Ultrasonic sensor for monitoring corn growth based on Raspberry Pi

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Abstract. For measuring plant height, an automated system as an indicator in the growing plant has developed in a modified micro propagation system. In the agricultural sector, there is some kind of work that needs monitoring, especially on corn. The monitoring will be used starting from the height measurement of plant manually or physical documentation condition from a plant using human resources. To capture and deliver the data by the farmer manually done and has to be informed quickly, then data from the farmer will be delivered to The Coordinator of Farmer. There is always occurred a problem with providing the data manually, more time is needed, and the accuracy of data not good enough. Because of this case, there is a required technology that can help this kind of work. The ultrasonic sensor as an electronic component is being used for the height of corn plant measurement automatically under the Raspberry Pi controller. The component work is being controlled by Raspberry Pi for how the system is working and deliver the data. The process of transmitting data will use Local Area Network (LAN) on the same IP Address. The monitoring results can be used as a reference regarding the health of the plant being monitored. This system can monitor the growth of corn, whether healthy or there is a problem, so that countermeasures can be taken more quickly and precisely.

1. Introduction
In recent years, the demand for automation building systems increases especially in agricultural systems [1,2]. Applications of many agricultural systems, including improved crop production, the precision of agriculture rely on crop information to react and detect spatial variabilities. The growth process plays a vital role in plant science and agronomics by maintaining and providing constant growing conditions in order to reduce variables that could bias experimental data. The characteristics plant of interest often includes plant height [2-4]. Indonesia has a vast area and rapid population growth rate that requires abundant crops to cover the needs of food for its population, so monitoring plants are needed to reduce the risk because of crop failure. The monitoring of plants starts from the plants in the form of seeds until the harvest period. Monitoring plant growth must be carried out continuously and requires accuracy to produce maximum crop yields, while manual plant growth monitoring methods can be said to be less than optimal due to human physical factors, such as fatigue and inaccuracy [6-8].

Another critical factor of integrating technology into the precision of the agricultural section that allows monitoring plants and crops in order to obtain the higher quality of plants that are will be used for food together with production increased is fundamental [3,9,10]. Due to various factors, this
importance is effected such as food shortage, climate change and the growth of population, the impact of these can be reduced using a sensor that can help to generate the optimal growth of plant conditions and the development of crops and plants[11–13].

2. Method
The methods used in this paper are prototyping methods. Raymond McLoad said these methods start from identified user needs, then prototype development, and when the prototype accepted, then the operating system will be coded as shown in Figure 1 [14,15].

![Figure 1. Prototyping system design.](image1)

Identified user needs

Prototype development

Prototype accepted

Operational system code

2.1. Design
For monitoring plant, the device will be placed precisely above the corn for height detection. The layout design for putting the ultrasonic sensor is shown in Figure 2.

![Figure 2. Layout design for monitoring system.](image2)

The system is working divided by several steps, starts from the ultrasonic sensor, Raspberry Pi as the controller, and intranet connection for data transfer. The ultrasonic sensor is being used as the input of the system to detect plant height when the data are received. It will be saved and being processed by the controller and will be shown in the personal computer through intranet connection for all device that has the same IP address as the device. About how the system will be working, it is shown in Figure 3.
Figure 3. Block diagram of process for system works.

Figure 4 is shown the design of the control system using Raspberry Pi. In Figure 4 are shown that the ultrasonic sensor is connected to the controller using a GPIO pin as an analog input, then it will be converting using code that is being used in the controller as a digital output.

Figure 4. The schematic of the ultrasonic and controller system.

The ultrasonic sensor that is chosen in this system are HC-SR04 type, because of its distance accuracy and simply processes using the controller. The use of Ultrasonic Sensors in Raspberry Pi should be noted on the side of the input pin sensor that requires a voltage of 5V, while the Raspberry Pi ideally works at a voltage of 3.3V. So we need a voltage divider by providing resistance (resistor) on the echo pin (output) of 330 Ohms and 470 Ohms of ground. The use of inappropriate resistance values results in the sensor not working according to its function.

Then to be able to transfer data from distance detection, Raspberry Pi needs to be installed in the samba application and set in the Program List.

Figure 5. Data transfer using wireless LAN.
Data transfer from the controller box to another device is using the same IP Address through the wireless LAN connection, data height can read from personal computer or notebook and smartphone then monitoring system can be more flexible and simply understands, the schematic process of data transfer using wireless LAN are shown on Figure 5.

