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PREAGRIOT: Precision Agriculture Iot Monitoring And Controlling System

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ABSTRACT – Precision agriculture is an emerging technology in Malaysia. It is a remote sensing-based technique combined with analysed data and relevant information to support management in optimizing and sustaining agricultural productivity. The yield of various agricultural products can be influenced by few factors such as the condition of soil, temperature, humidity, and weather. Traditional farming often requires a human presence on the site to monitor and control the ideal surrounding and this may consume time and money. Many system focus on monitoring only without embedding multipurpose controlling function. Thus, a precision agriculture for monitoring and controlling system (PREAGRIoT) is introduced to overcome this problem. PREAGRIoT is a system that integrates a free custom Telegram bot with an open-source Internet of Things (IoT) platform called NodeMCU ESP8266. It is specifically designed to monitor temperature and humidity by using a BME280 sensor. PREAGRIoT can control any electrical appliances for remote intervention at the monitored area. A test-bed of the prototype reveals the ability of PREAGRIoT to sense changes of temperature and humidity precisely at two decimal places and easily switch on any electrical output.

KEYWORDS : Precision agriculture, ESP8266, Telegram, Monitoring, Internet of Things

1.0 INTRODUCTION

United Nation (UN) Food and Agriculture Organization believed that the increase of world population will cause each country in this globe to produce 70% more food by 2050 [1]. Malaysia is not an exceptional. The country will need to leap rapidly to secure food supply in order to sustain independently. One of the objectives of the recent National Food Policy Security Plan 2021-2025 [2] is to involve private sector and the populations into the food system. This will induce technologies into agriculture. Internet of Things (IoT) based automation along with Precision agriculture (PA) will become a game changer to increase agricultural productivity with a reduced human effort [3]–[6].

Monitoring and controlling are among the major concern for technological solution and continuously manoeuvred at an agricultural area which is to improve the efficiency of daily task such as field management, soil and crop monitoring and even movement of unwanted objects [7]. Temperature and humidity monitoring are one of the frequently deployed [8]–[10] task among traditional farmers. They usually depend on conventional method such as using digital thermometer and even require human labor to execute the temperature and humidity control mechanism in order to have an ideal surrounding. Most of the countries in the world are having issue with declining number of agricultural workforces. This includes Malaysia. Thus, a simple, versatile and beginner-friendly IoT system must be made available and affordable to tackle this problem among our traditional farmers.

There are few methods of IoT based agricultural monitoring and controlling technologies that had been introduced previously. The technologies may differ between types of communication, the distance of the monitored area and even the speed of transferred data.

Global System for Mobile (GSM) communications is one of common IoT based platform for smart agriculture system. The ability to be able to connect to remote area had gained interest in some researchers such in [11]–[13] to develop GSM based monitoring system at their studied agricultural area. Despite this ability, GSM also requires specific instructions to be sent using short messaging service (SMS) and this will incur cost to users[14].

Researchers in [15] focus on designing a wireless sensor network (WSN) for precision agriculture using Zigbee network. Although according to [13], Zigbee has the advantage of low power consumption, but is also mentioned that the technology is not reliable for long distance transmission.

To overcome the distance problems, several researchers such in [16]–[18] also had looked into Long Range Wide Area Network (LoRaWAN) in monitoring their agricultural issues. Researchers in [19] had emphasised the ability of LoRaWAN to send data at long distance and conserve battery for years, but they also pointed out that the low data rate will cause data to unable be received in real time. This will cause a critical issue in monitoring system.

Most of these researches only focus on the monitoring part and do not embed controlling actuators in their system. Hence, this paper introduces precision agriculture for monitoring and controlling device (PREAGRIoT) which is an IoT temperature and humidity monitoring device with the addition of possible precise control of any electrical output from user with the aid of Telegram bot. The monitoring device is applicable to all types of agricultural area that requires temperature and humidity monitoring. Instead of using sophisticated ZigBee and LoRaWAN technologies for long distance monitoring and controlling which is too costly for traditional farmers, PREAGRIoT uses the available standard Wireless Local Network (WiFi) as the connection for IoT. This can ease the shifting of traditional farming to digital farming as it is less complicated and also reliable.

The rest of this document is organized as follows. Section 2 gives the insight of how PREAGRIoT was built and work. The next section presents the results and analysis of PREAGRIoT testbed. Lastly, conclusion and future works are presented.

2.0 METHODOLOGY

Figure 1 shows the block diagram of PREAGRIoT. It comprises with sensor, microcontroller, telegram bot and relay components. The sensor used is a BME280/BMP280 I2C sensor module [20] which is able to read barometric pressure, temperature, and humidity. In this project, only the temperature and humidity function will be used as the input for the NodeMCU. Table 1 shows the pin connection from the sensor to the NodeMCU.The sensor was powered up from ESP8266 NodeMCU shield. The same shield is also used with the ESP8266 NodeMCU, which is the main microcontroller used in PREAGRIoT.

