Technology Design to Improve Plant Quality with IoT-Based Plant Temperature and Humidity Monitoring System

1st Ganang Aris Setiawan
Electrical Engineering Dept.
Sebelas Maret University
Surakarta, Indonesia
ganang.arissetyawan@student.uns.ac.id

2nd Joko Hariyono
Electrical Engineering Dept.
Sebelas Maret University
Surakarta, Indonesia
jokohariyono@staff.uns.ac.id

3rd Agus Ramelan
Electrical Engineering Dept.
Sebelas Maret University
Surakarta, Indonesia
agusramelan@staff.uns.ac.id

***Abstract*—This project focuses on the issue of improving the quality of plants, especially lettuce. Lettuce grows best in a temperature range of 25°C to 28°C and a humidity range of 65% to 78%. In order to grow high quality lettuce, it is necessary to adjust the temperature and humidity. But when you don't have time to pay attention to these details for other important work, that becomes a problem. To solve this problem, we use the Internet of Things to monitor assets anytime, anywhere. We made it possible. Also, this monitoring system saves a lot of time. I use an instant messenger called Telegram. Telegram Messenger is an open source, free, cross-platform application. Use API Bot in Telegram to create intelligent bots that react to messages about surveillance. The DHT11 Temperature and Humidity Sensor is used to provide sensor temperature and humidity readings. The Arduino Integrated Development Environment (IDE) software is used to create the source code, and the ESP 12e acts as the brains of the technology we develop and can connect to the internet. The results of this temperature and humidity monitoring can be accessed by typing commands into the Telegram bot. Statistics and other visual data can also be monitored from websites developed by us. (**Abstract**)**

Keywords— Arduino IDE, ESP 12E, Monitoring System, Temperature and Humidity

I. INTRODUCTION

Everyone has different hobbies, from hobbies to cooking, fishing, sports, raising animals and growing plants. Animal and plant keepers need to provide food at the right time to keep animals and plants healthy and growing well. However, this is difficult because everyone has different activities and more important priorities [1].

Agriculture is one of the livelihoods of the community and is growing with the growing demand for the needs of the community. Lettuce is a type of leafy vegetable. As the population grows, public education improves, incomes and public welfare rises, and people become more interested in lettuce, the potential for market absorption of salad ingredients will continue to grow. Lettuce is another vegetable commonly grown using an aeroponic system. The most important variables to control are temperature and humidity, which are the most important supporting factors in aeroponics. Lettuce grows best in temperatures between 25°C and 28°C and humidity between 65% and 78% [2].

Therefore, this study is about time-saving plant monitoring that can be done anytime, anywhere, allowing you to do more important work and have a planting hobby that will give you healthy and good planting results. The Telegram application was chosen because it's free, lightweight, and cross-platform. Telegram also has a fairly complete and growing bot API that allows you to create smart bots that can reply to messages from the public [3].

Due to the range of countries monitored, environmental conditions may not always be the same in some locations. This requires monitoring at multiple locations so that environmental monitoring can cover the entire area of interest. This forms the basis for technological developments to monitor local environmental conditions [4].

The use of radio communication systems (wireless) as a communication medium in computer network systems is becoming increasingly popular today. The application of wireless technology makes information and communication quick and easy. Large agricultural fields require devices that can transmit and receive information over fairly long ranges. The NRL24l01 is a transmit/receive module capable of operating in line-of-sight (LOS) conditions up to 1.1km. So because the technology we design is a system that monitors temperature and humidity at multiple points in different regions then we decided to use the NRF24L01 module [5].

The Internet of Things (IoT) is a concept that aims to extend the benefits of Internet connectivity. The Internet of Things (IoT) was first introduced in 1999 by Kevin Ashton. The IoT concept is generally defined as the ability to connect smart objects and allow them to interact with other objects, the environment, or other smart computing devices over the internet. However, the reality is that the IoT concept is not optimally implemented, especially in Indonesia [6].

II. METHOD & MATERIAL

A. *Time and Place of Research*

This activity was carried out at Sebelas Maret University, to be exact, Internet of Things (IoT) Laboratory and Instrumentation and Control Laboratory, Faculty of Engineering, Electrical Engineering Study Program, Universitas Sebelas Maret Surakarta within a period of approximately 5 months both online and offline by implementing health protocol.

