Innovating Agriculture: Technologically advanced Approach to Crop Management and Protection

USING AI AND IOT TECHNOLOGIES

CONTENTS

1. Project Summary

Agriculture is one of the most important resources for mankind. This project is about making the agriculture easier and effective by using the trending technologies like Artificial Intelligence (AI) and Internet of Things (IoT). This proposed model is all about AGRICULTURE using AI and IoT. Through this model we can reduce the workload of farmer by more than 50% percentage and make efficient crop production. The proposed model is designed in a such a way that it will let the farmer to know about the proper crop to grow that would give him the best yield according to soil pH and also helps in the crop monitoring by providing the status of the nutrients in the soil and after growth of the crop it detects the pests or plant diseases which could effect the crop using AI technology.

This system consists of sensors which detects the nutrients contents of the soil and gives the output. The sensors used are NPK (Nitrogen, Phosphorous, Potassium) sensor that measures the ratio of Nitrogen, Phosphorous, Potassium in the soil, Temperature sensor, Humidity sensor, pH sensor, soil moisture sensor.

The output acts as input for predicting the best crop possible from the dataset provided. After sowing the particular crop, the IoT sensors will generate the data of the soil nutrients and sends to the farmer in order to add the nutrients to soil for getting the best yield. The system also generates the pest/ plant disease data from the images that were captured by using the camera.

In this project one of the classification algorithms like KNN, Decision tree, Naïve Bayes, Random forest and Gradient Boosting are going to be used.

2. Objectives

1. To develop a system on Crop Recommendation.
2. To develop a system on fertilizer Recommendation.
3. To develop a system on Pest Detection/ Crop Disease Detection.

3. Outcome

This project model will help the farmer to grow the crop according to the soil pH, soil moisture, temperature as well as N, P, K values so that there will be no issues with strength of the crop grown. Soil pH, soil moisture, soil temperature are the key factors to cultivate the land. With the help of these factors we can overcome all the problems and suggest suitable crop to cultivate. Through soil moisture sensor the farmer can get the information about water content in the soil. Through NPK Sensor we can detect the availability of nutrients in the soil. Through image detection we will have total control over the crop.

If crop has diseased with pests or any other crop disease then it detects. The Crop will be altered all the time with the help of AI and all these detections will be sent through cloud to farmer and he will be alerted by giving him/her the information. There are many drawbacks in agriculture where we can come over them with help of AI, IoT and deep learning techniques (ML). Agriculture is always left behind in terms of technology and it can be only solved using these type of deep learning techniques. With the help of this, we can create a relationship of farmer with the crop where he/she can alter or take care of their crop till they harvest. Agriculture is easy when it is done by using AI and IoT.

4. Introduction

Soil plays an important role in agriculture. The Traditional farming includes soil testing, soil preparation, sowing of seeds, adding of fertilizers, irrigation, weed protection and harvesting. The project model is mainly focused on soil testing and preparation, sowing of seeds (which crop should be grown for best yield), irrigation (nutrients detection and fertilizer prediction, pests/crop disease detection). Obviously, the main source of agriculture is soil and it is important for the soil to have good contents of N, P, K although these vary from crop to crop. So, it is important to test the soil before sowing the particular crop seeds. After sowing it is crucial to maintain and monitor the soil for getting good yield from the crop.

[1] In Traditional farming method, soil samples had been collected and tested them by taking to a laboratory. Then, farmers will decide the crop to be grown according to the contents of N, P, K. Usually, this would take a lot of time and also crop selected may not be accurate. But if this work is done by machine, there would be more accuracy and there are high chances of getting a good yield that would solve the scarcity of food due to over population [1].

Also, farmers need a lot of man power in the traditional farming method but incase of using AI technologies we can overcome this problem. Initially, farmers can face some problems while adopting the technologies like AI, IoT, Robotics etc., but this is not an issue. This can be solved by conducting meetings and awareness programs for farmers. AI with IoT can provide the information about crop to be grown, crop rotation planning, optimistic harvest planning, planting management, nutrients requirement, pest and disease control, strategic food production and marketing etc., [1].

