Smart Techniques Employed for Monitoring of Agricultural Parameters

Anuradha MR[1], Apoorva Raghunandan[2]

[1, 2]Undergraduate Student, Department of ECE, BNM Institute of Technology, Bangalore, India

Abstract: ***Agriculture is one of the primary occupations of man since early civilizations. Even today, manual intervention is inevitable. Around sixty to seventy per cent of the population depend on the resources from the agricultural sector. Asian nations rank second in terms of the farm field output. The agricultural sector is not fully automated with one of the main reasons being the cost. Controlled climatic conditions are very important for plant growth and hence for optimum produce. Farmers suffer large financial losses because of wrong predictions of weather and incorrect irrigation methods. In this context, with the evolution of miniaturized sensor devices coupled with wireless technologies, it is possible to remotely monitor parameters such as moisture, temperature, humidity and detect the leaf diseases. The project's objective is to design and develop an embedded system that can acquire the farm field parameters and efficiently process them so that it can be wirelessly transmitted to a remote place. According to the parameters that are received continuously by the end user, decision based on monitoring can be done. This improves the quality of plant growth and takes care of each of the nutrient parameters required for its growth. A part of the paper also deals with Greenhouse which plays an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. The proposed system is an embedded system which constantly monitors the digitized parameters of the various sensors and verifies them with the predefined threshold values and checks if any corrective action is to be taken by controlling the parameters inside the greenhouse by actuating a cooler, foggier, dripper and light respectively in accordance with the necessary conditions for the plants.***

Keywords: Sensors, IOT, Microcontroller, ZigBee, Greenhouse

1. Introduction

Most of the agriculture lands in India have been turned into real estate lands which is because of difficulties farmers face and the high loss to profit ratio. In this paper, various agricultural technologies which can increase the productivity of the crop are dealt with. The advanced development of wireless sensor networks can be used in monitoring various parameters in agriculture. Due to uneven natural distribution of rain water, it is very difficult for farmers to monitor and control its distribution to agricultural fields as per the requirement of the crop.

To achieve greater things on the technical requirements of the Internet of things, we adopt the technology of wireless sensor network based on ZigBee, GPRS and Web Services **[1]**. The next technology that emerged was web of things. IOT could be conceptually defined as a dynamic global network infrastructure with self-configuring potential based on standard and interoperable communication protocols where physical and virtual things have identities, physical properties, and virtual personalities. To monitor and communicate with one or more entities and to connect to the Internet, technical communication devices are becoming essential.**[2]**. The devices can be attached to or embedded in the entities themselves – thus creating smart things – or they can be installed in the framework of the things to be watched. To detect leaf diseases, the MATLAB software system is employed. For study purposes grape leaves and diseases related to it are considered. Once images are processed, results are sent via MATLAB to our e-mail account **[3**]. The basic nutrient requirements for a plant like potassium, nitrogen and phosphorous can also be measured so that the optimum yield can be obtained **[4]**. Greenhouse plays an important part of the horticulture and agricultural sectors in our country as they can be used to grow plants under controlled climatic conditions for appropriate yield **[5]**. Hence, agriculture has an important role to play in the economic situation of any country. The backbone of the Indian economy is the agricultural industry, which is why these methods that are proposed and can be efficiently used to obtain desired yields. In the field of agriculture, automation has not been adopted or not been put to a full-fledged use, perhaps because of several reasons one such reason is cost. Greenhouse plays an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. The proposed system is an embedded system which constantly monitors the digitized parameters of the various sensors and verifies them with the predefined threshold values and checks if any corrective action is to be taken by controlling the parameters inside the greenhouse by actuating a cooler, foggier, dripper and light respectively in accordance with the necessary conditions for the plants. **[6]**

2. Related Work

The creation and adaption of standardized benchmarks for routing in the Internet of Things may help in the advancement of the comparison of candidate protocols for the IOT **[2]**.Their direct comparison in both simulation and realistic test bed scenarios could provide further insight into their suitability for distinct IOT. Huge increase in users of web and modifications on the internetworking technologies alter networking of everyday objects **[1]**. Leaf disease Severity Measurement Image Processing in 2011 have projected an image process technique for plant disease region identification. Grapevine crop was chosen to obtain experimental results.[3]Here image processing included image acquisition, image segmentation, leaf region segmentation and disease region segmentation.

