Plant Growth Monitoring System

Subhanshu Gupta
Department of Electronics and Communication,
PEC University of Technology Chandigrah

Ajay Mudgil
Senior Design Engineer
C-DAC, Mohali

Amita Soni
Assistant Professor, Department of Electronics and Communication,
PEC University of Technology, Chandigarh

Abstract

Advancement in technology is changing the world at great pace. New methods and systems are being developed throughout the world in different application areas. This advancement can prove as a boon to agriculture industry to meet the increasing demands of food and fodder around the world. This paper proposes a non-contact plant growth monitoring system using infrared sensors. The proposed system measures dimensions of the plant by using an infrared sensor, and generates maximum height, width and diameter of the stem of the plant as plant growth parameters, using measured data. Once the growth parameters are measured, they are transmitted to a remote server/user by using GSM technology. The proposed plant growth monitoring system has been implemented by designing a automated scanning system. Finally, the system performance is compared and verified with the measurement data that have been obtained by practical field experiments.

Keywords: - Plant growth monitoring, Infrared sensor, Scanning Unit, GSM

1. Introduction

Agriculture is the backbone of human existence on earth. For any civilization to prosper, agriculture has to be healthy and sustainable. Agriculture provides nourishment to the world population and holds the badge of being the source of income for India and other developing nations [1]. Also the demand for food is expected to continue to grow as a result both of population growth and rising incomes [2]. It results in great pressure on agriculture industry to secure the growing demands for the food. Innovations in agriculture are increasingly needed to secure a growing world demand for food, in order to conserve and optimize the use of limited natural resources and to sustain the environment's ability to provide economic, social, and environmental services to society. Agricultural innovations in this context include invention, development, selection, and implementation. Increasingly these innovations must rely on a deeper understanding of the long-term functioning of agricultural systems and their resiliency [3].This understanding can be achieved through research that integrates multiple processes to measure plant growth under different environmental conditions. If plant growth per growth cycle can be measured precisely, a detail plant growth model can be prepared and at the same time production of plants can be predicted and controlled accurately depending on environmental changes [4]. Green houses are one of the greatest inventions in this context.As Green houses are capable of creating different environmental conditions, they can act as a platform for the study of different plant growth curves, Patterns, environmental sustainability under different environmental conditions, essential for understanding the long term functionality of the agriculture system. Data for the study can be achieved by continuous monitoring and understanding the plants growth.

Growth is a phenomenon of irreversible increase in size of tissues and organs as well as weight,. The overall plant growth stages can be summarized as follows: fertilization → gemmule → seed → germination → seeding → growth → flowering → fruit → aging. [5]. The growth characteristics of plants vary depending on the type of plant.

Generally, plant growth is measured as increase in size of plant height, width, roots, stems, leaf area, leaf fat, stem cross section and so on.

Visual monitoring of the plant growth as a mean of identifying the health status of individual plant or plantation crop has been undertaken widely throughout the world. This however depends on the human judgement and subtle changes are not readily identifiable by the human or identified too late. So a continuous growth monitoring system is required that is precise, cheap and user friendly. Also there is a need of remote data transfer as the data processing sites are usually far away from the fields/farms and collecting data by manually approaching each test site is impractical.

This paper presents design and development of a new real-time non-contact plant growth monitoring system based on the wireless technology to automate the plant growth measurement process. The system was implemented for a plant and the system performance was verified by comparing the results with the data obtained from the practical field experiments.

2. Principle of Operation

IR technology can be used effectively for object detection and ranging up to some distance and is very helpful in non-contact plant monitoring systems [6]. IR technology uses a pair of transmitter and receiver unit for detection and ranging. When the Infrared rays, transmitted from an IR transmitter falls on an object a portion of it get absorbed and the rest of the light is reflected back. The amount of reflected radiations can be measured by IR receiver. The amount of radiation reflected back to IR receiver depends on the distance of the object from the receiver. By measuring the amount reflected radiation, presence as well as the distance of an object in front of the sensors can be estimated. If an IR sensor (IR transmitter and receiver pair) is made to scan a particular area of interest, an approximate sketch of the object in front of the sensors can be obtained by just mapping, those coordinates of the area where the object detection was found. This map can be used to find the dimensions like height, width of the object. For example if an area space is considered as a matrix with a defined number of rows and column with constant distance between them say 0.5 cm and each point in the matrix is filled with one or zero depending on weather an object is present in front of that space in a defined range, a bit map can be generated as shown in figure 1. Here the grey shaded regions are one and other is zero. As it can be seen from the figure an approximate shape of the object was captured. By counting the number of ones in different rows and column height width of the object can be calculated. As can be seen from the figure1 the eight row of column one has first one, this column number when multiplied by the step size i.e. spacing between the columns, gives the height (8x0.5=4cm) of the object in that row.

