Surveillance and Steering of Irrigation System in Cloud using Wireless Sensor Network and Wi-Fi Module

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Abstract— **Internet of Things (IoT) has become very popular in the field of communication. IoT will become a reality over the next few years, with rapid and widespread smart devices will be able to execute independently according to the change in their surroundings. The use IoT techniques to identify and channelize the irrigation methods are discussed in this work. In order to develop an automated technique to analyze the water required by the plants at a particular time, a database is created. The database contains training samples related to the soil type, moisture content, temperature, plant leaf condition and the humidity level and the amount of water flow required for subsequent set of features. Different type of soils and plants differ in water content required. The database is build using the features extracted from the images of the soil and the plants. The color of the plants and the soil images can be retrieved using Fisher's linear discriminant analysis (LDA), The Fisher's LDA approach is used to project the plant and soil RGB images into the database to retrieve the color indicating the moisture level. The RGB images are needed to be analyzed accurately to determine the water requirement. However, color processing has great advantages for its simplicity, robustness, power and efficiency. The graph cut based segmentation can be implemented to segment the regions accurately and using this technique the water content in the leaf and the soil covering the plants can be differentiated. The processing of the images should be performed by differentiating the plant and soil segments. A novel classification algorithm called transductive support vector machine (TSVM) is used for classification and quantification. Thus, the required irrigation level of the plants can be determined and the process could be carried out in an efficient manner.**

Keywords—Wireless Sensor Network, Internet of Things (IoT), automated, sensing, classification, Web of Things (WoT).

I. INTRODUCTION

The Internet of Things is often referred as Internet of 'Everything' or the Internet of Intelligent Objects. The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data. It is a technology which enables the direct communication between physical devices and computer based systems. With the continuous evolution in technology today, the communication between people is reducing while human beings are getting more connected to their devices. The importance of IoT is continuously increasing due to the growth of cloud computing, mobile technology and data analytics. It includes various technologies that cover wireless sensor networks, RFID enabled. The Internet of Things (IoT) is changing the agricultural industry and empowering farmers to battle with the gigantic difficulties they confront. The industry must overcome expanding water deficiencies, restricted accessibility of grounds, hard to oversee costs, while meeting the expanding utilization needs of a worldwide population that is required to develop by 80% by 2050. New inventive IoT applications are tending to these issues and expanding the quality, amount, sustainability and cost adequacy of agricultural production. Cloud computing alludes to both the applications conveyed as administrations over the Internet and the equipment and frameworks programming in the datacenters that give those services. It offers assets, programming and data to PCs and other IoT empowered gadgets. Using cloud storage peoples can store and access their data and resources without any constraint over storage and maintenance.

II. PROPOSED SYSTEM

The various In-field sensors that can be used in agricultural field are Soil moisture sensor which measures the volumetric water content in soil, the Humidity and Temperature (DHT11) sensor which uses a capacitive humidity sensor and a thermistor to measure the humidity of air and the atmospheric temperature respectively, Light Dependent Resistor (LDR) which is a light controlled variable resistor whose resistance decreases with increasing intensity of incident light thus measuring the light intensity near the plant, the rainfall sensor which predicts whether there is rainfall or not and the pH sensor which measures the pH of soil are connected to the ZigBee Transmitter and provides corresponding outputs to the Arduino microcontroller wirelessly through ZigBee transmitter which is connected to the sensors and placed near the plant and ZigBee receiver which is connected to the Arduino which is at the base station. Arduino sends the sensor data to the IoT web server by using the Esp8266 Wi-Fi transceiver module. In

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the IoT cloud server we can analyze the sensor data in the form of graphs and access these values anywhere and anytime using internet connections.

