Intelligent Greenhouse Environment Monitoring and Automatic Controlling System Using IOT

Anuj Kumar Chauhan, Prashant Kumar Gupta

Abstract*: In any country, all the factors which are necessary to develop a solid economy are centered around an important sector and that is agriculture. This sector plays a very important role in the economic development. But there are so many hurdles for this sector that hinder its true potential. Some of them are dependency on weather, lack of land area suitable for farming, political ignorance etc. So considering all these now a days, greenhouse farming is gaining popularity among farmers. Even those who do not belong to a farming background can adopt it easily. In our work, five parameters which are necessary for the good quality product are discussed. An intelligent and very efficient monitoring and controlling system is suggested. These parameters are- soil pH level, light intensity in the greenhouse, temperature, humidity level and soil moisture level. These parameters have some specific range of values that is suitable for a particular crop. These are measured through different sensors like- soil pH sensor, DHT11 sensor for humidity and temperature, soil moisture sensor and LDR sensor for light intensity. These are interfaced with arduino platform. Some actuators like- cooling fan, water pump, exhaust fan etc are also connected to arduino that work according to the data given by sensors. All these work in the IOT (Internet of Things) environment and are monitored and automatically controlled.

***Index Terms*: arduino, automatic controlling, greenhouse, IOT, monitoring, sensors.**

I. INTRODUCTION

A greenhouse is a controlled environment to grow any kind of plants. Now a days in greenhouses, monitoring and controlling of various parameters are vital for the best quality and productivity of plants. Some of these are soil pH, soil moisture, ambient temperature, humidity and intensity of light. These are very important factors to achieve the desired goal. Now suppose how helpful it will be to control automatically and monitor these factors via internet through the phone in anytime anywhere basis [9]. Now this is what automation is and there is no limit to its application. To measure and control the above mentioned parameters an intelligent system using arduino platform is proposed. The central aim of our work is to design a simple, low cost, Arduino based system which is capable to monitor the values of environmental factors and that are constantly updated and controlled to achieve maximum plant growth.

Arduino is an open source platform based on a combination of hardware and software. It consists of a circuit board, which can be programmed and a software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board. Now in this project various sensors are interfaced with arduino to sense the parameters and to act accordingly various actuators are also interfaced. The sensors used in this project are DHT11 sensor for sensing temperature and humidity, LDR sensor for monitoring light intensity, a pH sensor to measure soil pH level and a soil moisture sensor [1] [2]. As actuators, a cooling fan, exhaust fan, water pump, light and motor pump are used. Arduino receives data from these sensors and sends signal to actuators to control the actuators.

The rest of the paper is organized in the following manner- Section II enlightens the system overview. Section III describes the flow chart of the system. Section IV presents results and discussion. Section V deals with conclusion and future work.

II. SYSTEM OVERVIEW

Following figure shows the block diagram of working of proposed system.

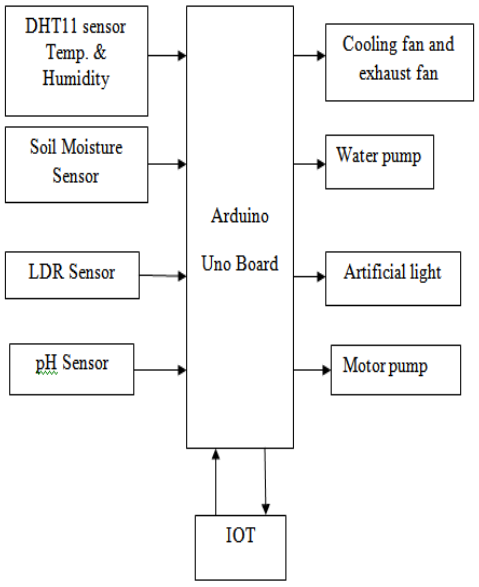

Fig. 1. Block Diagram of Proposed System

In this, there are basically two sections- one is monitoring section and other is controlling section. In the monitoring section, we have LDR sensor, DHT11 sensor, soil moisture sensor and soil pH sensor. A GSM modem SIM800 is used to upload the factors on the web page. In the controlling section, we have cooling fan, exhaust fan, water pump, motor pump and artificial light.