What is Artificial Intelligence? It is the ability of a machine to learn by its own with the help of algorithms so that the machine can work like a human brain [2]. IoT features along with AI technique will increase

the efficiency in agriculture. There are soil sensors to find the fertility of soil and AI algorithms to increase the efficiency in prediction and detections. The work of future AI does not stop here, with the help of IoT, it can continuously monitor the nutrient contents of soil and stores the data and trigger the farmer if there is a need of any fertilizer for the healthy crop growth. In this way he would get the better yield. Through the IoT, pests and crop diseases can be detected and information will be sent to farmer via SMS or an E-mail. The cloud technology also plays a important role in agriculture by storing all the data of recommendations, predictions.

5. Literature survey

In the coming years, farmers will face challenges to feed the increasing number of populations. They need to ensure the food security and reduce the dependency on imports [3]. The application of AI and IoT in agriculture has been widely considered as one of the best solutions to address all the difficulties [6]. These type-of problems can also be solved with help of AI and IoT. As the demand for food is being increasing day by day with the increasing population, the traditional farming is insufficient to feed the population. So, there should be some technology involved with the farming for improving the agriculture sector. Farmers work very hard in the ancient method of farming but the technologies like AI and IoT makes the farming easy and also solve the problem of food scarcity [7].

Now, coming to the trending technology AI, it has the capability to learn on it's own making the human life as simple and easier as possible. AI in farming is very innovative and it can be used in every step of traditional farming from seed sowing to harvesting by giving the better results than the traditional farming yield. Also, decreases the soil pollution by predicting the correct amount of pesticides or fertilizers should be used and becoming the eco-friendly technology [11].

Combination of IoT and AI makes the work even easier. The recommendations, predictions and detections will be done by AI and controlled by IoT. Monitoring and maintenance work done by the IoT devices and advices are given by AI technology.

With the increasing demand for food in the current circumstances, agriculture and farming applications have gained importance wide usage because the traditional ways have lost their efficiency. The ancient agriculture production is now of no use as the climatic conditions and pH levels of soil have been changing and it is lacking in the application of the knowledge and technology as in this present world difficulties in agriculture are growing rapidly. As these difficulties are increasing, we cannot overcome these issues with the help of ancient techniques, hence for futuristic issues we need to build a society in such a way that they can overcome these issues with futuristic technologies.

There has been always a negligence and inappropriate support to the farmers. The agriculture is always in helpless format, we need to protect in right way and overcome all difficulties face by farmers these day through different techniques in these evolutions of AI and IoT. The future of every sector is only AI and IoT, now we would like to evolve in agriculture. As per present trends and social and kind of these technologies or products can be use by anybody with basic knowledge and cultivate the land more efficiently [12].The emerging technologies like AI, IoT, Robotics, Machine learning and many more

things are stepping into farmer's life, trying to reduce his workload as well as giving all kind information about his/her crop and it leads to production of more yield.

An IoT based approach on the field of Agriculture which helps to farmer to analyze soil parameters during each crop cycle based on soil parameters such as nutrients (NPK), humidity, temperature, pH, moisture and suggest suitable crops, fertilizer and suitable pesticide if needed which results more yield [14].