B. Research Procedure

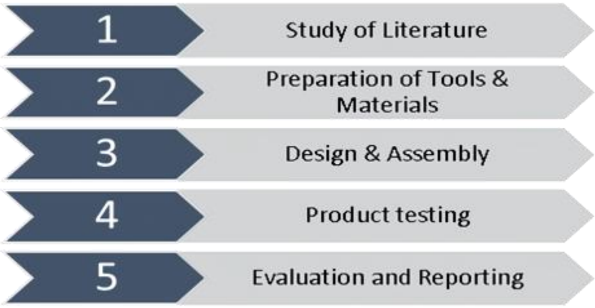

Fig. 1. Research Procedure Diagram.

1) Study of Literature

The activity process will begin with a literature study on lettuce, plant care, Internet of Things (IoT), and websites. After the literature study is deemed sufficient, the next step is to collect the required data and then use the data to collect data designing tools.

2) Preparation of Tools & Material

Before carrying out the program we make preparations such as making tool designs, buying tools and materials needed, designing PCB layout designs for integrating circuits, designing the tools to be made, as well as making the basic construction of websites.

3) Design & Assembly

The manufacturing process begins with printing the circuit board that has been pre-designed, assembling the components on the circuit board, making the hardware/body of the tool, placing the circuit board on the hardware/body of tools, and also creating a website for monitoring.

4) Product Testing

At this stage, we will do testing to see how successful we are in realizing the idea of monitoring the temperature and humidity of lettuce plants to improve plant quality.

5) Evaluation and Reporting

In order to refine and fix the problems that maybe we will face later, an evaluation process is needed so that the tools we make can improve even more in quality and can be applied to society. After the research is carried out, a report is made in the form of a scientific paper to convey the results of the research.

C. Materials Used

1) Lettuce Plants.

Fig. 2. Lettuce Plant

Lettuce is one of the vegetables that can be grown as a vegetable raw material for urban agriculture. The greatest market potential for lettuce is generally urban, where it is consumed directly in the form of fresh vegetables. Efforts to shorten the sales line for lettuce crops from farm to table are expected to produce lettuce crops that reach consumers faster and retain their freshness [7].

2) DHT11 Temperature & Humidity Sensor

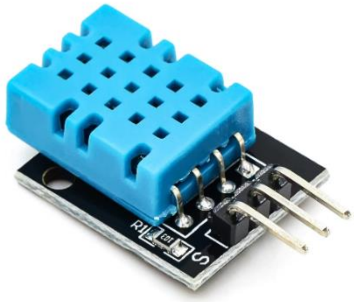

Fig. 3. DHT11 Sensor

The DHT11 sensor is a digital signal calibration sensor capable of providing temperature and humidity information. This sensor is classified as a component that has a very good level of stability and very accurate calibration features. The calibration coefficient is stored in a one time programmable (OTP) program memory, so that when the internal sensor detects something, this module includes the coefficient in its calculation with a signal transmission of up to 20 meters, with specifications Supply Voltage: +5 V, Temperature range: 0-50 °C error of ± 2 °C, Humidity: 20-90% RH ± 5% RH error. The working principle is to take advantage of capacitive changes, changes in the position of the dielectric material between the two plates, the shift in the position of one of the pieces and the area of the plates that are directly opposite [8].

3) Buzzer

Fig. 4. Buzzer

Buzzer is an electronic device that functions to convert electrical vibrations into sound vibrations. Basically the way the buzzer works is almost the same as a loudspeaker, the buzzer consists of a coil that is attached to the diaphragm. The buzzer is usually used as an indicator that the process has been completed or an error has occurred on a tool [9].

4) ESP 12E

Fig. 5. ESP 12E

ESP-12E is a wifi module using the ESP8266 chip which is covered in metal with the aim of reducing interference with other devices. The complete specifications of the ESP8226 chip are as follows: 1) Source voltage is 3.3VDC, 2) Wi-Fi Direct (P2P), soft-AP, 3) Current consumption: 10uA~170mA., 4) Maximum installed flash memory is 16MB (normal 512K)., 5) Integrated TCP/IP protocol, 5) 32-bit Tensilica L106 processor., 6) Processor speed 80~160MHz., 7) RAM(Random Access Memory) capacity of 32Kb + 80Kb., 8) GPIO(General Purpose Input Output) 17 (multiple with other functions)., 9) One ADC(Analog Digital Converter) 1024 resolution, 10) Output power +19.5dBm in 802.11b mode, and 11) Maximum number of TCP connections 5 [10].

