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by Moh Erkamim

Jurnal Sains dan Teknologi
Volume xx Number xx, Tahun 2022, pp. xx-yy
P-ISSN: 2303-3142 E-ISSN: 2548-8570
Open Access: https://dx.doi.org/10.23887/jst-undiksha.v11i1

IoT Prototype Measuring Plant Height In Real-Time

Moh. Erkamim[1*], Vera Wati[2], Sapto Priyadi[3]
[1,2] *Program Studi Sistem Informasi Kota Cerdas, Fakultas Teknik, Universitas Tunas Pembangunan, Surakarta, Indonesia*
[3] *Program Studi Agroteknologi, Fakultas Pertanian, Universitas Tunas Pembangunan, Surakarta, Indonesia*

ARTICLE INFO

Article history:
Received Mei 22, 2021
Revised Mei 29, 2021
Accepted Agustus 14, 2021
Available online November 25, 2021

Kata Kunci:
IoT, sensor ultrasonic, microcontroller, plant growth, smart farming

Keywords:
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ABSTRACT

Physically, development of plants will experience physical changes, one of which is the height of the plant. Monitoring activities will certainly be effective with the help of technology. The utilization of IoT is a technological breakthrough in that multitasking can be used for monitoring and sharing data simultaneously. So to support growth observation activities, this study aims to implement an IoT-based prototype modeling tool with ultrasonic sensors embedded in the NodeMCU microcontroller which is integrated with the database server. Modeling is used to analyze the workings of measuring plant height, involving case studies of mustard plant growth which are interpreted descriptively based on sensor capture height which is compared with expert-validated original observations. The research method used is quantitative data processing in the form of comparison charts. The data obtained in real-time by accessing the website address is available so that the data records are stored in the database server for as much as 1071 data for 33 days with 5 storage sessions a day. The results of the IoT prototype modeling managed to capture altitude data, with a comparison presentation between the height of the original plant and the sensor capture of 54.7% valid data without any difference. The conclusion from this study, there are still quite a lot of differences in the comparison of the two. This is due to modeling with improper sensor placement, so that it is detected outside the boundaries between predetermined objects.

1. INTRODUCTION

Understanding plants and plants have the same meaning. Growth is a change that occurs on a quantitative scale that can be observed in terms of size and volume (Doshi et al., 2019; Fahad et al., 2021; Pottinger, 2017). One symptom that occurs in plant growth is that it is permanent and cannot return to its previous condition (irreversible) (Kamruzzaman et al., 2019). These growth processes include changes in plants such as leaf width, increasing number of leaves, fertilization, and other changes (Abhiram et al., 2020; Bounnady et al., 2019; Serikul et al., 2018). Studies that occur in agricultural students in analyzing the characteristics of plant growth certainly have several parameters. Parameters in the observations can be utilized from the morphological and agronomic side of the plant (Bayati et al., 2022; Ullah et al., 2021; Yu et al., 2020). Documentation is done by recording the phenotypic appearance of agronomic characteristics by observing plant samples which is carried out periodically. Several parameters were recorded: observations of plant height calculated in centimeters (cm), physical visual observations, and root length in centimeters (cm). This is important for follow-up plant care. For example, if the results of measuring plant height physically do not increase because the plant collapses, it can be done by preparing stakes for support or fertilization and special care so that the plants have a longer life (Adam et al., 2019; Durani et al., 2018; Nooriman et al., 2021). This monitoring activity will usually be repeated and carried out within a certain period until the purpose of the analysis of plant characteristics is achieved.