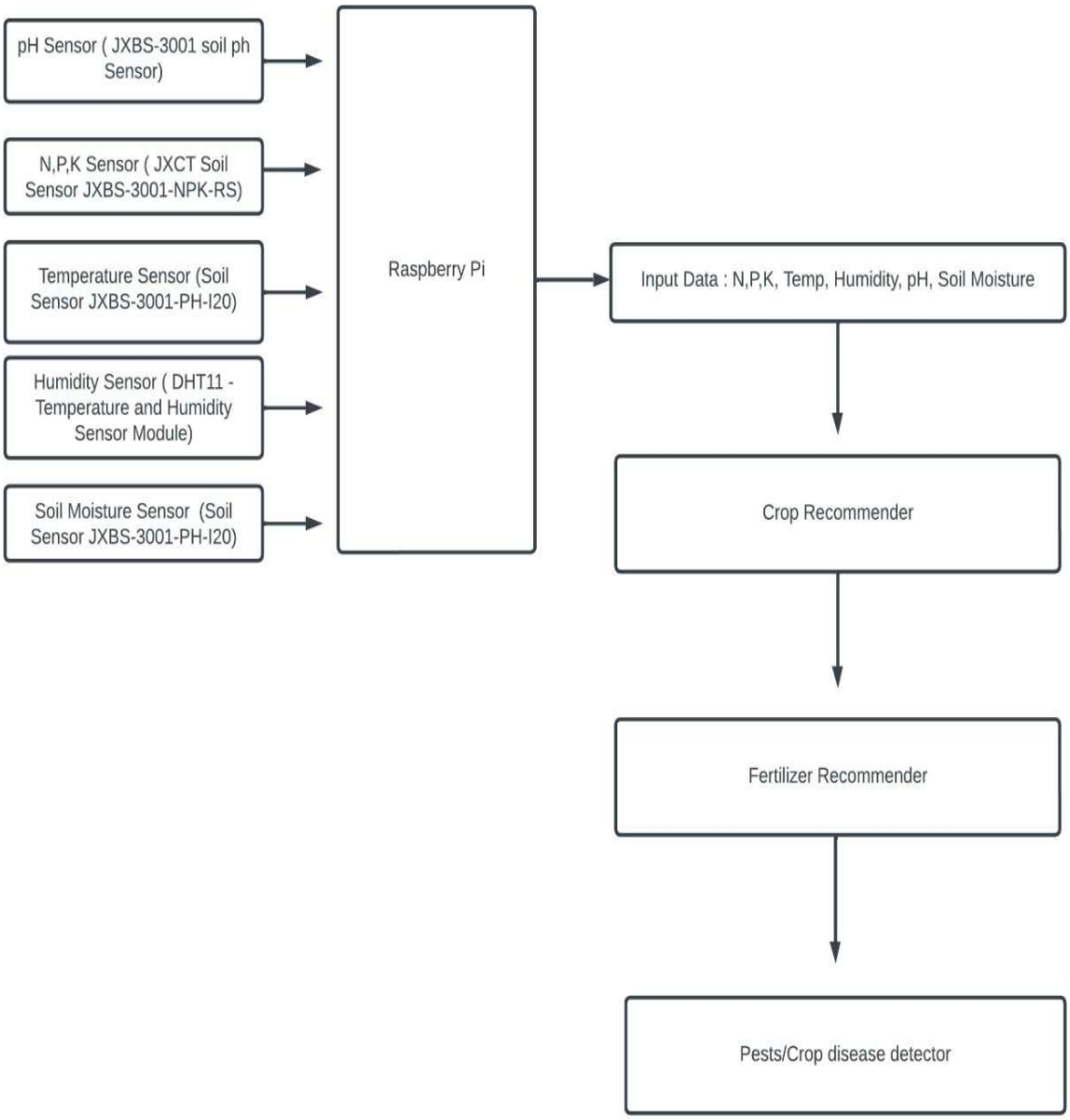
6. Importance of project

This project model reduces the workload of the farmer by giving all sort information related to cultivation land to pest detection of the crop. Soil quality can be predicted which facilitates healthy crop growth. The best crops and fertilizers are going to be suggested this would help the farmers to get more yield.

The project model given can test any type of soil and gives the accurate results for the soil testing. There has been always lack of communication with the crop to the farmer AI is the one of the factors that would help the crop to communicate with farmer easily. Farmers will have the information about their crop where ever they are on the world through cloud technology. The recommendations and detection results can be sent to farmer's phone through an E-mail or SMS in an understandable manner to make this model a user friendly.

