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IOT ENABLED FARMING ASSIST AND SECURITY USING MACHINE LEARNING

Nithin V., Shivam Mishra, P. Devarubiny and S. Muthulakshmi
School of Electronics Engineering, Vellore Institute of Technology, Chennai, India
E-Mail: muthulakshmi.s@vit.ac.in

ABSTRACT

Farming has now become a job that is of less interest, farm lands are being filled up and the new generation do not want to take up that job because of reasons such as higher risk, low returns etc. Due to this reasons we need to find an alternative to human work done in farms. This can be done by automation which can reduce human intervention and also providing security to the farmland which reduces the damages created by the animals or other conditions that may affect the proper growth of the crop. This paper concentrates to improve the security of the farmland as well as provides assistive technology that can guide the farmer to get the best result out from their fields.

Keywords: raspberry Pi, sensors, image processing, thingspeak, machine learning.

1. INTRODUCTION

Security is one of the most important aspects in any field along with technologies that can reduce the burden on people. In farming field there is always a worry about whether the crop will grow properly, will wild animals rampage on the field, or even worry due to weather conditions that can damage the crops. Hence the risks in couple with the low return rate make people not to take interest in this field of work.

In the field of automation the main focus has been on remote controlled functions such as weeding spraying and moisture sensing but to minimal to nil focus on security for animal intervention and other alerts [1]. The focus on real time values to analyse the field conditions is also in mainstream which includes data transfer through IoT and wireless devices where the data is being uploaded to online cloud for storage and very little is done in the field of processing the data that is stored in the cloud [2] [3]. The wireless data transfer is being done in different technologies like WiFi, Zigbee and a GPS based system attempts have also been made with the LAURA board to transfer the data into the cloud [1] [2] [4]. The research on crop prediction analysis based on the data collected from field is also minimal. Crop disease detection and security using image processing are not much researched into as most of the security just includes sounding an alarm to scare away smaller animals.

In this paper we have proposed a suitable security system that protects the field from intruders and wild animals due to which large amount of damage to the crops are seen in India by providing alert to concerned authorities whenever a wild animal like an elephant comes to the field so they can reduce the damage done. The paper also discuss about an assisting technology that can reduce the risk of crop damage by providing the details of the moisture contents and nutrients in the soil so that the farmer can know which crop is suitable to be cultivated and when is it necessary to add more fertilizers or water through online cloud application of “Thingspeak”, hence providing higher probability of good crops [2]. This proposed model is also suitable for installing in backyard gardens as it will provide safety from dogs as well as children playing nearby and notifying the owner when to add more fertilizer or water.

This paper is organised as follows. Chapter II discusses the overview of the system, hardware description and software description. Chapter III discusses the working principle of the system, data analysis, image processing for farm security and the results discussion. Chapter IV concludes the paper with findings.

2. SYSTEM OVERVIEW

The Model Consists of Raspberry pi(Rpi) working as main processor which integrates various sensors and drivers, interconnect them, control them and send data to cloud as shown in Figure-1. The sensors are mainly categorized for two purposes; one is for security and other for crop assisting. These sensors are connected to raspberry pi, some through Arduino as it can take in analog data from sensors which are not possible by raspberry pi and send the data to raspberry pi through serial communication [3]. The raspberry pi process the data given to it by the sensors and give the output to the driver modules and also send the data to cloud from where it can be downloaded to remote pc and processed for data analysis [2].

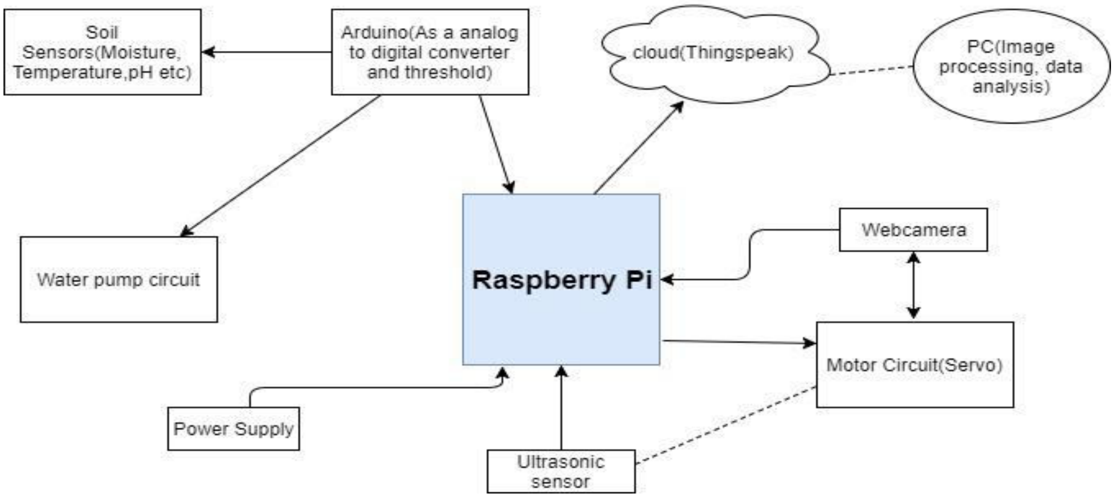

Figure-1. Architecture of the System.