The Internet of Things (IoT) is a multitasking technology breakthrough with the concept of expanding the benefits of internet connectivity, involving IoT that can be used for monitoring and sharing data simultaneously (Dahane et al., 2020; Jangam et al., 2018; Raviteja & Supriya, 2020). The involvement of technology is now widely used for efficiency and time effectiveness as a carrying capacity to realize smart agriculture (Kashyap et al., 2018; Shukla et al., 2020). Several previous studies have utilized technology, such as research conducted by (Ali et al., 2020; Saputra & Lukito, 2017) monitoring smart gardens with soil temperature humidity using an IoT-integrated soil moisture sensor, but the functionality of the system is not yet known because the interface is not yet available and the results have not been stored thoroughly. So Ali's research is not monitored in real-time through an easily accessible interface. So it's not only the IoT

*Corresponding author.
E-mail addresses: erkamim@lecture.utp.ac.id (Moh. Erkamim)

prototype, but the research that has been done has involved a database server as a monitoring medium to make it easier to observe at any time.

Another study by (Latifah et al., 2021) measured the height of corn plants with Arduino had access failure at a certain distance, the process of retrieval of transmission access data could not be detected so it was necessary to pay attention to internet access to overcome interference. So that in this research, it is necessary to find a solution to how the microcontroller used has embedded a website system in real-time so that it is detected as early as possible if there are obstacles that occur when starting to observe plant heights. Modeling testing in other studies measuring plant height was carried out by comparing the accuracy of manual measurements compared to the results of ultrasonic sensor sensing to ensure the accuracy of the developed system (Boonchieng et al., 2018; Chang et al., 2017; Farooq et al., 2020). The results of the study showed a significant correlation between the two (Chang et al., 2017; Chieochan et al., 2017). So, solving problems in research carried out with the help of IoT technology does need to involve calculations that compare the average result of the original height measurement with the height of the system result. Research with smart agriculture using IoT in research (Abhiram et al., 2020) uses NodeMCU for soil moisture analysis, but the sensor capture storage is still stored in the Blynk Cloud. Blynk cloud storage Optimization of smart farming monitoring with IoT-based sensors and microcontrollers, which are used in research (Doshi et al., 2019) but monitoring tools via Blynk. Blynk is an IoT platform that sends data to servers stored in mobile phone devices, but the drawback of Blynk storage is that if the application on the device has been deleted, the data captured by the sensor will be deleted. So in the research conducted, innovate using a cloud server to capture plant height data that has been transmitted from ultrasonic sensors. The use of ultrasonic sensors has a fast and accurate response so it has great potential as a high measuring tool (Bronson et al., n.d.; Soni & Aman, 2018; Sunitha, 2017). The use of ultrasonic sensors has a sensitivity of 2 - 450 cm, so the measurement results from the sensor to objects with a radius of 3 - 40 cm are almost close to the actual value (Baskoro & Reynaldo, 2018).

The research conducted aims to help improve smart agriculture in observing growth, by implementing a prototyping tool for measuring plant growth in real-time based on IoT. Ultrasonic sensor assistance as a means of transmitting plant height data that is embedded into the NodeMCU microcontroller circuit. Captured data is integrated with a server that has been created in an IoT technology-integrated website, where data records will be stored in the database periodically and can be accessed directly via a configured website address. So, looking for new knowledge about the performance of IoT system integration in realtime by testing the validation value between the plant height captured from the sensor compared to the expert validation results. In addition, a study was conducted to determine the performance of the ultrasonic sensor in capturing the signal of the measured plant object

2. METHOD

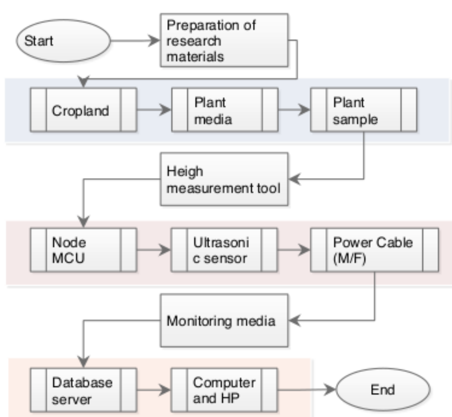

Figure 1. Research Method

The research approach uses quantitative data processing which is represented in a graphic table with the object of a case study recording the growth of mustard plants carried out on planting media during the nursery period. As shown in Figure 1, the research phase begins with the preparation of materials, procurement of measurement tools for data storage, and media as monitoring tools.