5) NRF24L01 Transceiver Module

Fig. 6. NRF24l01+PA+LNA Module

This transceiver module Equipped with an additional PA (amplifier) and LNA (low noise amplifier), i.e. distance transmission can be farther and more stable. Area that this transceiver module can reach a radius of 1000 meters outdoors. This module has 3 options Data rates are 250 Kbps, 1 Mbit/s, and 2 Mbit/s. data GFSK is used for modulation in this transceiver module. Transceiver module nRF24L01 + PA + LNA is a receiver and Radio Frequency Transmitter (RF / Radio Frequency transceiver) 2.4 GHz frequency, HF synthesizer, and baseband logic including extended protocols ShockBurst™ Hardware Protocol Accelerator Supports SPI interface (serial peripheral interface) high speed for control application. This SPI interface can be simple connects to the SPI pin of the module Arduino. The working voltage of this module is 1.9 to 3.6 volts max [11].

D. Product Architecture

The following is the architecture of the product that has been made. this product has 2 sides, namely the transmitter and receiver using radio communication that utilizes the nrf24l01 module so that data can still be uploaded to the internet even though it is placed in an open space where there is no internet connectivity.

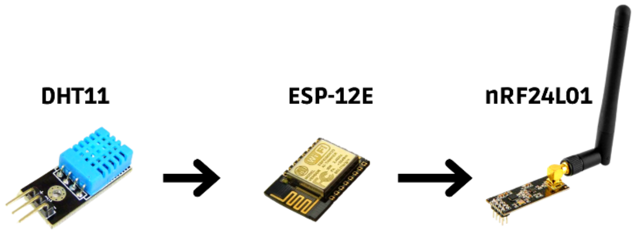

Fig. 7. Product Architecture on Transmitter Side

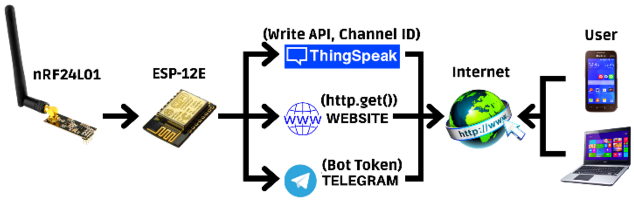

Fig. 8. Product Architecture on Receiver Side

III. Result and Discussion.

A. Precision Test

TABLE I. Precision Test of Sensor

Data	Precision Test		
	Time	*Temperature (°C)*	*Humidity (%)*
1	13.52.24	30,3	69
2	13.52.25	30,3	69
3	13.52.27	30,7	69
4	13.52.28	30,8	69
5	13.52.29	30,8	69
6	13.52.30	30,8	69
7	13.52.31	30,8	69
8	13.52.32	30,8	69
9	13.52.33	30,8	69
10	13.52.34	30,8	69
SUM		306,90	690,00
Average		30,69	69

Temperature Sensor

$$\text{Standard Deviation}=\frac{\sqrt{\sum_{1}^{n}(\bar{X}-X_1)^2}}{n-1} \qquad (1)$$

$$\text{Standard Deviation} = \frac{\sqrt{\begin{matrix}(30{,}69-30{,}3)^2+(30{,}69-30{,}3)^2\\+(30{,}69-30{,}7)^2+(30{,}69-30{,}8)^2\\+(30{,}69-30{,}8)^2+(30{,}69-30{,}8)^2\\+(30{,}69-30{,}8)^2+(30{,}69-30{,}8)^2\\+(30{,}69-30{,}8)^2+(30{,}69-30{,}8)^2\end{matrix}}}{10\text{-}1} \quad (2)$$

$$\text{Standard Deviation} = \frac{\sqrt{\begin{matrix}0{,}1521+0{,}1521+0{,}0001\\+0{,}0121+0{,}0121\\+0{,}0121+0{,}0121\\+0{,}0121+0{,}0121\\+0{,}0121\end{matrix}}}{9} \quad (3)$$

$$\text{Standard Deviation} = \frac{\sqrt{0{,}3890}}{9} \quad (4)$$

$$\text{Standard Deviation} = 0{,}0693 \quad (5)$$

$$\text{kv} = \frac{std}{\bar{X}}\ x\ 100\% \quad (6)$$

$$\text{kv} = \frac{0{,}0693}{30{,}69}\ x\ 100\% \quad (7)$$

$$\text{kv} = 0{,}0023\% \quad (8)$$

It can be seen in the standard deviation and kv values, namely the standard deviation of 0.0693 this indicates the range of sensor readings is not far apart then the kv value is 0.0023% indicating the sensor readings can be declared precise because the value is less than 2% [12].

