

Monitoring of Solar Radiation Intensity using Wireless Sensor Network for Plant Growing

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Abstract— Plant growth is highly depending on the sunlight, if the consumption of sunlight is enough, it will grow well. The plant will be green because of its chlorophyll and it can perform photosynthesis at maximum; but if the plants get less sunlight, it will make the plants be yellowing. Radiation is electromagnetic waves that are good for plants, so-called visible light. In the electromagnetic wave spectrum the best wavelength range from 400-700 nm for the plant. A monitoring of sun intensity is needed in order to obtain sufficient solar radiation consumption and provide notification if there is a high radiation. In this study, several sensors and devices were combined such as photosynthetic solar radiation sensors, GSM / GPRS and waspmote as a main board or a microcontroller. The test was carried out on at least three occasions; the system has a stable radiation in the morning with an average of 505.51 micrometers. IN this study, we have successfully developed a monitoring tools for solar radiation intensity applied on plant growth by using wireless sensor network.

1. Introduction

Information of intensity of solar radiation in the greenhouse is needed. If there is too much exposure to sunlight, the growth will be not be optimum, and vice versa if the plants are less exposed to sunlight it cannot perform photosynthesis at its maximum.

Technology is developing very fast. Technology penetrates almost all sectors, especially agricultural sector, to facilitate the farmers in producing a quality crop. One of them is the using of wireless network sensors. Sensor is a device that is able to detect changes in the physical environment or chemical which converts it into electrical signals both electrical current and voltage [1]. In the development of the latest sensor technology using wireless sensor network (WSN), a sensor-based wireless technology that can allow users to access the sensor from a distance without using wires like for robot [2]. The role of these wireless sensor technology on human life as the data retrieval and delivery of information including our surrounding environment [3].

There was a study in 2013 designing a control the intensity of sunlight, temperature and humidity in the greenhouse with PID method. The study consisted of two phases: the design of hardware and software. Hardware used was the sensor SHT11 to measure humidity and temperature, LDR sensors to measure the intensity of light, microcontroller ATmega32 as controlling the overall system, and



several actuators as control and maintain stability in the greenhouse such as blower (fan), heater (lights), water sprayer, fertilizer sprayer, ground sprinklers, ventilation, and curtains. Software used was Bascom AVR programming language. [4]

Another study conducted in 2013 focused on the design of a distributed sensor network for monitoring the temperature, humidity and light intensity. Researchers designed a system of distributed sensors to monitor temperature, humidity and light intensity in the greenhouse using the Arduino Uno board. The system consisted of two sensor-actuator nodes and one node controller connected to an Ethernet network using Ethernet Shield board. Sensor-actuator nodes with DHT sensor 11 served to retrieve information environment of temperature, humidity, and light intensity. Results were displayed in a web site [5].

A study about landslide monitoring system was conducted in China using a wireless sensor network. The data collection proved to be consistent with natural phenomena, compared with traditional monitoring methods [6]. The study describes a system for monitoring the temperature in the greenhouse by placing temperature sensors in several positions observations. The proposed system allows a more representative and comprehensive observations to conduct an analysis of changes in temperature using wireless communication. Besides glass house temperature can be monitored optimally [7].

The aim of this study was to develop a system that can monitor level of intensity of solar radiation on the plants in the greenhouse in real time and provides a warning or notification that in the greenhouse deficiency or excess solar radiation. In this study, GSM / GPRS were used for data transmission and for monitoring solar radiation using solar radiation sensor.

2. Material and methods

Solar radiation is a very important element in agriculture. First, light is a source of energy for a green plant through photosynthesis is converted into chemical energy. Second, radiation plays an important role as a source of energy in the process of evaporation that determines crop water needs. [8].

Spectral distribution of sunlight received by the leaves on the surface title ($1900 \text{ umol m}^{-2}\text{s}^{-1}$) is greater than the leaves in the shade ($17.7 \text{ umol m}^{-2}\text{s}^{-1}$). In the shade of light that can be utilized for the process of photosynthesis is very little [9].

Solar radiation is comprised of spectra of ultraviolet (wavelengths less than 0.38 microns) which have damaging because the fuel is very high, spectra Photosynthetically Active Radiation (PAR), which acts raised up the process of photosynthesis and spectra of infrared (greater than 0.74 microns) which is temperature-controlled. Spectra PAR radiation can be broken down into bands of spectrum that each has certain characteristics. It turns blue spectrum contributed the most potential in photosynthesis [10].

