Smart Garden Monitoring and Control System with Sensor Technology

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***Abstract*—Growing crops is quite a tedious task. The demand for this task has increased with the need for more food due to increase in population. In traditional farming, farmers have to visit the farming land regularly to measure the various environmental parameters such as temperature, humidity, light intensity and soil moisture to cultivate the crops healthily. Even though this system of traditional farming has been used for years, the system is strenuous and fails to give a high productivity as farmers usually are unable to measure all parameters accurately all the time. Hence there arises a need to have an automatic system that will monitor and control the plant parameters for efficient growth. Automatic garden monitoring and controlling is a way where all the parameters are automatically monitored without any human support. In our system, we use Arduino microcontroller which controls and monitors temperature, humidity and soil moisture through sensors and activates cooling fans, bulb, and motor to pump water respectively, in case of requirement. Information will be sent to the agriculturist or gardener, in case of any abnormal situation through an android app and the solution will be provided accordingly. The proposed system targets a smart way of monitoring the plant growth using automation and an Android app to monitor it. The use of an app technology through smartphones enables the system to reach out to many people as well. The main theme of this paper is to increase the plant yield and produce by improving the plant growth conditions through low water consumption by providing an automatic watering system, thereby saving a good amount of energy and resources as well. With the advancement of technology, plants are hence better monitored, nourished and grown healthily.**

Keywords*— *Temperature, humidity and moisture sensor; Arduino; monitoring and control; nursery; smart gardening

I. INTRODUCTION

Farming and crop production has been the primary occupations of our nation since times of yore. It is reported that more than half the population of our country relies on farming, agriculture and its associated activities for their livelihood. It is also stated that almost 22% of this sector depend purely on agriculture as a main occupation. It must be noticed that dealing with plants at the ground level, allots a sizeable amount in the country's economy as well-- a share of about 16% to the Gross Domestic Product (GDP). A pivot to both the nation and the citizen, it is quite obvious that we must put in the required and necessary efforts that this sector demands [1]. The reason for this is quite obvious since plants have innumerable uses. A source of survival (oxygen), purifying the air, vital food resources, builds the soil and much more. For the plants that give us so much, it becomes our onus and responsibility to provide them good and favorable conditions to grow, that help to increase productivity and yield, thus nourishing mankind [2]. To meet the growing demands of food owing to the concurrent rising of the population, it is essential to resort to some means that would help increase the produce and yield [3].

To overcome the tedious job of manual monitoring of a plant's health and growth, technology provides us a helping hand the plant parameters in an efficient manner. This is done with the aid of an automated monitoring and controlling system, thus nourishing the plants with ample amount of all the nourishing elements in a perfect environment as and when required. Protected cultivation is a popular technique where plants are cultivated by controlling them partially or entirely with an objective to increase cultivation and produce. This technology can be best implemented using a greenhouse or a nursery which provide a pseudo- natural environment to the plants. The concept of greenhouses in growth of plants is not new in this era. It has been made to use in more than a 50 countries including India, China, Japan, Bangladesh etc. China has implemented this protected agriculture in the form of plastic greenhouses while Japan has almost 42,000 acres of land covered by plastic and glass to augment crop production [4]. The country of Bangladesh too has introduced the concept of agribusiness that involves the use of an automated solution to solve the problems of reduced harvest due to droughts and rains. [5]

Apart from the concept of greenhouse and glass shields, automated solutions have also made their way to modern agriculture through aeroponics and hydroponics technology, where plants are not grown in soils but made to hang in the air while the roots are given nutrition in the form of a mist of nutrient solution ejected through a nozzle, periodically. [6] Similar to this is hydroponics, where plants are grown, again not in soils but in an aqueous nutrient solution [7]. However these concepts are just emerging and quite an amount of research is yet to be done. Looking on the other side, the concept of greenhouses and nurseries has taken a greater dimension and technology has been fully implemented in automating the monitoring and controlling these parameters. These include the use of different control algorithm to monitor temperature and humidity, thus increasing efficiency of monitoring a nursery [8]. Further, a wireless water monitoring system using a Zigbee module, accompanied with

soil moisture and temperature sensing using GPS and a Bluetooth implemented in plant growth paves the path for the control of water and fertilizers in efficient way [9]. These save at least 20-30% water consumption than conventional methods. The wireless sensor networks are used to collate data and process it from a central node to irrigate and grow plants in greenhouses [10]. The newest generation technology is Internet of Things (IoT) which is, in fact, the most widely used ideas for greenhouse or nursery monitoring by sending data to the cloud with different wireless communication technologies [11]-[15] .