Humidity Sensor

$$\text{Standard Deviation} = \frac{\sqrt{\sum_1^n(\bar{X}\text{-}X_1)^2}}{\text{n-1}} \quad (1)$$

$$\text{Standard Deviation} = \frac{\sqrt{\begin{matrix}(69-69)^2+(69-69)^2\\+(69-69)^2+(69-69)^2\\+(69-69)^2+(69-69)^2\\+(69-69)^2+(69-69)^2\\+(69-69)^2+(69-69)^2\end{matrix}}}{10\text{-}1} \quad (2)$$

$$\text{Standard Deviation} = \frac{\sqrt{\begin{matrix}0+0\\+0+0\\+0+0\\+0+0\\+0+0\end{matrix}}}{9} \quad (3)$$

$$\text{Standard Deviation} = \frac{\sqrt{0}}{9} \quad (4)$$

$$\text{Standard Deviation} = 0 \quad (5)$$

$$\text{kv} = \frac{std}{\bar{X}}\ x\ 100\% \quad (6)$$

$$\text{kv} = \frac{0}{69}\ x\ 100\% \quad (7)$$

$$\text{kv} = 0\% \quad (8)$$

It can be seen in the standard deviation and kv values, namely the standard deviation of 0 this indicates the range of sensor readings is not far apart then the kv value of 0% indicates the sensor readings can be declared precise because the value is less than 2%. this can happen because the resolution of the reading is not a decimal number so that the humidity sensor reading looks very precise because it reaches 0% unlike the temperature sensor reading which has 1 digit behind the comma [13].

B. Distance Test

TABLE II. DISTANCE TEST OF SENDING & RECEIVING DATA

No.	**Distance Test**	
	Distance (Meter)	***Success?***
1	25	YES
2	50	YES
3	75	YES
4	100	YES
5	125	YES
6	150	YES
7	200	YES
8	250	YES
9	500	NO
10	1000	NO

Based on the specifications from the website [14], the NRF24l01 module can reach a distance of up to 1km in an open space but in fact when we tested the distance located on Ir. Djuanda Road Surakarta obtained the maximum distance of successful data transfer is 250m, after that the device no longer responds. this discrepancy could be caused by a lot of interference such as metal power poles stuck to the ground, obstacles and others.

C. Monitoring Website Design

At this stage, a website is created that can display sensor readings so that it can be accessed from anywhere using Internet of Things technology. sensor reading data is received by esp12e and then sent to the internet using the API method to the thingspeak website then the website converts the raw data into readable values and graphs.

Fig. 9. Monitoring Website

The data displayed on the ThingSpeak website are: Current temperature and previous temperature data in graphic form, then current humidity and previous humidity data in graphic form, then there is also a heat indicator that will light up if the heat level reaches a certain limit, and finally heat index from the calculation of temperature and humidity.

D. *Telegram ChatBot Design*

In order to be closer to the users, a monitoring system was created that can be accessed using telegram social media. The user sends a command via the telegram chatbot, then the message will be received by esp12e via the internet, then esp12e will process the command and send back a reply message according to the command sent [15].

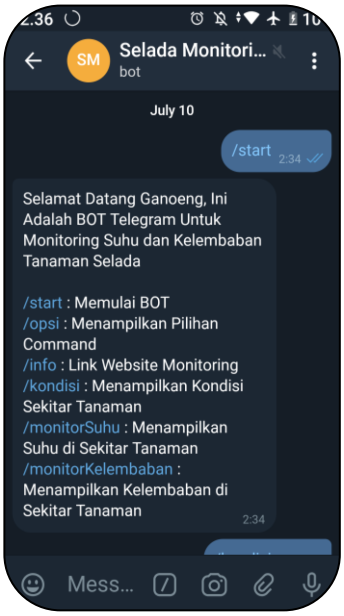

Fig. 10. Telegram Bot

The commands available on the telegram bot include: /start to start the bot, /opsi to display command options, /info to provide a link to the monitoring website, /kondisi to know the conditions around the plant, /monitorTemperature to determine temperature, /monitorHumidity to determine humidity, and /kalibrasi to calibrate the temperature and humidity readings so that the results are more accurate.

E. *Product Result.*

Fig. 11. Product Result

The resulting product is a plant pot that is integrated with a monitoring system that is packaged in such a way as to avoid damage. the components contained in the package are the battery, DHT11 sensor, ESP12E, and buzzer.