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These actuators are controlled automatically according to the readings sensed by sensors. In this we can say that microcontroller on the arduino board is the brain of the system. It reads the data sent by the sensors and instructs the actuators to act accordingly. The status of sensors and sensor value is monitored on webpage.

A. Arduino

In the proposed system Arduino Uno board is used which is mostly used in the Arduino group. The microcontroller used in this is ATmega328P of ATMEL Company. It is powered through the computer via a USB cable. "Uno" is an Italian word which means one. It consists of 14 digital I/O pins and 6 analog input pins. Some pins provide PWM output which are labeled as '~' [3] [7]. Figure 2 shows Arduino Uno board.

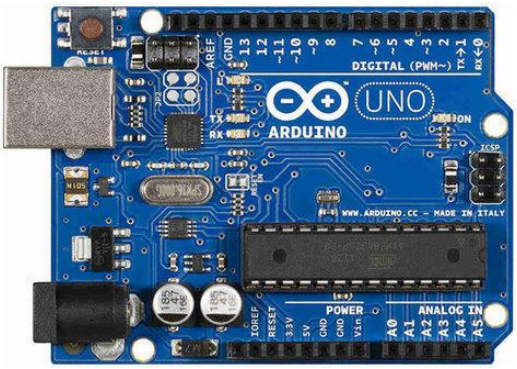

Fig. 2. Arduino Uno Board

B. Sensors

Sensors used in this project are- DHT11 sensor, soil moisture sensor, LDR sensor and soil pH sensor.

DHT11 Sensor

Following figure shows DHT11 sensor-

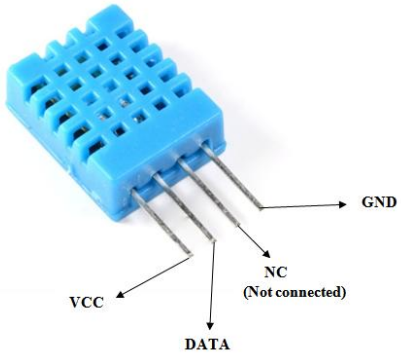

Fig. 3. DHT11 Sensor

It measures temperature and humidity. It contains two things- a thermistor to measure the temperature and a component for measuring humidity. A thermistor is a variable resistor. That means its resistance is changed with the change in temperature. The component which measures the humidity has two electrodes with moisture carrying substrate between them. Due to change in humidity resistance between the two electrodes changes. The temperature is calculated from output voltage by following equation-

$$Temperature = \frac{(V_{OUT} \times 100)}{5}\,^{0}\mathrm{C} \quad (1)$$

Humidity can be calculated from following equation-

$$Humidity = \frac{\left(\left(\frac{V_{OUT}}{V_{SUPPLY}}\right) - 0.16\right)}{0.0062}\% \quad (2)$$

Soil Moisture Sensor

Following figure shows soil moisture sensor-

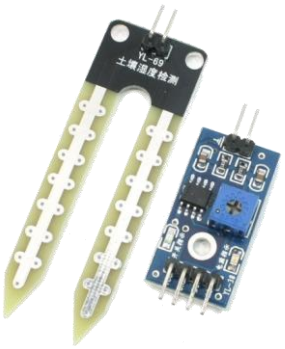

Fig. 4. Soil Moisture Sensor

Soil moisture sensor is used to measure the water content of soil [4]. When the water content in the soil is low then sensor goes in a high output state otherwise it remains in a low output state. So this sensor can be used as a reminder to water the crop. It is widely used in the field of agriculture. The sensor module shown above works on a simple principle. In this two metal rods are used to pass current through the soil. If the water content in the soil is high then resistance will be low and if the water content is low then resistance will be high. A potentiometer is also provided in the module to adjust the sensitivity.

LDR Sensor

LDR refers to light dependent resistor. It is also known as photoconductor, photoconductive cells or photocells. This is used to measure the intensity of light. To make an LDR cadmium sulphide (CdS) is used. In this deposition of CdS is done on an insulator in the form of a zigzag line.