The general architecture of this study can be seen in Figure 1.

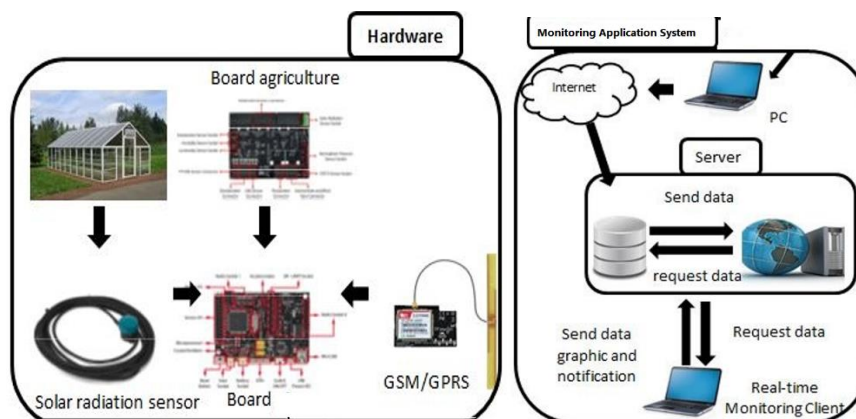


Figure 1. General Architecture

2.1 Hardware Design

2.1.1 Photosynthetic Solar Radiation Sensor. Photosynthetic Solar Radiation sensors are placed in the greenhouse, the agriculture board, there are some pins are connected to the Photosynthetic Solar Radiation sensor. Ie pin +, -, GND dam. This pin is used as the sender of the data from the sensor to the main board waspmote after it is stored in SD card, seen in Figure 2.



Figure 2. Photosynthetic Solar Radiation Sensor and Board Agriculture

2.1.2 Wasmote Master Board and GSM/GPRS Module. Wasmote main board is a vital part of the sensor, because on this board program code to be uploaded and also on this board will be put agriculture board, GSM / GPRS, and waspmote 802.15.4, as well as on the main board, there are waspmote on / off, port usb and also a battery which is connected directly. It can be seen in Figure 3.



Figure 3. Main Board, GSM/GPRS, Wasmote 802.15.4

This board is a data repository that is sent after the waspmote store sensor data into SD card. In the GSM / GPRS module there is a sim card slot that can be used as a signal gprs to send data to the internet or to a server database. Furthermore waspmote Pro 802.15.4, this module is a wireless communication device that sends a signal contained in waspmote sensor. The tool communicates using the 2.4GHz frequency with 12 channels and each channel using a 5MHz Bandwidth.

2.2 Data Communication and Monitoring system

2.2.1 Data Communication. Figure 4 describes data communication using the GSM / GPRS, initially solar radiation data captured by the sensor, then the data stored in the SD card contained in the sensor board, from SD card then the data is sent using the gsm module / GPRS. In the gsm module / GPRS card providers were used as signals to transmit data to the database, the data in the three grades who submitted that value, temperature, and battery. Value is the radiation data, temperature is the temperature of the sensor board, and the battery is a battery sensor, and these values are sent to the url and then entered into the database according to the field in the database.

2.2.2. Monitoring. Each incoming data from the sensors will be sent via GSM / GPRS to the url and then entered into the database server. And this data is then sent to the web server and ready to be shown to the client in the form of real-time graph, and the client can see all the information about the state of the sensor and greenhouse conditions were monitored remotely.

2.2.3. Notification. The incoming data on the sensor waspmote will be entered into the database, and if it has been entered in the database, the data will always be checked by php. In the solar radiation there is a range of values between 400nm-700nm good for crops as the supply of energy in the process of photosynthesis. The system checked if there was a value more than 800 nm then php will provide notification letting you know that radiation is too high, then a notification is displayed to the client , But if the data is entered into the database less than 800 nm, the program will check back but not sent a notification on the client side. The notification flowchart can be seen in Figure 5.

