Smart automated irrigation system with disease prediction

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Smart Automated Irrigation System with Disease Prediction

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Abstract- **Precision agriculture have gained wide popularity in recent years for its high-ranking applications such as remote environment monitoring, disease detection, insects and pests management etc. In addition, the advancement in Internet of Things (IOT) through which we can connect real world objects to obtain the information such as physical phenomenon through sensors in the field of agriculture. This paper reports on the smart automated irrigation system with disease detection. The system design includes soil moisture sensors, temperature sensors, leaf wetness sensors deployed in agriculture field, the sensed data from sensors will be compared with pre-determined threshold values of various soil and specific crops. The deployed sensors data are fed to the Arduino Uno processor which is linked to the data centre wirelessly via GSM module. The data received by the data centre is stored to perform data analysis using data mining technique such as Markov model to detect the possible disease for that condition. Finally, the analysis results and observed physical parameters are transmitted to Android smart phone and displayed on user interface. The user interface in smart phone allows remote user to control irrigation system by switching, on and off, the motor pump by the Arduino based on the commands from the Android smart phone.**

Keywords- ***Disease detection, precision agriculture, IOT, Hidden Markov model, Sensors.***

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I. INTRODUCTION

India is an agriculture oriented country with more than 60 percent of population depends directly or indirectly on agriculture. 80% of our country's GDP is contributed by agriculture. As per the recent estimation India would require more than 450 million tons of food grains to feed 1.65 billion people by the end of 2050 which will be a herculean task. Although no exact estimates on total crop loss due to insect, disease and weeds could be found and it approximately ranges from 10-30% loss on farm field [1]. In terms of monitory values, $12 billion accounts due to stress on biotic factors. As a result of diversified agro-echo system, a huge number of crops grown in India often serves as host to many different kinds of insects, pests and pathogens. In India, most of the regions are subtropical to tropical, the agro climate is more conducive for the development of insect pests. Lepidopteran, coleopteran and dipteran insect pests cause severe yield losses in many of the commercial crops grown all over India. For instance, Helicoverpa armigera infests a variety of crops like cabbage, tomato, cauliflower, brinjal, red gram, cotton etc. Insect like white flies serve as vectors for spreading viral diseases in plants. During rainy season, fungal diseases in many crops of commercial importance are a problem in India. Specifically, the Genus phytophthora is the most severe on many crops such as citrus, rubber, black pepper, cardamom, potato etc. Mildews like downy mildew affect a wide range crops (cucurbits, wheat, grapes) [1].

Pathogens	Disease
Fusarium	Fusarium wilt
Thielaviopsis	Black root rot
Magnaporthe grisea	Rice blast
Selerotinia selerotiorum	Cottony rot
Ustilago	Smut

Table. 1 Disease caused by pathogens.

Along with biotic there are some abiotic conditions like temperature, moisture, light etc., which leads to loss in agriculture. Although, India stands at second place in largest irrigated country of the world after China, only one third of the agricultural area is irrigated. Irrigation plays a major role in tropical monsoon country like India where rain is uncertain, unreliable and erratic [1]. However, care must be taken to safeguard against effects caused by over irrigation. To overcome all the above problem, IOT technology can be implemented. IOT is an emerging trend which has its application in all the fields. It can be referred to as “connected devices”. [10]

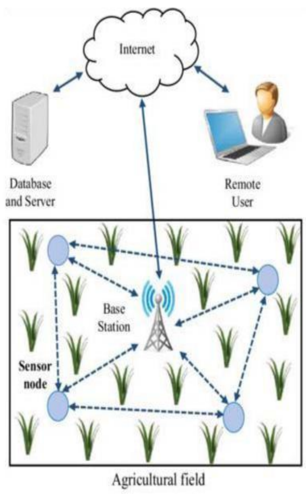

Fig 1. Architecture of Precision Agriculture

As shown in above Fig 1, The devices which are connected will possess some sensors. In 2013, the global standards initiative on Internet of things define the IOT as “The infrastructure of the information society” The IOT allows the object to be sensed or controlled remotely across the existing network infrastructure, creating opportunities for more direct integration of the physical world into computer based systems and resulting in improved efficiency, accuracy and economic benefit in addition to reduce human intervention. IOT is expected to offer advanced connectivity of devices, systems and services that goes beyond machine-to-machine communications and covers a variety of protocols, domains and applications. The organization of paper is as follows, section II deals with Methods and Materials used in our proposed work. Section III deals with Related work in field of Precision agriculture, Section IV provides the different phases associated with our proposed work, Section V provides overall proposed system architecture. Finally, paper ends with conclusion and few references.

