CropSense – A Smart Agricultural System using IoT

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Abstract
Agriculture plays a vital role in the development of a growing economy. As far as India is concerned, agriculture accounts for 18% of the Gross Domestic Product (GDP). Problems encountered in this sector have reduced crop productivity and the quality of crop production. The solution lies in modernizing conventional farming techniques by engaging new age technology to tackle problems that are caused due to manual and external intervention. Traditional methods involve constant monitoring from time to time that is exhausting for the farmers as well as results in reduced crop quality. These methods also consume a lot of water and cause either over-irrigation or under-irrigation. Wild animals, pests and rodents are also major threats to crops. Installing cameras requires constant network connectivity and may not be efficient enough to detect motion and sound caused by the intruder. This project proposes smarter ways of controlling irrigation and crop security of an agricultural field using the Internet of Things (IoT). In order to control the system, the collected field data is analyzed using Raspberry Pi an onboard computer and alert is given. The intruder image is captured using Pi Camera and sent to the farmer’s phone. The system is turned ON/OFF as and when required using an app installed in the farmer’s smart phone. This ensures timely irrigation only when the field is dry as well as warns the farmer of a possible wild animal attack. Thus, CropSense provides a feasible solution to farmers and helps in enhancing crop quality and productivity in the long run.

Keywords: Application development, android, crop quality, internet of things, smart, soil moisture, Raspberry Pi, real time control, wild animal attacks

INTRODUCTION
Agriculture is the heart of a developing nation like India. Technological advancements in this sector are necessary to improve the crop produce and saves time and money [6]. Over the years, innovative modern technologies have been adopted to improve crop quality and production. Conventional methods of farming are being replaced with new age methods that have reduced manual labor [1]. Collecting data manually requires effort and constant monitoring. For example: Conventional methods of irrigation like drip irrigation and sprinkler irrigation have many disadvantages. In drip irrigation, initial cost is more and the tubes used are affected by the sun that reduces its life. It also faces the risk of getting clogged often [8]. Similarly, sprinkler irrigation cannot be used in windy climate and also poses the risk of over irrigation [7]. Thus, new methods that conserve water are crucial.

Another aspect of agriculture system that needs attention is crop security. Wild animal attacks damage crops by running across the field resulting in yield losses. It is not possible for farmers to be physically present at the field all the time. Thus, real time monitoring solutions are the need of the hour [2].

METHODOLOGY
In the proposed work, smart irrigation and
crop security is implemented using Internet of Things (IoT). IoT is a recent technology that is used to monitor and control a system remotely with the help of internet. It helps to connect devices and other objects by forming a network. Devices may be connected using Wi-Fi, Ethernet, LoRa etc. Raspberry Pi serves as an embedded platform for the system. IoT can be used to control sensors from a distance thus, eliminating the need for the farmer to be physically present at the field every time [4]. The block diagram is shown in Fig. 1.

This project uses a protocol called MQTT which stands for Message Queue Telemetry Transport and HTTP (Hypertext Transfer Protocol). MQTT helps reduce network bandwidth and device requirements. It works with a client – server model using messages. Every message is published to an address called ‘topic’. Every client subscribed to a topic receives every message published to that topic. This allows clients to communicate with each other.

Soil moisture sensor is used to detect presence of moisture in the soil. The values are read by the Pi and stored in a server. A remote control connection is established between the clients using MQTT protocol. An AC submersible motor is connected to Pi using a relay. An application is developed using Android Studio to control and monitor the entire system.

When moisture is present in the soil, motor is switched off and vice versa. The app shows the soil moisture level as ‘DRY’ or ‘WET’ and also displays the motor status as ‘ON’ or ‘OFF’. It also has control key icons to switch the motor status manually. In this way, Motor works only when required. This helps to save water and eliminated the problem of under or over-irrigation.