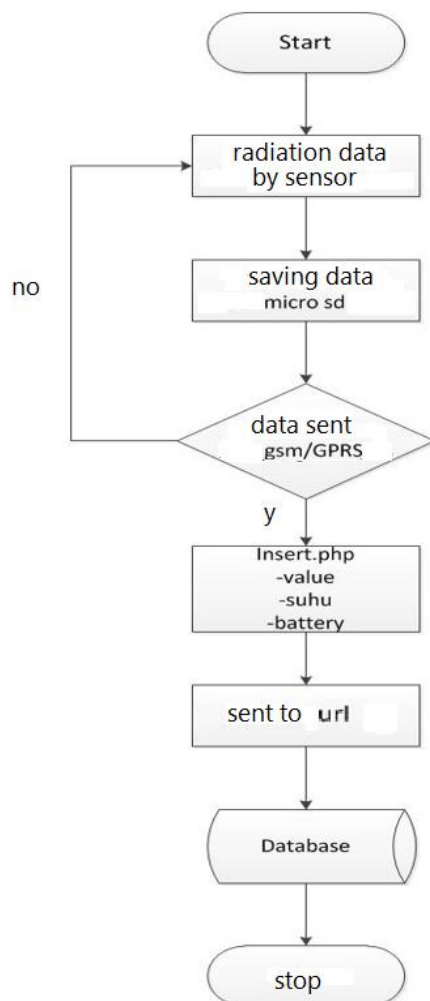


Figure 4. Flowchart data communication using GSM/GPRS

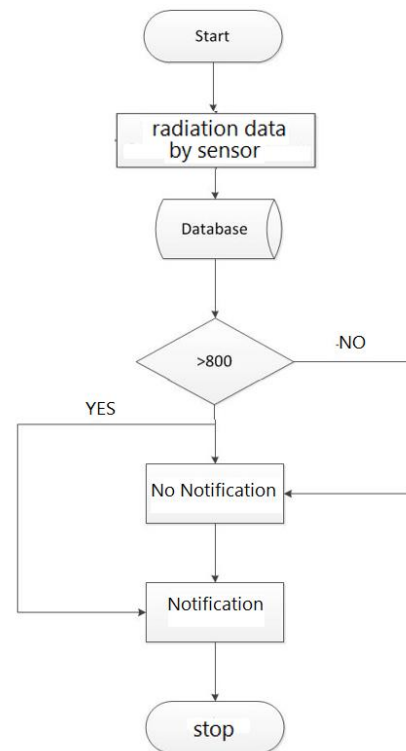


Figure 5. Flowchart Notification

When there is high solar radiation it will show a notification popup message on the right top on the web. This notification appears if radiation captured by the sensor was more than 800nm, and the value on the graph will change as well. The page views high radiation can be seen in Figure 6.

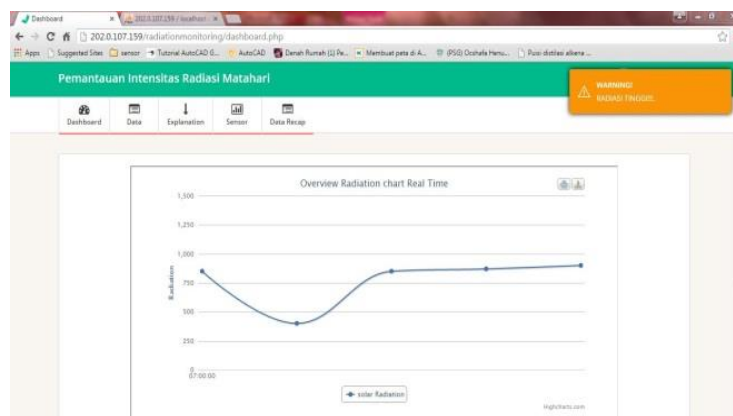


Figure 6. Notification on high radiation

3. Result

System performance testing was conducted to determine the level of intensity of solar radiation at the time was monitored by sensors. In this test we focused on monitoring solar radiation. The monitoring process can be seen at the time of the solar radiation captured by the sensor, after the radiation data obtained and the data is sent to the database server. Then the result was displayed to the user in graphical form. The higher the solar radiation it will be bad for the plant because not all of the radiation can be absorbed by plants. Only the range of 400-700 nm can be absorbed by plants. In performance testing systems to analyze the level of solar radiation we divided in three periods: morning, noon and afternoon. For a morning test observation was held on 8:00 to 10:00 am, noon test at 11:00 am to 02:00 pm, and for the afternoon at 03:00 to 05:00 am. The test system can be seen in Figure 7.