II.MATERIALS AND METHODS

In this section, we are providing a brief review on the methods and techniques that we’re going to implement in our proposed system followed by the materials required.

A. Sensors

Sensor is an electronic component whose purpose is to detect events or changes in its environment and sends the information to other electronic devices like computer processor. A sensor’s sensitivity indicates how much the sensor’s output changes when the input quantity being measured changes. In this paper, we are using sensors that senses external parameters of agriculture. Namely, Water level sensor is used to detect the level of substances that can flow. Soil moisture sensor that measures the volumetric water content in soil. Temperature sensors measures ambient temperature.

B. Arduino Uno and GSM Module

Arduino Uno is a microcontroller board based on ATmega328. It contains everything needed to support the microcontroller, it may be connected to a computer with a USB cable or to AC-to-DC adapter or to battery to get started. It has a memory of 2KB of SRAM and 1KB of EEPROM. It has number of facilities for communicating with a computer or another Arduino or other microcontroller. GSM is a cellular network used for communication purpose. It has a key feature of detachable SIM card containing the user’s subscription information. Its network operates in number of different carrier frequency and has secured wireless system.

C. Data mining

It's the process of extracting useful information from large sets of data. There are many techniques in data mining. General applications of data mining are biological data analysis, interaction among the genes of a living being, relationship among web pages available in internet, in agricultural related fields [3]

III.RELATED WORK

A. Precision agriculture

The main objective of this work is to deploy a low costs sensor system, gather field data and display the data through a graphical user interface (GUI). Sensors such as humidity, temperature, luminosity, electrical conductivity and leaf wetness was used for data acquisition and the Raspberry Pi, acting as a local server, was used for data processing and transfer. The data sent was stored in a main server and organised using SQL.A GUI was developed to provide visualization of the data gathered. The whole system was tested and proven to work by the application of fertilizer to the soil and seeing its response in the GUI. This work presents development of WSN application as sustainable and accurate solution in monitoring different environmental parameters that would affect crop development [11]. Temperature, humidity of the surroundings, soil moisture, leaf wetness, electrical conductivity should be frequently monitor and framing decision should revolve around the acquired sensor values. These sensor nodes consist of all the circuitry of the sensors including the Arduino and X-bee. Each sensor will measure and collect data that is to be forwarded to the base station. The Raspberry Pi stored all the data and forwards to main server via internet. Main server house all data and display them in a manner that enables its users to visualize the status of the environment and soil around their crops. This system helps farmer to get greater crop yield.

B. Data mining in Precision Agriculture

In agriculture, data mining is used to predict the abnormal conditions such as drastic change in climate and diseases that are favourable with respect to observed physical phenomenon. Data mining techniques are mainly divided into classification and clustering. In classification technique, there are two types training sets and k-nearest neighbour. In training set technique, unknown samples are classified by using information given by a set of classified samples. In k-nearest neighbour technique, every time classification must be performed using training set. Clustering technique can be used to split the group of unknown samples into clusters. K specifies the number of clusters in which data must be partitioned [3]. The main goal of this technique is to group the similar data in a same cluster and to find partition of the set when unknown classification of data is given.