In spite of all these advances, the implementation that is dominating nursery, garden or greenhouse monitoring is the use of Arduino microcontroller. Arduino UNO is the widely used microcontroller for interfacing the measurement of humidity, temperature, moisture and sometimes, even pH using sensors [16]. An automated greenhouse system for measuring all parameters, is implemented using Arduino and sensors such as Soil moisture, pH sensor, DTH 11 sensors that activate a water pump, the cooling fans and the lights depending on the use case [17]-[19].

Implementing all these within a greenhouse have the advantages of production quality, productivity, manage the entire cycle of production and also save energy due to low cost [20]. However using software to simulate these results and program the automation can increase the efficiency. In the proposed system, the automatic monitoring and control of parameters of a gardening and nursery are considered. These include temperature, humidity, soil moisture and which are controlled using a Arduino UNO microcontroller and can be monitored in an app. The work is designed in such a way that when the measured value is greater than the threshold value the system automatically controls itself. The paper is organized as follows: Section II deals with the system description of automated gardening control and the flow diagram of the method employed. Section III deal with the prototype results and analysis.

II. AUTOMATED GARDEN MONITORING AND CONTROL SYSTEM

The proposed work consists of two sections namely the monitoring and the controlling. Arduino UNO R3 acts as a controller for monitoring and controlling the system with environment conditions obtained using the sensors namely DHT11 temperature and humidity sensor and soil moisture sensor. The controlling section consists of Motor pump, Lights and Cooling fans. To display the status of the sensors an app is used. The block diagram of automated gardening control and monitoring using Arduino is shown in Fig. 1.

A. Arduino

The ATmega328P-based UNO is a microcontroller board is an open-source platform in which the hardware and software are freely available and can be modified to meet the needs of the user. The software used here is an Integrated Development Environment (IDE), which requires only a basic understanding of programming. This IDE can be used to code projects and then feed them into the Arduino board by simply copying and pasting the hex files. Arduino is selected in this work since it enables to monitor and experience external electronic devices in the real life [22]. In this work the interface of different sensors to monitor the real time environment conditions and soil for efficient growth of crops and saplings in nursery is done.

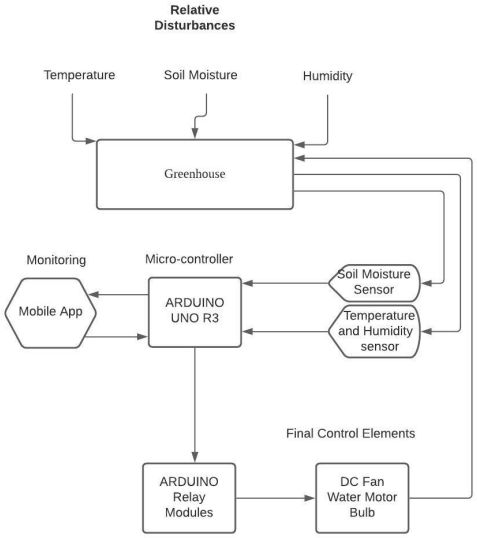

Fig. 1.Block diagram of automated gardening control and monitoring using Arduino

B. Sensors

In the monitoring of garden, three sensors namely DHT11 Temperature and Humidity Sensor, Soil Moisture Sensor are used. Their features and their role in the monitoring and controlling plant growth in garden are discussed.

1. DHT11 Temperature and Humidity Sensor

Humidity is an important factor that needs to be measured in greenhouse and nursery gardening since humidity level in the air influences a variety of physical, chemical, and biological processes. The DHT11 sensor is made up of a capacitive humidity sensing portion and a thermistor for temperature sensing. A moisture-holding substrate serves as a dielectric between the two electrodes of the humidity sensing capacitor. The capacitance value changes as the humidity level changes. This measures, processes and converts the resistance values into digital form. This sensor measures temperature with a negative temperature coefficient thermistor, which causes its resistance value to decrease as the temperature rises. This sensor is usually made of semiconductor ceramics or polymers to achieve higher resistance values even with slight temperature changes [23].

2. Soil Moisture Sensor

The volumetric value of water in the soil is measured by a soil moisture sensor [24]. Permittivity is mainly used to assess the water content of the soil (dielectric permittivity). The moisture content of the soil can be determined by putting this sensor into the ground, and the condition of the water

content in the soil is recorded as a ratio. The sensitivity is equivalent to the difference of water in the soil; more the water in the soil, the higher the conductivity and, as a result, the lower the sensitivity.