IV. Conclusion

The technology designed to improve plant quality with IoT-based plant temperature and humidity monitoring systems is expected to be the solution to improve the quality of plants, especially lettuce because paying attention to the details such as temperature and humidity factors really helps the plants to grow better and healthier so that it also improves the quality of crops yields. The use of this IoT-based monitoring system is effective and practical. The users of this monitoring system can also monitor in various forms of attractive and easy-to-understand visual data. This IoT-based lettuce temperature and humidity monitoring system can be developed further so that it not only monitors the temperature and humidity but also can manipulate the temperature and humidity using a fan with a fuzzy method with adjustable speed.

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References

[1] W. A. Prayitno, . A. Muttaqin dan D. Syauqy, “Sistem Monitoring Suhu, Kelembaban, dan Pengendali Penyiraman Tanaman Hidroponik menggunakan Blynk Android,” *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer,* vol. Vol. 1, no. 4, pp. 292-297, 2017.

[2] I. A. Darmawan, “Pengaruh Topoklimat terhadap Produksi dan Kualitas Selada (Lactuca sativa L.),” Universitas Gadjah Mada, Yogyakarta, 1997.

[3] B. M dan J. A, “Student Presence Using Rfid and Telegram,” *Widyatama University and IEEE,* 2016.

[4] A. H. Alasiry, E. Suryawati, E. Satriyanto dan R. R. A, “Desain dan Implementasi Jejaring Sensor Nirkabel Inframerah untuk Sistem Informasi Parkir Gedung Bertingkat,” EEPIS, 2010.

[5] A. Raafi’ilman, A. Bhawiyuga dan R. A. Siregar, “Implementasi Protokol RF24Mesh dalam Wireless Sensor Networkpada Lahan Pertanian,” *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer,* vol. 3, no. 7, pp. 6757-6763, 2019.

[6] T. A. Prabowo, “Prototype Sederhana Pengendali Lampu,” Dalam *Universitas Pelita Bangsa*, Bekasi, 2019.

[7] B. Frasetya, A. Taofik, R. dan F. , “Evaluation Of Variationelectrical Conductivity Value On Thegrowth Oflettuce (Lactuca Satival.) In The Nft System,” *Jurnal Agro,* vol. 5, no. 2, pp. 95-102, 2018.

[8] Aosong, Temperature and Humidity Module DHT11 Product Manual, Aosong Electronic, 2019.

[9] H. A. Fani, S. J. D. Hartama dan I. Gunawan, “Perancangan Alat Monitoring Pendeteksi Suara di Ruangan Bayi,” *Jurnal Media Informatika Budidarma,* vol. 4, no. 1, pp. 144-149, 2020.

[10] N. H. Lusita Dewi, M. F. Rohmah dan S. Zahara, “Prototype Smart Home Dengan Modul Nodemcu Esp8266 Berbasis Internet Of Things (Iot),” Universitas Islam Majapahit, Mojokerto, 2019.

[11] R. Wijayanto, “Sistem Pengendali Irigasi Pertanian Desa Nguken Berbasis Wireless,” Universitas Teknologi Yogyakarta, Yogyakarta, 2018.

[12] H. Firdhausyah, R. Maulana dan E. Setiawan, “Sistem Pendeteksi Atrial Fibrilasi BerdasarkanFitur Mean, Median, Standar Deviasi, Min, Dan Maks Interval RRMenggunakan Metode K-NN,” *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer,* vol. 5, no. 6, pp. 2327-2333, 2021.

[13] P. Ferdiansyah, R. Indrayani dan Subektiningsih, “Analisis Manajemen Bandwidth Menggunakan Hierarchical Token Bucket Pada Router dengan Standar Deviasi,” *Jurnal Nasional Teknologi dan Sistem Informasi,* vol. 6, no. 1, pp. 38-45, 2020.

[14] Last Minute Engineer, “How nRF24L01+ Wireless Module Works & Interface with Arduino,” [Online]. Available: https://lastminuteengineers.com/nrf24l01-arduino-wireless-communication/. [Diakses 28 September 2020].

[15] J. Mailoa, E. P. Wibowo dan R. Iskandar, “Sistem Kontrol dan Monitoring Kadar pH Air pada Sistem Akuaponik Berbasis NodeMCU ESP8266 Menggunakan Telegram,” *Jurnal Ilmiah KOMPUTAS,* vol. 19, no. 4, pp. 597-604, 2020.