A. Hardware descriptions

a) Raspberry Pi: This is the main processor computer used. It is a single board computer with wireless LAN and Bluetooth connectivity. It is used to connect various sensors together and process the data and control the drivers based on received data [2]. The model used in this paper is *raspberry pi 3 model B.*

b) Arduino Uno: This is one of the development board used. It uses AVR microcontroller and is a single board microcontroller DIY kit. It is used in model to get analog data from sensors and transmit the serially to Rpi. The model used is *Arduino Uno Rev3.*

Security Sensors:

c) Ultrasonic sensor: The ultra-sonic sensor operates on the principle of sound waves and their reflection property. It measures the distance between an object in its path and itself. This is used detect any object which is coming near to it, that is if it detect an object within 1m. Here, Ultrasonic Distance Sensor Module - *HC-SR04* is used.

d) Servo motor: It is a type of rotatory actuator that allows precise control of angular position, velocity or acceleration. It turns the camera attached to it in the direction of ultrasonic which detects the object [2]. The model used is *SG90 9g Mini Servo.*

e) Web camera: This is a type of video camera input that is connected through USB. It is used to take the picture of the object that made the camera to turn and do image processing on that photo so that it can detect what the object is and send alert to user. It also stores the picture to the database for future review [2]. The model used is *Quantum QHM495LM Webcam.*

Assisting sensors:

f) Soil Moisture sensor: *Generic Soil Moisture Sensor - MSMSM* is used in this work to measure the water content in the soil by using properties of soil such as electrical resistance, dielectric constant etc. In this model a electrode pair is placed in the soil which measures the water content based on the amount of electrons passed between them [3].

g) Waterpump: It is a simple motor, *UGpump0046 that* can suck the water from a container out to the required place with help of a tube. Here if the moisture content in soil is less than the required level then the pi gives signal to water pump to provide water to soil.

h) Temperature and humidity sensor: It measures the temperature and humidity value in the air near the plant which is sent to Rpi which sent data to thingspeak. The model used is DHT11 Module Temperature and Humidity Sensor Module.

B. Software descriptions

a) Python: It is a high-level programming language for general purpose programming. It is used to write most of the codes in the model and all the sensors and other modules are connected to raspberry pi with the help of this coding language. It is also used in the model to download data from the cloud and process it using the processing code written in it so that it can provide information about the current statistics of the soil to user.

b) Thingspeak: This is an open IoT platform with MATLAB analytics used to store and retrieve data over the internet. In the model we use this to store the data from the sensors in separate fields and then download it into MATLAB.

c) Spyder IDE: This is an IDE environment which uses python language and has a set of libraries useful for data analysis and processing. This is used in the model for analysing the data from the field. For that purpose some important libraries used are:

- **pandas:** pandas is open source data analysis tool for in python.
- **sk learn:** it is a simple and powerful tool for data analysis and data mining in python [9].
- **keras:** it's a deep learning library that allows easy and fast prototyping [10].

WORKING PRINCIPLE

The systems is grouped into two groups one group include security purpose sensors and modules and the other one includes assisting sensors and related modules.

Security modules

The security purpose sensor includes an ultrasonic sensor which is placed in different sides of the field, which when it detects something or someone coming from their respective side sends a signal to raspberry pi, which in turn gives a signal to the motor which is attached to the camera to turn in the direction it received its signal from as well as activate the camera so that once the camera is pointing in the direction of received signal it can take the photo of the object and do some image processing to detect the animal or person present and sent the appropriate alert. In our model we have included an alert if elephant is detected. The alert is send through the email to the account registered in the code so that the user can reduce the damage by doing required actions. The system also saves the image for review by the user when needed.

Assisting modules

The assisting sensors include a moisture sensor which detects the moisture content of soil with help of electrodes. If it is below a certain threshold that we can set the water pump is turn on until it met the needed threshold. Similarly it contains other sensors like temperature, humidity and pH sensors whose data is taken and sent to thingspeak account from where it is downloaded to a PC, Anaconda IDE software in which we can do data analysis using neural networks to give the users.

Smart farming -data and its analysis

The most important part for the smart farming is data that we collect from the field. It includes soil moisture, humidity, and other minerals content, temperature etc [11]. We can use that data for various kinds of analysis and modelling which can help us in extracting important information such as crop prediction, soil quality, the amount of fertilizers to be given to the soil, how much we could water the fields. Such analysis is very useful in maximizing the production and indirectly maximizing the profit.

The data analysis part is divided into stages such as:

Data collection

Collecting data is the most crucial part. Sensors like soil moisture sensor, temperature sensor etc are installed in the field. For our research we have created a small model for that and collecting in small scale.

Figure-2. Set up of the proposed Model.

Data is collected from some special sensors through raspberry pi. All the sensors are directly connected to raspberry pi. Now one important thing here is how the data is collected? Now just based on an instance of data we cannot predict or analyse anything. So for prediction to be accurate and analysis to be efficient we have to collect the several days of data. This is done by raspberry pi. For our research purpose we have collected 5 days of data from our model shown above. The other important thing here is where the data is collected. Since we want the data to be available to all we are directly storing all the data to thingspeak cloud platform in a public channel.

The advantage of doing so is data will be publicly available and anyone can use it for further analysis. Moreover being stored in the cloud we can access it from any corner of the world and do the analysis for that particular area. So it gives us advantages in terms of flexibility and ease to do the analysis.