Figure 7. System Testing

Test performance was done to know the average solar radiation in the morning, noon and afternoon. The test was done for three days in a row. The first test was conducted in the morning with the sun's radiation to produce an average 505.31 micrometers, solar radiation produced quite stable in the morning.

The first test showed the radiation generated in the observation in the morning was 505.31 micrometers. The test results are shown in Table 1.

Table 1. Test in morning

No	Radiation (mm)	Time	Delay (s)
1	749	9:49:42	46
2	700	9:50:28	45
3	572	9:51:13	45
4	529	9:51:58	45
5	511	9:52:43	45
6	512	9:53:28	46
7	542	9:54:14	45
8	593	9:54:59	46
9	667	9:55:45	46
10	786	9:56:31	43
radiation 505,51		Avg delay	47,03

Table 2. Test in noon

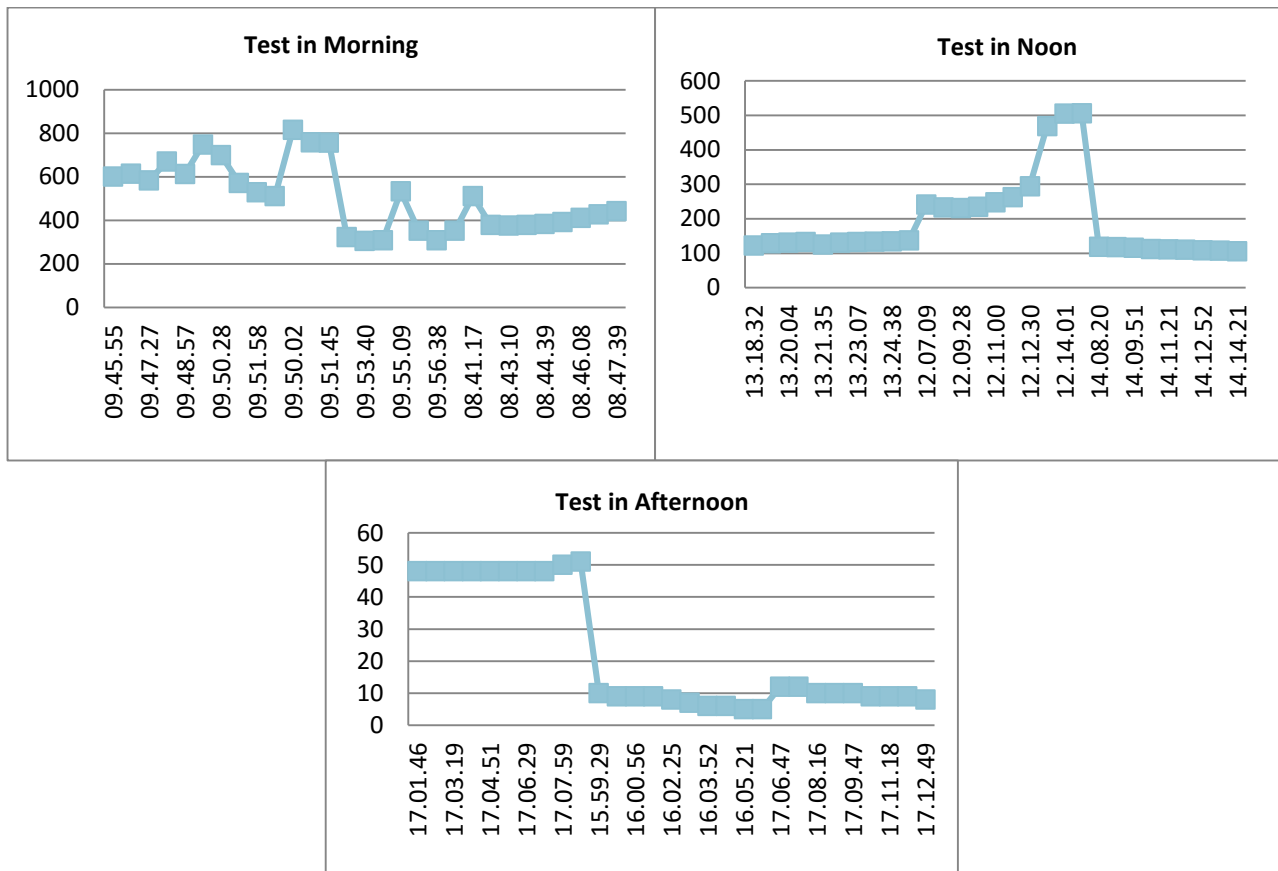
No	Radiation (mm)	Time	Delay (s)
1	166	13:27:39	47
2	177	13:26:28	45
3	184	13:29:11	45
4	182	13:29:56	47
5	174	13:30:43	45
6	163	13:31:28	51
7	146	13:32:19	45
8	137	13:33:04	52
9	137	13:33:56	43
10	140	13:34:39	46
radiation 191,55		Avg delay	46,65

