Cloud based soil monitoring and smart irrigation system using IoT and precision farming

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Abstract
The impact of Wireless Sensor Networks (WSN) provides the new path to development and research on precision farming. It is mainly focused upon various WSN usage and issues related to that and overcoming the challenges in it to enhance the precision agriculture. To eye on particular specifications and requirements, it is mandatory to analyze the devices used, technology behind the Wireless Sensor Network. The main objective is to design a device that could improve the efficiency and performance by reducing the water usage by performing drip irrigation and enhance the soil fertility. The end-user requirements have been identified using a set of high-level scenarios, which capture the context and illustrate the motivation for building the platform. To interconnect with the IoT, a working Wi-Fi module known as Node MCU ESP8266 is used. This wifi module is designed in such a way that it incorporates Arduino in it and it can be connected to available LAN. DHT22 sensor is used to calculate the temperature and humidity present in the air and soil. The devices are interconnected to Node MCU ESP8266 module and program is written to it to send the observed value to open cloud server called Adafruit where the parameters can be visualized in real time. The paper notion is to create a smart farming field which shows the soil temperature, moisture and humidity using web-based platforms via IOT enabled devices within the particular geographical area. It basically gives a proper communication between a smart agronomists and farm. The main objective is to utilize the technology to build a platform for data aggregation and automatic controlled irrigation.

Keywords: Drip Irrigation; Sensor Network; NodeMCU ESP8266; Web-Service; Internet of Things.
1. Introduction

Agriculture is a tremendous space which predominantly comprises of development, rising of creatures, developing products like wheat, rice millet and so forth. Agriculture assumed an essential part in the advancement of humankind, where as cultivating has expanded the development in nourishment generation. Agriculture has started more than thousands years back where the humanity got an immense improvement the creation of sustenance where it has been for the most part determined by the components like atmosphere, culture, etc. These days because of the advancement of industrialisation, modern cultivating has taken up its situation in business advertise. Yield from mechanical cultivating is expanding as the innovation progresses. Different devices produced by the industries are specified to corresponding fields, the internet, nowadays, facing many shortcomings because of the vast number of network device. It may be simplified by providing a standard worldwide [1].

The art of soil administration and utilization of pesticides has strongly expanded the creation of yields however the use pesticides greatly affect mankind. Specific rearing and current practices in livestock have comparatively expanded the generation of meat; however have brought numerous issues up in human wellbeing as the chemicals are utilized for the creation of meat. So as to expand the nature of creation we have executed numerous strategies, for example, crossover cultivating, high yielding harvests. Nourishment creation and water administration are one of the significant issues that everybody is confronting today [2]. Intemperate use of manures and rehashed generation of same yield has diminished the richness of the dirt and furthermore prompts the consumption of groundwater which has been seen as of late. The impacts of a dangerous atmospheric devation greatly affect corruption of rural field and numerous specialists are as yet making sense of [3].

For nations like India agriculture assumes an essential part in GDP. Because of the declinement of horticultural exercises as the nation creates in the way of digitalization. New mechanical upgrades have been made to expand the yield of harvests with less utilization of pesticides and bug sprays which will be less destructive to mankind and to the dirt. Agriculture can likewise be consolidated utilizing Internet of Things by detecting all the imperative parameters like soil dampness, pH and temperature[4]. Along these lines agriculture should be possible more exact, cost-effective and less exertion.

The scientists have acknowledged various techniques have to be handled for different topologies for e.g. based on soil water temperature and humidity irrigation is done and described in “Remote Sensing control of an irrigation system using a distributed wireless sensor Network” by Kim, Robert G.Evans, William M.Iverson, 2008. Various decision support systems using Internet of Things is explained in Junyan Ma, Xingshe zhao, “connecting the agriculture to Internet of Things using sensors”,2011 IEEE. Farmers can access more benefits from data alert system and decision support information developed for information exchange and soil monitoring. The overall system architecture is depicted is figure 1.
2. Designing and Implementation