Research Material Preparation

In the first step, there are several preparations, especially those used for research samples, including plant land, and plant media choosing an environment that is conducive to growth. In the plant sample section, researchers used mustard greens. Measurements with IoT are carried out after the minimum height of mustard greens has reached 3 (three) cm.

Plant Measurement Tool

The next stage is to prepare tools for prototype plant measurement tools. The tool is related to IoT technology such as NodeMCU V3 ESP8266 as a microcontroller for program storage media that is processed for automation of measurements in real-time. In addition to the NodeMCU, the tools needed by the ultrasonic sensor HC-SR04 are useful for measuring distances over long distances. The working principle of this sensor is based on reflection to calculate the distance between the sensor and the object so that it can detect the presence of an object being captured. The ultrasonic sensor equation is as follows:

$$S = \frac{x * t}{2} \qquad (1)$$

Information:

S= Distance

x= speed of sound

t = time difference between emitted and received a wave

The synchronization process between the NodeMCU and the ultrasonic sensor is assembled using Male and Female cables. The circuit is a communication transmission between the microcontroller and the sensor. The circuit can be seen in Figure 2.

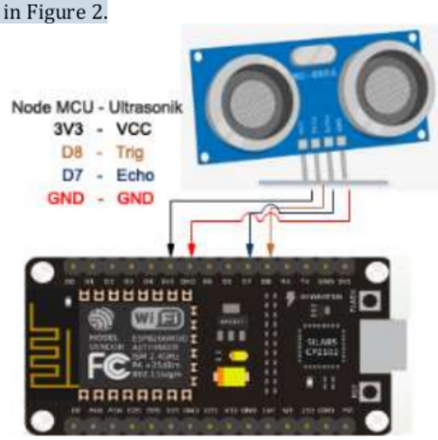

Figure 2. Nodemcu Transmission with Ultrasonic Sensor

The communication transmission circuit between the NodeMCU and the sensor as shown in Figure 2 is synchronized with the Male-Female cable in the order. NodeMCU which has been given a plant height measurement program is connected with a USB cable to be plugged into the power supply. The IoT prototype is certainly used as a data collection tool for the observed plant object height. The data collection method is based on observational survey observations by experts who are monitored based on monitoring media that is updated in the database server. In addition, experts validated by measuring plant height manually to find out the difference in comparison between the two.

Media Monitoring

The prototype of the measurement tool is installed correctly, then the next step is setting up the monitoring media. If the sensor can capture plant height data, it will be accommodated in the server database. In this study, changes are captured in real time so that changes can always be monitored. However, automated storage will store for a month with a target storage capacity of 1000 records during the study. Researchers conducted a website-based development to accommodate plant size records in centimeters (cm), so that access can be done using a computer or smartphone. The data that has been collected will be processed for later analysis. The data analysis process is carried out by quantitative processing, including processing the grouping of sensor-captured plant height data from the monitoring media, and expert validation data groups. Furthermore, presenting the data in the form of graphs for comparison, then calculating the difference to conclude.