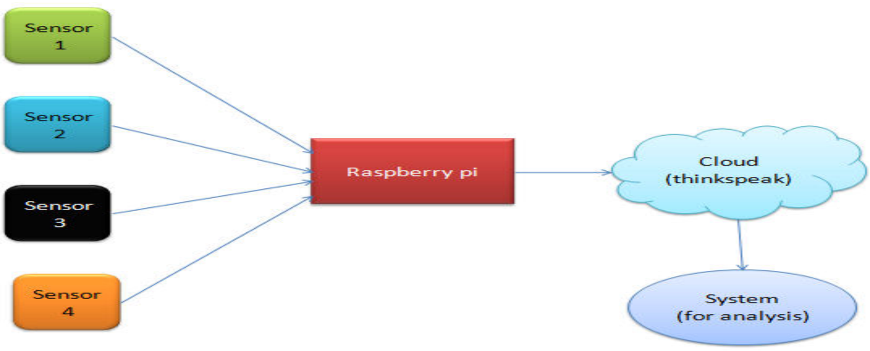

Figure-3. Flow diagram of the proposed system.

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In thingspeak cloud the data is stored in various fields of the channel which makes it easier to analyse.

Model field data analysis: Dummy and real

As mentioned above data collected from the fields, will not be just an instance of data, rather it would be data of at least 5 days for the sake of our model. Now for training our network in deep learning, we take dummy data for favourable conditions for a crop. In real time implementation and for implementing it on a large scale we actually have to visit a field which is best known for growing a particular crop say wheat, then collect real time data of the same crop and train our network based on that data. Now when we are installing our system to some other place, the same data could be used to find out,whether or not that same crop can be grown at this place.

Data analysis: Role of machine learning algorithms

Deep learning algorithms pay a significant role in our data analysis for data extracted from our model. At first as mentioned above, the network is trained with the favourable data which is required for a particular crop. All the data collected from our model is given as the input to our network. With the help of deep learning we are able to predict, whether that particular crop can be grown here, based on the real time conditions of the place12].

Analysis flow

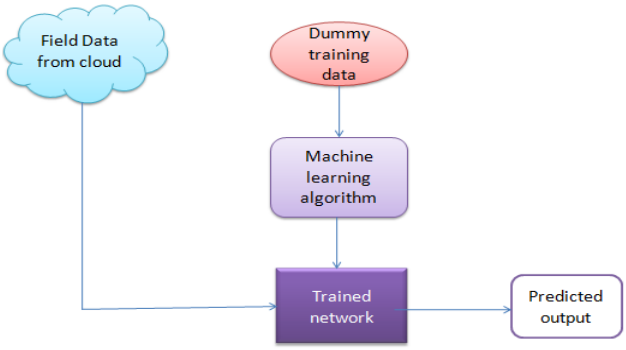

Figure-4. Flow diagram of data analysis.

The accuracy of the system depends on the algorithm and the amount of data used to train the network. The same system can be used to be trained for multiple crops and predict the proper output. The dummy data taken from our model to think speak is shown below. For now we have considered taking 4 fields. But for future work, many other fields can be added as in growth of a crop, there are several other parameters which are required [12].

Model dummy data in Thingspeak cloud

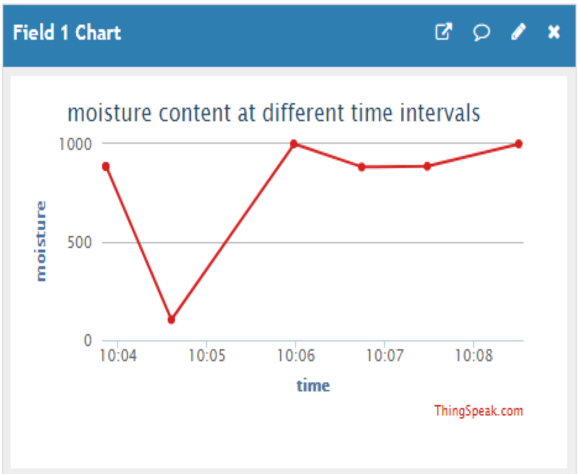

Figure-5(a).

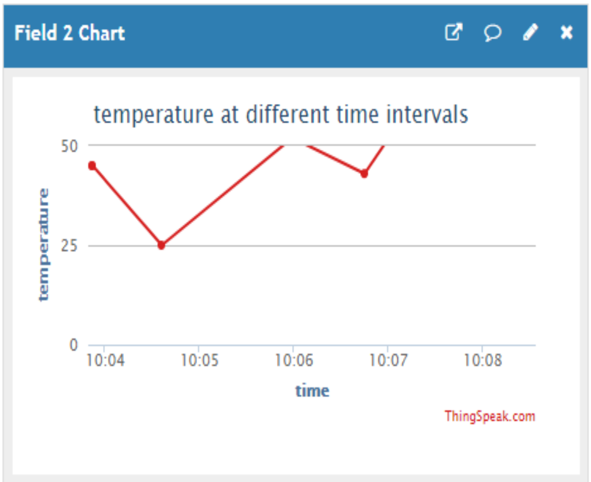

Figure-5(b)

