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Development of IoT enabled polyhouse monitoring system

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Abstract:

Agriculture using the traditional farming techniques is lacking the proper quality and quantity of the crops. It is resulting in the lowering of farmers' income. It is necessary to overcome the problem and find the immediate solution. Polyhouse farming is one technique that can increase the crop quality. It operates under the controlled environment that involves continuous monitoring and analysis of factors such as temperature, humidity, light and CO2. The house is completely polythene covered which reduces the investment and maintenance cost. The proposed system is completely IOT based polyhouse system which can bring precision in the farming. This system has different sensors to analyse various parameters. The system helps in monitoring the soil quality and maintaining the minerals required for the crops. Fertilisation is provided to the plants through drip irrigation. The house is ventilated without gripes of pests which could eliminate the usage of pesticides. It can assist the farmers in the decision making and proper crop cultivation. The system brings out the quality in the crop to the maximum extent and helps in increasing the production. It also helps in conserving the soil and water resources.

Keywords:

Polyhouse, Internet of Things, Monitoring System, Agriculture

1. Introduction:

A Polyhouse is a structure made of polythene which is used to grow plants in a controlled environment. This structure provides protection from extreme weather conditions and pests, allowing for cultivation of crops throughout the year regardless of external climatic conditions. Polyhouse based farming play prominent role in the revolution of the agriculture. It could overcome the challenges faced in the traditional farming techniques. It incorporates the innovative ideas that could ease farming in this generation. It inculcates the use of internet and technology in the agriculture sector. This system could work in real time situations and effectively use various environmental conditions such as temperature, humidity, light. Polyhouse farming can be done with reduced investment and low maintenance cost. Moreover, it effectively uses the resources with minimal wastage, improve efficiency and maximise the crop quality. Polyhouse farming could present a transformative approach to agriculture by leveraging controlled environment to enhance productivity, quality, and sustainability. Whie the initial setup costs and technical requirements can be barriers, the long-term benefits make it worthwhile investment for many farmers.

2. Technical approach:

The proposed Polyhouse monitoring system consists of microcontroller boards, sensor subsystem and controlling unit. Fig-8 depicts the integration of the sensors with the microcontroller boards Arduino and ESP32 and other hardware components. Microcontroller boards, sensors and other related components used in the development of the Polyhouse Monitoring System is briefed below

2.1. Arduino uno R3:

It is robust and flexible microcontroller based on Atmega238P. It is known for its ease of use, large community support, and extensive range of compatible accessories. It has 6 Analog input pins and 14 Digital I/O pins (of which 6 pins can provide PWM output). Operating at a voltage of 5V it has a clock speed of 16MHz. It is widely used for developing and testing new ideas. Its ease of use and extensive ecosystem makes it suitable for beginners and experienced developers alike.