C. Sensor drone in agriculture

The Electronic nose(E-nose) module based on six polymers/single walled carbon nano-tube (SWCNT) gas sensors was installed and tested on quadcopter. This system was found to detect volatile compound such as ammonia and toluene. In the static gas measurement, the sensors were observed to increase response with increasing concentration of ammonia and toluene. Polyvinyl Pyrrolidone (PVP)/SWCNT-COOH shows the highest sensor response to both ammonia and toluene. The E-nose has been demonstrated under two situations, i.e., in a closed cleaned room with presence of ammonia evaporation and in open air with low wind environment. The sensor responses from all sensors under different situation are clearly distinguished. If we collect enough characteristic odour data from various places into the database, then we can identify irregular situation when new data pattern shows differs from the database

D. Disease and Pest Control in agriculture

This work introduces the concept of IOT technology to percept information, and discusses the role of IOT technology in agriculture disease and insect pest control, which includes agriculture disease and insect pest monitoring system, collecting disease and insect pest information using sensor nodes, data processing and data mining etc., [5]. A disease and insect pest control system based on IOT is proposed, which consisted of three levels and three systems. The system can provide a new way to access agricultural information for the form.

IV. SMART IRRIGATION SYSTEM

The Smart irrigation system provides a way to save water on timely management of water resources to agriculture field based on the real-time data sensed by the sensors. The hidden Markov model is used on recorded data to predict the possibility of diseases based on threshold values which are favourable for any disease growth in our proposed work. Finally, our proposed system works on two major constraints such as water supply and diseases associated in the field of agriculture. Our proposed work consists of five different phases as shown in Fig 2

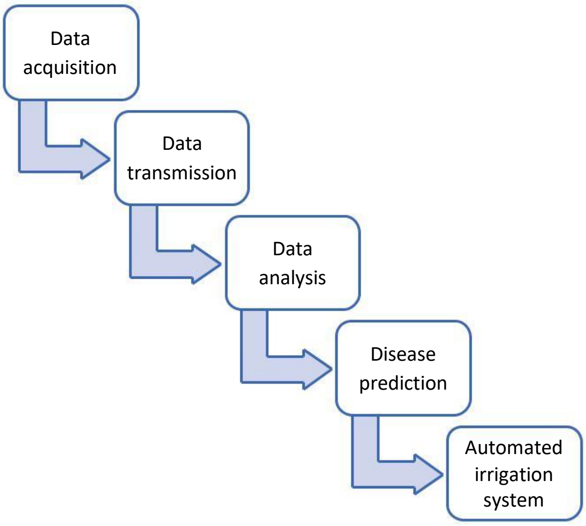

Fig 2. Phases of our proposed system.

A. Data acquisition

We use different types of sensors like temperature sensor, moisture sensor, leaf wetness sensor that takes real time weather parameters as input and provides signals to micro controller (Arduino Uno). An Arduino based irrigation system that operates automatically via signals provided by soil moisture sensors which is subject to remote control by an android smart phone.

B. Data transmission

In farm land sensors are deployed at various places to sense external data like temperature, soil moisture, relative humidity(RH), pressure. These sensors collect data at continuous intervals. Arduino Uno which are connected to sensors converts Analog signals to Digital data. Then data is transferred to data server using GSM module.

GSM module is basically a GSM modem connected to PCB with different types of board and RS232 output to interface directly with data server. This modem accepts a sim card, and operates over a subscription to a mobile operator, just like a mobile phone. The practically obtained data is compared with the predefined values present in database. The resultant data is sent to phone through SMS by GSM.

C. Data analysis

Hidden Markov Model

In this stage, we are analysing data acquisition which are collected from 'n' number of sensors from agriculture farm.

Table 2. favourable conditions for growth of diseases [4].

Disease	Temp	RH (%)	LW (hours)
Bacterial leaf spot	25-30	80-90	-
Powdery mildew	21-27	More than 48	-
Downy mildew	17-32.5	More than 48	2-3
Anthracnose	24-26	-	12
Bacterial cancer	25-30	More than 80	-
Rust	24	75	-

Hidden Markov model is a statistical Markov model in which the system being modelled is assumed with unobserved states [6-10]. Based on the data collected we are discriminating the possible disease according to their favourable aspects which can be done using hidden Markov model.

D. Disease prediction

The platform includes administrators, experts and ordinary visitors through computers, mobile phones, tablet computer etc., they can login the remote server and choose to view real time data, historical data and remote parameters setting collected by the sensors; agricultural experts can analyse the collected data, construct and expert data base. Information platform of disease, insects, pests and amount of water required monitor based on IOT would be an integrated system that integrates all these kinds of information. The core function is fast acquisition, seamless connection, reliable transmission and in-time search and track back of information.