The above diagram depicts the overall architecture of the implementation. The solenoid valve is used to control the motor on/off and is designed in such a way that it can be connected with NodeMCU ESP8266-12E using MQTT IoT protocol. 12V SPDT Relay is used between NodeMCU and Solenoid valve because signal from the NodeMCU cannot give appropriate amount of voltage to run the solenoid valve directly. Therefore, the theory behind the Single Pole Double Throw (SPDT) switch is that the poles are number of switches separated electrically which are directly controlled by the physical actuator. On the other hand, throws are the number of physical path options other than normally open which can later be adopted for each pole. A single throw switch basically has a pair of connection that can either open or close. MQTT server is used to visualize the real time values of the parameters. There are two sectors implemented in the project, first one comprises of sensors and relays which is kept in the field for monitoring the soil temperature and humidity. The second section is basically MQTT server which is used to display the obtained results. Thinger.io is an open MQTT platform which helps to plot various fields and analyze the threshold value to alert the smart agronomists. NodeMCU provides the network gateway between the relay and various sensors. Thinger.io library is installed in Arduino IDE to dump the program or the instructions in the NodeMCU and message being sent and received is once tested. It uses light weight messaging protocol and it is basically a publish and subscribe method used in IoT protocols [5]. Thinger.io platform also provides basic security protocols such as Transport Layer security which gives integrity of data and privacy over communication devices and Secure Socket Layer which secure communications between the browsers and various servers. The appropriate authentication is required to access the observed values, creating login ID and password. It basically provides the user an appropriate security through preventing an intruder to access the particular database.
3. **Modules and Sensor**

3.1. ESP8266 NodeMCU-12E

NodeMCU is used widely in embedded applications for its user friendly approach. It uses Wi-Fi and Lua script to run complex programs without any issue and recompilation and it is shown in figure 2. It is breadboard friendly as the pins are designed narrow and compact and it also used for the Arduino development environment [6]. It has the ability to control the readings of the sensor and has the property of bringing all the sensors into opt memory system processing. From the external hardware, it takes only limited number of value in consideration and only takes very little space in PCBs. It does not take any external hardware support for the Radio Frequency as it adjusts itself with the on-board RF signals. It can also integrated with Bluetooth, BLE, etc.

![NodeMCU ESP8266-12E](image)

Fig 2. NodeMCU ESP8266-12E

3.2. DHT22 Sensor

It is a low cost, easy to handle, highly accurate and spot-on humidity and temperature sensor and the pin description of DHT22 sensor is shown in figure 3. It consume low power and gives highly reliable and steady output. The sensing technology behind DHT22 sensor is that it aggregates digital output. Therefore, it is easily visualizable in MQTT server. It interfaces with an 8- bit microcontroller providing phenomenal accuracy and capable of adequate result obstruction. The communication between the sensor and microcontroller make system blend accordingly.
4. **Existing methodology**

4.1. **Existing approach in remotely sensing environment**

Spatial resolution of images taken by satellite imaging is difficult to distinguish irrigated fields and may cover only significant parts of the land. Because of the consequential overlap in spectral signatures, it is hard to identify irrigated fields from non-irrigated part in humid conditions. Mapping accuracy may decrease if there is an overlap from the flooded irrigated fields with natural wet areas [7]. In Humid tropical and sub-tropical atmosphere, optical data availability is quite delicate with frequent cloud cover. Observations are not always aggregated at ideal times such as harvesting period, therefore the collection of remotely monitored data is fixed.