3. LM293D Motor Driver

A motor driver is an integrated circuit chip that is commonly used to power motors in self-driving robots. The motor driver serves as a bridge between Arduino and the motors. The motor used in this work is used to pump the water to plants. L293D is a driver circuit made up of two H-bridges and these integrated circuits are intended to power two DC motors at the same time.

4. Relay

Electric current flowing through the relay's coil produces a magnetic field, which draws a lever and changes the switch contacts. Since the coil current can be turned on or off, relays have two switch locations and double-throw (changeover) switches. The relay in this work acts as a switch to the electric bulb. The bulb is used to control the humidity acting as a heat source. When the sensed humidity is greater than the threshold value then the microcontroller will give signal to the relay and it switches on/off the bulb accordingly.

5. DC Fan

A fan is a mechanism that induces movement within a fluid, most commonly a gas such as air. The fan is made up of a revolving series of vanes or blades that work on the fluid. An impeller, rotor, or runner is a revolving assembly of blades and a hub. The fan in our project acts as a cooling system. When the recorded temperature is greater than the threshold value then the micro-controller will turn on/off the fan which controls the temperature of the plant.

C. Software Requirements.

The Arduino IDE and Embedded C play a major role here for smart controlling the growth of plants. The Arduino Integrated Development Environment (IDE), also known as the Arduino program, includes a text editor for writing code, a message field, a text console, a toolbar with buttons for common functions, and a series of menus. It communicates with and uploads programmes to the Arduino and hardware. Here in the working system the IDE is used to program the Arduino micro-controller. We can mention all the threshold values such as temperature, moisture, humidity and compile the program. Once it is compiled the content is copied and the hex file is pasted in the appropriate place and the arduino will act accordingly to control the operation of the pump. Here the entire coding of this work did using Embedded C. It is a similar format to C and can be easily understood when programmed.

D. Boundary Conditions

Here in the system, temperature and humidity are inversely proportional to each other. When temperature increases humidity decreases and vice versa. Table 1 shows the ranges for different temperature and Table 2 day and night temperature ranges for growing plants that to be taken as reference.

TABLE 1: VARIOUS TEMPERATURE PREFERENCES

Temperature Preference	Temperature (°F)
Cool	40-50
Intermediate	60-75
Warm	>75

TABLE 2: OPTIMAL DAY AND NIGHT TEMPERATURE RANGES FOR GROWING PLANTS

Types of Plants	Day (°F)	Night (°F)
Foliage Plants	70-80	60-68
Flowering plants	70-80	55-60

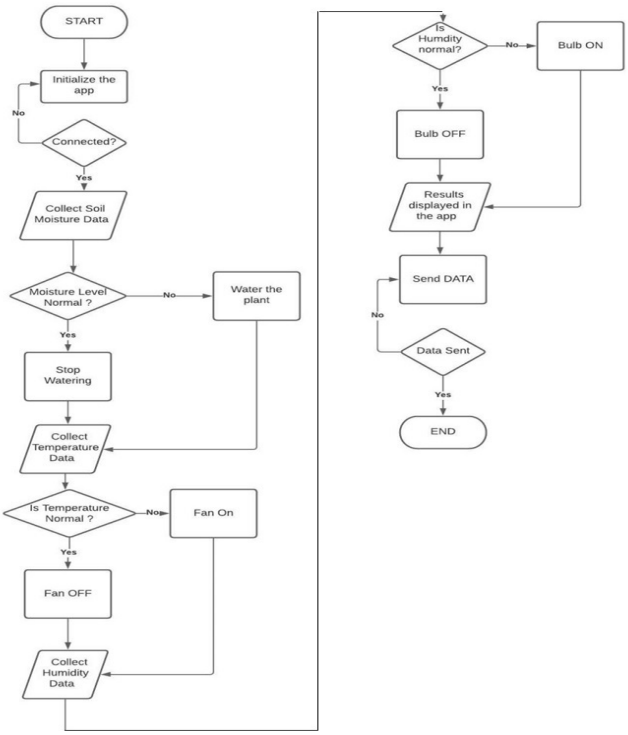

Fig. 2. Flowchart for proposed system

The work flow is shown as chart in Fig. 2. In the flowchart the temperature sensor works when the value is higher than the threshold value then turn on the fan else turn off the fan. Humidity sensor will work the value is higher than the threshold value then turn off the extraction fan else turn on the extraction fan which will help to improve the humidity level inside. The Moisture sensor will work the value is higher than the threshold value then switch on the pump else switch off the pump and these are stored in Arduino. The output controlling

devices will retrieve these parameters and will act accordingly and then displays the values in the app.