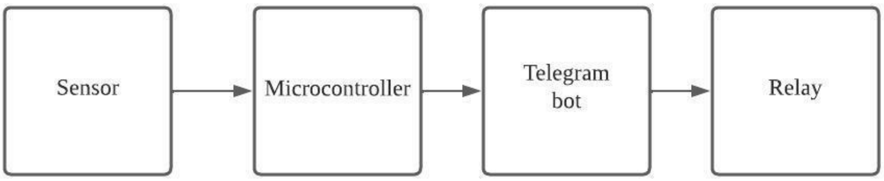

Figure 1. PREAGRIoT block diagram

Table 1. Pin connection between sensors and NodeMCU

BME280/BMP280 pin	NodeMCU pinout
VIN	3.3 V
GND	GND
SCL	D1
SDA	D2

ESP8266 NodeMCU is an open source IoT platform firmware that runs on ESP8266 wifi chip. In PREAGRIoT, the NodeMCU was powered up with a socket 5V DC Supply. This is to ensure no power shortage happens to the main controller which may cause catastrophe. A two-channels relay module which was powered up by a replaceable 9V battery through a 5V supply module is also connected to NodeMCU as the output. This two-channels relay allow PREAGRIoT to control two different outputs. The hardware connection is depicted in Figure 2.

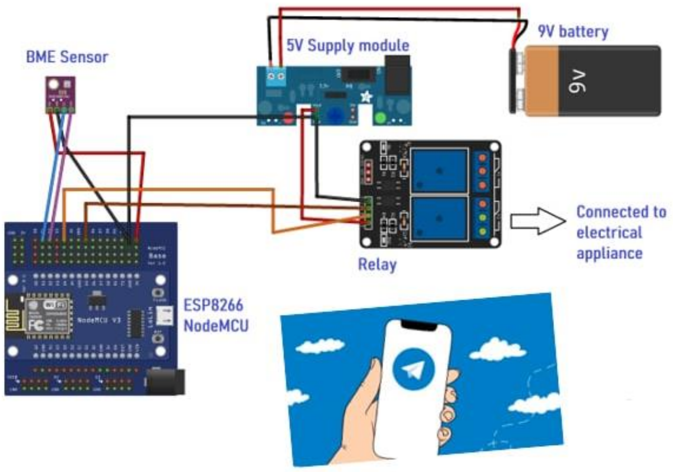

Figure 2. PREAGRIoT hardware connection

Integrating NodeMCU and other components such as sensor, telegram bot and relay requires programming process which was done with Arduino IDE software. Figure 3 shows the algorithm for the coding process.

```
Start
Get temperature and humidity
If bot request
   Display options
      If option selected
         Execute option
End
```

Figure 3. The algorithm

Adafruit BME280 and Universal Telegram bot library was included in the main coding to enable NodeMCU interact with the sensor and telegram bot. A special telegram bot called PREAGRIOT2 was created using BotFather and the token string number will be obtained for security and also placed in the coding such in Figure 4. A chat ID was also needed to initialize the telegram bot which can be obtained from ID bot. Both BotFather and ID bot needs to be accessed from Telegram application.

```
// Initialize Telegram BOT
#define BOTtoken "XXXXXXXXXX:XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX"  // Bot Token from Botfather
#define CHAT_ID "XXXXXXXXXX" //insert Cha ID from @myidbot
```

Figure 4. Inserting bot token and chat ID in coding

In order for user to be able to control the relay output, a simple instruction list was design in the customised telegram bot which allow users to choose their respected action. The instructions follow the Telegram bot naming rules which has "/" symbols at the front. Table 2 shows the denotation of each instructions listed in the PREAGRIOT2 bot.

Table 2. Bot instructions and the actions.

Bot instructions	Denotation
/start	Activate PREAGRIOT2 bot
/bacaan	Display temperature and humidity
/onSuis1	Turn on relay 1
/onSuis2	Turn on relay 2
/offSuis1	Turn off relay 1
/offSuis2	Turn off relay 2
/statusSuis1	Check the ON/OFF status of relay 1
/statusSuis2	Check the ON/OFF status of relay 1

2.1 Testbed setup

A testbed for PREAGRIoT was setup in a swiftlet farmhouse. The farmhouse is located in Kota Samarahan which is about 60 kilometers from Sarawak's capital city,Kuching. A swiftlet farmhouse was chosen because it requires close monitoring on the temperature and humidity in order for producing a high-quality bird nest [21]. This farmhouse used a home wall hanging thermometer to monitor the temperature. During rainy and warm season, the temperature inside the farmhouse may reach 25ºC to 30ºC. There was no available mechanism to check humidity as the owner only depends on their personal experience in detecting any humidity changes. The temperature and humidity can be quite extreme depending on the weather. Hence, it will be a suitable place to test the ability of the sensor. The PREAGRIoT was enclosed in a designated casing that can ease user to carry it around and connect it to existing electrical appliances. In this testbed, output relay 1 was connected to a fan in the farmhouse. As for internet connection, personal hotspot was used.