3. RESULT AND DISCUSSION

Result

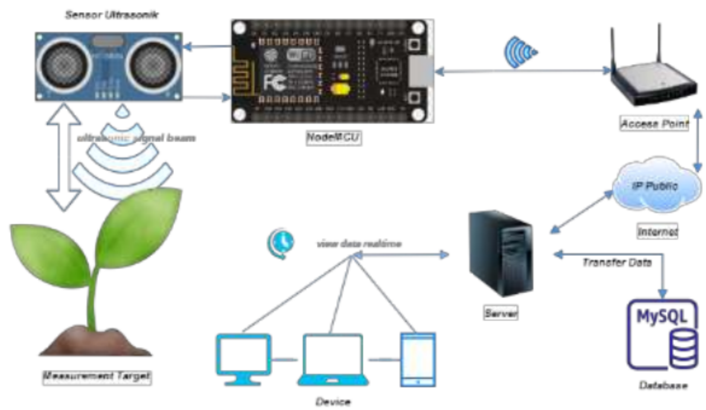

Figure 2. Block Diagram of System

The explanation in Figure 3 the implementation of plant height measurement begins with assembling an ultrasonic sensor that is synchronized with the NodeMCU according to Figure 2. Besides that, the researcher prepares plant media as a measurement target. If the plant height has been successfully detected with the IoT prototype, the next step is to create a system to store the sensor results in a database connected to a server and the internet. The resulting database design is in Figure 4.

Figure 4. System Database Design

The explanation in Figure 4 is that there is a user table to accommodate users as validation of measuring native plant heights which are directly related to IoT heights. The IoT altitude table is used to automatically store sensor results for each session at 06.00 WIB, 10.00 WIB, 14.00 WIB, 17.00 WIB, and 19.00 WIB for 33 days, so that 1071 data are obtained. The real-time altitude table performs automatic updates displayed on the web page, in contrast to the IoT altitude table as a result of comparison with the original height according to expert validation. Validation is carried out by experts by comparing IoT height data with original plant height data, to then be processed by calculating the difference then the data obtained is processed into a graph as in Figure 5 (a)(b)(c) and (d).

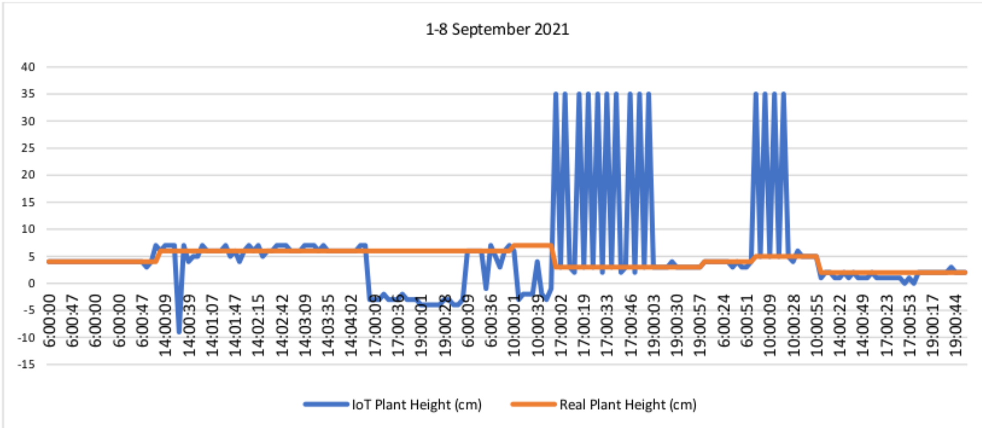

Figure 5 (a)

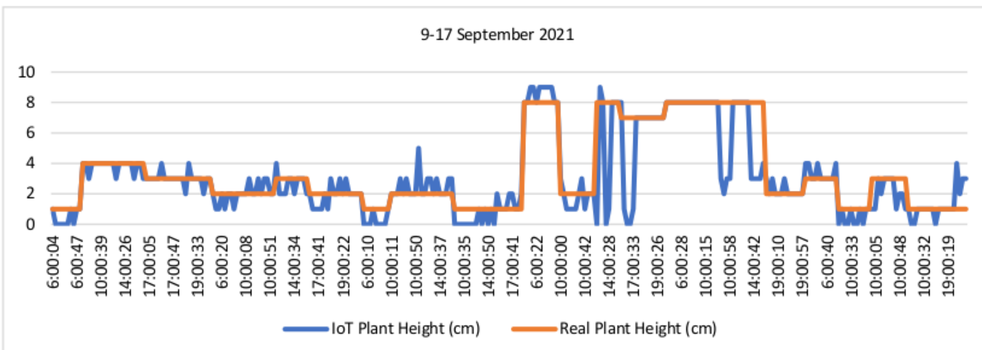

Figure 5 (b)