The crop security phase of the project is implemented using Pi Camera. A buzzer is connected to alert the farmer. Image processing techniques are used for identify the intruders. Wild animals that are threat to crops are identified using a machine learning model which is trained with multiple images of these animals. The model is trained using Python programming.

For demonstration purpose, when the image of a wild animal is shown, the PiCamera captures the image and matches it with the trained images. A message identifying the animal is generated and published to the application installed on the farmer’s smart phone. A message ‘Intrusion Detected’ with name of the animal detected is displayed on the app screen accordingly and buzzer rings at the same time to give an alert.
HARDWARE

The hardware components used in the proposed system are discussed below in detail.

**Raspberry Pi 3 Model B+**

Raspberry Pi 3 Model B+ (shown in Fig. 2) is the embedded hardware platform used in the system. Built in with a 1.4GHz 64 bit quad core ARM Cortex A53 processor which is faster than the Pi 3 Model B processor and 1GB RAM, it also supports 802.11ac Wireless LAN and Bluetooth 4.2 [1].

It has 40 GPIO pins, 4 USB ports, HDMI port, Ethernet port, and Video Camera interface (CSI) and Micro SD card slot. The operating system used is Raspbian OS. Python is the most commonly used programming language for Pi [1].

![Raspberry Pi 3 Model B+](image)

**Figure 2: Raspberry Pi 3 Model B+.**

**Soil Moisture Sensor**

A soil moisture sensor as shown in Fig. 3 is used to measure the moisture content of the soil. It consists of two probes that is connected to an LM 393 driver circuit which contains a potentiometer that acts as a comparator. The potentiometer is set with a threshold value and it compares the measure value with the threshold one [4].

When the soil is dry, the module output is high else it is low. The working voltage is 5V and the working current is less than 20mA. It measures dielectric permittivity of the surrounding medium. In soil, water content depends on electric permittivity. The sensor generates an output voltage proportional to this value [5].

**Motor**

An AC submersible motor is used to pump water in the system. It is commonly used in fish tanks and aquariums. It is a 220V, 5W pump and is connected to the Pi using a relay. A motor is shown in Fig. 4.

![Motor](image)

**Figure 4: Motor.**

**Relay**

A 5V DC relay is used to power the pump. It has three pins: VCC, GND and IN1 output voltage. It opens or closes the contacts to control a device. It has normally open and normally closed contacts. A relay is shown in Fig. 5.

![Relay](image)

**Figure 5: Relay.**

**Buzzer**

A buzzer that works on 6V DC is used to give sound alert to the farmer. It is connected to the 38 pin of Raspberry Pi. The image of a buzzer is shown below in Fig. 6.

![Buzzer](image)

**Figure 6: Buzzer.**
Raspberry Pi Camera Module
The Raspberry Pi Camera Module v2 has a Sony IMX219 8-megapixel sensor. It can be used to take high-definition video, as well as still photographs. It takes photographs of 3280x2464 pixels. The board is around 25mm x 23mm x 9mm. It weighs around 3g. It captures the image of the intruder and identifies it using image processing techniques [3]. A PiCamera is shown in Fig. 6.

Mosquito
It is an open source message broker that is used to implement MQTT versions 3.1 and 3.1.1. It is written in C and is available for download in windows.

Android Studio
Android Studio is an IDE used for the development of applications in Android platform. JAVA is the programming language used for writing the application code. Android SDK tools need to be downloaded before using Android Studio.

SOFTWARE
The software components used in the proposed system are discussed below in detail.

Operating System
The operating system used for this project is Raspbian OS. It is compatible with Raspberry Pi 3 and works easily with it.

For writing the program code
Python 3 is the programming language used to write the codes. It is a very simple language that is easy to use and reduces the code size.

XAMPP
It is a free and open source cross platform web server package consisting mainly of Apache HTTP server, MariaDB database and interpreters for scripts written in PHP and Perl programming languages. In the project, a moisture database has been created in the web server where the soil moisture sensor values are stored.