Now this zigzag formation is needed for increasing dark resistance and decreasing dark current [6] [8]. The basic structure of an LDR is as shown below-

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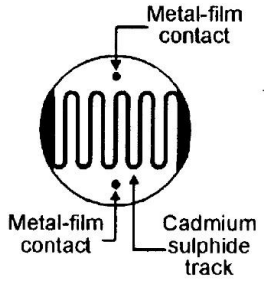

Fig. 5. Basic structure of LDR

Figure 6 shows LDR sensor module used in the project-

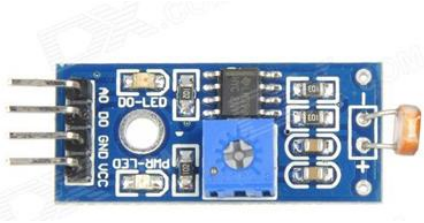

Fig. 6. LDR Sensor Module

Figure 7 shows the schematic diagram of light sensing circuit-

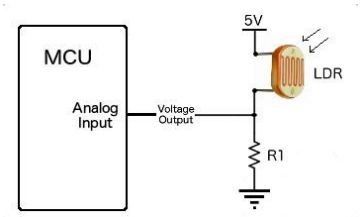

Fig. 7. Light Sensing Circuit

When the circuit is powered up by 5V supply then LDR generates an analog voltage which is proportional to the incident light. Now the arduino has inbuilt analog to digital converter (ADC). This converts the analog voltage ranging from 0 to 5V to equivalent digital value ranging from 0 to 1023. Let the resistor R1 shown above is of 10K ohms, then the output voltage is given by-

$$V_{OUT} = \frac{(5 \times R_{LDR})}{(10 + R_{LDR})} \quad (3)$$

And from equation (3) we can conclude that-

$$R_{LDR} = \frac{(10 \times V_{OUT})}{(5 - V_{OUT})} \quad (4)$$

The inbuilt ADC on arduino board assumes 5V as 1023 and voltage less than 5V is the ratio $\frac{5}{1023}$. So we can get the value of V_{OUT} by-

$$\frac{5}{1023} = \frac{V_{OUT}}{Analog\,Reading}$$

$$V_{OUT} = 0.0048875 \times Analog\,Reading \quad (5)$$

We can calculate the light from LDR-

$$Lux = \frac{500}{R_{LDR}} \quad (6)$$

$$Lux = \frac{(500 \times (5 - V_{OUT}))}{(10 \times V_{OUT})} \quad (7)$$

Soil pH Sensor

A typical pH sensor is as shown below-

Fig. 8. Soil pH Sensor

The pH of a material indicates how many hydrogen ions it generates in certain amount of water. In a simple way it can be said that the pH value indicates the acidity or alkalinity of the material [5]. The pH probe shown in the figure contains two electrodes. One electrode is called the glass electrode which is very important and other is called the reference electrode. The glass electrode has a silver chloride wire which is suspended in a solution of potassium chloride. The reference electrode contains a potassium chloride wire which is suspended in a potassium chloride solution. The probe measures the difference in the voltages of a known liquid which is inside the glass electrode and an unknown outside liquid. These voltages are generated due to hydrogen ions in the liquids.

C. GSM SIM800

The GSM modem SIM 800 is used to send the environmental factors to the system via internet. Following figure shows the GSM modem-

Fig. 9. GSM SIM800

It is a Quad band GSM modem which supports 850 MHz, 900 MHz, 1800 MHz and 1900 MHz frequencies. It transmits data, SMS and voice by way of low power utilization. It also combines GPS technology for satellite navigation. It persists following features-

- Quad- Band 850/900/1800/1900 MHz
- GPRS multi slot class 12/10
- GPRS mobile station class B
- Bluetooth support
- AT commands control
- 5V to 12V supply voltage
- Low power consumption
- Standard SIM card

In this a normal SIM card is inserted because Micro or Nano SIM cards are not supported. To power up the modem, a power jack is provided on the modem to which a 12V adapter gets connected.

Now when powered up, an led present on the modem will glow for 1 second. When SIM card will search for the network, this led will start blinking. After establishing connection this led will blink with delay of 4 seconds.