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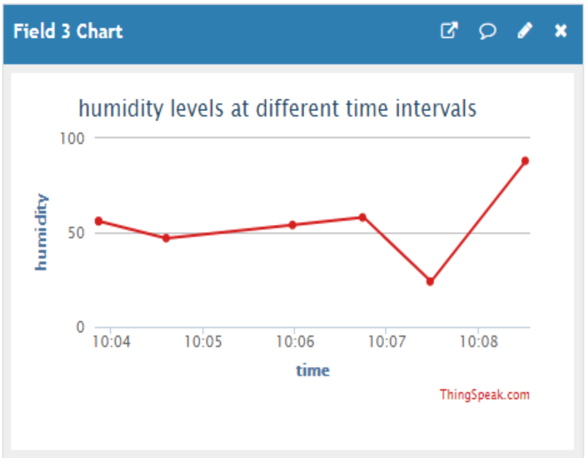

Figure-5(c)

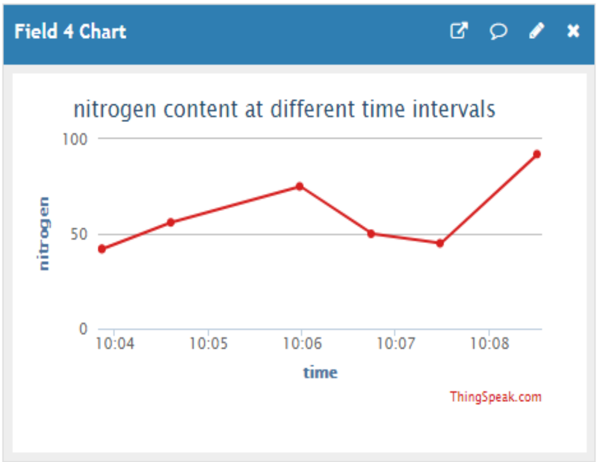

Figure-5(d)

Figure-5. (a) Thingspeak value of moisture sensor (b) Thingspeak value of temperature sensor (c) Thingspeak value of humidity sensor (d) Thingspeak value of nitrogen sensor.

As of now, there is no sensor available to measure nitrogen content, but while creating database we can measure it manually and further use for analysis [13].

This is the Thingspeak cloud data collected from the model and will be given to network. The network is KNN (K Nearest Neighbours - Classification)

A case is classified by a majority vote of its neighbours, with the case being assigned to the class most common amongst its K nearest neighbours measured by a distance function. If K = 1, then the case is simply assigned to the class of its nearest neighbour. It should also be noted that all three distance measures are only valid for continuous variables. In the instance of categorical variables the Hamming distance must be used. It also brings up the issue of standardization of the numerical variables between 0 and 1 when there is a mixture of numerical and categorical variables in the dataset [14].

The following equations can be used to calculate the distance in the neural network.

$$Euclidean: \sqrt{\sum_{i=1}^{k}(xi-yi)^2}, Manhattan: \sum_{i=1}^{k}|xi-yi|, Minkowski\left(\sum_{i=1}^{k}(|xi-yi|)^q\right)^{1/q}$$

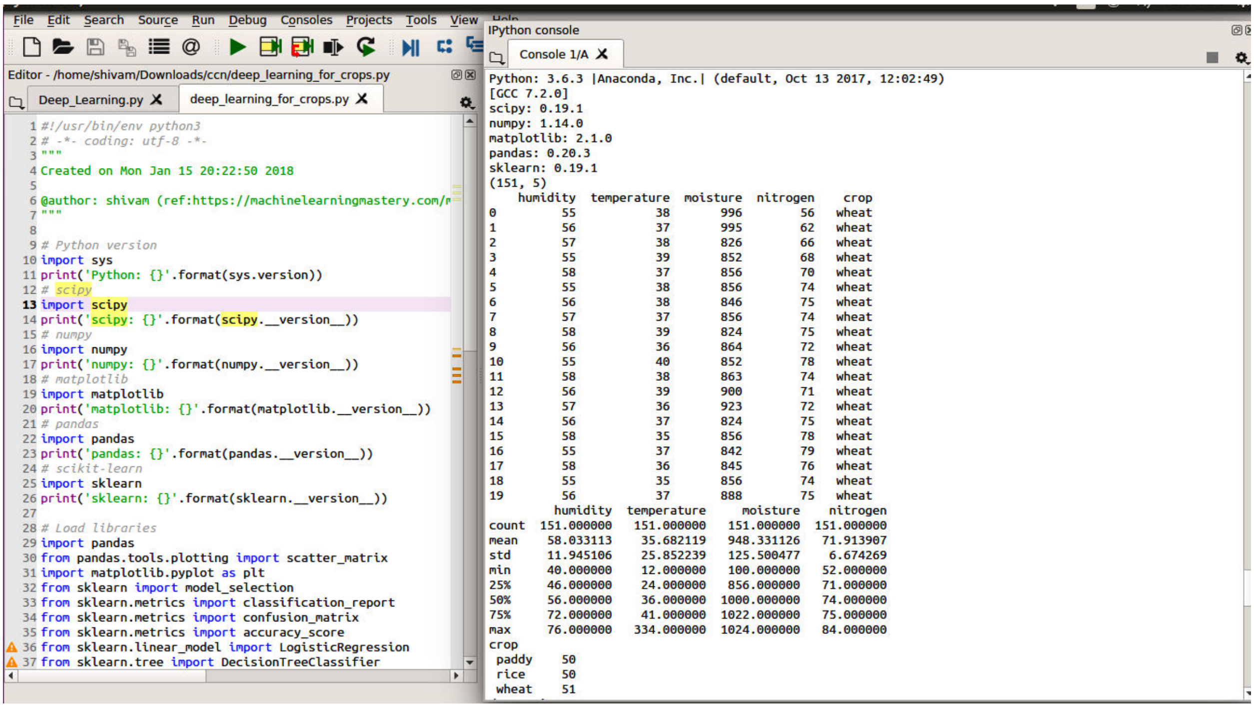

Figure-6(1).

