Smart Irrigation System for Indian Agriculture (CAIPOS)

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Project Idea

To overcome some of the problems faced by farmers in today's world we are trying to make a project which can help farmers to overcome some of these difficulties.

Over irrigation occurs because of poor distribution or the lack of management wastes water, chemicals, and may lead to water pollution. Under irrigation is giving only just enough water for the plant which gives poor soil salinity which leads to increased soil salinity with a consequent build-up of toxic salts in soil surface in areas with high evaporation.

To overcome these irrigation difficulties, we have made a project by the use of IoT (internet of things) and ML (machine learning). The hardware consists of various sensors like temperature sensor, humidity sensor, pH sensor operated by Arduino and ESP 8266 module. Our temperature sensor will read the weather condition of that area through which farmer will make less use of water in the fields. Our pH sensor will sense the pH of the soil at a regular interval and predict whether that soil needs more water or not. Our main target is to make an irrigation system automatically and to save water for the future purpose. The current trends in the smart irrigation market include the following techniques which are:

• *Drip Irrigation:* allows for precise control of the application of water and fertilizer, which can greatly reduce the amount of water needed for crop irrigation.

• *Measuring Water Flow:* Precise measurement of water usage with water flow meters can prevent over-watering and reduce costs for farmers.

• *Drilling More Wells*: Farmers are relying more on groundwater sources for irrigation and as the water table falls due to unsustainable levels of pumping.

The mobile application is to control the system remotely which allows a user to monitor the whole system and if there is any problem or passing of water user can switch off the system through this application.

We have used Machine Learning algorithm(ANN) to predict the water level and allow the pump to irrigate the plant automatically and we have used another algorithm(CNN) to detect plant diseases by training the model using various images and upon scanning the plant it will notify the user about plant disease(if any) and send a notification regarding the type of fertilizer to be used in order to prevent the disease.

Technology Stack

Internet of Things:

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction It's a technology that has slowly gained momentum and is now silently shaping our future. IoT is the result of mankind's curiosity and intention to lead a convenient and connected lifestyle, reducing labor and eliminating the chances of human errors. That's why we decided to make irrigation system smart and take care of things that will bring in efficiency. We've figured out that data is the new currency and tons of crucial concerns can be addressed and resolved through data and this is what drives the concept of the Internet of Things.

Machine Learning:

Machine learning (ML) is the scientific study of algorithms and statistical models that computer systems use to perform a specific task without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence. Machine learning algorithms build a mathematical model based on sample data, known as "training data", in order to make predictions or decisions without being explicitly programmed to perform the task.

Android Development:

Android software development is the process by which new applications are created for devices running on the Android operating system. The Android operating system is a mobile operating system that was developed by Google to be primarily used for touchscreen devices, cell phones, and tablets. Its design lets users manipulate the mobile devices intuitively, with finger movements that mirror common motions, such as pinching, swiping, and tapping.

Use Cases

The design of automatic irrigation system is based on Microcontroller. Various sensors are placed in paddy field. Sensors sense water level continuously and give the information to farmer through cellular phone. Farmers will control the motor using mobile phone without going in paddy field. If the water level reaches at danger level, automatically motor will be off without conformation of farmer.

CASE 1: Dry Condition (without Rain):

If the sensed signal is greater than the threshold voltage for every particular soil, it means it executes the true condition and thus the soil is dry. The above statement is based on the property of the moisture sensor, i.e., if the sensed value is greater than or equal to the threshold voltage, then the soil is dry and also if there is no rain. Since the condition is true, the Boolean LED will glow ON and the water pump should turn ON in order to irrigate the plant.

Implementation Process:

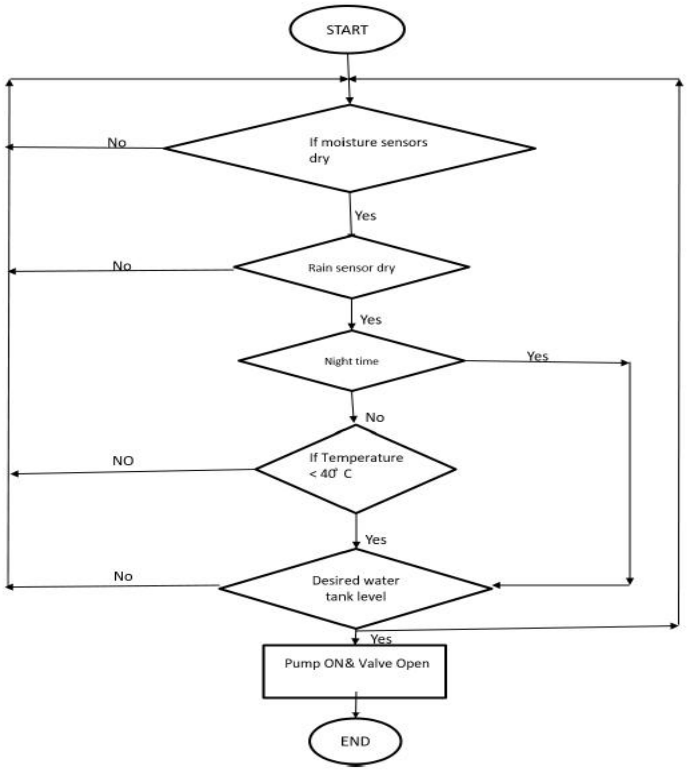


Fig: Flow chart of Implementation Process

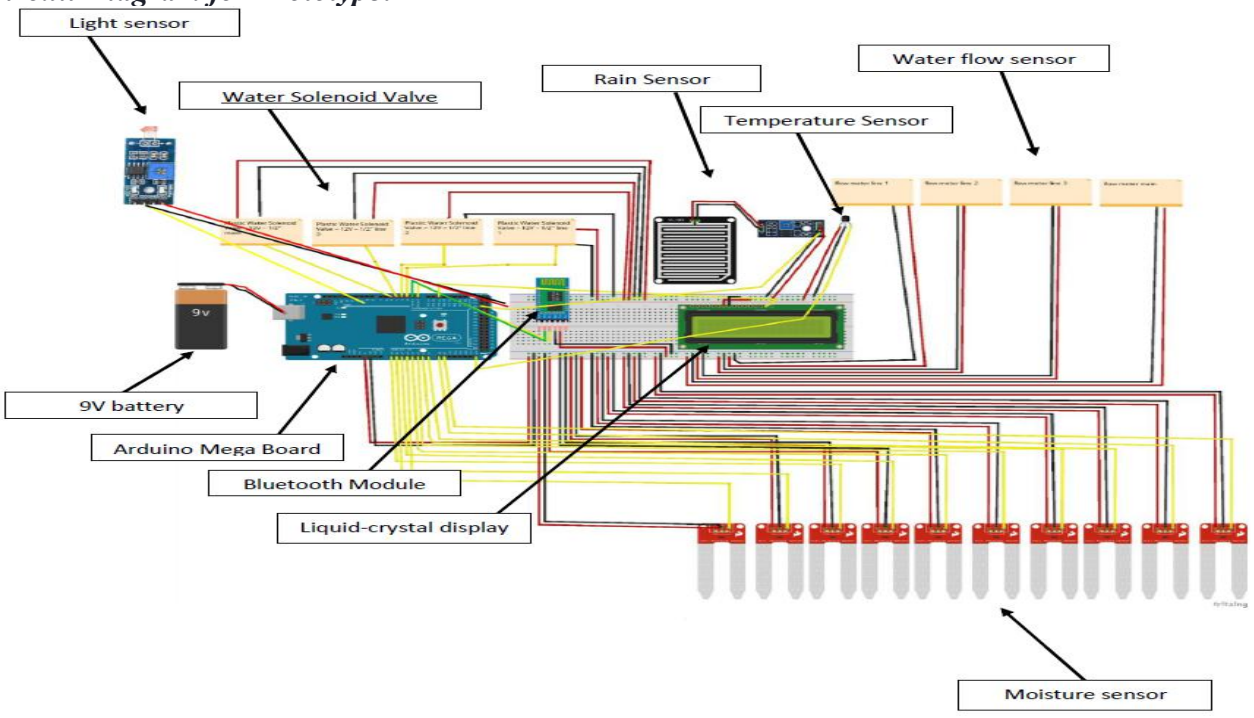
Case 2: Dry Condition (with Rain):

If the sensed signal is greater than the threshold voltage for every particular soil, it means it executes the true condition and thus the soil is dry. The above statement is based on the property of the moisture sensor, i.e., if the sensed value is greater than or equal to the threshold voltage, then the soil is dry. Since the condition is true, the Boolean LED will glow ON and the water pump should turn ON in order to irrigate the plant. When it's raining, even though the soil is dry, automatically motor gets turned OFF. After the rain stops, it again checks the condition of soil moisture and work accordingly.

Case 3: Wet Condition:

If the sensed signal is less than the threshold voltage for every particular soil, it means it executes the false condition and thus the soil is wet. Above statement is based on the property of the moisture sensor, i.e., if the sensed value is less than the threshold voltage, then the soil is wet. Since the condition is false, the Boolean LED will glow OFF and the water pump should turn OFF because the plant has excess of water content in the soil, irrespective of rain.