There are more than 50 countries now in the world where cultivation of crops is undertaken on a commercial scale under cover. United States of America has a total area of about 4000 ha under greenhouses mostly used for floriculture with a turnover of more than 2.8 billion US $ per annum and the area under greenhouses is expected to go up considerably, if the cost of transportation of vegetables from neighboring countries continue to rise. The Netherlands is the traditional exporter of greenhouse grown flowers and vegetables all over the world. With about 89,600 ha under cover, the Dutch greenhouse industry is probably the most advanced in the world. Dutch greenhouse industry however relies heavily on glass framed greenhouses, to cope up with very cloudy conditions prevalent all the year round. A very strong research and development component has kept the Dutch industry in the forefront. In Saudi Arabia cucumbers and tomatoes are the most important crops contributing more than 94% of the total production. The most common cooling method employed in these areas is evaporative cooling. Egypt has about 1000 ha greenhouses consisting mainly of plastic covered tunnel type structures. Arrangements for natural ventilation are made for regulation of temperature and humidity conditions.[5] The main crops grown in these greenhouses are tomatoes, cucumbers, peppers, melons and nursery plant material. In Asia, China and Japan are the largest users of greenhouses. The development of greenhouse technology in China has been faster than in any other country in the world. With a modest beginning in late seventies, the area under greenhouses in China has increased to 48,000 ha in recent years. Out of this 11,000 ha is under fruits like grapes, cherry, Japanese persimmon, lemon and mango. The majority of greenhouses use local materials for the frame and flexible plastic films for glazing.

3. Wireless sensor network

Figure 1: Wireless Sensor Network

The wireless sensor networks that are used in agriculture consist of already existing sensor modules that sense the values near the crop. These values are processed and transmitted to the remote place where the decision based on monitoring is done. The sensors are also the actuators that can be made to take commands from the end user to adjust to the proper climatic conditions and help the plants to produce better. This information can be passed on to the user through SMS, emails etc.

4. ZigBee and GPS technology

A. System architecture

The design of the system includes various sensors like temperature sensor, humidity sensor, pH sensor along with Samsung's S3C2440 microcontroller in the intelligent ARM processor. These values are processed and then it is integrated with ZigBee module. This is connected to the GPS or the central node through which parameters can be accessed from a far-off place.

B. Working

1) S3C2440:ARM Intelligent Monitoring Center uses Samsung's S3C2440 processor as its main controller, the performance and frequency of which are suitable for real-time video image capture and processing applications.

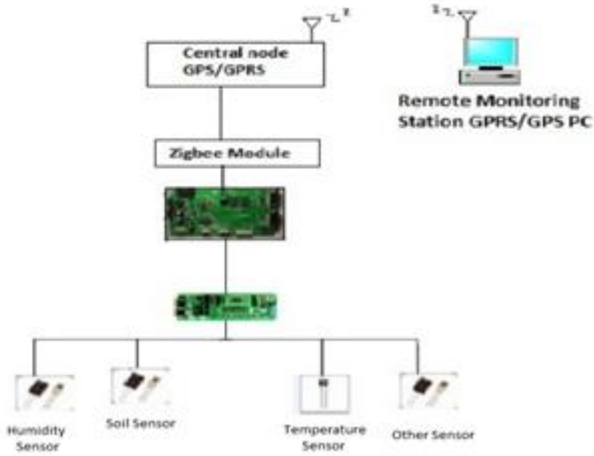

Figure 2: Basic block diagram of ZigBee system

1) **Sensors:**

- **Temperature sensors:** SHT15 is small-sized intelligent sensor that can measure relative parameters such as temperature, humidity and temperature measuring range is - 400C~123.80C, Resolution is 0.1, response time is less than 3s.
- **Humidity sensor:** Values usually depend on other quantity such as temperature, pressure, mass or a mechanical or electrical change in a substance as moisture is absorbed. By calibration and calculation, these measured quantities can lead to a measurement of humidity.
- **Soil sensor:** The soil sensors collect information on soil temperature and soil moisture in the outdoors environment.

2) **ZigBee station:** The ZigBee coordinator node is embedded into the gateway, as a fully functional device, collecting all nodes data. Communication between Coordinator and GPRS is through serial, also can directly communicate with the PC, realizing real-time data checking and monitoring.

3) **GPRS/GSM**: This system uses SIM100-E GSM / GPRS dual-band module for voice transmission, messages and data services. It provides wireless interface and communicates with the ARM Intelligent Monitoring

Center through the RS232 interface.

4) **The solar energy power supply**: In this experiment, according to the current, voltage and other data measured from gateway and the application requirements are designed with the solar power for gateway node using the 12V volts.
5) **GPS**: In this Global positioning system (GPS) is used for finding the location of the agriculture field location.

Figure 3: Agricultural monitoring system

C. Output and Future Work

The smart monitoring of on field parameters is achieved very easily usingZigBee and GPS methodologies. The control panel contains three sections which are Sensor Ports, Current Temperature and Set Maximum Temperature. The Sensor Ports set the connection between computer and the wireless temperature sensor. **[1]** For communication to be done, the end user must select the communication port from the drop-down menu. Besides, the Current Temperature section displays the retrieved temperature data.The system can realize rapidly automatic networking and real-time data acquisition, transmission, display. With the characteristics of low cost, low power consumption, flexibility networking, without cabling, friendly interface, etc. Through GPRS technologies and Web Services technology, we can realize the function of the data networking, remote monitoring, it shows that the system can meet the requirements of the temperature and humidity of soil environmental monitoring 113 and unified management. In future, we can monitor the ground water level using appropriate sensor.