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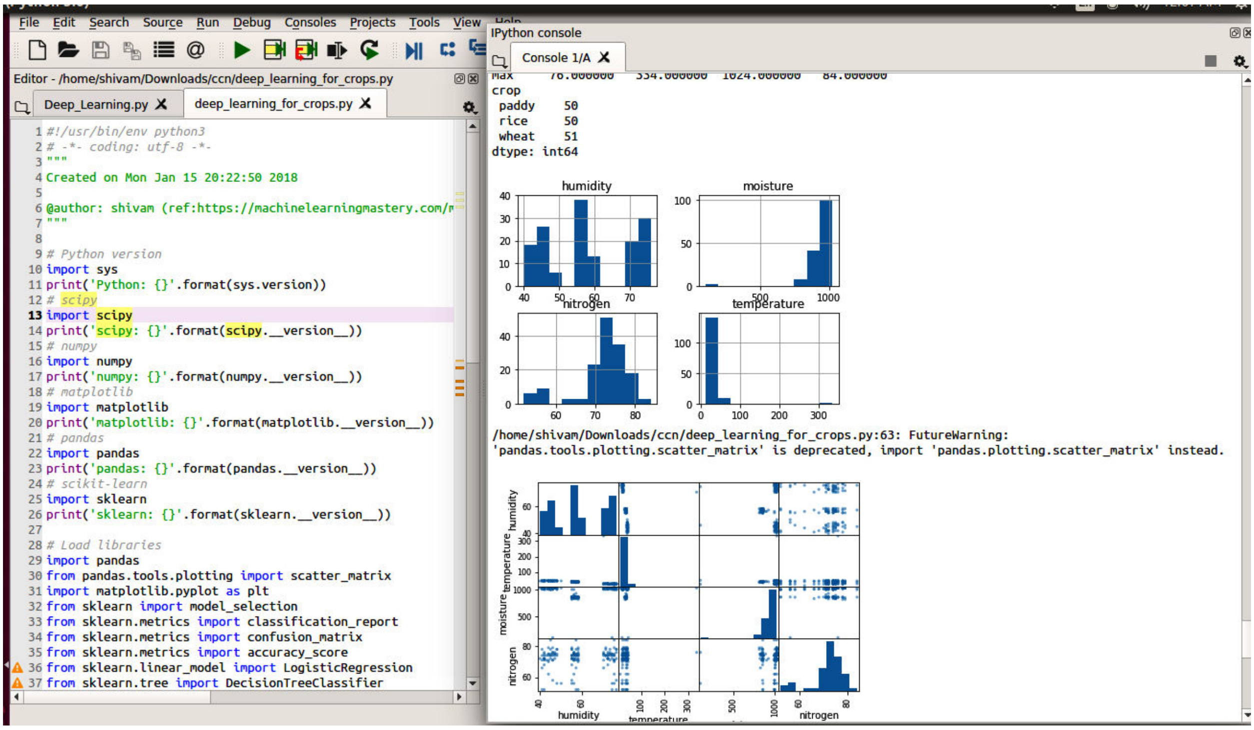

Figure-6(2).