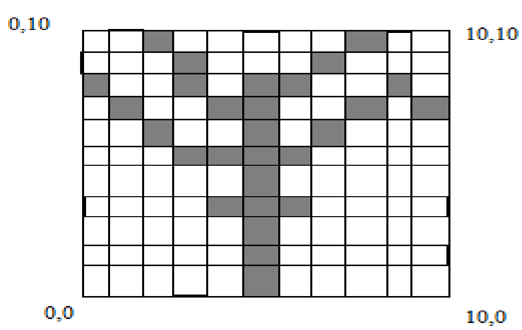

Figure 1 Bit map of scanned area

3. Overview of Plant Growth Monitoring System

For measuring the dimensions of the plant a fully automatic system was designed developed and constructed. A number of sensors and modules were successfully introduced, tested, and integrated into the system including infrared sensors, temperature sensors, humidity sensor and GSM module. The entire system was integrated into a fully automated package. This allowed the system to autonomously return to specified sites at set time intervals to identify changes in the growth rates with minimal human input. Basic block diagram of plant growth monitoring is shown in figure2. The complete system can be divided in to six units .Below is the detailed description of each unit.

3.1. Control unit:-

This unit is the heart of the system. This unit controls and synchronise the whole system and also contains the database of the system. Unit takes data from different sensors convert that data in meaningful format, calculates dimensions of the plant and environmental conditions and stores the data in to the information for future use.

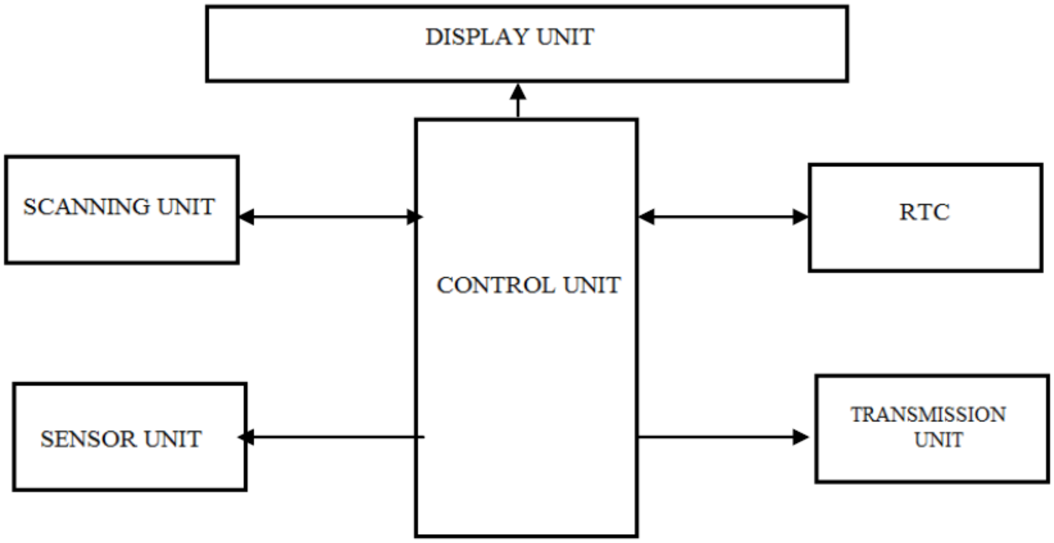

Figure 2 Units of plant growth Monitoring system

3.2. Scanning Unit:-

This unit consists of the mechanical system as shown in the figure 3, which moves the IR sensor in predestined path to scan the complete area. This unit also consists of motor driver to move the mechanical system and an ADC to get data from the IR sensors in digital format. This data is used to generate a bit map by the control unit.