Circuit Diagram for Prototype:



Execution Process:

The scenario of application starts from installing the app on phone then open the application, first of all, the main screen of the app will be loaded when the user will choose which device is connected to Internet. The system will check if the device is connected if it is connected then it notifies the user that the device is connected otherwise notify the user device is not connected. In the main screen, the user can directly switch ON /OFF the entire system. Moreover, if Details Button pressed it loads to details screen. In this Screen user will able to see all details related to whole system For example if he pressed on plant1 button he will be able to see (amount of water, Soil moisture, Temperature) if there is problem only in this line he can switch ON /OFF line so he is able in this page to control line by line.

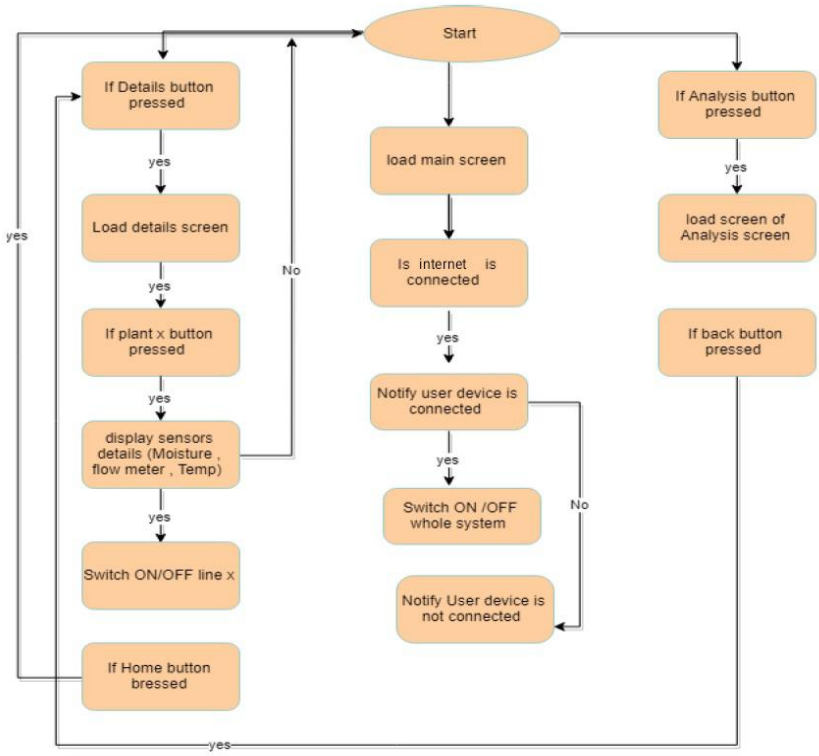


Fig: Flow Chart of Application Process

For detection of plants disease, the farmer will capture the image of plant leaves through the mobile camera and it will show the name of plant disease and the name of fertilizer to be used in order to prevent that disease. This can also be done by using a drone camera (having a payload capacity of approx. 25kg) so along with capturing the images of plants at a certain interval of time it can also sprinkle the fertilizers and other insecticides and pesticides that doesn't affect the health of farmer as well. We have

used CNN (a neural network algorithm) in order to train our model that predicts the diseases of the plants.

Prototype Dependencies

Internet of Things (IoT):

- **Arduino UNO and ESP8266-01:**

Arduino is the one of the most commonly used micro-controller board that has advantages like low cost, small in size, it is open-source, easy to programme with Arduino IDE via a USB (Type B) cable. This micro-controller consists of 6 number of Analog Pins, and 14 number of Digital Pins that makes this controller best for using a greater number of analogue and digital sensors and many input-output devices. With the use of 6 number of PWM pins analogWrite() could also be performed. In order to provide Wi-Fi connectivity to the Arduino UNO, the ESP8266-01 generic board is used with UART (Universal Asynchronous Receiver Transmitter) serial communication. For communication between Arduino and the other components, it has I2C, UART and SPI (Serial Peripheral Interface). This is the main controller unit of this project to control all sensors, to collect data and to process it. With the help of ESP8266-01 board the data will be sent to the cloud platform.