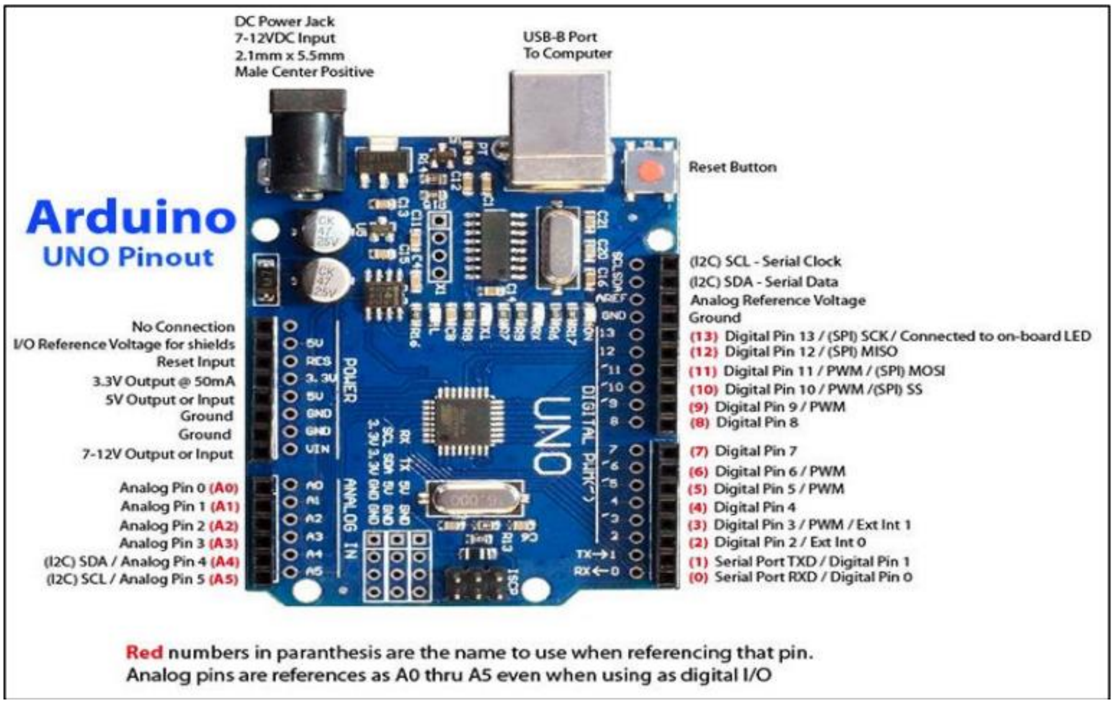


Figure. 1: Arduino Uno Board

2.2. ESP32:

It is a powerful and versatile microcontroller based on Xtensa dual-core 32-bit LX6 microprocessor developed by Espressif Systems. It is popular for its advanced features including built-in Wi-Fi and Bluetooth capabilities making it ideal for wide range of IoT applications. It has a clock speed of 240MHz operating at a voltage of 3.3V. Esp32 Wi-Fi capabilities can be expressed in two modes. One is STA mode which is a station and another one is SAP mode (Soft Access Point). Major difference between both is that in STA mode esp32 act as a client of the router. But in SAP mode esp32 act as router and assigns IP address to the clients. It can be slightly more complex to program compared to the Arduino Uno.

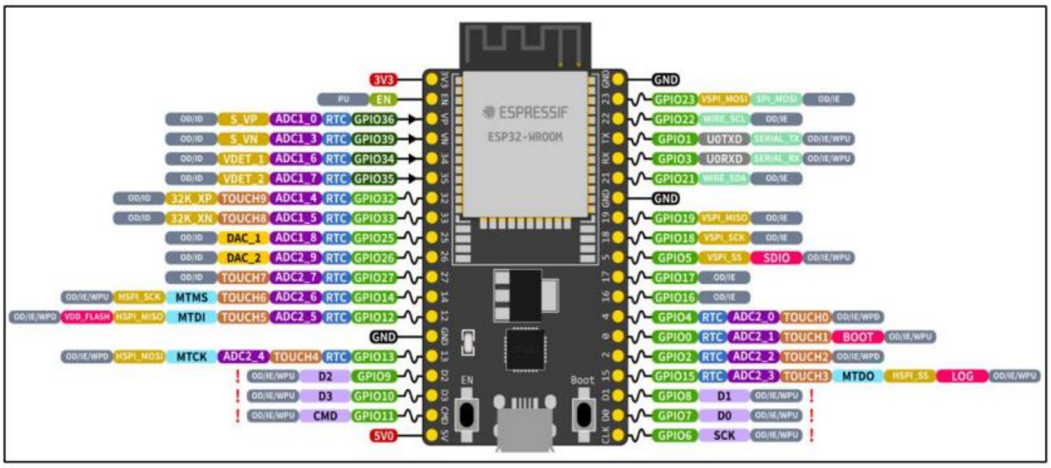


Figure. 2: Esp32 Microcontroller

2.3. LM35:

It is a reliable and straightforward temperature sensor that is easy to use with microcontrollers like Arduino and ESP32. It provides an Analog output voltage that is directly proportional to temperature in degree Celsius. It can provide temperature readings in the range of -55 °C to +150 °C.