The project model is going to build in such a way that it should consume low power, so that the farmer utilizes their money with other expenses. Low Power Consumption model is always a difficult task to come up with and with this project model we can conquer these difficulties. As in many parts of the world farmers aren't educated well enough to through such modern machines as well as there was always a language barrier ,with help of this project model we give the information through cloud to corresponding app in which they can select regional language or mother tongue accordingly .As per according language selected the information would briefly available in their comfortable language and it can saved though pdf or word document where they can refer these documents several times.

7. Block diagram

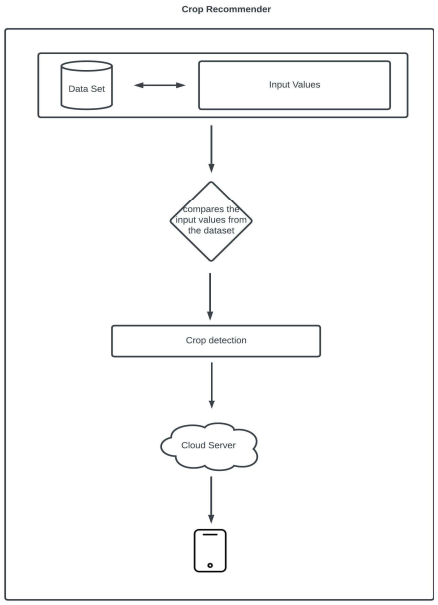


(i)CROP RECOMMENDER

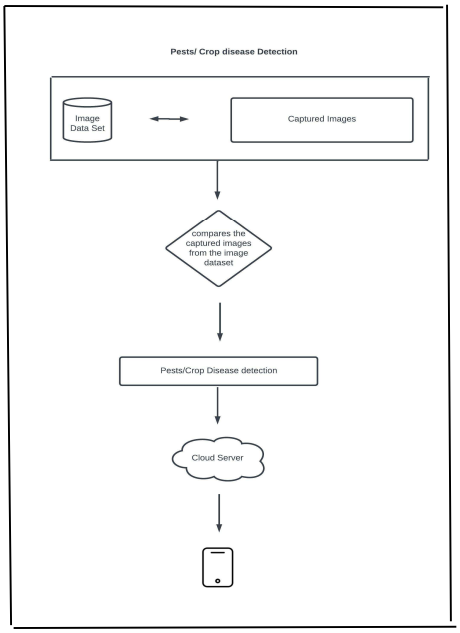
(ii) FERTILZER RECOMMENDER

(iii) PESTS/CROP DISEASE DETECTION

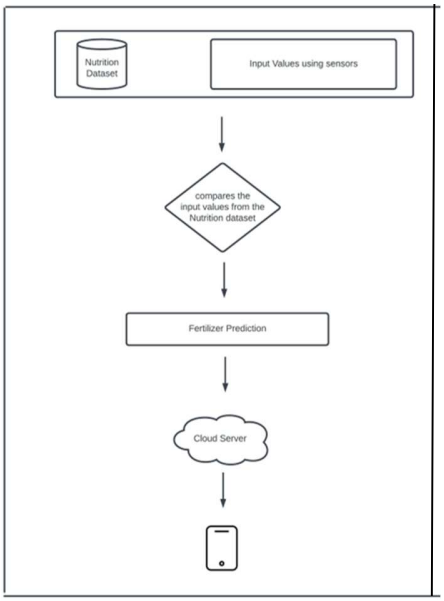
(i) CROP RECOMMENDER



(iii)PESTS/CROP DISEASE DETECTION



(ii)FERTILZER RECOMMENDER



8. Description of Block diagram

1. Soil Testing using IoT sensors

pH sensor -

Soil pH meters are devices used to measure the Acidity or Basicity of the soil. The pH scale ranges from 0 – 14 with 0 being Highly acidic, 7 being Neutral and 14 being alkaline.

Soil Moisture and Temperature Sensor –

The Soil Temperature sensor gives the value of temperature of the soil and Soil Moisture sensor gives the value of water content in the soil for the prediction of crop.

NPK sensor –

This sensor provides the ratio of content of Nitrogen(N), Phosphorous(P) and Potassium(K) present in the soil.