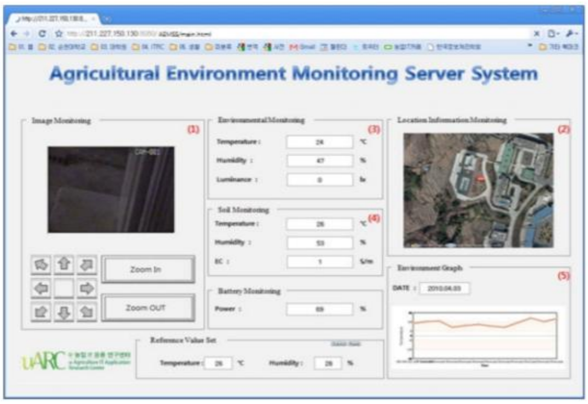

Figure 4: Web GUI for Agricultural environment monitoring Server system.

5. Sensor acquisition and leaf disease detection using IoT

A. Design

The architecture of the system in this method makes use of the IoT technology for the detection of leaf diseases. The embedded hardware is the controller unit that is connected to different sensor units. These values are then processed and sent via the Xbee module.

The **internet of things** model can be used here for transmission of images of defective leaves. The Internet of things and its relationship with devices is as shown in the figure:

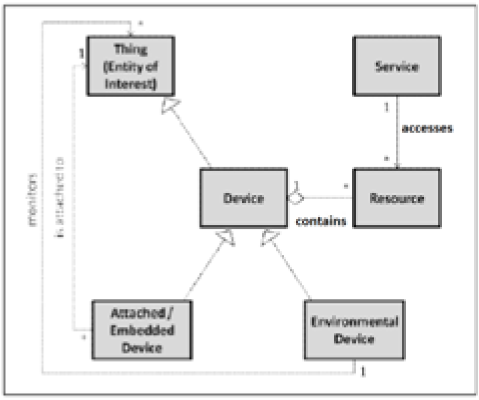

Figure 5: Relationship between things, devices, resources and services.

The advent of Wireless Sensor Networks (WSNs) spurred a new direction of research in the agricultural domain. In recent times, WSNs are widely applied in various agricultural applications. To focus on the specific requirements, the devices, sensors and communication techniques associated with WSNs in agricultural applications are analyzed comprehensively**.**

Wireless sensor networks represent an enabling technology for low-power wireless measurement and control applications. The elimination of lead wires provides significant cost savings as well and creates improved reliability for many long-term monitoring applications. Wireless sensor networks represent an enabling technology for low-power wireless measurement and control applications. The elimination of lead wires provides significant cost savings as well as creating improved reliability for many long-term monitoring applications.

The System is a combination of three domains which include embedded systems, image processing and wireless networking. System consists of clusters of sensors, grouping differing kinds of information, concerning the crop. The information transmission of the sensible sensing devices is with the ZigBee network. MATLAB software is employed for detection of leaf pictures. For experimental purposes, Grape leaves and diseases related to it are considered. Once image processing is done, results are sent via MATLAB to our e-mail account. The block diagram of the system is shown in the below figure:

B. Design Flow

All the sensors sense and collect data from the environment around the crop and give it to the Arduino board. Arduino performs different necessary functions like analog to digital conversion, interfacing with different sensors, interfacing with LCD etc. By performing various conversion factors, results are sent to the LCD display as well as to theZigBee module for serial communication. There are two ZigBee S1-modules that are used.One is used to collect data from the Arduino and the other is used to transfer parameters wirelessly to the computer. Personal computer or laptop can be used to perform image processing operations on the defective leaves. The USB camera takes live pictures of plant leaves. Images are sent to the PC for further operation. MATLAB gives results finally on the web display.

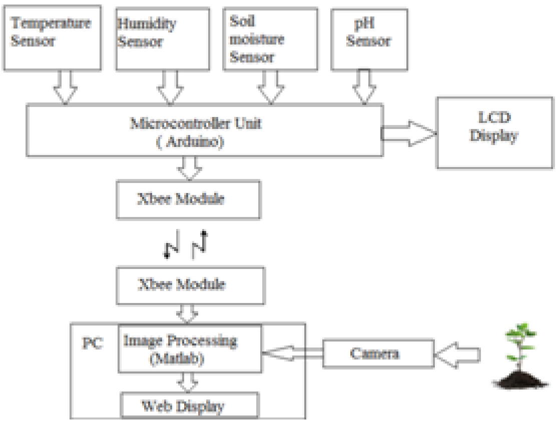

Figure 6: Proposed schematic of the system

C. Leaf disease detection

The detection of defective leaves forms an important part of the optimum crop yield. Mildew is a form of fungus. It is distinguished from its closely related counterpart, mold, largely by its color: molds appear in shades of black, blue, red, and green, whereas mildew is white. The prior information regarding the disease of a plant can prevent the loss of optimum yield and economy.

There are four main steps for image process on leaf that includes:

1) **Image Acquisition**: Spot pathological leaves area unit taken for this study. Pictures area unit taken in controlled surroundings and area unit keep within the JPEG format.
2) **Image Segmentation**: Image segmentation is that the necessary step to separate the various regions with special significance within the image.
3) **Leaf region Segmentation**: Input image is initial reborn into gray scale image. Since image is taken in controlled surroundings putting pathological leaf on the white background, it makes massive distinction in grey values of 2 values, object and background.
4) **Diseases region segmentation**: Segmentation of region with spots is completed here. For fulfillment of experiment it's necessary to section the region accurately.