4.2. **Problems in irrigation**

- Need investment/finance
- Inadequate physical infrastructure
- Poor farming
- Limited access to quality farm inputs
- Too much relying on rain
- Inadequate production and post-harvest technologies.
- Lack of awareness by farmers on precision farming methods

5. **Proposed Methodology**

The scientists have overcome these drawbacks by using the terrestrial information of planting the crops, and its growth and finally the harvesting stage in convergence with spectral information. Unlike conventional sensor network, the use of the sensor data can be sent to the cloud to mitigate the data where it stored in particular database and once it reaches a particular threshold in soil parameters like temperature, humidity, pH, and micro and macro nutrients availability, controller can conclude how
much amount of water is needed for the crops and it also monitors the over flooding parameter by finding the percentage of water level in the soil. The proposed methodology uses specific protocols like MQTT, http and web sockets for light weight messaging and end user notification to the farmers [8]. The clustering of the data also done using various adaptive fuzzy logic. In proposed clustering technology, it is better suited for heterogeneous surrounding in which there are four levels of nodes are defined. It helps in increasing the stability of the network in identical clusters. The distance between cluster heads and no of member nodes are determined and it is made ensure that minimum distance is only formed into cluster [9]. Request message is sent to the cluster head which satisfies the minimum routing condition. The energy consumption is reduced to possible extent from one member node to cluster head which increases network lifetime. The proposed methodology ensures the cluster head is selected different at consecutive rounds. Without checking the residual energy the previously chosen cluster head is cleared from the CH (Cluster Head) position. The proposed methodology ensures an oncoming CH is elected by determining which node has maximum residual energy in whole cluster for the next round. It repeats for particular number of rounds. It ensures the uniform energy consumption at different rounds by selecting different cluster heads and stability is increased to possible extent without having affect on possible number of rounds.

Figure 4. Use case diagram for platform-specific applications

The proposed platform ensures quick access to configure IoT nodes, implementing and aggregating the variable parameters on sensors and it also ensures adding, equipping and modifying the sensor nodes and faster configuration into working prototype. The use case diagram for common platform specific
application is depicted in figure 4. On the hardware part, sensors like DHT11/22, pH rod, soil conductivity, soil moisture, nutrients like NPK are identified and aggregated. Solenoid valve is used to control the water level which is irrigated via drip irrigation[10]. In this way only appropriate amount of water is sent to crops thereby controlling the wastage of water.

5.1 Configuration of NodeMCU

- In Arduino IDE, install the DHT11 sensor libraries and drivers
- Write the appropriate instructions and dump it on Node MCU.
- Give the appropriate pin connections.
- Establish the connections with the server using available Wi-Fi
- Open corresponding channels and fields in thinger.io
- Separate fields are created and visualized with observed values.

5.2 Interfacing Blynk android application

- Same Application Programming Interface(API) and User Interface(UI) for software and hardware requirements.
- Connecting to the cloud using:
  - Ethernet
  - Wi-Fi
  - Bluetooth and BLE
  - USB(serial)
- User friendly widgets access
- Pin manipulation with reduced instruction and program
- Integrating and adding new functionalities using digital, analog and virtual pins
- Historical view of data monitoring using historical data widgets
- D-to-D communication using Bridge Widget
- Sending emails, tweets, push notifications, etc.
- Easy upgradability

The interconnection of blynk application with Node MCU ESP8266 is connected via a blynk server which is shown in figure 5.
6. Results

The appropriate results are shown in figure as it can be viewed in Mobile applications. The soil, temperature, humidity and moisture level are displayed in the figure 6. It also shows the status of the motor. When particular threshold is reached, the motor is tend to on and it sends up the notifications to the user and once the irrigation is done, the sensor aggregated data are compared and it automatically turns off the motor is shown in figure 7.

Figure 5. Blynk application interface with NodeMCU ESP8266

Figure 6. Real time observations of Temperature and Humidity

Figure 7. Status of Motor visualized in Mobile Application
7. Conclusion and Future Scope

It may conserve water usage up to 45% from the conventional irrigation. Recently it is found to be a significant rise in deploying Wireless Sensor Network (WSN) and the major challenge is providing network stability and power consumption. Therefore in this proposed model, expanding solutions for data aggregation and analytics, efficient cluster head selection and integrating with open source programming platforms, including support for further IoT protocols such as Message Queue Telemetry Transfer (MQTT) and constrained Application (CoAP), giving detailed experimental evaluation of performance metrics.

References