2.2. Implementation

Implementation of the system is an advanced stage of the design stage, namely to realize the design that has been formulated regarding the specification - aspects that have been determined at the design stage. Hardware implementation is the implementation of the system that has been designed at the design stage so that the operation can be seen clearly and can be accounted for by their functions at the testing stage.

![Figure 6. System implementation.](image)

Ultrasonic sensors are installed using a buffer/pole made of the iron plate that can be adjusted in height and protective sensors made of plastic ultrasonic. The implementation of the system in the cornfield is shown in Figure 6.

3. Result and discussion

Ultrasonic sensors work based on a comparison of the amount of time captured after a wave is emitted. The farther away from the object, the longer the reflection time, while the closer the purpose, the reflection will be faster. In the design of the system that is made. Ultrasonic Sensors need to be programmed in the Raspberry Pi control system to work according to their functions. The following settings for the Ultrasonic Sensor program on the Raspberry Pi controller with the command to show results pf height detection on the corn plant. Table 1 is shown the measurement result of corn height using a distance meter and an ultrasonic sensor.

| Height measurement using distance meter | Height measurement using Ultrasonic sensor | Error Presentation |
|----------------------------------------|-------------------------------------------|--------------------|
| 15 cm                                  | 15.64 cm                                   | 4.2%               |
| 25 cm                                  | 25.07 cm                                   | 2.8%               |
| 35 cm                                  | 35.33 cm                                   | 0.9%               |
| 45 cm                                  | 45.28 cm                                   | 0.6%               |
| 55 cm                                  | 55.19 cm                                   | 0.3%               |
| 65 cm                                  | 65.22 cm                                   | 0.3%               |
| 70 cm                                  | 70.35 cm                                   | 0.5%               |
| **Mean Error**                         | **9.6%**                                   |                    |
From Table 2, it can be seen that the measurements detected by the Ultrasonic Sensor have an average error of 9.6%. However, this error does not interfere with the performance of the Ultrasonic Sensor. One of the causes of these errors is the uneven texture of the soil and the placement of the Ultrasonic Sensor that is not suitable.

From Figure 6 with hardware realization. The data will send from Raspberry Pi to PC or Laptop using WLAN (Wireless Local Area Network) using Portable Hotspot from Mobile. Measurements were made with three trials with different conditions or locations to analyze the comparison of data transmission speeds. The measurement results can be seen that the influence of data transmission from Raspberry Pi to a Laptop via LAN (Local Area Network) connection, at a distance of 5 meters measurement does not occur a delivery delay. While at a distance of 10-20 meters, there is a delivery delay, and at a range of 30-60 meters, the network connection access fails. So it can be concluded that the conditions in the settlement greatly affect the process of transmitting data from the Raspberry Pi to the Laptop because the signal is blocked by the house or building.

The measurement results are also carried out on a flat agricultural area where the results obtained that access to data transmission from Raspberry Pi to a laptop from a distance of 5 - 115 meters through a LAN connection at a rural location with no building barriers, no data transmission access delay or failure of network connection access. However, at a distance of 120 meters, access cannot be detected. So it can be concluded that the network connection in this tool can only be reached with a maximum distance of 115 meters.

The process of collecting height data is carried out once every 4 hours, once a day the average height of the detected height will be taken, this is to overcome the problem if there are disturbances such as winds with varying firmness that will affect the results of the measurement process detected by the sensor ultrasonic.

4. Conclusions
In this research, prototyping was made to monitor only one corn crop, but this can be utilized so that this research can be used on a cornfield using an ultrasonic sensor so that it is sufficient, this is due to the use of raspberry pi control from the specifications and completeness of the existing system. allows this to happen, unlike the case when using other controls such as only Arduino or microcontroller, which is limited by the speed in processing data and the need for complementary devices to be accessed by using the internet or LAN network. The shortcomings that exist in this device where access from the network is limited if there are obstacles such as buildings during the data transfer process, it would be better if the system to access data transmission or output from the work of the whole system can be accessed with a wider network (Internet), so that monitoring can be done anywhere and anytime, for other things the addition of other devices with the work function detects the thickness of the trunk and the length of leaf strands of corn.

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