Humidity sensor –

This sensor gives the value of humidity present in the soil.

2. Crop Recommender

It uses 'data set', A data set contains soil parameters data like N, P, K, pH, moisture content, humidity, temperature. Crop Recommender compares the data given against the dataset and suggests the best crops that can be grown with the help sensors like soil pH, soil moisture and soil temperature senor. This would help farmers to ensure about better crop yield therefore, making the work of farmer easier than before using AI and IoT.

3. Fertilizer Recommender

It uses the 'Nutrition dataset', A nutrition data set contains the parameters like ratio of N, P, K. It compares the data collected from IoT sensors against the nutrition dataset and tells the fertility rate of the given samples. Fertilizer Recommender suggests the Fertilizer required for the best yield possible.

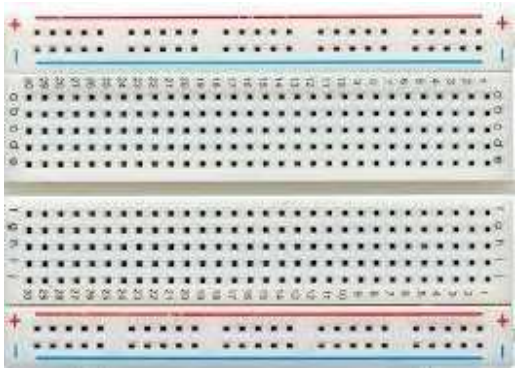
4. Pests/Crop Disease Detector

It uses the 'Image dataset', An image data set contains the images of pests and other crop related disease images. It compares the images of present crop that were captured by the device (camera) against the image dataset and tells the health status of the given crop. This would help farmers to take safety measures before the crop being effected by the pests/disease.

9. COMPONENTS USED

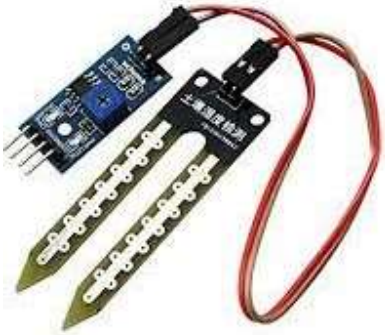
RASPBERRYPi 4 Model B

BREAD BOARD



PI CAMERA

SOIL MOSITURE SENSOR



NPK SENSOR

WIRES

10. Methodology:

(i) Dataset collection

While implementing an accurate prediction model, we need a dataset to compare with the query data to classify it and to give a label to the query data. Specific algorithms are being used for comparing.

(ii) K-NN Algorithm

The k-nearest neighbor (k-NN) method is a non-linear classification algorithm, it is a lazy algorithm which means it stores the training data and wait till it gets the query data but it takes less time in training and more time in prediction.

Implementation of Algorithm:

1. Firstly, loading the dataset for comparing.
2. Here input value is considered as query data which needs to be classified and we already have present data in the dataset.
3. Now, initializing the value of k according to number of rows in the dataset (data is represented in excel).
4. Finding the Euclidian distance between query data and present data for each present data available.

