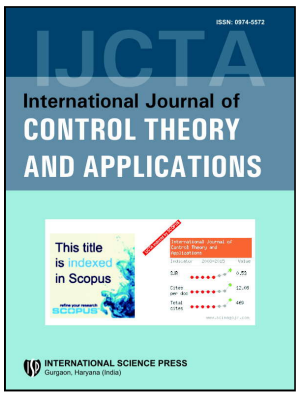

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Automatic Crop Height and Health Monitoring System with Soil Nursing using IoT

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Abstract: Precision agriculture intended for enhancement of health and growth of the crops can be done if there is an automatic system available for computation of each and every aspect which is responsible for the development of crops. This research is based on a system which can measure plant's growth and its health. It consists of the ability to tell whether the soil condition of land is suitable for the proper development of crop. To obtain features like soil conditions and plant growth more quickly and in low expenses has always been one of the biggest limitations of precision agriculture. According to the research, this system will collect most of the information about the various aspects of the soil comprising of the amount of moisture content, amount of soil nutrients like nitrogen, phosphorus, iron, manganese, pH level and temperature of the soil which is essential for the proper growth and decision-making processes. The system also has the capability to determine the height of the crops with the help of digital image processing. All the data containing the information about soil condition and plant growth is uploaded to a cloud server via the internet using IoT technology. Moreover, a water supply motor is attached which will water the crops automatically as soon as the soil water content starts to decrease. The basic objective is to increase the crop production and to improve the quality of the soil by taking proper steps to meet the demands of the ever growing population. This research results in a precise and profitable agriculture technique with no human intervention.

Keywords: IoT, Digital Image Processing, Soil conditions, Crop's height, Water supply.

1. INTRODUCTION

Till date, technology has not entered in agriculture area up to the required extent. The farming tools and machines are not good enough to produce healthy, fertile and rich crops. The demand for good quality food is increasing as people are becoming smarter and health conscious with time. The use of the fertilizers and steroid boosts to increase the speed of growth of the crop has been increased considerably. This results into crops that are harmful and poisonous for the health of people, spreading lots of diseases and infections which is clearly explained by Md. Wasim Aktar in his research paper [1]. That's why people prefer quality food which is possible to achieve through precise agriculture techniques. Introducing technology in agriculture area is truly a worthy idea for profitable and quality farming. Therefore, the automatic tools that are used to improve crop production and quality are being adopted at a growing rate recently. The automatic monitoring system is thus an effective and

reliable approach to improve crop production and farming proficiency. Various types of sensors can be used to get all the information about the soil conditions where crop is to be grown.

In this research, four different sensors are used to measure the amount of moisture content, amount of soil nutrients, pH level and temperature of the soil. Along with that height of the crop is measured by consuming an effective method called Digital Image Processing and all the data is sent to a field server from where all the information will get uploaded to the cloud server using IoT technology. Many of the researchers have used the field servers for various applications. For instance, Fukatsu [2] designed a field server along with a web server to observe some environmental parameters with the help of the internet. Several other studies [3, 4] have tried to connect field servers with a sensor network system that works wirelessly and comprises of different cameras, atmospheric sensors and a wireless network system to deliver information which can be retrieved in applications that are internet based with the help of a wireless communication system. We can also use some other techniques