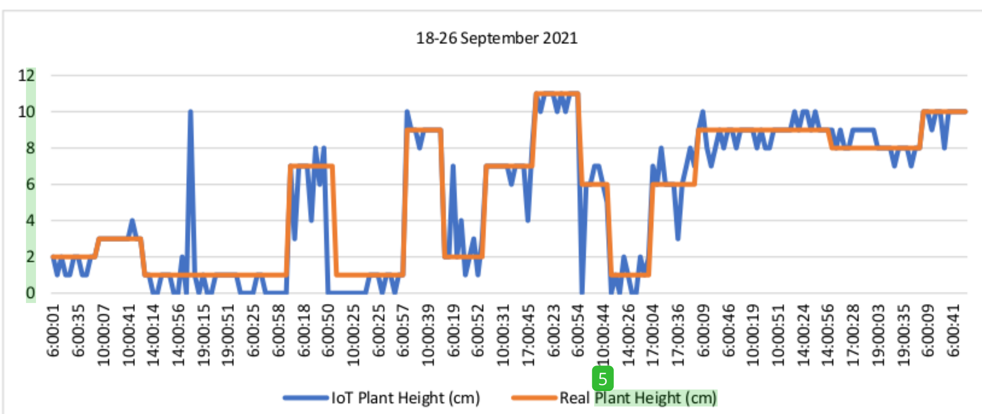

Figure 5 (c)

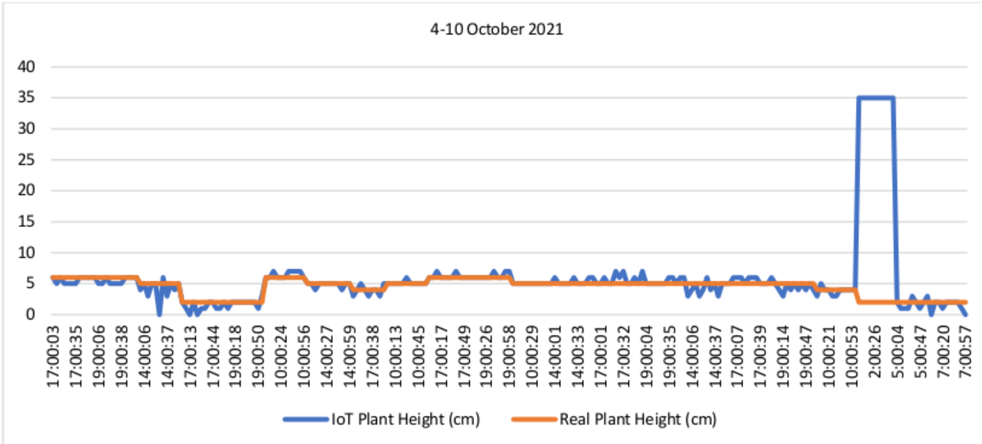

Figure 5 (d)

It can be seen in Figure 5 that the comparison of the IoT height and the original height has several graphs of differences in each detection, the results are affected by the performance of the ultrasonic sensor that works continuously not detecting the exact part of the plant. Settings on the system contain a maximum limit of 35 cm which is based on the sensor distance shot between the lips or the edge of the plant container.

(a) Prototype IoT (b) Validation (c) Web View

Figure 5. Actual Automated Prototype IoT Plant Growth

The implementation in Figure 3 is then assembled into an IoT prototype to be used to measure plant height as in Figure 6 (a), the ultrasonic sensor is directed directly above the plant object. The installed NodeMCU provides a signal as a sensor storage medium to be transmitted to the system database so that it can be displayed as shown in Figure 6 (c). Users as validation experts measure plant height according to predetermined sessions to find out the accuracy between sensor performance and actual plant height (see Table 1).