2.4. DHT11:

It is low-cost digital temperature and humidity sensor that provides reliable readings with relative's simple interfacing. It can provide temperature in the range of 0 °C to 50 °C and relative humidity in the range of 20% to 90%. To use this sensor, one must install the DHT sensor library and use header.

2.5. LDR:

Light Dependent Resistor also known as photoresistor, is type of resistor whose resistance changes based on the amount of light falling on it. Resistance varies non-linearly with light intensity. It has two terminals. One is variable and other is fixed. It is recommended to use resistor while connecting to a microcontroller.

Soil Moisture Sensor: It is a device used to measure the moisture content of the soil. It usually consists of two electrodes that measure the electrical conductivity of the soil, which correlates with the moisture content.

2.6. Relay:

It is an electromechanical switch that operates using an electromagnet to mechanically control the switching of one or more circuits. Electromagnetic coil when energized generates a magnetic field that attracts an armature, causing the switch contacts to close or open. It can be normally open (NO), normally closed (NC), or changeover (CO, also called single pole double throw-SPDT or double pole double throw-DPDT).

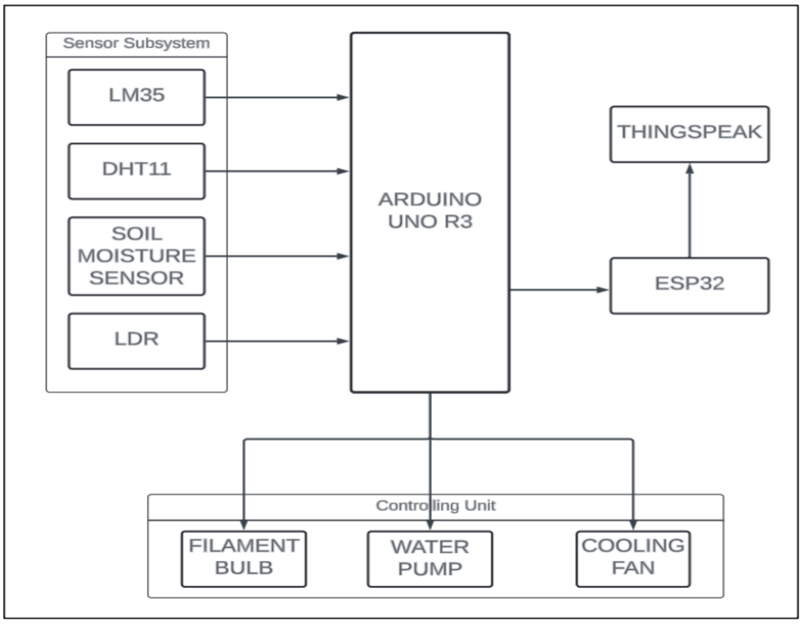


Figure. 3: Block Diagram of Polyhouse Monitoring System

Sensors such as lm35, dht11, soil moisture sensor and LDR sensor as unit is connected to the Arduino microcontroller. Arduino is then connected to ESP32 microcontroller and the controlling unit having cooling fan, filament bulb and water pump.

3. Methodology:

Fig. 4. Represents the methodology adopted to implement the proposed Polyhouse monitoring system. It depicts the flow of work from the sensors to Arduino and then to ThingSpeak through ESP32 and to controlling unit.