d_n (X, Y) = $\sqrt{(X - x_n)^2 + (Y - y_n)^2}$

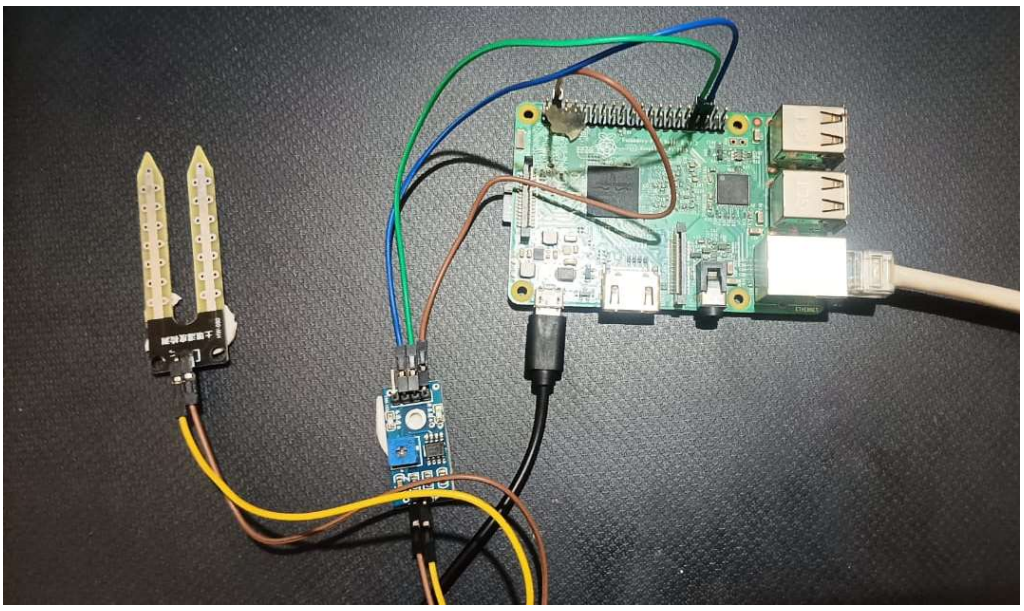
5.After getting the distances between the query data and present data as d1, d2, d3 ……. d n, arrange these distances in the order of ascending by giving them the ranks. The smallest distance calculated will be ranked as 1.
6.Choosing the first k distances among the n distances as these represents the nearest neighbors
7.We will be getting the respective labels (crop) corresponding to the k distances as d1, d2, d3 ……. d_k. The majority labels among these k ranked distances will be recommended.

11. Programs & Interfacing Sensors with RaspberryPi

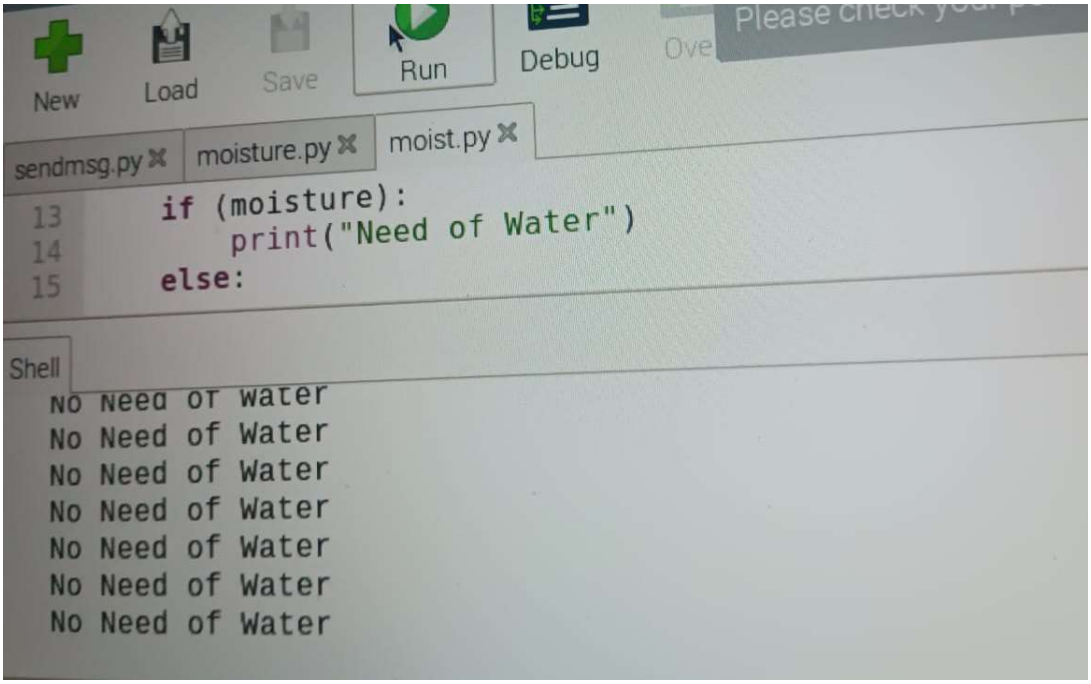
1. SOIL MOISTURE

```
 import os
import RPi.GPIO as GPIO
import time
import smtplib

GPIO.setmode(GPIO.BOARD)
moisture_sensor = 36
GPIO.setup(moisture_sensor, GPIO.IN)

moisture = GPIO.input(moisture_sensor)

while True:
    if (moisture):
        print("Need of Water")
    else:
        print(" No Need of Water")

    time.sleep(2)
```