III. FLOW CHART OF THE SYSTEM

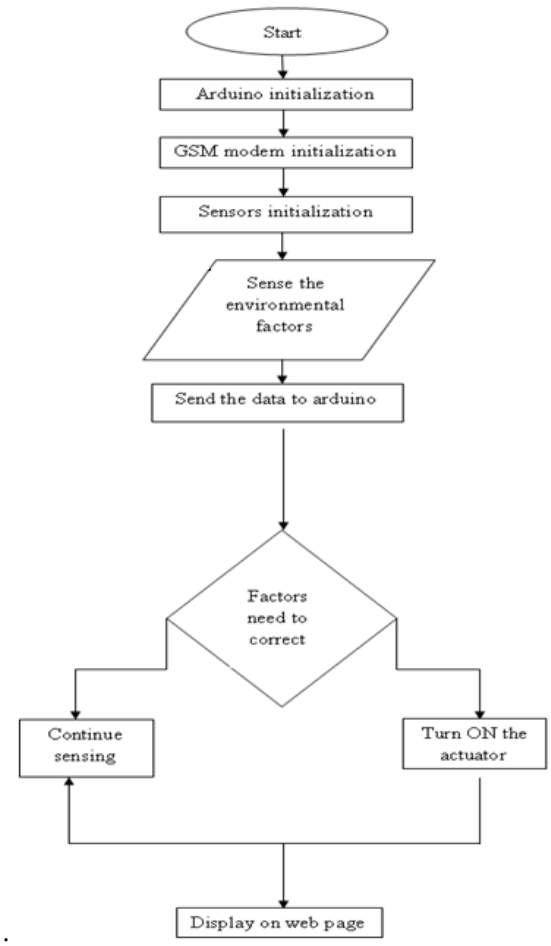

Fig. 10. System Flow Chart

Figure 10 represents the flow chart which shows the working of the intelligent greenhouse monitoring and automatic controlling system. All the sensors are supplied by a 5V power supply and GSM SIM800 is powered using a 12V adaptor. The actuators turns ON and OFF automatically according to the data given by sensors. This data and status of sensors is displayed on the web page.

IV. RESULTS AND DISCUSSION

In the proposed system we have used various sensors to monitor the parameters and actuators to work accordingly. All the data regarding sensors and status of actuators is uploaded to the server through GSM modem and we can see it on web page. Now let us discuss about the scenario observed in the working of the system. First of all the components were connected as shown in the figure 11. Then we initialized them by 5V power supply. Since all the sensors are connected, we observed the working of actuators accordingly. First we talk about soil moisture sensor.

When the moisture of the soil reduced from the specific point then the water pump started automatically to pump the water in the plant vicinity. And when moisture content reached to a sufficient level then it turned off. Basically soil moisture sensor contains two metal rods by which it measures the resistance. So when water content in the soil is enough the resistance is low. In that case the state of water pump is off.

Now let us move to the soil pH sensor. The pH value represents the acidity or alkalinity. The pH scale ranges from 0 to 14. The value less than 7 shows the solution is acidic and the value greater than 7 shows the solution is alkaline. When the soil pH crossed the specified limit, then the system turned on the motor pump to spread the required material to compensate the pH level. And when it came in the defined range then the motor pump turned off automatically. Now we will talk about humidity and temperature in the greenhouse environment. If the humidity is too much then it restricts the photosynthesis process. So it is essential to control. Also with the temperature variations, many hurdles can be faced by the plant growth. So here we have used a cooling fan to control the temperature and an exhaust fan to withstand the high humidity. When the both temperature and humidity exceeded the defined level then, their corresponding actuators turned on. After reaching the required level of temperature and humidity, they automatically turned off.

As we know, sunlight is necessary for everyone. Even for plant to grow, it is essential. So in the greenhouse environment, it is desired to have a controlled fashion on the environmental parameters. We cannot fully develop a natural environment with artificial components but we can calibrate them to work like that to a certain level. Here we have used an LDR sensor to sense the intensity of light in the created greenhouse environment.

When the light intensity was below from a certain level then the arrangement of artificial light was turned on. In the presence of sufficient lighting, this arrangement was turned off. So we observed that all the sensors sensed the environmental factors and all the actuators acted accordingly. This whole procedure was automatic. The sensor data and status of all the actuators was uploaded through a GSM modem to the server. GSM modem was given a 12V power supply. A 2G/3G SIM was inserted in the slot of modem.