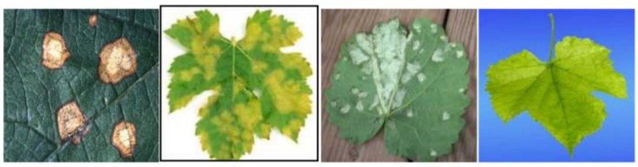

Figure 7: black rot,downy mildew,powdery mildew and a normal leaf

Based on the above factors, the image transformed from RGB color space to HSI color space, which is more suitable for visual characteristics of human beings. Since the brightness component is independent of the color component and the vision of the human being is more sensitive to Hue compared to Saturation, the color component can be good to eliminate glare, shadow and other light factors during color image segmentation.

The similar gray value of the shallow color of the midrib and the leaf in color component can decrease the interference of the midrib in the follow up lesion image segmentation to a large extent. If the lesion characteristics are varied the boundaries between the lesion and the healthy part are also varying so there is weak edge. Hence triangle thresholding method is used here for selection of thresholding value of gray image. To select the thresholding value, triangle is constructed by drawing a line between the maximum of the histogram at brightness b-max and the lowest value b-min in the image. The distance 'd' between the line and the histogram h[b] is computed for all values of 'b' from b=b-min to b-max. The brightness value 'bo' where the distance between h [bo] and the line is maximum is the threshold value.

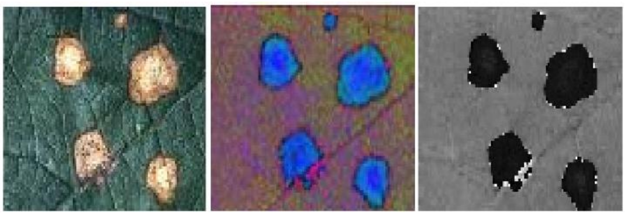

Figure 8: RGB Image, HSI Image and Hue component

The flowchart depicts the sequence of image processing operations involved in leaf disease detection. These steps can be applied to any plant for experimental study. One advantage of the above proposed system is that, apart from smart monitoring of agricultural parameters, a particular plant conditions including its various diseases can be studied using MATLAB by comparing the previously obtained images with the current image.

D. Hardware and Software tools

1) **Sensing Units**: Four differing types of sensors are used. The first sensor finds the attributes of a hydrogen ion concentration level of soil in farm i.e. pH of soil. The second sensor measures the wetness within the air that gives humidity.

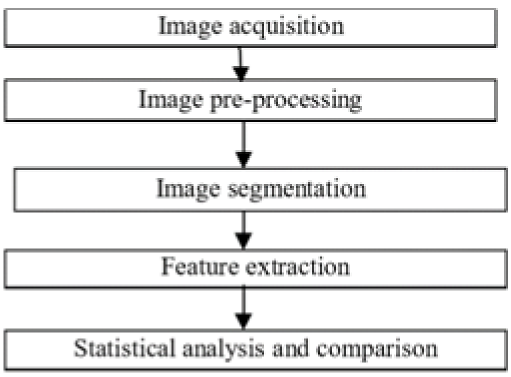

Figure 9: Flowchart of defective leaf detection

The temperature sensor is the third sensor which supplies the specified temperature level for that crop. The soil moisture sensor forms the fourth sensor that measures the soil wet level within the soil which supplies the thought regarding water level in soil.

2) **Arduino Board**: Here we have a tendency to use Arduino board that acts as a microcontroller unit for embedded side. Arduino board consists of Atmel 8-bit AVR microcontroller with complementary parts that facilitate programming and incorporation into alternative circuits. Also, ADC and interfacing operations are performed by the controller.

3) **ZigBee module**: Xbee-S1 module is employed for wireless information transmission of all parameters from field to computer.

4) **Web Camera**: One i-ball ROBO K20 USB camera is employed for taking live leaf pictures which might be simply interfaced to the computer by USB port.

5) **LCD Display**: 20X4 alphanumeric display is employed to display the values of various parameters perceived by sensors ceaselessly.

6) **Software unit**: Software tools are equally important along with the hardware components to run the entire system. The two tools used here are MATLAB and Arduino software. Here, MATLAB is employed for plant disease detection i.e. image processing methods are used to compare samples of images of the grape leaves. This data is sent to our e-mail accounts via internet. Thus, we tend to use MATLAB R2013a version for programming a part of image process.

Arduino provides an open-source and easy-to-use programming tool**,** for writing code and uploading it to your board. It is often referred to as the Arduino IDE. The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board.Arduino 1.0.6 version is employed here for interfacing purpose. It includes a code editor with options like syntax lightness, brace matching, and automatic indentation. It’s conjointly capable of compilation and uploading programs to the board with one click. Arduino programs are written in C or C++.