Algorithm works as follows

1.Accepting input from humidity, leaf wetness, soil moisture and temperature sensors.

2.The data from sensor are convert into digital format using inbuilt Analog to digital converter which present in Arduino Uno.

3.Generated data is transferred to server using GSM module and stored the data in database.

4.Find Euclidean distance at each point. In our system for calculating probabilities at hiding states we need to first calculate the Euclidean distance by using equations shown below,

E.D. at hidden state $=\sqrt{(RH-\overline{RH})^2+(LW-\overline{LW})^2}$

Where,

RH= Input relative humidity,

LW= Input leaf wetness duration,

$\overline{RH}$ = Mean relative humidity at hidden state,

$\overline{LW}$ = Mean leaf wetness duration at hidden state.

At observing state the Euclidean Distance is calculated using the formula,

E.D. at Observing state$=\sqrt{(TM-\overline{TM})^2}$

5. The calculated data is compared with standard data and disease is predicted [2,10]

E. Automated irrigation

An automated irrigation system was developed to optimize water use for agricultural crops. This system has wireless network of soil moisture and temperature sensors placed in the root zone of the plants. A key input to ensure optimum yield of a crop is the regulation of water at various stages of its life cycle and protecting plants from insect, pests and disease causing pathogens. Automated irrigation requires mechanism that precisely regulates water commensurate with the specific growth stage of the crop and various parameters including soil moisture, ambient temperature, sunlight, humidity etc. The irrigation pumps in conjunction with the valve system can be used to regulate water flow and direction of flow. While the quantity of water is controlled by switching the pump motors of irrigation. In this paper, an Arduino-based irrigation system that operates automatically via signals provided by a soil moisture sensor and subject to remote control by an android smart phone is proposed.

V. SYSTEM ARCHITECTURE

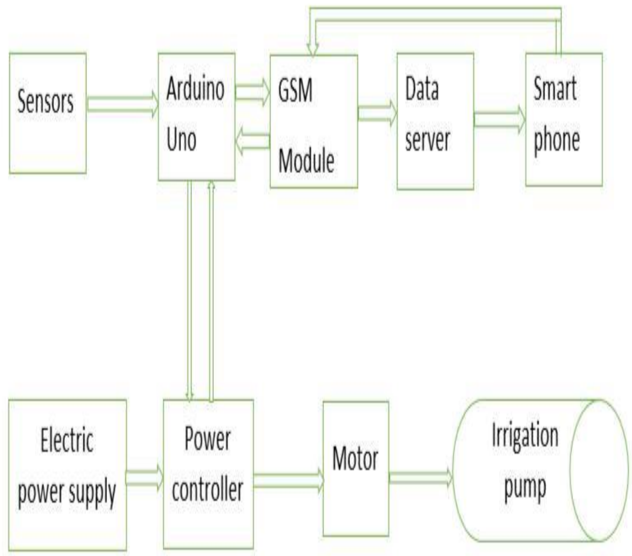

Fig 3. Smart irrigation System Architecture

Fig 3 presents the overall system architecture of our proposed work, as shown in above figure the sensors such as soil moisture sensors, temperature sensors, leaf wetness sensors deployed in agriculture field, the sensed data from sensors will be compared with pre-determined threshold values of various soil and specific crops. The deployed sensors data are fed to the Arduino Uno processor which is linked to the data centre wirelessly via GSM module. The data received by the data centre is stored to perform data analysis using data mining technique such as Markov model to detect the possible disease for that condition. Finally, the analysis results and observed physical parameters are transmitted to Android smart phone and displayed on user interface. The user interface in smart phone allows remote user to control irrigation system by switching, on and off, the motor pump by the Arduino based on the commands from the Android smart phone.

CONCLUSION

The Smart automated irrigation system provides a way to save water on timely management of water resources to agriculture field based on the real-time data served by the sensors. The hidden Markov model is used on recorded data to detect the possibility of diseases based on threshold values which are favourable for any disease growth in our proposed work. Finally, our proposed system works on two major constraints such as water supply and diseases associated in the field of agriculture. In future, we are planning to advance our work to detect insects and pest's growth favourable conditions in the field of agriculture.

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