During the noon, the intensity was decreased compared with the d the morning. The test results are shown in Table 2. The second test is done during the day, at noon produce solar radiation in the range 191.55 micrometers. The third testing done in the afternoon, on the afternoon of 22.34 micrometers generating solar radiation, radiation produced later in the day lower compared with the observations made in the morning and afternoon. The test results are shown in Table 3.

Table 3. Test in afternoon

No	Radiation (mm)	Time	Delay (s)
1	59	17:16:42	48
2	59	17:17:30	46
3	58	17:18:16	46
4	57	17:19:02	50
5	56	17:19:52	48
6	56	17:20:40	48
7	54	17:21:28	49
8	54	17:22:17	46
9	51	17:23:03	46
10	48	17:23:49	45
radiation 22,34		Avg delay	45,06

The test results were then converted into a line chart and a comparison chart can be seen test data on at least three occasions, conducted over three consecutive days. Charts difference can be seen in the morning, noon and afternoon. Solar radiation generated in the afternoon at about 22.34 micrometers, these results are lower compared with the observations made in the morning and afternoon. In the system testing conducted by the authors, the resulting solar radiation in the morning is around 505.31 micrometers. The graph line on the test data delay on the system can be seen in Figure 8.



The observations made by the author only three days, therefore the authors suggest the observations should be longer to get more data.

5. Conclusions

We have successfully developed a monitoring tools for solar radiation intensity applied for plant growth by using wireless sensor network. Here, a WSN system with integrated sensors simultaneously in real time situation to monitor the intensity of solar radiation. This result will help farmers optimize the growing and encourage the idea of *smart farming*.

References

- [1] Kretschmar M and Welsby S 2005 Capacitive and Inductive Displacement Sensors *Newnes Burlington*.
- [2] Siregar B, Purba AH, Efendi S and Fahmi F 2016 Fire extinguisher robot using ultrasonic camera and wifi network controlled with android smartphone *Proc. Of Annual Applied Science and Engineering Conference (AASEC) Bandung*
- [3] Siregar B, Nasution ABA and Fahmi F 2016 Integrated Pollution Monitoring System for Smart City *Proc of Int. Conf on ICT for Smart society (ICISS) Surabaya*
- [4] Defriyadi YS 2013 Pengendali Intensitas Cahaya, Suhu, Dan Kelembapan Pada Rumah Kaca Dengan Metode PID *under publication*
- [5] Pamungkas BA 2013 Perancangan Jaringan Sensor Terdistribusi Untuk Pengaturan Suhu, Kelembaban, Dan Intensitas Cahaya *under publication*
- [6] Yueshun H and Wei Z 2013 The reseach on wireless sensor network for landslide monitoring *IntJ On Smart Sensing and Intellegent Systems* Vol. **6**, No. 3.
- [7] Hastriyadi H et al 2014 A Multi Sensor System for Temperature Monitoring in a Greenhouse Using Remote Communication *IntJ of Latest Research in Sci and Tech* Volume **3**, Issue4: Page No.81-87.
- [8] Wisnubroto and Soekardi 1981 Asas Meteorologi pertanian *Ghalia Indonesia* Jakarta.
- [9] Taiz L and Zeiger E 1991 Plant Physiology *The Benyamin/Cumming Publishing Company Inc* Tokyo. p: 219-247.
- [10] Koesmaryono and Yonny 1991 *Kapita Selektu Agroklimatologi* IPB. Bogor