E) Results

For the experimental setup, we can select any plant like grape, mango or cucumber or any vegetable plant like tomato etc. The embedded hardware shows all recent values of various environmental parameters like temperature, humidity, soil hydrogen ion concentration and soil wet level area unit ceaselessly and displays on the 20X4 alphanumeric display with its units. Same information is distributed to the computer by the ZigBee network.The diseases in grapevine not only reduce the yield but also deteriorate of the variety and its withdrawal from cultivation. Excessive uses of pesticide for plant diseases treatment increases the danger of toxic residue level on agricultural products and has been identified as a major contributor to ground water contamination also pesticides are among the highest components in the production cost their use must be minimized **[4]**. This can be achieved by estimating severity of disease and target the diseases places, with the appropriate quantity and concentration of pesticide.

The defective leaf detection process will improve the quality and quantity of the crop yield. Effective image process methods are used to gather information and accordingly the corrective measures are taken.

The farmers are aware of the agricultural parameters well in advance so that the health condition of the field is taken care of. Diseased leaves information is mailed to our e-mail account over the net using MATLAB. Therefore, automation and smart monitoring can be imbibed in the agricultural field by using appropriate hardware and software.

6. Analysis of an Irrigation System

A. Objective of the method

Agricultural industry contributes to the Indian economy in a great manner. About 70% of the economic situations depend on the optimum produce of the crops. The main aim of the system is to measure different parameters such as Temperature, Humidity, Moisture, pH, Nitrogen, Potassium, and Phosphorus. This fertilizer play an important role in crop production. This system reduce water, no man power is required and save the electricity. The effective management of water and fertilizer is done by this system. By using this system increase the crop production.

The objective is to design such a system which will:

a) Conserve energy, water resources and man power in agricultural sector.
b) Handle the system automatically as well as manually.
c) Detect different parameter of soil like moisture, temperature, humidity, pH and nitrogen. Potassium, Phosphorus
d) Build a system which enhances crop productivity.
e) To design, build and test the system which will be economical, efficient and effort reducing of the farmer.
f) With the characteristics of low cost, low power consumption, flexibility, friendly interface

Maintaining appropriate level of moisture in the soil is the main aim of the system. Plants are very sensitive to water level, water deficiency can be hazardous to the plants or excess water is also harmful to plants. Hence the system is designed such that it will help to maintain appropriate moisture level according to the plant requirement. The system senses the soil moisture, atmosphere humidity and temperature and depending on the sensed data the system will take the corrective action whether to start or stop the valve of the drip irrigation system. A setup is built which helps to measure the nitrogen, Phosphorus, Potassium in the soil and which is sensed by the sensor. Nitrogen (N), Phosphorus (P), Potassium (K) is one of the important macronutrient which helps for plant growth. The system is interfaced with keypad. Keypad is used to set the threshold points depending where the system is installed. So that system can be used under any conditions. All the sensed data from the soil is send to LCD for displaying purpose. The data from controller is send to personal computer (PC) through serial communication using UART 0. The data fetched on PC can be used for analysis purpose and the database is also maintained. Thus, the system will help to monitor, control and analyses.

B. Methodology of the proposed system

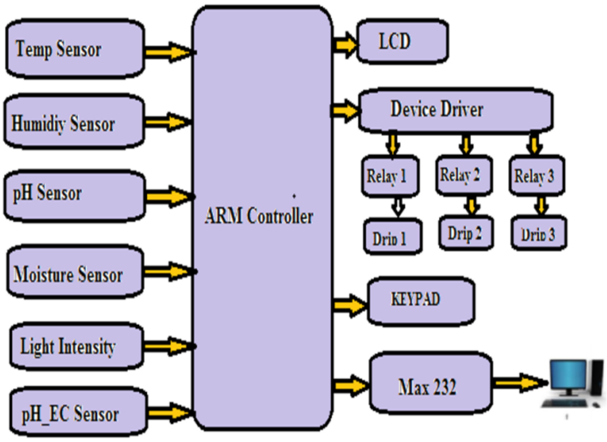

Figure 10: Design of the system

1) Humidity Measurement: There are several types of humidity sensors, the system uses P-HS-230 sensor to detect humidity in environment. The output of humidity is proportional to output voltage. At 30% relative humidity, the output is 990 mV, while at 80% relative humidity; the output is 2640 mV, i.e. 2.64 V.

2) pH Measurement: A pH scale measure is truly, a particular meter that measures the generated voltage of a pH scale electrodes. Here Alpha pH scale five hundred Transmitter with pH scale conductor is used(EC100GTSO05B). The necessity of such measure is to associate degree electronic equipment with high input electrical resistance and it has the advantage of voltage-pH conversion. The quality pH scale probe generates voltage of 59mV per pH scale.

3) Moisture Measurement: Tensiometer with electrical device (Soil wet sensor) is employed that having wet Tension vary 0-100 Centibar, Output 4-20 mA, Power needs 12 to 24 VDC, Current Consumption 20 mA soap.