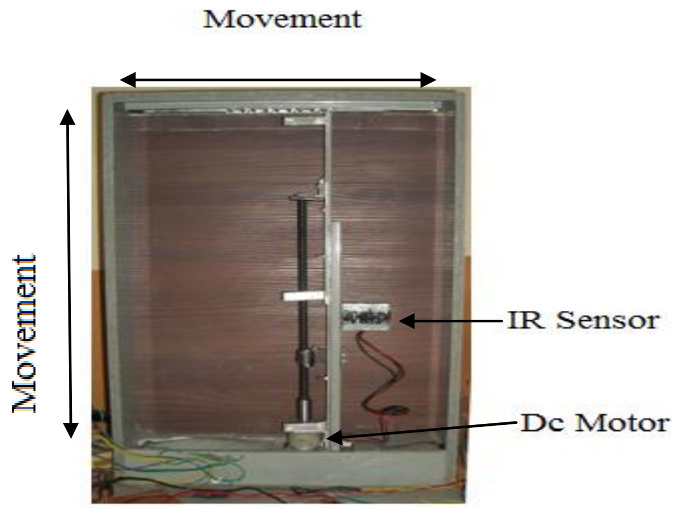

Figure 3 Scanning unit

3.3. Sensor Unit:-

This unit consist of sensors an ADC to measure the environmental conditions and provide data in digital format to the control unit. LM35 and HR202 were used as temperature and humidity sensor. When required the control unit sends signal to sensor unit for the data. This unit gets data from the sensors, converts the data in digital format by using an ADC and sends data back.

3.4. RTC:-

In this system DS1307 Real Time clock was used for giving the information of date and time to the control unit. This information is used by the control unit to start plant monitoring at scheduled time. The RTC works on 2 wire I2C protocol and also contains information about schedule of plant growth monitoring.

3.5. Display Unit:-

This unit contains an LCD to show information to the user and is in direct control of the control unit.

3.6. Transmission Unit:-

This unit contains the GSM module for sending data to the remote user/server.SMS was used as a medium to transfer.

The complete working of the project can be summarized by the algorithm shown in the figure 4. When the system starts, scanning unit first scans the predestined area to generate a bit map of the region by using data of the IR sensor and generates a bit map. Control unit find out height and width of the plant at different points in the space maximum height in each column and maximum width in each row. This data is then stored in the data base of the microcontroller. In the next step maximum height, width and stem diameter of the plant are calculated. This data is also stored in the memory of the system. Then the system find out the environmental conditions i.e. Temperature and humidity near the plant. This data is also stored in the memory of the system. Measured data is then compared with the previous data to find out the increase or decrease in the dimensions of the plant. And then the all information i.e plant present dimension, increase in height and width of the plant, environmental conditions and time and date of the measurement are shown on the LCD and is also transmitted to the remote location by sending SMS to the remote location.