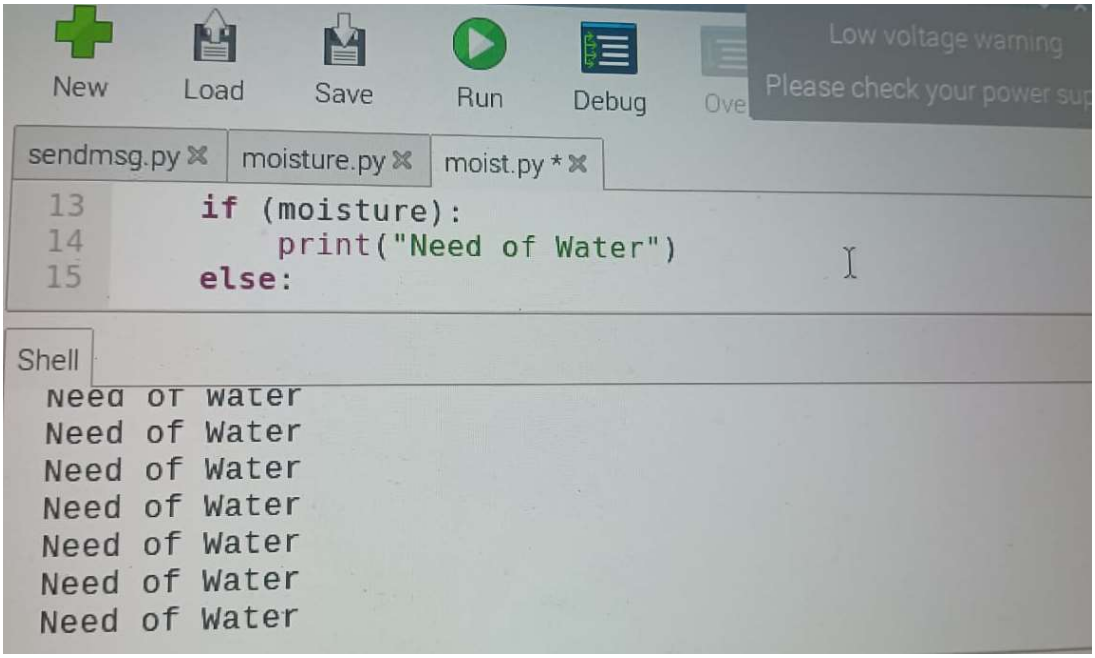
INTERFACING SOIL MOSITURE SENSOR WITH RASPBERRY PI



OUTPUT (i) When there is No Need of Water



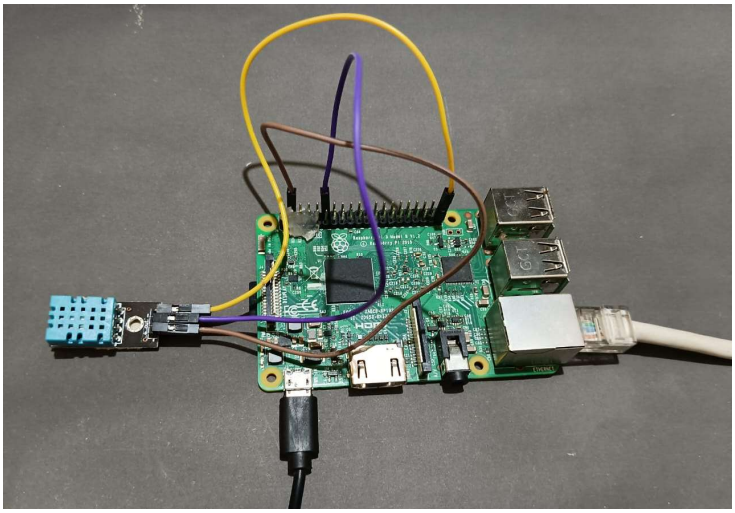
Output (ii) When there is Need of Water



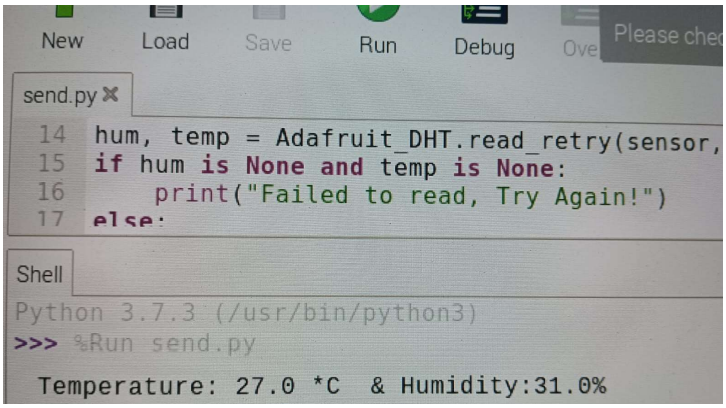
2. SOIL TEMPERATURE & HUMIDTY SENSOR

```
import os
import Adafruit_DHT
import time
import RPi.GPIO as GPIO
GPIO.setmode(GPIO.BCM)
sensor = Adafruit_DHT.DHT11
pin = 18
while True:
hum, temp = Adafruit_DHT.read_retry(sensor, pin)