Table 1. Comparison Table of High IoT and High IoT

Date	Description of Plant Height Difference		
	Saved Data	***Total Height Difference (cm)***	***Average Height Difference (cm)***
1-8 Sept 2021	307	1347	4,39
9-17 Sept 2021	303	213	0,70
18-26 Sept 2021	220	142	0,65
4–10 Oct 2021	241	440	1,83
Amount	1071	2142	7,57

The comparison table as shown in Table 1 totals the largest difference between 1-8 September 2021 with an average of 4.39 cm according to the graph in Figure 5 (a) it can be seen that the amount of data stored reaches 35 cm. Overall data storage is 1071 data with the difference between plant heights detected by IoT and original heights that have been validated by experts, 586 data with a percentage of 54.7% (see Table 2).

Table 2. Expert Validation Table

Date	Description of Data Validity				
	Saved Data	***Total Valid Data***		***Total Data Invalid***	
1-8 Sept 2021	307	149	48,53%	158	51,47%
9-17 Sept 2021	303	178	58,75%	125	41,25%
18-26 Sept 2021	220	121	55,00%	99	45,00%
4–10 Oct 2021	241	138	57,26%	103	42,74%
	1071	**586**		**485**	

Discussion

The results of data interpretation prove that the IoT prototype for measuring plant height can work in real-time, although it has shortcomings in ultrasonic sensor performance as shown in Figures 5 (a) and (d) storage data is detecting up to 35 cm, this is because the sensor does not detect plants with appropriate. The possibility of the calculation is caught between the distance of the pot to the ultrasonic sensor. This is because the ultrasonic sensor requires a fairly wide field and there are no objects around it, so it only focuses on detecting 1 (one) object (Abhiram et al., 2020). The value of plant height detection with minus results obtained in the study (see Figure 5(a)), indicates that the sensor shot detects outside the boundary between a predetermined object as well as detects under the lip of a plant pot until it exceeds the specified maximum height distance limit. Like the research conducted by (Latifah et al., 2021), it is stated that the need for precision tools and case study objects is not too small. Ultrasonic sensors work based on the ratio of the capture time after the wave is emitted. Wider reflection points will certainly increase the accuracy of the stored high values (Saputra & Lukito, 2017). The farther away from the object, the longer the time needed, and vice versa, the closer the object is, the faster the reflection (Latifah et al., 2021). Other factors that cause plant heights are not detected properly, namely changes in plant conditions that move with the wind or other environmental condition factors that make sensor detectors work less than optimally leading to actual plant height (Jyostsna Vanaja et al., 2018). The use of ultrasonic sensors The integrated website system has been running optimally because it can accommodate high data, but this study has limitations, namely only using 1 (one) ultrasonic sensor for detection on 1 (one) plant media. We recommend that the prototype use more than 1 (one) with the same object detection because it can increase the level of accuracy (Kashyap et al., 2018).

The limitation of this research is the use of a limited number of sensors so that the high accuracy of the plants obtained is still experiencing problems. The target object of using ultrasonic sensors for monitoring heights with objects that are not too small for example water levels will produce more accurate values and the characteristics of the tool tend to take advantage of low costs (Mohammed et al., 2019; Rocchi et al., 2019). Integration using the IoT database server prototype can certainly help in the agricultural sector, such as in research (Desnanjaya & Nugraha, 2021) that goes well. So it can be concluded that database integration with IoT can be done for sending data in real time, but it is necessary to select the right measurement object.

4. CONCLUSION

IoT-based prototype modeling involving a website system as a monitoring medium can work optimally in measuring plant heights integrated with a database server. IoT-based system settings can update data in real-time, even if the plant height data is valid or vice versa. However, the implanted ultrasonic sensor is still not running optimally, because based on the results of the performance analysis between the plant height obtained from the ultrasonic sensor compared to the original height measured by the expert, there is a difference. The main factor causing the discrepancy is the placement of the ultrasonic sensor which does not capture the plant object properly and the planted object is still too small in size.

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