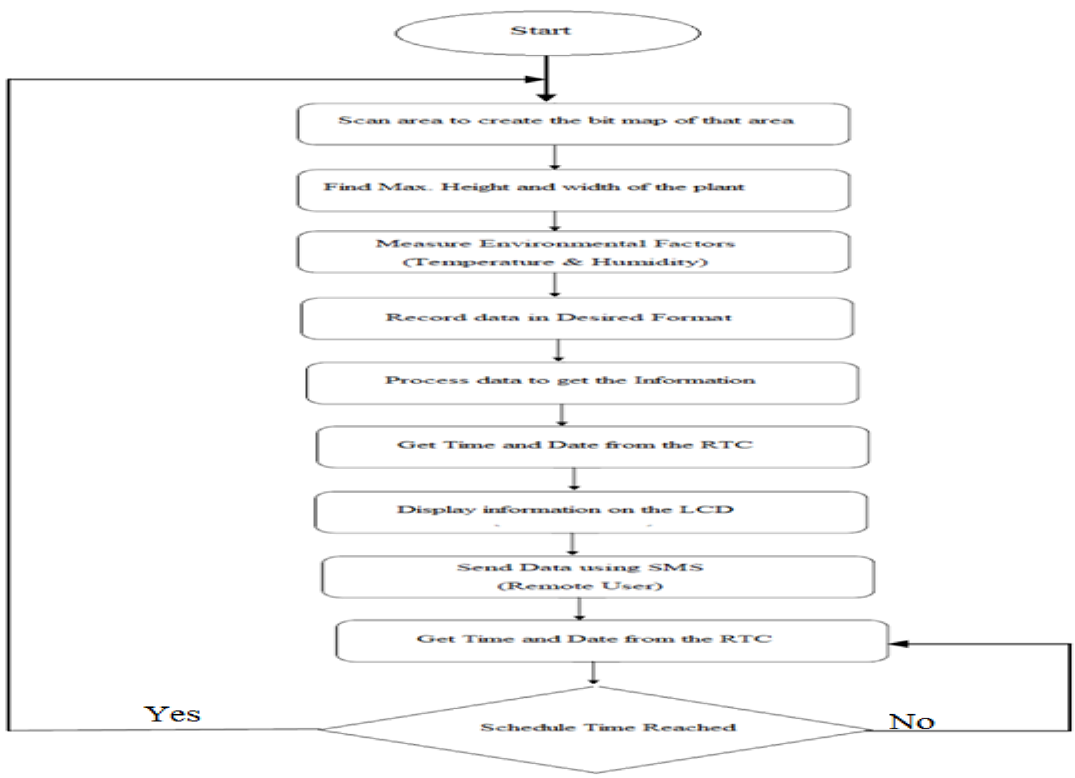

Figure 4. Algorithm of complete plant growth monitoring system

4. Experiment and Results

4.1. Implementation and Experimental Environment

A plant was randomly selected and the proposed system was implemented to monitor the growth of the plant under normal environmental conditions as shown in the figure 5(a) and figure 5(b).The plant pot was placed in front of the system at a distance of 15 cm from the base of the system. The system was programmed to divide the space in a matrix of 50x40 with a step size of 0.5cm. The system was scheduled to take two observations in a day at an interval of 5 hour and to store the data in the internal memory of the system. The system also notified the collected data to user, by sending SMS of the data collected through SMS. The snap shot of the data sent by the system to notify the user is shown in the figure 5(c).

Figure.5 (a) Field test environment front view. (b) Field test environment front view. (c) SMS Received at user end

4.2. Experimental results:-

Table 1 shows the data obtained from the database of the system. Column in this table shows the day and time of measurement, height of plant in each column of bit map, width in each row of the bit map, maximum height, maximum width and temperature of the environment. Three days data has been tabulated in the table because of space considerations. Height width of each column and rows were calculated by the system using the bit map of the scanned area. Then maximum height and width were calculated by the system from this data. Table 2 shows the comparison of Height and width obtained by the system and by the manual measurement.

Table 1 Data samples obtained from plant growth monitoring system

DAY	Height in each column(cm)	Width in each row(cm)	Max. Height of plant	Max. Width of plant	Temp-perature (centigrade)
Day1 11 AM	0,0,0,0,0,0,0,0,0,.5,1,3,3.5,5.5,,7,7.5,8,8.5,9,14.5,15,15.5,16,16.5,17,17,18,17.5,18,17.5,18,16.5,15.5,14.5,14.5,14.5,14,0,0,0,0,0	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 1.0, 1.5, 2 , 2.5,3,3.5,.5,.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5,0.5,4,3.5,6,5.5,5,4.5,4,3.5,3,1.5,2, 2.5,0,0, 0,0,0,0,0,0,0,0,0,0	18 cm	6cm	38
4 PM	0,0,0,0,0,0,0,0,0,.5,1,3,3.5,5.5,,7,8,8.5,9,14.5,15,15.5,16,16.5,17,17,18,17.5,18,17.5,18,16.5,15.5,14.5,14.5,14.5,14,0,0,0,0,0	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 1.0, 1.5, 2 , 2.5,3,3.5,.5,.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5,0.5,4,3.5,6,5.5,5,4.5,4,3.5,3,1.5,2, 2.5,0,0, 0,0,0,0,0,0,0,0,0,0	18 cm	6 cm	43
Day	0,0,0,0,0,0,0,0,0,.5,1,3,3.5,5.5,	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 1.0,	19 cm	6.5 cm	34