During the testbed, readings of temperature and humidity was taken more than 3 times at random period to reduce random errors. This is to obtain precise readings with PREAGRIoT. These readings were compared to the wall thermometer. The operation of fan was also observed when /onSuis1 and /offSuis1 were pressed. Lastly, the status of fan was also monitored.

Figure 5. The swiftlet farmhouse

Figure 6. The fan inside the swiftlet

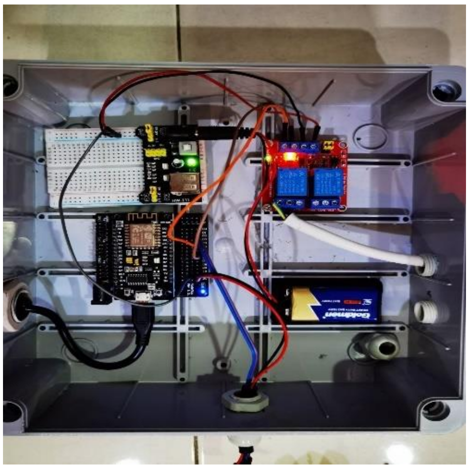

Figure 7. The physical connection of PREAGRIoT system

3.0 RESULT

In this section, the prototype of PREAGRIoT is explained and the analysis results of the testbed are also included.

3.1 Prototype

In this project, a prototype of PREAGRIoT such in Figure 8 has been produced for the testbed. The prototype body with a dimension of 20 centimeters width, 20 centimeters length and 10 centimeters height was built from Polyvinyl Chloride (PVC) which is an economic and versatile choice for casing design [22]. The PVC enclosure casing is also suitable for wiring and cabling.

The sensor was placed outside of the casing and there were two outputs which are labelled as SWITCH 1 and SWITCH 2, respectively. These outputs can be instantly connected to any electrical appliances.

Figure 8. PREAGRIoT prototype

PREAGRIOT2 bot was successfully built to integrate with the PREAGRIoT system. The interface for the bot is shown in Figure 9. The bot is activated when command */start* is sent to the bot. The bot responded by sending back options for users to choose the required action. The options of actions had already been explained in Table 2.

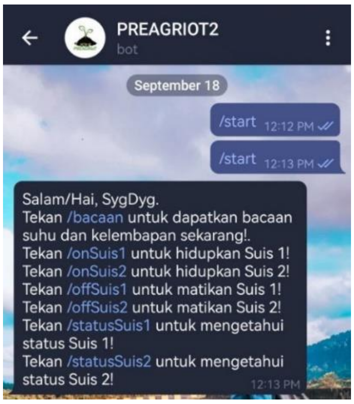

Figure 9. The PREAGRIOT2 bot

3.2 Testbed results

In the first test, results show that the BME280/BMP280 sensor had worked as expected. Figure 10 shows the output from the PREAGRIOT2 bot when option */bacaan* was selected. Table 3 shows the analysis of the results of the temperature values.

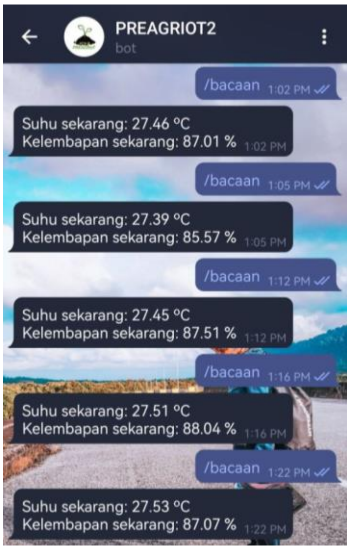

Figure 10. Outputs of /bacaan

Table 3. Temperature readings and the accuracy.