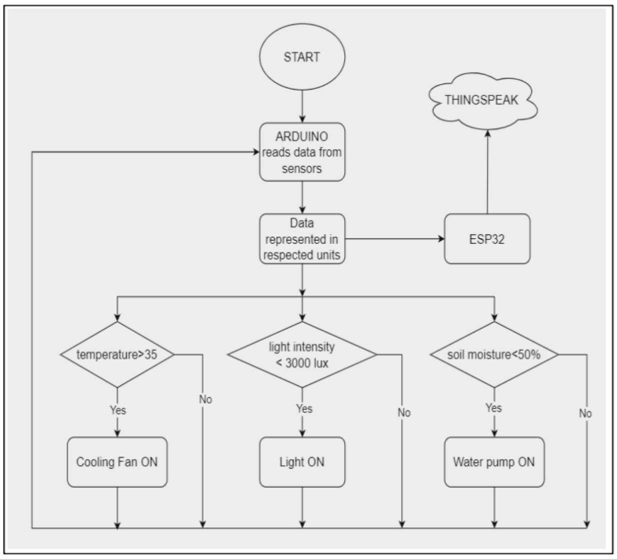


Figure. 4: Working flow of the Polyhouse System

Arduino uno collects the data from the sensors used. Output of LM35 is in degree Celsius and DHT11 is in degree Celsius and % relative humidity. Whereas the output of Soil moisture sensor and LDR sensor is in terms of voltage levels. Output of moisture sensor is caliberated into % moisture and light intensity is caliberated in terms of lux. Data obtained is checked with the optimal levels of these parameters. If the temperature exceeds its optimal level, then cooling is turned ON to bring down the temperature. If the light intensity is below the optimum level then the filament bulb turns ON to maintain sufficient intensity. Water pump turns ON and provides irrigation whenever the moisture content is well below the optimal level. The same obtained data is transmitted to Esp32 from Arduino through serial communication. ESP32 then uploads the received data on the Thingspeak in the structured channels which can be analysed and visualized when required. The optimum levels of various parameters are illustrated in Table. 1 below.

Table. 1: Optimum levels of various parameter in a Polyhouse

Parameter	***Optimum level***
Temperature	20-35°C
Relative Humidity	50-80%
Soil Moisture	60-90%
Light Intensity	3000-130000 lux
Soil PH	5.5-6.5

4. Results:

LM35 temperature sensor, LDR sensor and Soil moisture sensor are all analog in nature and are connected to Arduino board through Analog input pins. Whereas DHT11 is digital sensor hence it is connected to digital I/O pin. Tx and Rx pins of Arduino Uno are connected to Rx and Tx pins of ESP32 respectively to setup serial communication between Arduino and ESP32 boards. Cooling fan, Bulb and Water pump are connected to Arduino using digital I/O pins. ThingSpeak is accessed by ESP32 with API Keys to write the data on it. The integration of the sensors with Arduino and ESP32 can be seen in below Fig. 5.

