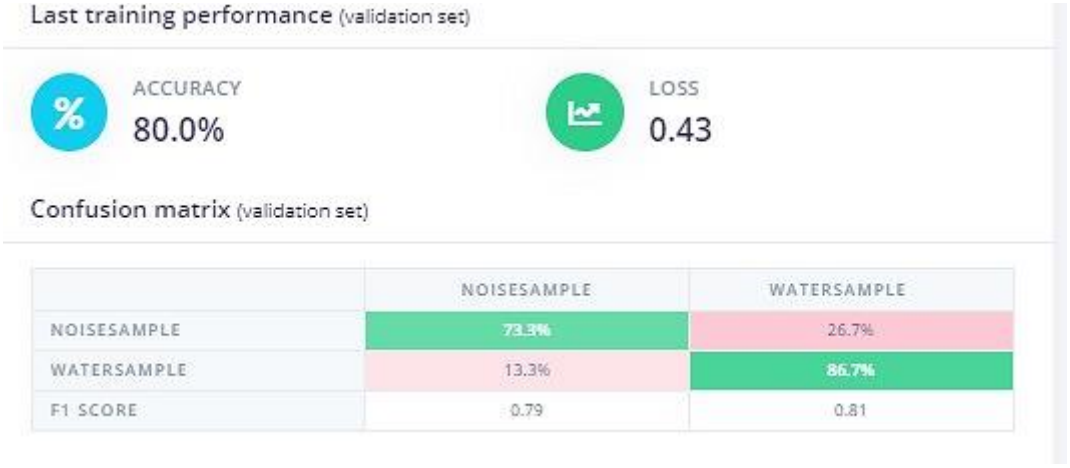

Figure 7: The output training result

Figure 8: The test data of the model

3.2 Implementation of Water Sound Analyzer

The design was tested after the code is adjusted in the Arduino IDE software. The design was tested on the system fertigation at the Pejabat Pertanian Batu Pahat, Johor. The initial condition for the connection on the fertigation tank is shown in Figure 9. When the water starts running through the Blynk application, the Arduino Nano Ble 33 senses will detect the sound of water flow and the green led board will be on. The green led indicates the system is starting the process of filling water and the fertilizer as well. Figure 10 indicates the Arduino sensor triggered the sound of running water.

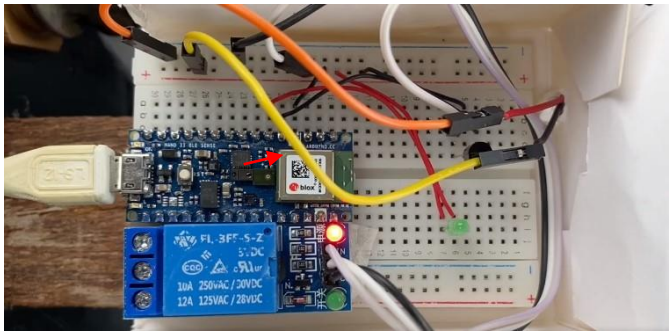

Figure 9: The initial condition of the system

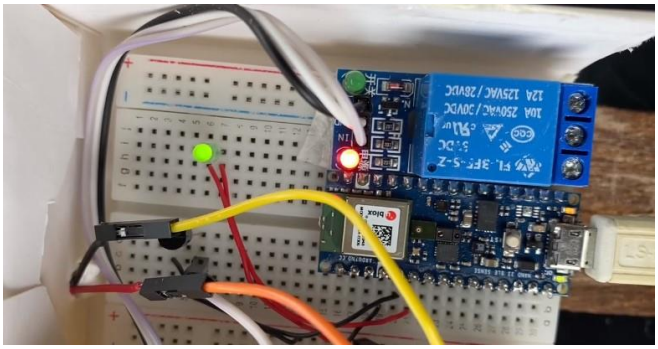

Figure 10: The condition when water sound detected

3.3 Performance of an automatic fertilizer system

The system runs normally despite a minor error on the flow rate sensor. The water level is monitored from all tanks after the Arduino Nano BLE 33 Senses start to detect the run of the water source. The water pump A and B start functioning after the Arduino is triggered by the motion of water sources. Therefore, the ultrasonic sensor can correctly detect the water level. However, the delay in detecting motion by the Arduino Nano BLE 33 Senses causes a slight lack of accuracy in water level readings. As a result, the system can be implemented in a real-world automatic fertilizer system to reduce the workload of farmers. The system is advantageous to farmers since the reading of electrical conductivity (EC) for mixer fertilizer is reliable because the ratio is already calculated and set in the Arduino coding. Table 1 summarizes the automatic fertilizer system's observation performance.

Table 1: The observation of the performance of the system

Condition	Observation	Process involved
Initial Condition	UltraSonic 1: 30cm	Water Sources Valve Open
	UltraSonic A: 40cm =150L	Water Pump A On
	UltraSonic B: 40cm = 150L	Water Pump B On
	EC value: 0mS/cm	-
Final condition	UltraSonic 1: 27.96cm =800L	Water valve close after 20minutes counted
	UltraSonic A: 38cm =149.75L	Water pump A off after 15seconds counted
	UltraSonic B: 38cm =149.75L	Water pump A off after 15seconds counted
	EC value: 1.3mS/cm	Measured by EC meter

3.3 Packaging design

Figure 11 shows the concept design of the device consisting of an Arduino microcontroller, LED driven circuit. The casing of the device is made of polycarbonate plastic as it is an ideal material widely used in industry for its characteristics. Polycarbonate plastic has high strength from fracture and is very lightweight. Polycarbonate plastic with excellent waterproof properties makes it suitable to be placed directly for outdoor use. Polycarbonate panels are very light when compared to glass, acrylic, or other plastics, thus easy transportation, installation and lower labour costs.

Figure 11: Packaging setup for Arduino nano BLE sense

4. Conclusion

In conclusion, a prototype of a water sound analyzer based on an Arduino controller using Edge Impulse machine learning was successfully demonstrated. A simulation and modeling of water sound classification were developed using Edge Impulse, which was later embedded into Arduino Nano BLE Sense and detected the sound of water running in the fertigation tank. This system is automatically run after being triggered by the Arduino and the setup of the ratio for EC reading of the mixture is already built in the Arduino. Although, the positive result is that the EC reading obtained by the mixer is within the required range which is 1.3mS/cm to promote growth and provide adequate nutrition to the plant. However, this ratio is suitable only for the plant that used a ratio of 1:100 of mixer for fertilizer. Using the Blynk App, farmers can monitor the water level in all of their tanks from a distance. This system is advantageous in many ways, including cost, human energy, and time. This intelligent system improves environmental sustainability and reduces carbon footprint.

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