Fig: Arduino UNO

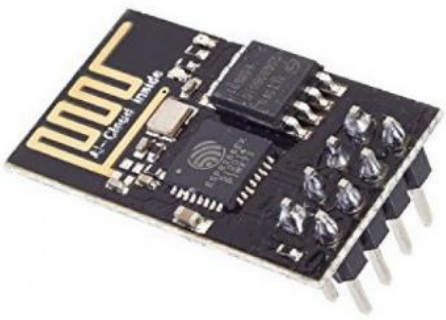


Fig:ESP8266-01

- **Temperature and Humidity Sensor:**

In today's market a wide variety of Temperature Sensors are available. In this paper, the proposed Temperature and Humidity Sensor is the DHT-11. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. This sensor has a low output impedance,

low self-heating, low power consumption, a linear output, and precise inherent calibration in °Celsius that makes the interface of the control circuitry easy and efficient.

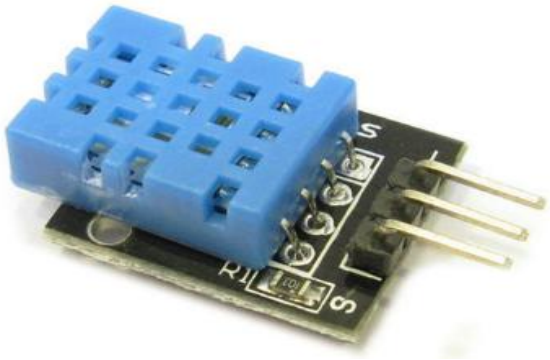


Fig: DHT 11

- **Soil Moisture Sensor:**

This is an easy to use digital soil moisture sensor. Just insert the sensor in the soil and it can measure moisture or water level content in it. It gives a digital output of 5V when moisture level is high and 0V when the moisture level is low in the soil. The sensor includes a potentiometer to set the desired moisture threshold. When the sensor measures more moisture than the set threshold, the digital output goes high and an LED indicates the output. When the moisture in the soil is less than the set threshold, the output remains low. The digital output can be connected to a micro controller to sense the moisture level. The sensor also outputs an analog output which can be connected to the ADC of a micro controller to get the exact moisture level in the soil."

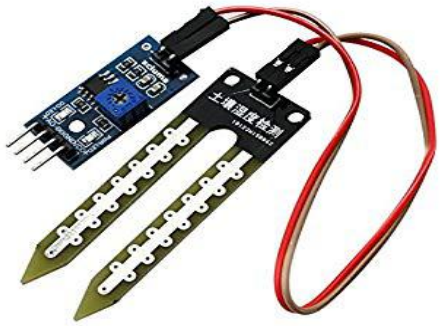


Fig: Soil Moisture Sensor

- **Photo Resistor:**

In this project Photo resistor or LDR will be mainly used for sensing light intensity. The light required for crop can be sensed by this and the micro-controller can adjust the light. The resistance of it depends on the intensity of light. According to resistance analog output voltage is varied and sensed by the micro-controller.

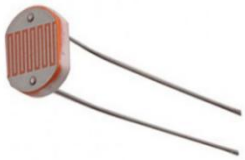


Fig: LDR

- **Rain Sensor:**

Rain sensor is to sense if it is raining or not and also measure the amount of rain-fall. It has a rain sensing plate, by depending the resistance of water on it, it sends an analog data to rain sensing module. The IC amplifies the signal and also convert it to digital signal (ADC) and sends to the micro-controller.

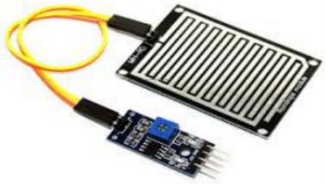


Fig: Rain Sensor

- **LCD Display:**

LCD display is the most commonly used display in most of the projects. To display the current status of all the sensor, the project uses a 16x2 Liquid Crystal Display (LCD) display. It has 16 columns and 2 rows and can print total 32 character.

Fig: 16X2 LCD

- **Water Pump:**

It is used in this project to pump the water needed for irrigation from the main water tank through pipes. This pump can be used for different applications, in household include cleaning, bathing, space heating and flower of water. This pump is selected for this project because it has good advantages. Such as, it has a lightweight. Also, it has a small size, so it is easy to install and replace it. Furthermore, it has an enough efficiency to pump water for irrigation. Since it operates in 12 volts, so it consumes lower power. In addition, this pump has a very Low of noise. Finally, the cost of this pump is very cheap.

Fig: DC Water Pump

- **Plastic Water Solenoid Valve:**

Is to control the flow of fluid, a valve is ordinarily closed and has a 1/2" non-taped outlets on each conclusion. On the off chance that 12V is connected through the two terminals of the valve the solenoid will open the valve.

Fig: Water Solenoid Valve

- **Other components:**

  Battery (DC): For power supply.
  Bread-board and PCB board: For connecting the wire and other components.
  Motor-driver: To control the water-pump.
  Connecting wires: For connecting all sensors and components.