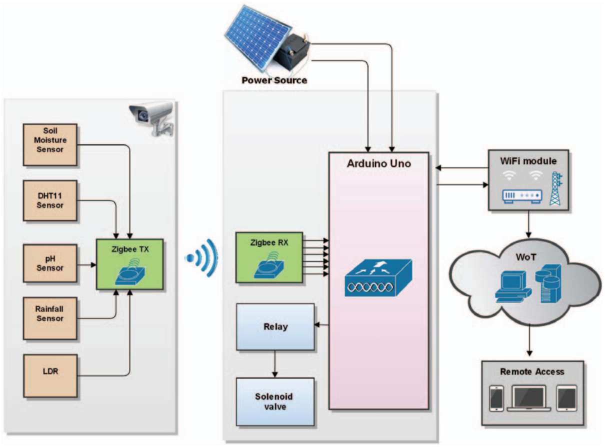

Fig. 1. Configuration of an Irrigation system

. The color of the plants and the soil images can be retrieved using Fisher's linear discriminant analysis (LDA), The TSVM module is used to detect the condition of the plants and soil from the images of them. TSVM consists of two phases: training and testing. The images to be classified are given as input. The TSVM first trains the sample images to extract the required features from the images and uses it to build a training set. Then the real-time images are taken and classified as per the TSVM module. Then the classified images are compared with the training set to discover the water and moisture content of the plants in the given images. Based on these results, the water supply can be maintained. At the same time, according to the sensor data Arduino switches ON/OFF the solenoid valve which provides water supply to the plants through relay. Solar panels are implemented to power up the sensors and microcontrollers.

III. MATERIALS AND METHODS

A. Wireless Sensor Unit (WSU)

A Wireless Sensor Unit (WSU) is composed of a various in-field sensors, ZigBee transceiver, and a power sources (Figure.2). The WSUs can be deployed In-field to configure a distributed wireless sensor network for the crop watering system. Each element is primarily based on the Arduino UNO microcontroller that controls the RF module (ZigBee) and processes soil wetness, temperature, humidity, heat index, light intensity and rainfall which senses the amount of water present in soil, condition of plants and soil that provides signal to the ZigBee Transmitter consequently.

TABLE I. COMPONENTS FOR WSU

Description	Part number
Microcontroller	Arduino UNO
Transceiver	ZigBee Pro
Soil moisture Sensor	VH400
Humidity & Temperature sensor	DTH11 module
Rain sensor	Bosch RSM3ALS
Light Intensity sensor	LDR
Solar panel	1 Amp
Batteries (1)	5V
Miscellaneous (Connectors, Relay, etc.)	

These signals are transmitted to ZigBee receiver wirelessly. These components (Table 1) are powered by 12V batteries with solar panel for charging battery so that there no worry about replace battery every time. These low cost components were designed to minimize the power consumption for the projected application.

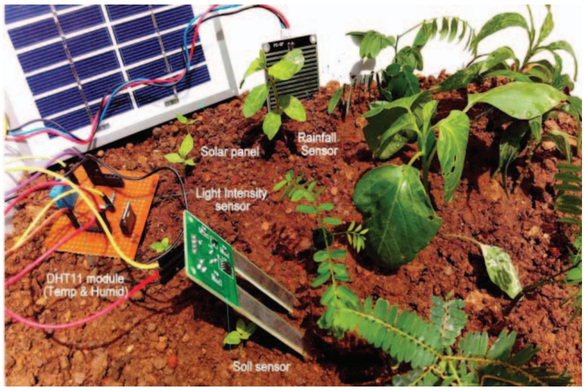

Fig. 2. Various In-field sensors in a greenhouse test setup

B. Wireless Information Unit (WIU)

The data packet coming from wireless sensor unit is discovered, analyzed, monitored and controlled within the Wireless Information Unit. WIU consists of an Arduino UNO microcontroller, a ZigBee RF module development kit, a Wi-Fi module, two electronic relays, Solenoid valve, 100Ah rechargeable battery which may be recharged with a lightweight solar recharging kit. A solenoid valve is an electromechanical actuated valve to regulate the flow of gases and liquids. ZigBee receiver receives data from ZigBee transmitter and inputs it to Arduino microcontroller. According to the data received, Arduino microcontroller switches ON/OFF the valve through Relays. The WIU can be located at the unobstructed vision from the WSUs placed in the greenhouse field and sensitive electrical components were protected from the moisture by a plastic coating spray.

TABLE II. COMPONENTS FOR WIU

Description	Part number
Microcontroller	Arduino UNO
Receiver	ZigBee S2 Pro
Wi-Fi module	ESP8266
Batteries (1)	12V
Camera	1
Miscellaneous (Connectors, Relay, etc.)	