4) Temperature measurement:LM36 sensor is used for measurement. LM36 is the temperature device accustomed sense the temperature from field.It having Linear + 10mV/°C multiplier ,Calibrated Directly in ° Celsius (Centigrade) ,0.5°C Ensured Accuracy (at +25°C) ,Rated for Full −55°C to +150°C vary, Operates from 5 to 30 V.

5) pH_EC sensors: This sensor is used to measure nitrogen, Phosphorus, Potassium. They use micro-sensors for in-field observation of environmental parameters is of nice interest, notably semiconductor-based micro-sensors, owing to their several benefits over standard sensors like tiny size, robustness, low output resistance and fast response.
The sensors area unit victimization ion Selective Field Impact Transistors based mostly micro-sensors, for environmental applications and area unit useful for measure primary macronutrients in soil. Selected target ions embody measure potassium, phosphate and nitrates.

6) Light Intensity Measurement: For Intensity measure, LDR is employed. LDR is light Dependent device. As light will increase, the resistance decreases, and vice versa. Because the intensity changes, the voltage drop across the LDR conjointly changes, and thus potentials proportional to the sunshine intensity. Electronic equipment amplifies this modification in potential.

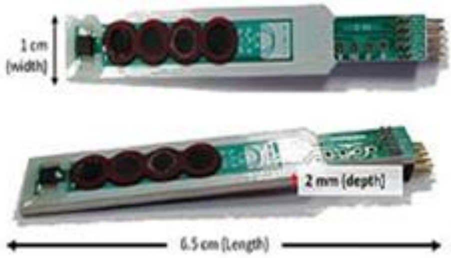

Figure 11: pH_EC sensor

C. Observations

From the graphical results, the farmer can get an idea about his farm field. In summer, water requirement for plant is more so drip irrigation is useful method to save the water. We can provide nutrient and water through drip irrigation. By using Graphical analysis, mini nutrient contain present in the farm can be studied. Proper water and nutrient is supplied time to time as the production increases.

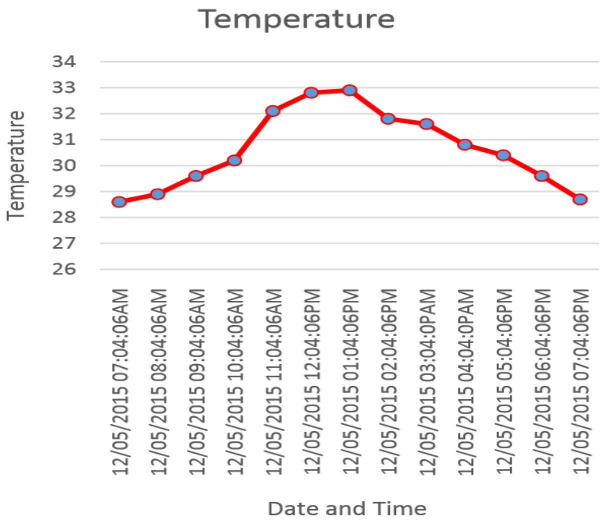

Figure 12: Graph of temperature v/s time\

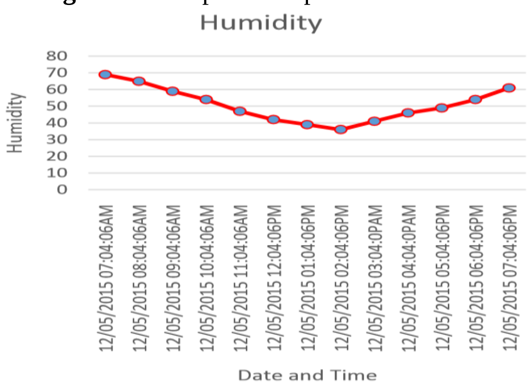

Figure 13: Graph of humidity v/s time

D.Output

This system is helpful to extend the assembly and reduce the man power and save the electricity. This method deals with the planning, optimization and development of a sensible resolution for application to the agricultural watching and management. The projected system utilizes sensing element for small parameter measure, temperature level detection, Motion detection, Humidity, Soil wetness, Soil pH scale for management of Agricultural setting.

7. Control of Environment for a Greenhouse Using Sensor Networks

In modern precision agriculture, green houses play an increasingly important role to meet the demand-driven economic. The primary issue of green house is to manage the green house environment optimally to compete with the economic and environmental requirements. The objective of this work is to design a simple, easy to install, microcontroller-based circuit to monitor and record the values of temperature, humidity, soil moisture and sunlight of the natural environment it continuously modified and control to optimize them to achieve maximum plant growth and yield. The design is quite flexible as the software can be changed at any time. It can does be tailor-made to the specific requirements of the user. These makes the proposed system to be an economical, portable and low maintenance solution for green house applications, especially in rural areas and for small scale agriculturist.**[6]**