Reading number	BME280/BMP280	Wall thermometer	Accuracy	%Accuracy
1	27.46º C	27.8	0.34	98.78%
2	27.39º C	27.7	0.31	98.88%
3	27.45º C	27.8	0.35	98.74%
4	27.51º C	27.9	0.39	98.60%
5	27.53º C	27.8	0.27	99.03%

Based on the datasheet in [20] , the accuracy for the temperature is ±1ºC.This matched with the accuracy data in Table 3. This shows that the temperature reading is reliable with PREAGRIoT and can be delivered correctly through the PREAGRIOT2 bot. Although there was no mechanism to compare the reading for humidity, the owner of the farmhouse had agreed that the humidity readings were above 80% which were the optimum humidity for swiftlet breeding based on their personal experience. The readings of the humidity from the sensor are shown in Table 4.

Table 4. Humidity readings in swiftlet farmhouse.

Reading number	1	2	3	4	5
Humidity	87.01%	85.57%	87.51%	88.04%	87.07%

As for the fan operation, PREAGRIOT2 bot had successfully controlled the on and off condition. The status of the fan before and after */onSuis1* and */offSuis2* options were chosen can be observed from Figure 11.

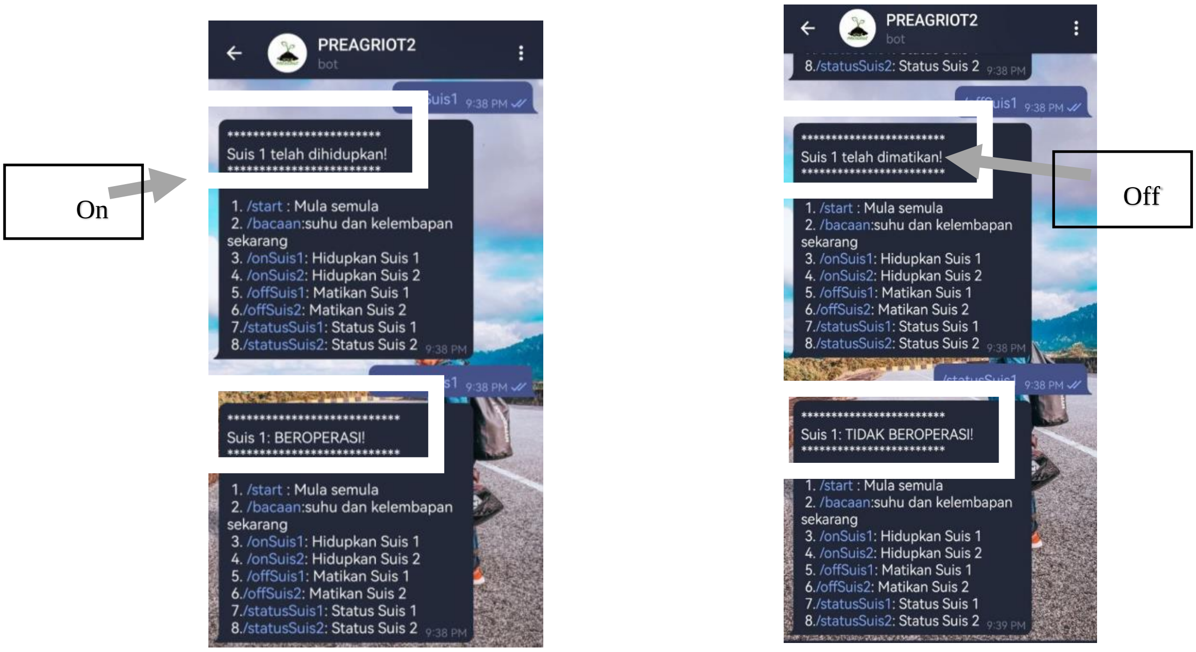

Figure 11. Turned on and off fan status

Both output scenarios obtained from the PREAGRIOT2 bot in the previous figures had reflected the physical operation of the fan in the swiftlet farmhouse. These results are simplified as in Table 5.

Table 5. Physical fan condition corresponds to the bot instructions.

Scenario number	**1**		**2**	
Bot instructions	***/onSuis1***	***/statusSuis1***	***/offSuis1***	***/statusSuis1***
Physical fan status	ON	ON	OFF	OFF

4.0 CONCLUSION

PREAGRIoT has been proven to be precise and accurate to monitor temperature and humidity in an agricultural area with the advantage in simplifying IoT technology for traditional farmers. The temperature and humidity results are also consistent with similar monitoring process in work [23] and [24]. The system also successfully control fan using the PREAGRIOT2 bot. Some farmers may feel anxious of changes and the additional cost, but with PREAGRIoT, it can humanise control through a simple and affordable Telegram application. This can give confidence to farmers to shift their agriculture monitoring towards more sophisticated IoT application. In contrast, although Telegram is accessible by all users without extra cost, the means to access the internet may become an issue in certain farming area. Hence, for future study, the suitable options of internet connection for IoT platform in an agricultural area must be reviewed extensively.

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