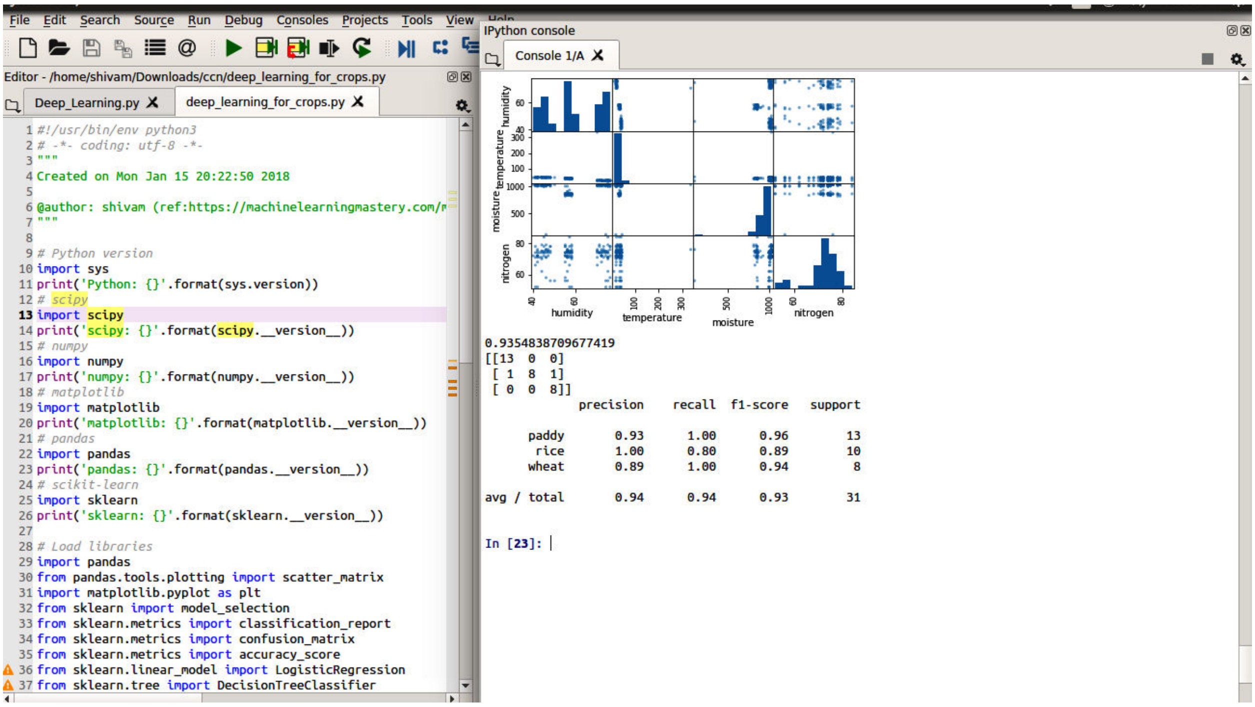

Figure-6(3).

Figure-6. (1) Shows Data visualization (2) Data grouped (histogram and scattering plot) (3) Crop prediction based on 20% test data.

Similarly data from Thingspeak cloud will be given to this KNN network for prediction of crops in real-time scenarios [15].

The security part after the camera takes the picture is done through image processing which includes

Field protection - image processing

It is necessary to protect the field from wild animals. PIR sensor may not be effective as it would detect even the presence of humans. Hence we go for image processing for more accuracy. A camera will be placed at the centre of farmland. When an animal nears a

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field, this camera will capture the image of that animal and process it further in order to find if it's a wild animal.

Case study - elephant

The given image is processed in order to find the presence of an elephant. The given image is processed and percentage of grey pixels is calculated. If the percentage is greater than 50, we can conclude that there is elephant. This is because, elephants are bigger in size and always come in groups and hence would occupy the maximum portion of image.

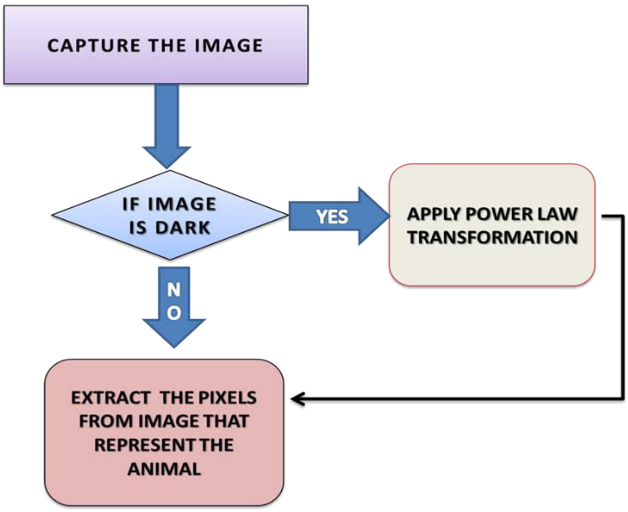

Figure-7. Flow chart of image processing to find animal in picture.

Thus we extract the pixels which represent the animal and analyze it further in order to determine its presence.

Figure-8(a) Figure-8(b)

Figure-8. (a) The original image (b) image after applying power law $S=C_r^{\gamma}$.

We use two types of analysis based on the surroundings

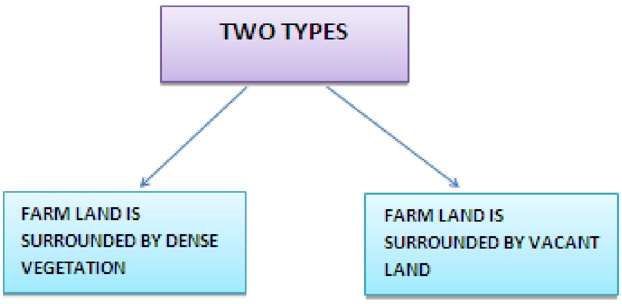

Figure-9. Types of analysis for detection.

FARM LAND SUUROUNDED BY MORE TREES

When there is more number of trees (forest) around the farm land, it is tough to get a clear picture of the animal.

CASE STUDY-ELEPHANT

We calculate the percentage of gray pixels when there is no animal in order to estimate the reference value. And we calculate the increase in percentage of gray pixels in output image as shown in Figure-11. If the increase in percentage of gray pixels is considerable, we will send warning to the farmer; this is feasible because, elephants are huge in size and they come in groups.