Fig: Jumper Wire

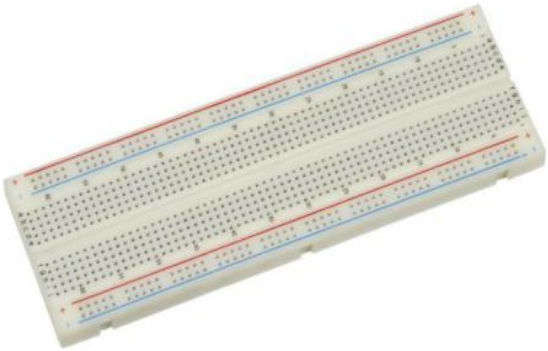


Fig: Bread board

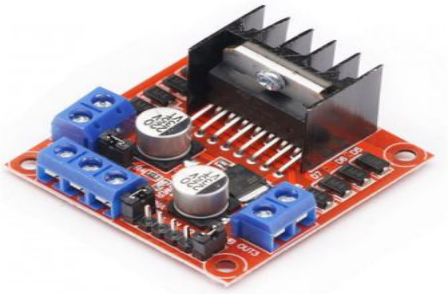


Fig: Motor Driver(L298)

Fig: Battery

Software Platforms:

Android Studio

It is the official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. The app is created using Android Studio.

Firebase

Firebase is a mobile and web application development platform developed by Firebase, Inc. in 2011, then acquired by Google in 2014.We are using Firebase Cloud functions to send notification to user and our data is stored on the firebase real-time database.

The app provides remote control to the user on the water pump. Pump can be switched on or off both manually and automatically. The user would receive notifications whenever there is any critical change in the temperature, humidity, moisture content or state of motor.

Machine Learning:

Machine learning technology plays important role in smart irrigation system. It uses computational method to learn agriculture data. The focus of the learning process is to learn from training data to perform a given task. Also, in agriculture it uses for crop management, yield prediction, weed detection, diseases detection, species recognition and crop quality. Irrigation system uses both of the learning process i.e. Supervised and Unsupervised Learning. But most used learning process is supervised learning, it uses labelled data used as an input data for training purpose. It consists of both input factors and required output. Unlabeled data used for training purpose under unsupervised learning. The clustering of training data into a particular group will be done on the basis of the similar nature between the variables. Neural network techniques are applied widely in irrigation systems using machine learning. It has different types and it uses different principles. Multiple parameters are given as inputs in input layer. The input layer contains more than one node or neuron for better result. It may be the stages of plant’s growth or different types of environmental characteristics Then the hidden layer is placed after input layer. It accesses the data from input layer’s each node.

Then the output layer is placed after hidden layer which shows the desired output or expected output according to the trained data in hidden layer. The lack of proper timing in irrigation is an important production factor and that delaying irrigation may result in loss of water and crop yield. We proposed an ANN based controller. The input attributes such as soil moisture, air temperature, humidity and radiations are demonstrated. Four interconnected stages in that system are input values from sensors, evapotranspiration model, desired soil moisture and ANN controller. These controllers don't require an earlier learning of system and have capacity to adjust to the changing conditions.it is unlike conventional techniques. But the model is prototyped, it is not implemented in filed using hardware.

Plant disease has also been one of the major threats to food security because it dramatically reduces the crop yield and compromises its quality. Accurate and precise diagnosis of diseases has been a significant challenge. Among various network architectures used in deep learning, convolutional neural networks (CNN) are widely used in image recognitions consist of convolutional layers, which are sets of image filters convoluted to images or feature maps, along with other layers. In image classification, feature maps are extracted through convolution and other processing layers repetitively and the network eventually outputs a label indicating an estimated class. Given a training dataset, CNN, unlike traditional machine learning techniques that use *hand-crafted* features, optimizes the weights and filter parameters in the hidden layers to generate features suitable to solve the classification problem. In principle, the parameters in the network are optimized by back-propagation and gradient descent approaches to minimize the classification error. we provide a deeper evaluation of the visualization methods against the CNNs in plant science applications. Our results show that several visualization methods are usable in their original form, indicating that the CNN captures the lesion-specific features of respective diseases. However, several methods have to go through a process of targeted layer optimization to generate an optimum result owing to the differences in the CNN architecture and the datasets.

For the disease detection of various plants this project is developed only for Tomato and Cotton plants. More varieties of plants will be added depending upon the availability of data.

With the result of the project first step in the future will be to transfer this project to a large scale so that it will work for every type of soil. Moreover, to create more responsive mobile application which have more controlled data. We can also develop this system by using renewable energy which is solar power instead of batteries using solar energy will help to reduce future cost.