A) Proposed Work

The proposed system is an embedded system which will closely monitor and control the microclimatic parameters of a greenhouse on a regular basis round the clock for cultivation of crops or specific plant species which could maximize their production over the whole crop growth season and to eliminate the difficulties involved in the system by reducing human intervention to the best possible extent. The system comprises of sensors, Analog to Digital Converter, microcontroller and actuators. When any of the climatic parameters cross a safety threshold which must be maintained to protect the crops, the sensors sense the change and the microcontroller reads this from the data at its input ports after being converted to a digital form by the ADC. The microcontroller then performs the needed actions by employing relays until the strayed-out parameter has been brought back to its optimum level. Since a microcontroller is used as the heart of the system, it makes the set-up low-cost and effective nevertheless. As the system also employs an LCD display for continuously alerting the user about the condition inside the greenhouse, the entire set-up becomes user friendly. The knobs present set the reference value for the ADC which decides the status of the climatic parameters (temperature, humidity, moisture, light intensity). Relay switches the water pump, exhaust fans, humidifier and LED's based on the instruction given by the microcontroller. Thus, this system eliminates the drawbacks of the existing set-ups mentioned in the previous section and is designed as a flexible method which gives a low-cost solution than the existing system. This system is easy to install and portable.

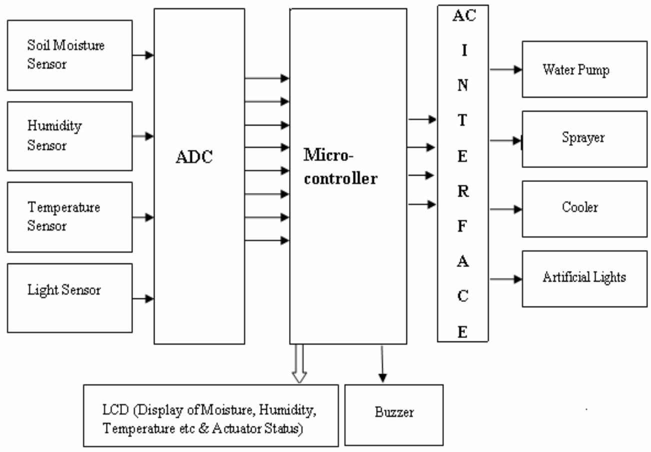

Figure 14: System Model of Greenhouse

B) Steps Followed in Designing the System

Three general steps can be followed to appropriately select the control system:

Step 1: Identify measurable variables important to production. It is very important to correctly identify the parameters that are going to be measured by the controller's data acquisition interface, and how they are to be measured. The set of variables typically used in greenhouse control is shown below table.

Table 1: Importance of various parameters

Sl. No.	*Variables to be monitored*	*Its importance*
1	Temperature	Affects all plant metabolic functions
2	Humidity	Affects transpiration rate and the plant's Thermal control mechanisms
3	Soil moisture	Affects salinity and pH of irrigation water
4	Solar Radiation	Affects photosynthetic rate responsible for most thermal loading during warm periods

Step 2: Identify the control strategies an important element in considering a control system is the control strategy that is to be followed. The simplest strategy is to use threshold sensors that directly affect actuation of devices. For example, the temperature inside a greenhouse can be affected by controlling heaters, fans, or window openings, once it exceeds the maximum allowable limit. The light intensity can be controlled using four threshold levels. As the light intensity decreases one light may be turned on. With a further decrease in its intensity a second light would be powered, and so on; thus, ensuring that the plants are not deprived of adequate sunlight even during the winter season or a cloudy day

Step 3: Identify the software and the hardware to be used. It is very important that control system functions are specified before deciding what software and hardware system to purchase. The model chosen must have the ability. To expand the number of measured variables (input subsystem) and controlled devices (output subsystem) so that growth and changing needs of the production operation can be satisfied in the future. To provide a flexible and easy to use interface. To ensure high precision measurement and must have the ability resist noise.

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C) Hardware Description

1) **Transducers**: A transducer is a device which measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. Monitoring and controlling of a greenhouse environment involves sensing the changes occurring inside it which can influence the rate of growth in plants. The sensors used in this system are:
1. Soil Moisture Sensor
2. Light Sensor (LDR)
3. Humidity and Temperature Sensor (DTH 11)

2) **Arduino Mega 2560**: The Arduino mega 2560 is a microcontroller board based on the Atmega 2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with USB cable or power it with a Ac to Dc adapter or battery get started. The mega is compatible with most shields designed for Arduino Duemilanove or Diecimila.

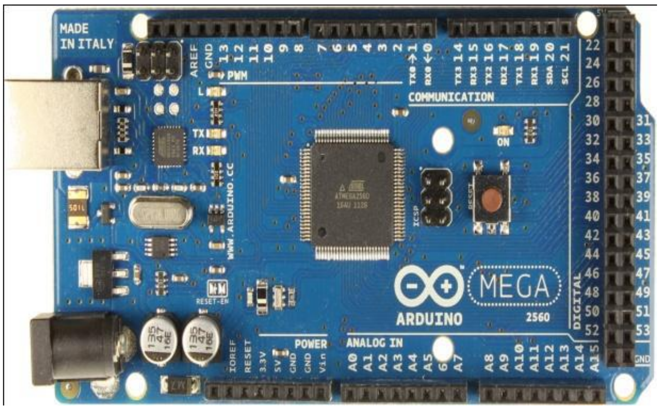

Figure 15: Arduino mega 2560

D) Results and Discussion

Soil moisture sensor senses the moisture content of the soil, depending upon the moisture level in the soil an analog voltage is given as output. This analog voltage is compared with reference value in 1m324. Table 2 shows the soil moisture sensor readings which have been taken under room temperature