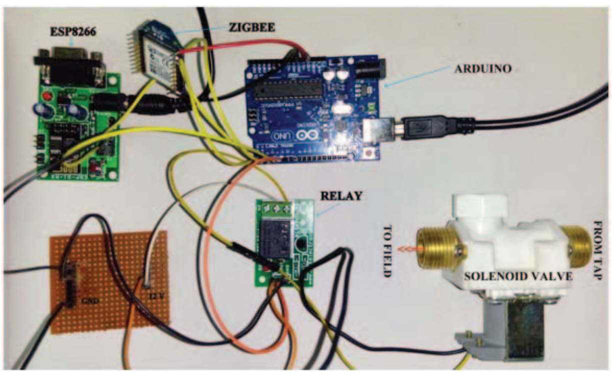

Fig. 3. Experimental setup (WIU)

C. *Transductive support vector machines (TSVM)*

Transductive support vector machines (TSVM) has been extensively used as a means of treating partially labeled data in semi supervised learning. The image datasets retrieved from the remote sensing satellites or databases are different from the lively photographed images using high quality cameras. In the preprocessing stage, considering the diversity of images, two approaches are utilized. The Fisher's LDA approach is used to analyze the remote sensing images and project the features to provide efficient segmentation using methods like graph cut methods. But when using the high quality camera images of the plants and soil, the Fisher's LDA method increases the complexity. The use of high quality color images has great advantages for its simplicity, robustness, power and efficiency in accurate prediction of the water level. For segmenting the high quality color images, TSVM is utilized.

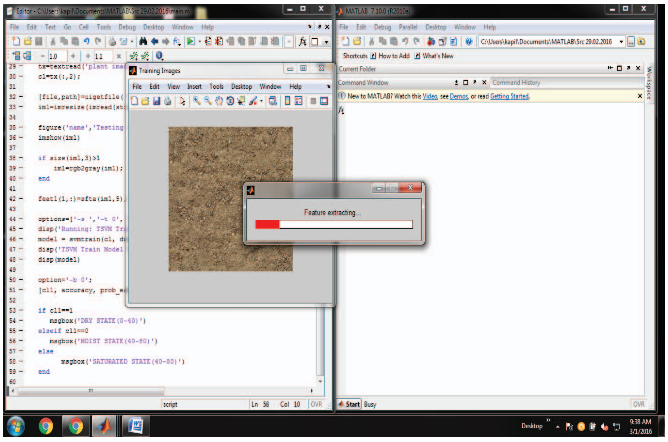

Fig. 4. Feature Extraction of RGB Images

When the images are fed into the TSVM module, the classifiers are generated and the features of the samples are segmented. The classifying features are color, moisture and texture of the plants in the images. Using these features, the images are segmented. From the segmented images, the water level can be predicted and used along within a sensor module to decide the water flow.

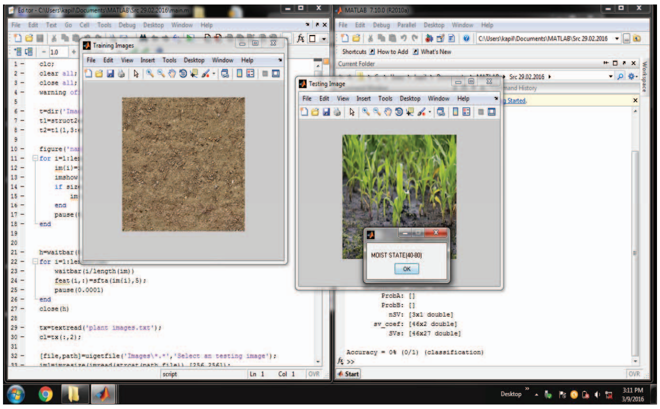

Fig. 5. Classification result (Moist State)

In TSVM, the samples with an expected accurate labeling are selected. The most informative samples are only utilized to segment the features. In the input phase, the labeled and unlabeled points of the color image samples are taken as input and initialized in a working set. The label vector is calculated for the unlabeled set of samples. The positive and negative samples are determined by the information that can be obtained from the samples. If the features and information's obtained from a sample are useful in analyzing the water content then they are called as positive samples. If the information's are not much useful, then the samples are called negative samples. Then the samples are updated and trained. The training set has to be performed with more number of positive samples than the negative samples. This improves the accuracy of segmentation.