Percentage of Gray Pixels = (No Of Gray Pixels/ (M X N)) X 100;

Where, m is width of image matrix. And n is height of the image

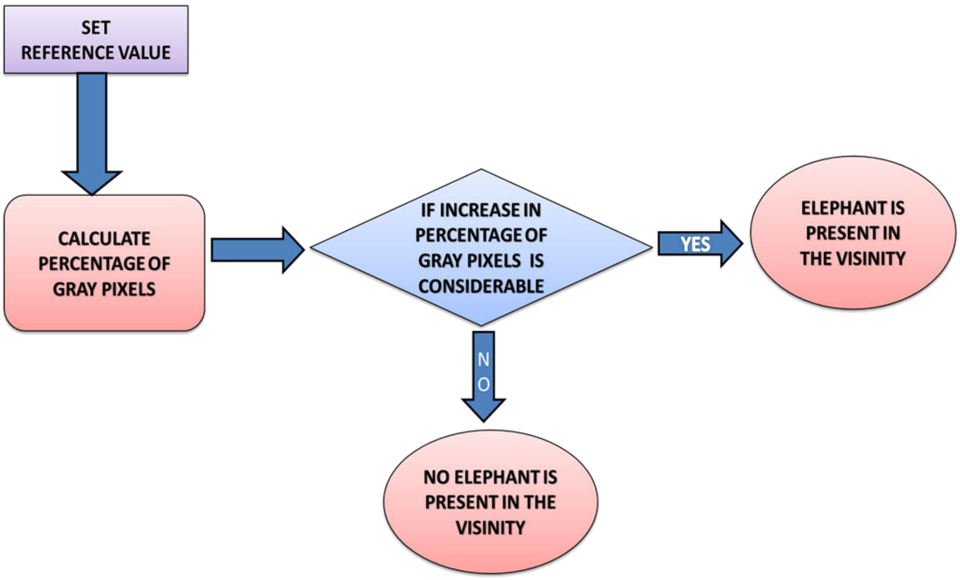

Figure-10. Flow chart for the case when farmland is surrounded by dense vegetation.

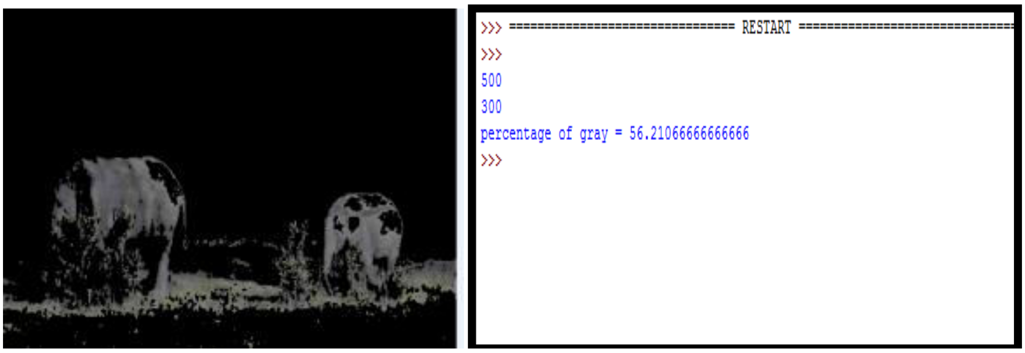

Figure-11(a) Figure-11(b)

Figure-11. (a)Calculation of gray scale. (b) Calculation output.

WHEN THE FARM LAND IS SURROUNDED BY VACANT LAND:

When the farm land is not surrounded by forest or large number of trees, we would get comparatively clear image since there are not so many obstacles. Hence we can calculate the structural similarity between our output image in stage 1 and 10 sample images of that animal. If the similarity is greater than 70%, we can say that the animal is present.

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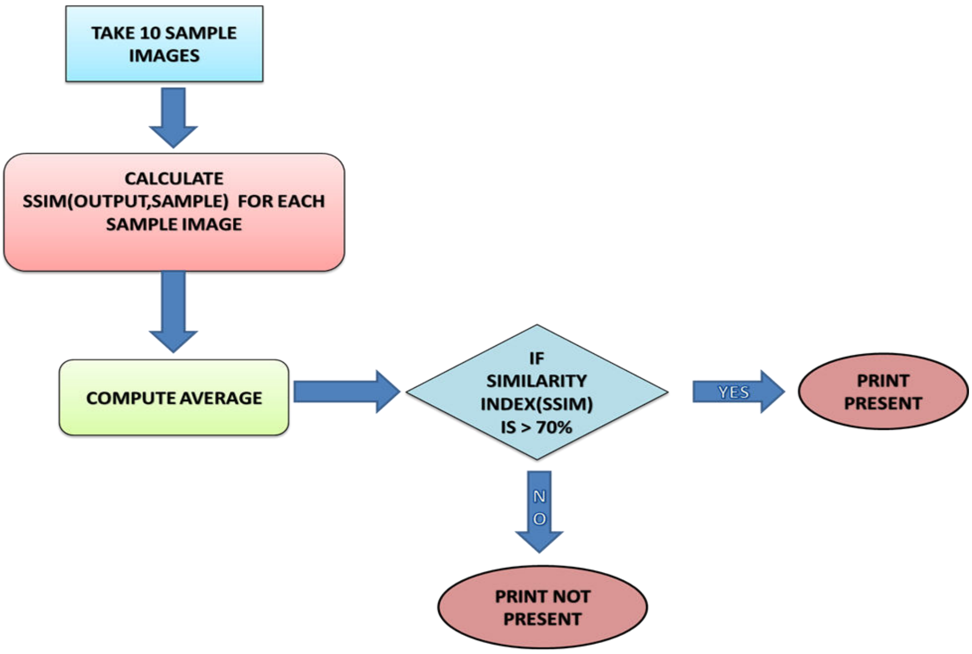

Figure-12. Flow chart for the case when farmland is surrounded by vacant land.