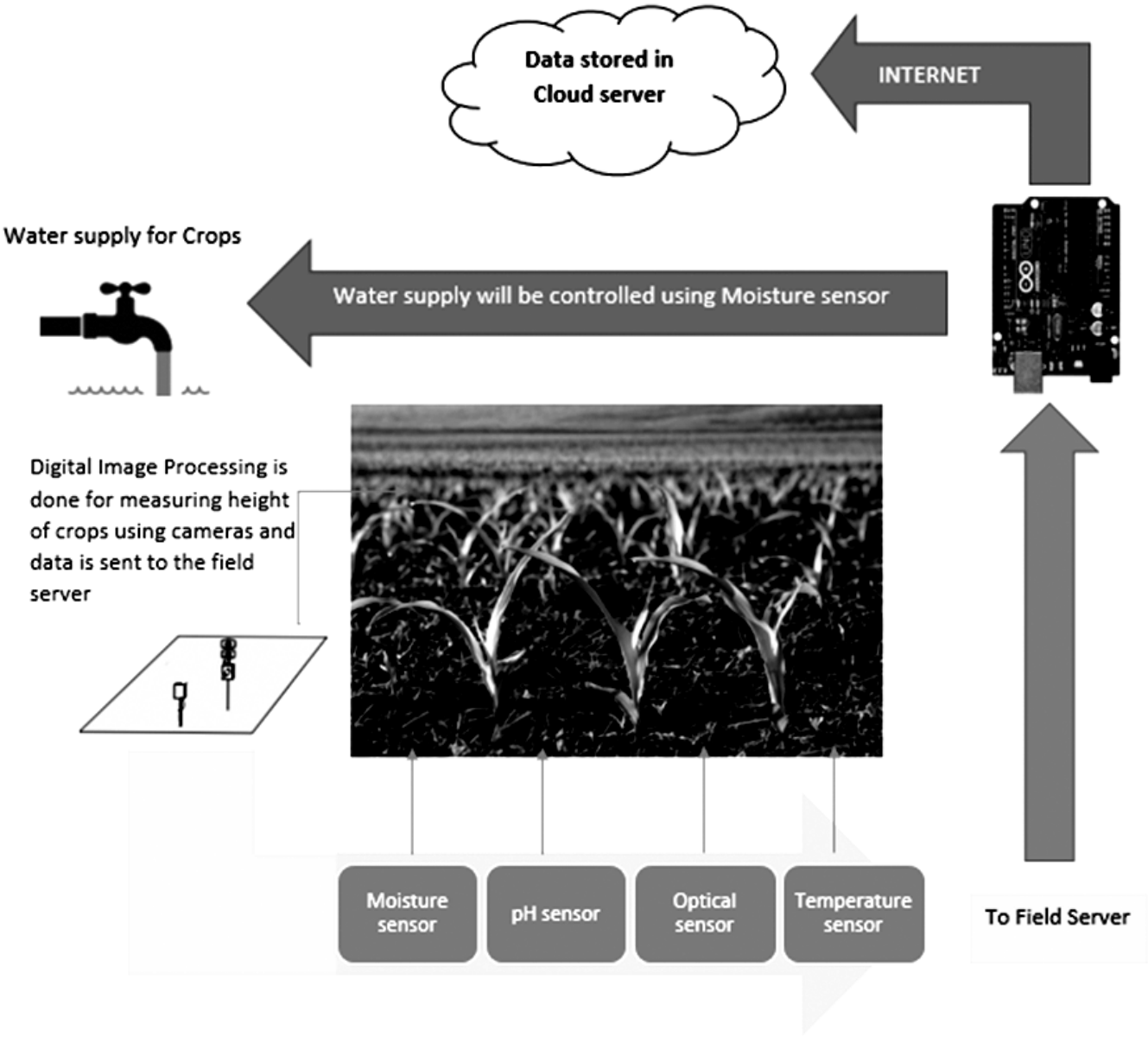

Figure 1: Block diagram of Automatic Monitoring System

like GSM modems and RF modules for data transferring as used in several studies like [5]. Here we have considered wireless public area network or LAN as the most suitable method for our research. This method of data transferring is used in some studies which have been clearly demonstrated in [6,7]. As internet is the main part of lives of the people, it will be a privilege if all the monitored information gets uploaded to a cloud, by which they can access their data sitting anywhere by using the internet.*fig*.1. shows the automatic monitoring system.

2. EXPERIMENTAL RESULTS AND DISCUSSION

2.1. Different types of sensors used to measure various aspects of soil influencing plant growth.

2.1.1. Moisture Sensor for soil

Water is obligatory for the basic growth and maintenance of crops. When a satisfactory amount of water is not provided to crops for their necessities, then problems can occur and in the end can lead to reduced quality or death of the plants. To prevent this from happening, the automatic system should consist of soil moisture sensor to take care of the soil water content from time to time. To measure the moisture content of the soil, a sensor named SEN-13322 is used [8]. The moisture sensor for soil is pretty direct and easy to use. The two exposed plugs or legs will work as the probes for the sensor. These probes will collectively act as a variable resistance. When the amount of water in soil is high, better conductivity between the legs of the sensor will be observed and will cause a lesser resistance, and a higher signal output.This data will be then delivered to our field server controlled by a microcontroller. In our research Arduino development board based on an 8-bit microcontroller working very efficiently and without any type of error, is taken in use.