15 11 AM	7,7.5,8,8.5,9,15.5,16,16,16.5,17,17.5,18,19,19,18.5,17.5,17,16.5,14, 0,0,0,0,0	1.5, 2 , 2.5,3,4,3.5,.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5,0.5,0.5,4.5,6.5,6,6.5,5.5,4.5,5.5,3, 4, 4.5,4.5,1,0,0, 0,0,0,0,0,0,0			
4 PM	0,0,0,0,0,0,0,0,0,.5,1,3,3.5,5.5, 7,7.5,8,8.5,9,15.5,16,16,16.5,17,17.5,18,19,19,18.5,17.5,17,16.5,14, 0,0,0,0,0	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 1.0, 1.5, 2 , 2.5,3,4,3.5,.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5,0.5,0.5,4.5,6.5,6,6.5,5.5,4.5,5.5,3, 4, 4.5,4.5,1,0,0, 0,0,0,0,0,0,0	19 cm	6.5 cm	40
Day30 11 AM	0,0,0,0,0,0,0,0,0,.5,1,3,3.5,5.5, 8,8,8.5,9,15.5,16,16.517,19.5, 19.5,19,20,19.5,19,19,17,14.5,0,0, 0,0,0	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 1.0, 1.5, 2 , 2.5,4.5,4,3.5,.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5,0.5,0.5,5,8,7.5,7,6.5,5,,5.5,3, 4, 4.5,4.5,1,0,0, 0,0,0,0,0,0,0,	20 cm	8 cm	38
4 PM	0,0,0,0,0,0,0,0,0,.5,1,3,3.5,5.5, 8,8,8.5,9,15.5,16,16.517,19.5,19.5 , 19,20,19.5,19,19,17,14.5,0,0,0,0,0	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 1.0, 1.5, 2 , 2.5,4.5,4,3.5,.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5,0.5, 0.55,5.5,3, 4,4.5,4.5,1,0,0, 0,0,0,0,0,0,0,	20 cm	8 cm	41

Table 2 Comparison of the data obtained from growth monitoring system and by manual measurements

Measurement Period(days)	Plant growth monitoring unit			Manual measurement			Error in measurement		
	Maximum height	Max width	Evening Temp.	Maximum height	Max width	Evening Temp.	Maximum height	Max width	Evening Temp.
1	18	6	37	18.5	6.5	37.5	0.5	0.5	0.5
5	18	6	38	18.5	6.5	38	0.5	0.5	0
10	18.5	6.5	40	18.5	6.5	39.5	0	0.5	0.5
15	19	6.5	39	19.0	7.0	40	0	0.5	1
20	19	7	40	19.5	7.5	41.5	0.5	0.5	0.5
25	19.5	7.5	38	20	7.5	37.5	0.5	0	0.5
30	20	8	41	20.5	8	41	0.5	0	0

Table 2 shows the comparison of the data obtained from plant growth monitoring system and by manual measurement processes. The system measured the dimensions of the plant with good accuracy and required no human input.

Table 3 Qualitative comparison and analysis of measurement system.

Qualitative performance items	Existing measurement System	Proposed System
Remote Measurement & Control	Impossible	Possible
Real-time Measurement	Impossible	Possible
Labor Cost	High	Negligible
Measurement error	High	Moderate
Initial Installation Costs	Low	High
Damage to the Plant in Measurement	Much	Negligible

Table 3 compares and analyzes the qualitative performance items of the existing system (manual measurement) and the proposed system. According to these comparison results, the proposed system has been verified to outperform the existing methods in almost all of performance features. In particular, the proposed system makes it possible to measure dimensions of the plant, environmental factors, increase in the dimensions of the plant and perform remote measurement in real-time.

5. Conclusion

The paper proposed a plant growth monitoring system using IR technology. The proposed system was implemented and then installed for plants to measure the plant growth parameters such as dimension height and width, stem size of the plan. Environmental conditions temperature and humidity were also measured by the system. Through the field tests, it was verified that the proposed system can be used in the field of plant growth measurement. The proposed system makes it possible to perform remote monitoring, which is nearly impossible with existing measurement methods.

6. REFERENCE

[1] Vandana Tyagi " India's Agriculture: Challenges for Growth & Development in present scenario" International Journal of Physical and Social Sciences Vol. 2,Issue 5, 2012,pp:116-128.

[2] "How to Feed the World in 2050" FAO Discussion Paper in World Summit on Food Security Sited on http://www.fao.org/wsfs/forum2050/wsfs-background-documents/issues-briefs/en.

[3] G. Philip Robertson, Vivien G. Allen et. al. "Long-Term Agricultural Research (LTAR): A Research, Education, and Extension Imperative" White Paper Report of the LTAR-EE Workshop, USDA-CSREES, Washington, DC, 2006.

[4] B.K. Ryu. "Digital Agriculture Era" SERI: Seoul, Korea, 2007.

[5] http://textbook.s-anand.net/ncert/class-11/biology/15-plant-growth-and-development.

[6] Jinweon Suk, Seokhoon Kim and Intae Ryoo "Non-Contact Plant Growth Measurement Method and System Based on Ubiquitous Sensor Network Technologies" Sensors Journal, 2011, Vol.11,pp: 4312-4334.