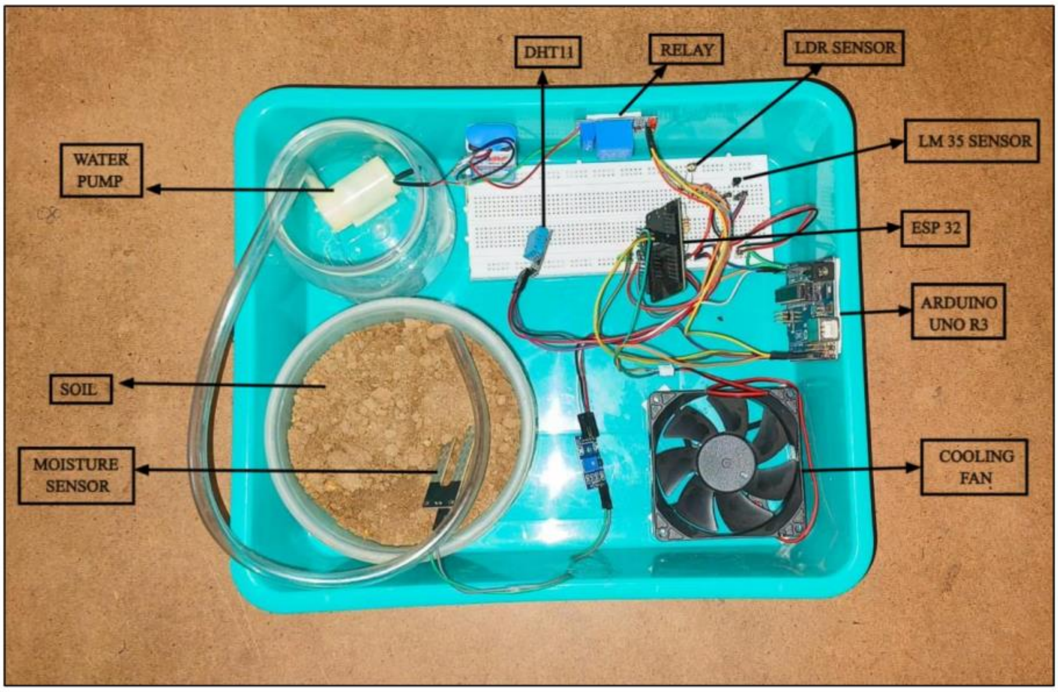


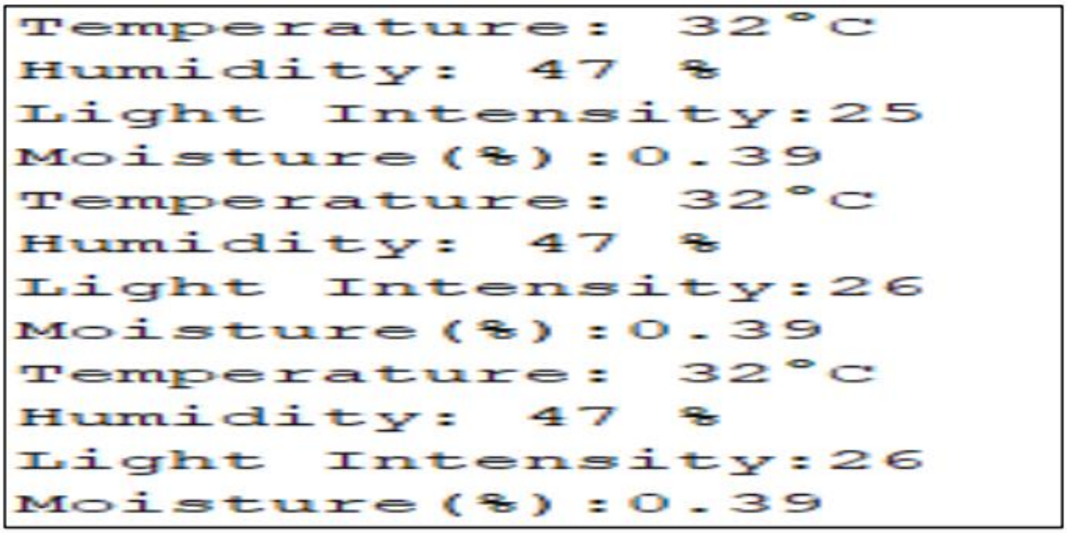
Figure. 5: Hardware implementation of Polyhouse System

Fig. 6: and Fig. 7: illustrates the top view and side view of the developed polyhouse system respectively.

Figure. 6: Top View of the developed Polyhouse System

Figure. 7: Side View of the developed Polyhouse System

Data read and acquired by the Arduino from sensors used can be seen in Fig-13 below.



```
Temperature:  32°C
Humidity:  47  %
Light  Intensity:25
Moisture(%):0.39
Temperature:  32°C
Humidity:  47  %
Light  Intensity:26
Moisture(%):0.39
Temperature:  32°C
Humidity:  47  %
Light  Intensity:26
Moisture(%):0.39
```