2.1.1.1. Providing water supply with the help of moisture sensor readings

When the moisture content of the soil starts to deplete and falls below a particular defined value or in other words when soil starts becoming dry, signals will be given to the Arduino and the output will drive the motor. With the help of this, water is supplied to the crops. The supply stops as soon as the moisture content in soil reaches the defined value,which is detected with the help of moisture sensor. This is an automatic way of supplying water to the crops without human interference.Studies like [9] have also emphasized on the need of water for the crops and have designed a ZigBee and PSO based system that is used to control the level of water in paddy fields. Research can be extended further like we can fix a wireless system that tells about the quality of the water before supplying as demonstrated in [10].

2.1.2. pH Sensor for soil

pH tells us about the acid/alkaline nature of the soil. pH scale ranges from 0 to 14 representing very acidic and very alkaline respectively. pH is a basic parameter contributing towards crop productivity therefore, it should be properly handled in order to make proper precision agriculture related decisions. Michael Schirrmann *et al.* [11, 12, 13] built a sensor named Veris pH Manager™ for recording the values of soil pH at the field area. This pH determining sensor is commercially obtainable in the US and many other regions also. To measure pH level of the soil, a dual probe pH sensor is used and an analog- to- digital data converter (ADC) is used to provide a user understandable digital output data using Arduino. Readings are to be taken and sent to a microcontroller based Arduino (Field server) where received data is to be compared with the standard pH data associated with the soil. From our field sever all the data will get uploaded to a cloud server and user can access the data using Internet.

2.1.3. Optical Sensor for chemical constituents of soil

Plant nutrients are very important for the growth. Nutrients like nitrogen, potassium, calcium, magnesium, sulfur and phosphorus are very essential. Plants also require trace elements like iron, zinc, copper, manganese,

molybdenum and boron. Measuring these constituents of the soil is the most difficult task under soil monitoring. This can be achieved with the help of an optical sensor [14]. This optical sensor has three light emitting diodes. It also consists an input/output circuit using a PIC device. Now according to the absorption band of the chemical reagents, light emitting diodes are chosen whose wavelength matches these absorption bands. Also the color of these reagents develops on reacting with the soil nutrients. This sensor is used to detect nutrients like nitrogen, phosphorus and it also has the ability to detect trace elements like iron and manganese. All the data is then delivered to the field server from where it will be uploaded to the cloud server from time to time.

2.1.4. Temperature Sensor for soil

Soil temperature is one of the important factors that influence the properties of soil under plant growth. It governs soil chemical and biological processes (Bucchan, 2001) [15]. So it is very necessary to measure the temperature of soil for the proper growth of crops. RT-1 sensor for determining the temperature of soil is easy to handle. It is a rugged soil sensor that provides continuous, consistent accuracy measuring temperature of the soil. Like other sensors, it will read the temperature of the soil and send the data to the Arduino from where further process of uploading to the cloud server is to be done.

2.2. Measuring the health of the crops with the help of reflected near-infrared energy

Why are plants green? Can we use the color of the plants as a measure of their health? The answers to the questions like why are plants green and not violet? The answer may be evolution. But the reason for their green color can be used as a method to determine their health which could be further used for advancement in agriculture. When the sunlight falls on the plants, the red and blue wavelengths are absorbed by the pigments in the leaves whereas the green wavelength is reflected back giving green color to the plants (refer to *fig.2)*. Thus this research involves analyzing the reflected near-infrared energy which lies between the visible and the microwave regions by using infrared sensors. The plant having more chlorophyll will reflect more near-infrared energy depicting the health of the plant. The unhealthy plant will reflect lesser near-infrared energy. Thus measuring the chlorophyll content through the sensor which will measure the intensity of reflected near-infrared energy, we can determine the health of the plant. The position of the sensor will be such that it is in direct contact with the reflected energy. Therefore, leaf color can be used as a guide for determining the plant health. Data received by the sensor will be sent to the local field server and further uploaded to the cloud server using IoT.