Fig. 11. Working Model of Intelligent Greenhouse Environment Monitoring and Automatic Controlling System Using IOT

The data on the web page is displayed as shown in figure 12.

Data	Date Time
LDR_Value=0774;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=16%;ON;Temp =08;IP=10.164.122.122	2018-07-02 12:40:43
LDR_Value=0783;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=14%;ON;Temp =20;IP=10.164.122.122	2018-07-02 12:40:28
LDR_Value=0792;ON;MS1_Value=0699;ON;MS2_Value=0448;ON;DH2_Value=16%;ON;Temp =97;IP=10.164.122.122	2018-07-02 12:40:13
LDR_Value=0774;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=16%;ON;Temp =08;IP=10.164.122.122	2018-07-02 12:39:58
LDR_Value=0782;ON;MS1_Value=0704;ON;MS2_Value=0448;ON;DH2_Value=16%;ON;Temp =97;IP=10.164.122.122	2018-07-02 12:39:43
LDR_Value=0788;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=16%;ON;Temp =08;IP=10.164.122.122	2018-07-02 12:39:28
LDR_Value=0792;ON;MS1_Value=0697;ON;MS2_Value=0448;ON;DH2_Value=16%;ON;Temp =97;IP=10.164.122.122	2018-07-02 12:39:13
LDR_Value=0775;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=16%;ON;Temp =47;IP=10.164.122.122	2018-07-02 12:39:00
LDR_Value=0783;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:22:50
LDR_Value=0783;ON;MS1_Value=0702;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:22:29
LDR_Value=0790;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =47;IP=10.165.107.240	2018-07-02 12:22:14
LDR_Value=0782;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:21:59
LDR_Value=0783;ON;MS1_Value=0699;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:21:44
LDR_Value=0775;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:21:29
LDR_Value=0783;ON;MS1_Value=0704;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:21:14
LDR_Value=0771;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:20:59
LDR_Value=0783;ON;MS1_Value=0704;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:20:44
LDR_Value=0783;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:20:29
LDR_Value=0775;ON;MS1_Value=0704;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:20:14
LDR_Value=0775;ON;MS1_Value=0704;ON;MS2_Value=0446;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:19:59
LDR_Value=0771;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =75;IP=10.165.107.240	2018-07-02 12:19:44
LDR_Value=0783;ON;MS1_Value=0704;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:19:29
LDR_Value=0771;ON;MS1_Value=0700;ON;MS2_Value=0446;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:19:14
LDR_Value=0775;ON;MS1_Value=0700;ON;MS2_Value=0448;ON;DH2_Value=40%;ON;Temp =74;IP=10.165.107.240	2018-07-02 12:18:59

Fig. 12. Data Display on Web Page

V. CONCLUSION

This proposed system is designed to monitor and control a greenhouse environment. All the parameters mentioned in this project can be monitored via a web page and controlling of these parameters is done automatically. The main aim of this project is to reduce efforts in farming and to boost the quality factor in the crop production. In this two sections are discussed regarding greenhouse monitoring and controlling- first is sensing the value of environmental factors and second one is how to control them through actuators automatically. The major concern of the work is flexibility in use. We can feed the data regarding any crop into the code and all the sensors and actuators will work accordingly. For example if we want to grow strawberries in greenhouse then we need to fill the value of parameters such as soil pH value for strawberry farming, temperature, humidity etc in the programming code. That will provide an ideal situation to compare with. All the components used in our work are easily available and economically suitable to everyone.

We have utilized this design to monitor and control five parameters- temperature, soil pH level, humidity, light intensity and soil moisture. In the future, it can be implemented to calibrate other parameters also like- CO_2 level, N_2 and potassium level needed for the crop and further we can also add drip irrigation process. In the upcoming years, absence of water will be the major problem in the whole world. Due to greenhouse effect, the temperature of our environment is getting higher day by day. So water level is getting reduced every year. Now a days, a new irrigation technique is used in the agriculture sector that is drip irrigation. It is very effective technique especially in the areas where water content under the surface of the earth is very low because in this, least water quantity is required for irrigation. So this technique can be fused with our proposed project so that it will become more efficient.

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