Figure. 8: Serial Monitor display of data acquired by Arduino

The data acquired by Arduino is sent to ESP32 and the same is reflected on serial monitor of ESP32 program. Figure 8. Illustrates the data received by ESP32 which is same as that of Arduino. Data displayed on serial monitor of ESP32 program is used to test whether the data is correctly received by ESP32 from Arduino. If there is any mismatch between the data received then it can be used as a debugging tool.

```
Received data: Temperature: 32°C
First part of the data: Temp
Last part of the data:  32°C
%. Send to Thingspeak.
Waiting...
Received data: Humidity: 47 %
First part of the data: Humi
Last part of the data:  47 %
%. Send to Thingspeak.
Waiting...
Received data: Light Intensity:25
First part of the data: Ligh
Last part of the data: 25
%. Send to Thingspeak.
Waiting...
Received data: Moisture(%):0.39
First part of the data: Mois
Last part of the data: 0.39
%. Send to Thingspeak.
Waiting...
```

Figure. 9: Serial Monitor display of data received by ESP32 from Arduino

Data in the Fig. 9: Shows that the temperature is within in optimal range whereas the light intensity and soil moisture is below the optimal range. As the temperature is optimum, the cooling fan is OFF. The light switched ON as light intensity low in the polyhouse and since the moisture content is low, water pump switched ON. Fig. 15 below depicts the same.

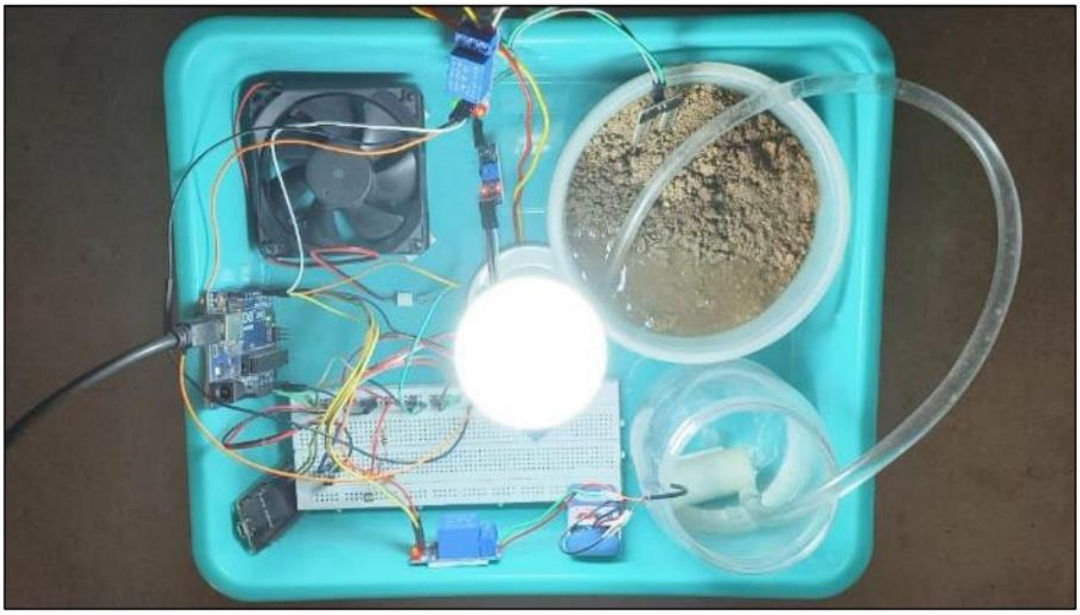


Figure. 10: Working of the Polyhouse Monitoring System

5. Conclusions:

IoT enabled Polyhouse Monitoring System is designed. The developed prototype is tested under the optimal conditions of the polyhouse and also under the exceeded levels of optimal conditions. The system is working well under optimal conditions. The controlling unit responded properly when the optimal conditions are not met. The data obtained and uploaded on ThingSpeak is analysed and visualized. The system can help in effective usage of soil and water resources, increases the efficiency and improves the crop production. This system can protect the crops from the external environment.

The developed prototype can be further integration with smart devices and automated systems for controlling irrigation, ventilation, and shading based on sensor data. It is also possible make it as a Predictive Model to forecast climate conditions, pest outbreak, and crop yields, allowing or proactive management

6. References:

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