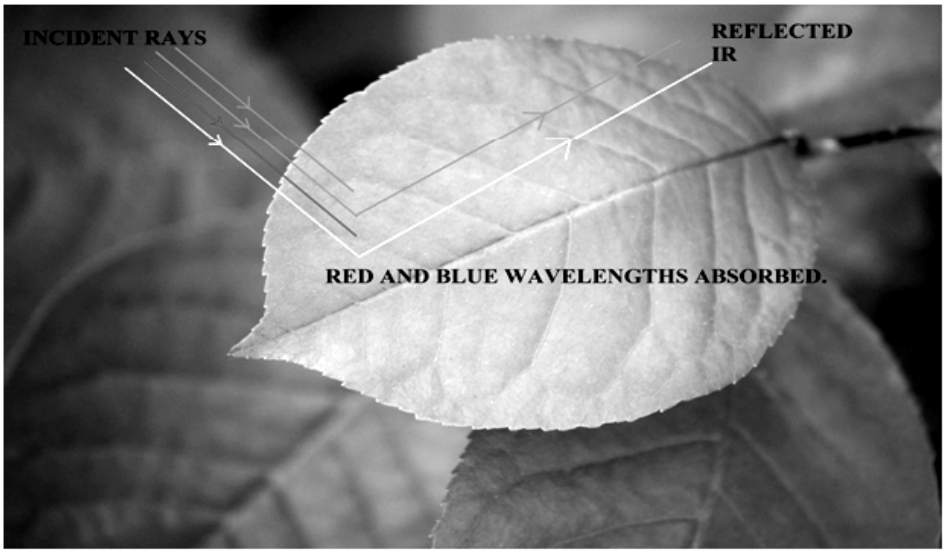

Figure 2:

2.3. Digital Image processing for measuring height of crops

This method is used for determining the height of crops with the help of two digital cameras. This technique consists of a field server, a marker pole in the camera's field of view. To calculate the height, this method practices image processing using MATLAB. This method involves steps like band selection, filtering and thresholding. These steps are the major part for image processing to be carried out effectively. A flowchart of this method is shown in *fig.3.* The photos are taken by the camera and saved in the field server memory. This is a task carried out daily for more accurate result. Further, the saved photos are uploaded to the cloud using IoT technology. A red and white colored marker pole is installed within the view of the camera and is used as the reference for measuring the height of the crops. Here height can be manually calculated by simply measuring the height of the marker pole but image processing is used for accurate results. The marker pole should be chosen in such a way that it depicts a uniformly high or in other words it should have a homogeneous area because an object exhibiting homogeneous properties can be easily differentiated from the other objects in its vicinity. Red band of the photograph is used as the primary feature in this method as both the red and the white colors of the pole will have high intensity values in the red band. Similarly, band selection is carried out for the selection of appropriate marker pole and to distinguish it from the crops. After band selection, filtering is carried out where features like edges, textures etc. are extracted with the help of spatial filters. Laplacian filters are used to extract or to find edge features. The Laplacian shows the portion of high and low-intensity changes. After filtering process, we will get a modified image in which marker pole stands out from the other objects. Further, the process is followed by Thresholding the image.

The main objective of thresholding is to simplify or convert the image into something that is more significant and easily examinable. It will change the greyscale image into a binary image. The received binary image with