III. EXPERIMENTAL RESULTS

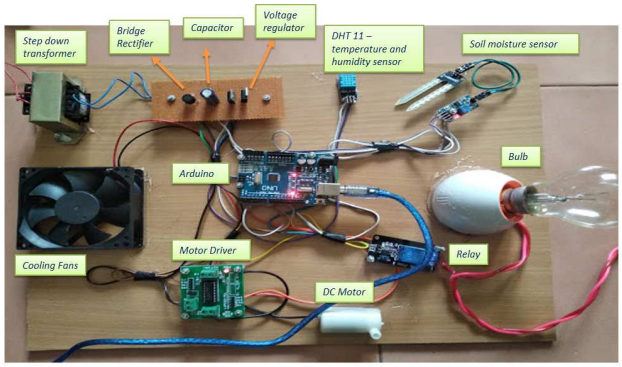

Fig. 3. Proposed smart gardening system with the sensors technology

TABLE 3: COMPONENTS AND SPECIFICATIONS

S.No	Equipment	Specifications
1	Arduino	UNO(5V)
2	Temperature and Humidity Sensor	DHT11 (3.5V-5.5V)
3	Soil Moisture Sensor	SM100 (3.5-5.5V)
4	Motor Driver	LM293D (4.5V-36V)
5	Electric Bulb	10W
6	Relay	-
7	DC Motor	12V - 1A

Fig. 4. Temperature Sensor operation

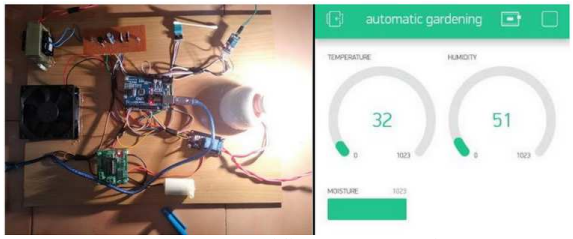

Fig. 5. Humidity Sensor operation

Fig .6. Soil Moisture Sensor operation

TABLE 4: OBSERVED TEMPERATURE AND HUMIDITY READINGS UNDER DIFFERENT CONDITIONS

Temperature (°C)	Humidity (g/m^3)
32	51
32.1	50
32.8	37
33.2	45
33.4	46
34.1	39
34.4	38
35.6	35
35.9	36
36.1	34

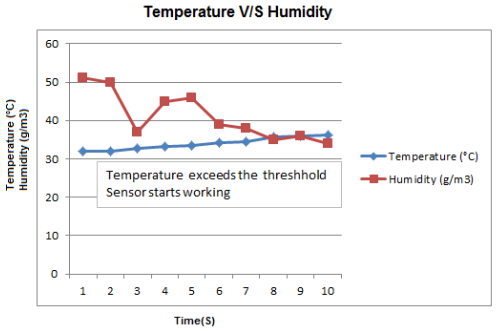

Fig.7. Graph drawn against temperature and humidity

Our proposed system is shown in Fig. 3 and Table 3 shows the equipment involved in it and its specifications. Based on the results collected by all the sensors, the environmental factors are controlled. First the DHT11 temperature sensor will gather the temperature reading of the surroundings and that reading will be sent to the Arduino micro-controller. If the temperature is higher than the threshold value then the fan will switch on automatically to cool down the temperature. This is working is shown in Fig. 4.Next the HH10D Humidity sensors measure the humidity around it and transmit it to the Arduino. If the humidity is greater than the threshold value, then electric bulb will automatically turn on and controls the humidity.The working of humidity sensor is shown in Fig. 5.

Finally the Soil Moisture Sensor will detect the moisture content of the soil and when the soil is too dry it will send signal to the controller and then the water pump is turned on automatically is shown in Fig. 6. We can monitor all the values such as temperature, humidity and soil moisture using android application. In this way the system is monitored and controlled with the environmental factors which affect the plant growth in our garden. Table 4 indicates the observed temperature and humidity readings under different conditions and Fig.7 shows the graph which is plotted against the values in Table 4.

IV. CONCLUSION

The smart automated garden monitoring and control using Arduino with sensor technology is proposed, simulated and tested. Agriculturists or gardeners can utilize and implement this system, to control and monitor all parameters such as temperature, humidity, soil moisture, and light intensity. This system is designed not only to monitor the plants but also for the healthier growth of plants without wastage of water and is successfully controlled remotely through mobile application in our personal device. The optimal environment provided by these sensors result better growth and productivity. In future the work can be improved with image processing technology to monitor the plant diseases with the variation occur with the leaves and stems.

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