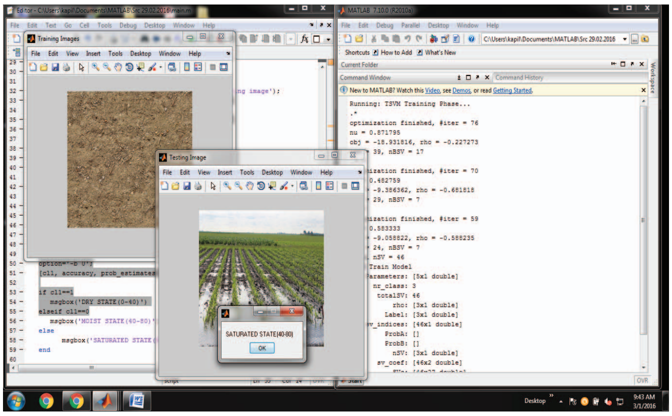

Fig. 6. Classification Result (Saturated State)

D. *Watering Module*

A solenoid valve is an electromechanical actuated valve to control the flow of liquids and gases. According to switching ON/OFF of relays, the pump will water the plants. The harvest watering is performed by controlling the pump through 12V electromagnetic relays associated with the Arduino UNO microcontroller. The various crop watering actions are implemented in the WIU algorithm:

Fig. 7. Solenoid Valve

1) Automated watering system with a fixed duration, when the contents of the soil moisture exceed the set value set by the potentiometer, the analog output (AOUT) goes high i.e. 5V.
2) Automated watering system with a fixed duration, when the contents of the soil moisture less as compared to the set value set by the potentiometer, the analog output (AOUT) goes low i.e. 0V.

E. Wi-Fi module

Wi-Fi modem is a great way to connect Arduino or other microcontrollers to a wireless technology that allows an electronic device which communicate over various network interfaces. It includes an embedded TCP/UDP/IP protocol stack to bringing up the node for network connectivity. The Wi-Fi module is capable of transfer 115200*40 (4.5Mbps) of data and directly interfaced to a UART or a microcontroller. Wi-Fi module has the ability to run independent of a host controller. This small board allows Arduino microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using AT commands. The main aim is to achieve the lowest power consumption (5V-12V) with a combination of several proprietary techniques. Time of switching ON/OFF data is sent to the predefined web server (ThingSpeak) through Wi-Fi modem.

IV. WEB APPLICATION

IoT Cloud Server (ThingSpeak) was introduced for real-time monitoring and programming of irrigation based on soil type, moisture content, temperature, plant condition, humidity level and the amount of water flow required for subsequent set of features. The data received using Wi-Fi module is displayed using GUI. The primary goal of the client software is to displaying the data of the remote monitoring and control, sending control commands according the appropriate algorithms for displaying the system operation.

The database contains training samples related to the soil type and plant condition. The RGB images are needed to be analyzed accurately to determine the water requirement. The web application approves the users to graphically see the information from Wireless Sensor Unit and Wireless Information Unit remotely observed, recorded and examined using IoT gadgets (ThingView) associated with Internet.

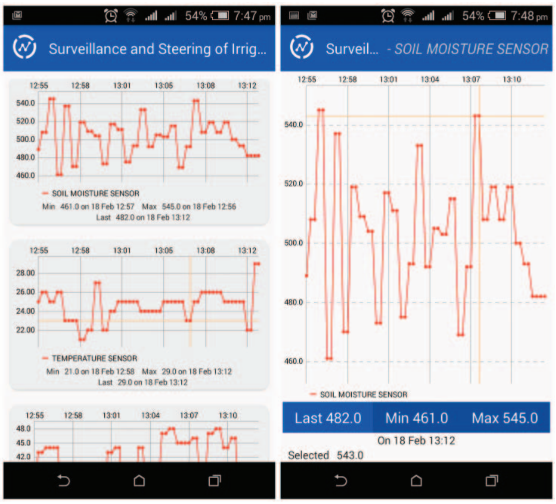

Fig. 8. Collected data's of the WSUs, in the Smart Phone (ThingView)

The savvy application additionally empowered the user direct programming of scheduled irrigation schemes and conforming the trigger values in the WIU as indicated by the harvest species and season management. As indicated by the information got by the application, it has a capacity of switches ON/OFF the valve. All these data are stored in a database.