Table 2: Soil moisture sensor readings

S. No.	*Soil condition*	*Transducer Optimum range*
1	Soil is dry	0V
2	Optimum level of soil moisture	1.9-3.5 V
3	Slurry soil	>3.5V

Light sensor senses the light intensity of the atmosphere, depending upon the light intensity of the atmosphere an analog voltage is given as output. This analog voltage is compared with reference value in 1m324. Table 4.2 shows the light sensor readings which have been taken under room temperature.Three selection knobs are provided to set the threshold levels which can be varied to use different crops. Knobs are used to change the reference value for 1m324 which compares this value with analog output of sensor. The knobs are movable in clockwise direction based on which three sort of micro climate margin (LOW, OPTI, HIGH) is fixed. This variation can be done for all four climatic parameters (temperature, humidity, soil moisture and light intensity). LCD prints the status of the micro climatic parameters in each layer of vertical farming.

Table 3: Light sensor readings

Sl. No.	*Illumination Status*	*Transducer optimum range*
1	Optimum illumination	0-0.69V
2	Dim light	0.7-2.5V
3	Dark	2.5-3V
4	Night	3-3.47V

Figure 12 shows the status of the all micro climatic parameter (temperature, moisture and light intensity, humidity) inside the greenhouse. Depending upon the value given via knobs the status of the climatic parameter varies.**[6]**

E) Scope of the Work

A step-by-step approach in designing the microcontroller based system for measurement and control of the four essential parameters for plant growth, i.e. temperature, humidity, soil moisture, and light intensity, has been followed. The results obtained from the measurement have shown that the system performance is quite reliable and accurate. The system has successfully overcome quite a few shortcomings of the existing systems by reducing the power consumption, maintenance and complexity and at the same time providing a flexible and precise form for maintenance of the environment.

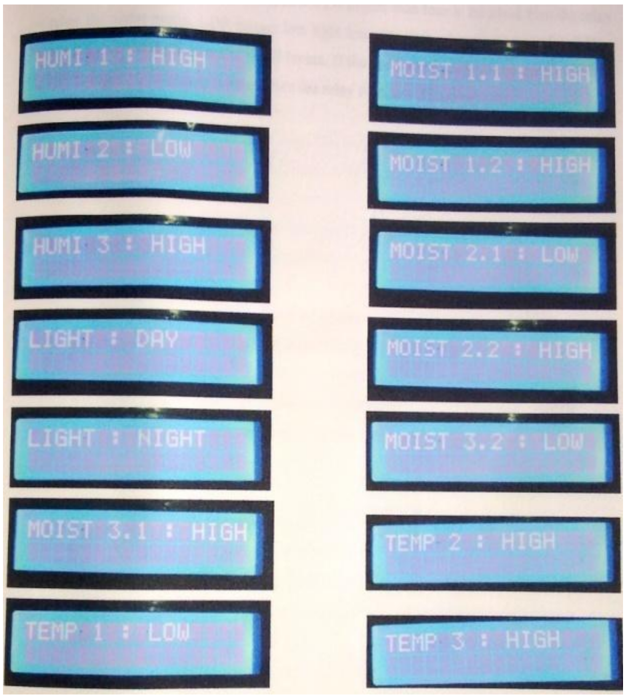

Figure 16: Climatic parameter status in an LCD

7. Conclusion

The smart monitoring of agricultural parameters has to be automated in order to increase the crop productivity. The ZigBee and GPRS technologies can be used to realize the function of the data networking and remote monitoring.

Further the research could also be enhanced to produce a system that can monitor the whole crop weather conditions for a large area like state or country.

The second paper deals mainly with the leaf disease detection wherein the experimental studies can be extended to any other crop like tomato, mango, cucumber, sugarcane etc. The IoT provides three layers to carry the data in packets efficiently.

The third method that is implemented in irrigation system is mainly concerned with conservation of water and ceaseless monitoring of parameters. It enclosed the planning of intelligent drip irrigation network system .After the right measure of N, P, K content from soil it will become easy to evaluate the chemical combination of the nutrient. By analyzing parameter graphically, maintaining the appropriate level of water and nutrient is main aim of the system.

The performance of the system can be further improved in terms of the operating speed, memory capacity, and instruction cycle period of the microcontroller by using other controllers such as AVRs and PICs. The number of channels can be increased to interface more number of sensors which is possible by using advanced versions Microcontrollers.

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Author Profile

Anuradha MRR is a final year student of Bachelor of Engineering at BNM Institute of Technology, Bangalore. Her research interests include Embedded Systems , Communication Engineering and wireless communication.

Apoorva Raghunandanis a final year student of Bachelor of Engineering at BNM Institute of Technology, Bangalore. Her research interests include Embedded systems, Signal processing and Environmental science.