SYSTEM DESCRIPTION
The system working is depicted using a flow chart shown in Fig. 7. The first step is to set up an HTTP server using the XAMPP control panel, and a connection is established between the sensor and the server. PHP language has been used to write the program. A database named ‘moisture database’ is created which has a table called ‘moisturedata’ to store the sensor values [5]. These values get updated each time the sensor senses moisture. Next step is to set up an MQTT publisher-broker-subscriber model. For this, software called Mosquitto has been used. The Pi is the subscriber and the PC is used as the publisher.

Once the MQTT server has been set up, the connections are made. The soil moisture sensor has three pins: VCC, GND and IN1. VCC pin is connected to the 3.3V VCC pin 1 of Raspberry Pi and GND is connected to pin 4. Sensor works with 3.3V. The output voltage of the sensor is connected to pin 18 of the Pi. Once the sensor connections are made, the next step is to interface relay with the Pi. A 5V DC relay has been used. It is connected to pin 21 of the Pi. Now the working of the sensor can be checked by dipping the sensor in some water. The relay switches ON and OFF after a time delay of 10 seconds.

Now, a 220V AC submersible motor pump is connected to the relay. Relay has three
terminals: Normally open, Common and normally closed. Connection from the motor is given to common and normally closed terminals. The motor needs to be completely submerged in water before switching it ON [4]. Program code for moisture control is written in Python. When the sensor senses moisture i.e. when there is enough water, the relay switches and the motor is OFF. When the sensor does not sense water, the motor is turned OFF [1].

To implement the crop security part, Pi camera is connected to the camera port in Pi. The program for image detection and recognition is written in Python. When the image of an animal or person is shown it detects the intruder and displays the type of intruder. A buzzer is connected to pin 38 of Pi. As soon as the intruder is detected the buzzer rings [3].

For manual as well as automatic control, an app ‘Farm controller’ has been developed in Android studio. It shows the real time soil moisture level and motor status and also displays a message if an intruder is detected [2].

Figure 8: System flow chart.
RESULTS AND CONCLUSION
The screenshots of the results obtained are given below:

![Figure 9: Screenshots of the Android app.](image)

Compared to traditional systems of irrigation, this system provides a smart solution to save water as well as protect crops from wild animals. The system thus effectively gives alert messages on the farmer’s phone making it possible for him to know the conditions of the field even when he is away. This reduces human effort and also saves water as the motor is switched ON only when the crops require water. MQTT protocol that is used is 93 times faster than HTTP protocol and acts instantaneously without any time delay. The system has been found beneficial especially in places with water scarcity. It can be implemented for potato farms where the major intruder is pig and sugarcane fields where elephants are the threat.

Buzzer rings when a person/animal is detected. The application ‘Farm controller’ clearly displays the motor status and the water level as shown in Fig. 8. The message gets updated whenever the moisture goes below or above a certain level. Also, the sound alert produced by the buzzer warns the farmer of any possible intrusion. It is cost effective and beneficial. For larger areas, highly sensitive sensors can be used to sense the moisture, temperature and humidity levels.

FUTURE SCOPE
The proposed system has been found to be low cost and effective. The system offers good results with very less delay. It is offers a feasible solution to farmer’s problems and also helps in water conservation and crop security. To reduce power consumption, solar power can be used. This system can be implemented in urban gardens, greenhouses and small farms. It is very beneficial in places where water availability is less. At a time when groundwater levels are decreasing and monsoon rains are scarce, water conservation is the key. The system offers a sustainable solution to farmers in the long run.

The future scope of this work extends to a much larger concept called ‘Precision Agriculture’. In the future, systems can decide the soil conditions, type of crop, sowing density, treatment of soil bed etc on its own. Artificial intelligence is instrumental in bringing major advancements in the field of agriculture wherein, the system responds to the crop requirements based on real-time data inputs and requirements.

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