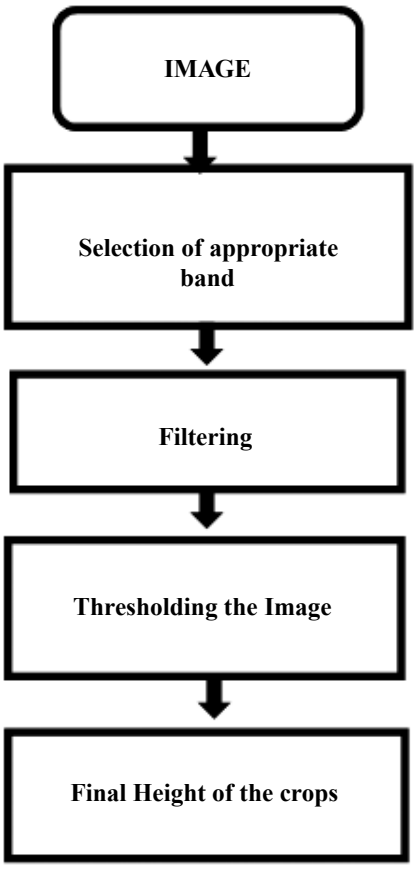

Figure 3: Flow chart for Image Processing

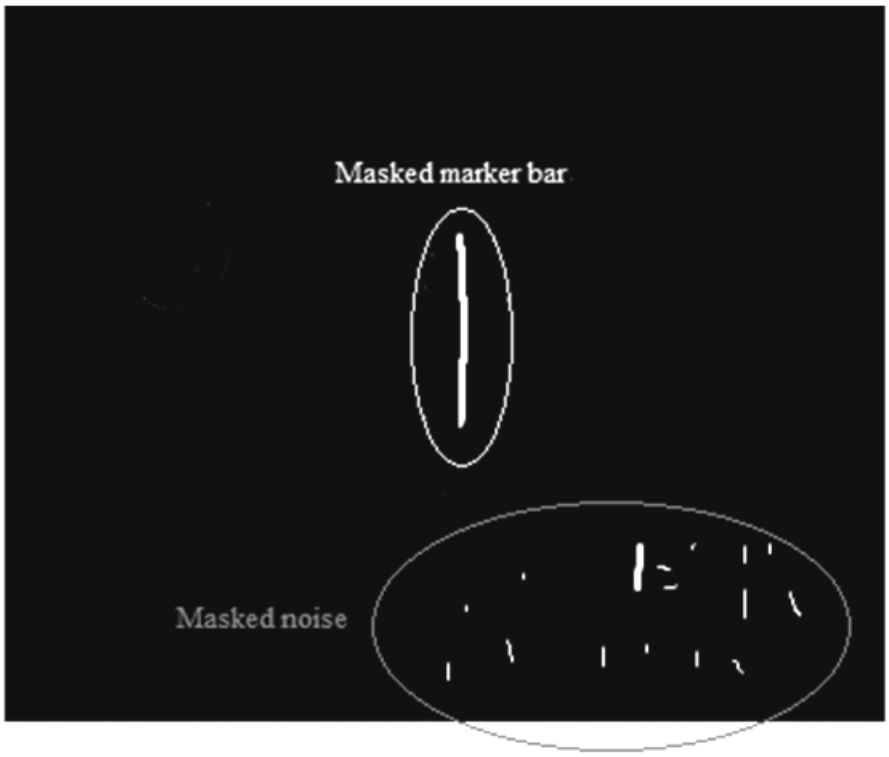

Figure 4: Received Binary Image

masked marker pole and noise is shown in *fig.4*.Further, comparison of this binary image is done with the original RGB image and the height of the crops is determined. After measuring the height of the entire field, we look for areas where height of crops is comparatively less and then aim at improving the soil conditions at that particular area. Thus height can be used as one of the measures for crop's health.

3. CONCLUSION

Precision agriculture for the betterment of the crops can be done with the help of an automatic system to meet the demands of the increasing population of the world. These days farmers use pesticides to curb the presence of insects and it is somehow affecting the crops. Precision agriculture can help in managing the health and quality of the crops these days in an environment friendly way. Factors like soil moisture content, pH level, chlorophyll content, plant height are very important for the growth and health of the crops and these factors are determined with the help of an automatic system. To achieve these various factors, sensors are used as mentioned. The amount of chlorophyll present acts as an indicator for determining the health of the plant. Infra-red energy reflected by the crops are sensed and examined for the same. This method of analyzing health condition of the crop will be beneficial considering the farming methods contributing towards the modern agriculture system. Image processing using MATLAB is used to find the height of the crops and this method has turned out to be the effective way of measuring crop height. These precise and eco- friendly techniques require no human interference and are done to satisfy human needs for food. These techniques are also aimed at enhancing the quality of farmer's life and health of society

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