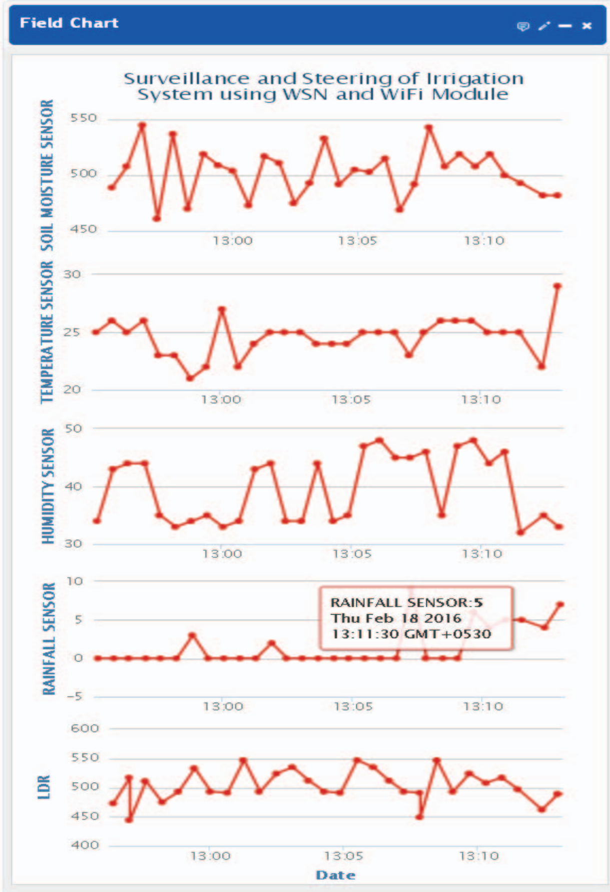

Fig. 9. Collected data's of the WSUs, in the IoT Cloud server (ThingSpeak): soil moisture, temperature, light intensity, humidity and rainfall sensor

V. CONCLUSION

Automatic systems in the field of agriculture with the help of Internet of Things (IoT) and Web of Things (WoT) are an innovative research topic. In this research work, the automatic system is introduced to control the amount of water flow in the water supply systems. The automatic crop watering system is designed in such a way that the cost for installation and maintenance is very much reduced than the existing water flow management systems. In the existing systems, the automatic irrigation system with distributed wireless sensor networks is used to optimize the water flow. As the existing system consumes more power and the maintenance cost is also high. Hence in the proposed system, the automated technique to analyze the water required by the plants at a particular time, a database is created. The database contains training samples related to the soil type, moisture content, temperature, plant leaf condition and the humidity level and the amount of water flow required for subsequent set of features. The database is build using the features extracted from the images of the soil and the plants. A novel classification algorithm called transductive support vector machine (TSVM) is used for classification and quantification. The images are stored in the distant storage centers. Initially, the sample images are trained in TSVM and the features are extracted. When the original plant images are inputted into TSVM the images are clustered and compared with the training samples. From the comparison, the appropriate features are identified and the moisture level is determined. Based on the current water level, the triggers are initiated to control the water supply valve. Thus the required irrigation level of the plants can be determined and the water supply can be automatically adjusted with less cost of operation.

VI. FUTURE WORK

As per the facts, different plants grow on different types of soil which means the requirements are different. In drought areas, the plants with the high resistance are grown which can survive even in less water supply. Similarly, the vegetation in wetlands is not possible in drought areas. Our project aims to eradicate these hindrances and support efficient water management. But still the automatic water supply control can be enhanced. The proposed method can be enhanced to support different types of crops with different nutrient content of soils. The proposed system can be improved to support the nature of soils. As our method, only considers the moisture level in the soil at that particular instant, the water requirement for each plant may not be even. Hence adaptive water supply is required for maintaining the constant growth of the plants. Finally, wishing to embed into Raspberry Pi 3 which requires very low power consumption. Raspberry Pi 3 can be the future for smart applications and client-server communications.

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