All the codes are tested finally in Spyder IDE (Python).

For detecting the diseases of the plant so that it can be used to inform the user of the disease also we use the image processing.

Detection of plant disease:

We need to detect the disease in a plant before it spreads and spoils the whole crop in farm land. Hence it's very much necessary to detect the disease at the early stage so that we can prevent the disease from spreading. The disease is identified by detecting the change in colour of plant due to disease.

Case study - wheat

The green leaves of wheat will turn yellow when it is infected as shown in Figure-14(a). We detect the presence of yellow colour in the given image of wheat leaf. If it has yellow pixels, we can conclude that the leaf is infected. This is done by comparing the R G B value of pixel with that of boundary values of yellow colour.

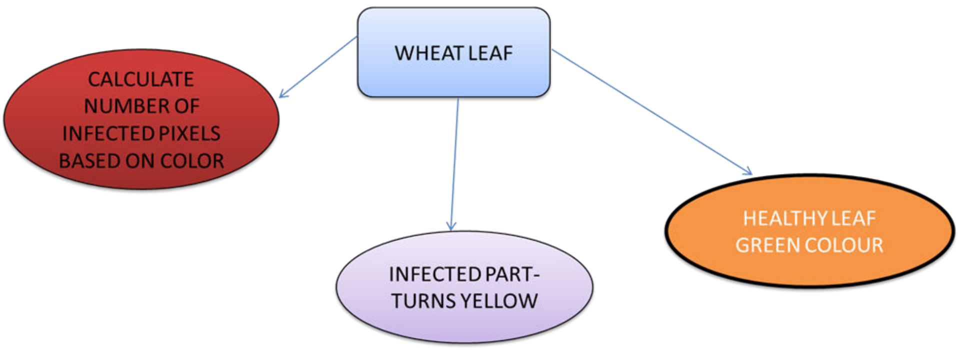

Figure-13. Flow diagram for detection of disease in wheat.

Figure-14(a)

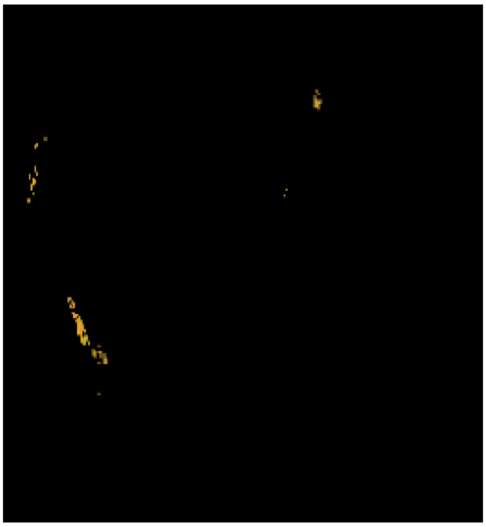

Figure-14(b)

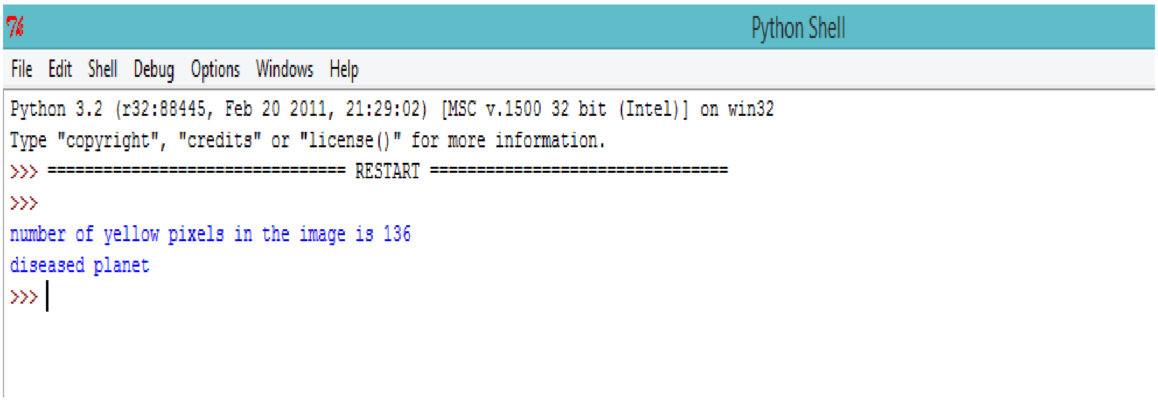

Figure-14(c)

Figure-14. (a) Input image of wheat. (b) Yellow pixel detection for disease identification. (c) The final output based on the amount of yellow pixel

Here as we are detecting the yellow pixels in the wheat we can identify the disease in the beginning stage of crop growth itself hence reducing the losses

4. CONCLUSIONS

We have proposed an idea on how agriculture field can be integrated with smart technologies to provide security and assist the user to identify the best condition for the crop so that the user can know what is best for their crop for maximum yield and benefits. It helps in reducing human effort. Future development of automatons for farming process can also be connected together with this model as the base creating a good pathway for farming without any human intervention. This model is also applicable for back yard farming and even for gardens.

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