if hum is None and temp is None:
print("Failed to read, Try Again!")
else:
print("Temperature: "+str(temp) + " *C " + " & Humidity:"+ str(hum) + "%")
```

INTERFACING DHT11 SENNOR With RASPBERRY PI



Output:

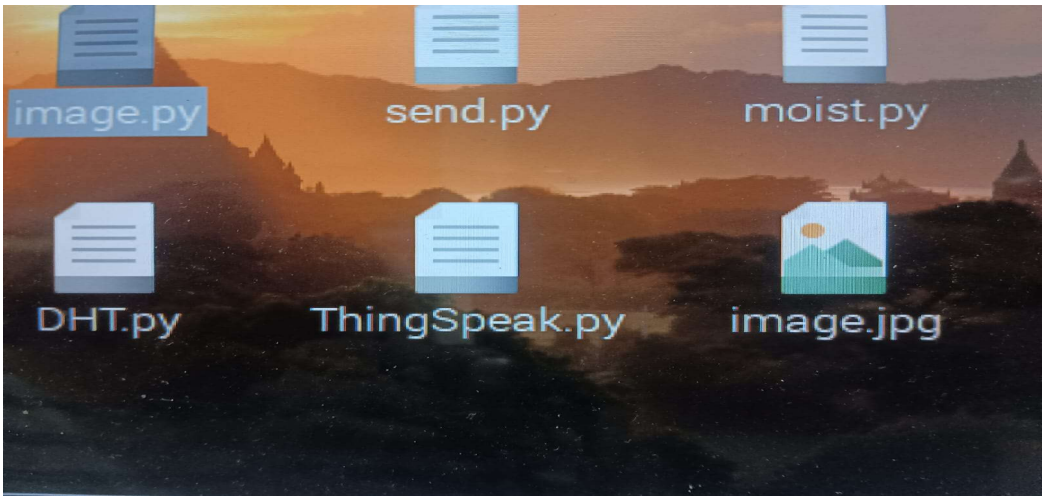


3. PI CAMERA

```
import picamera
print("about to capture")
with picamera.PiCamera() as camera:
camera.resolution = (1280, 720)
camera.capture("picture captured”)
```

INTERFACING PI CAMERA WITH RASPBERRYPI

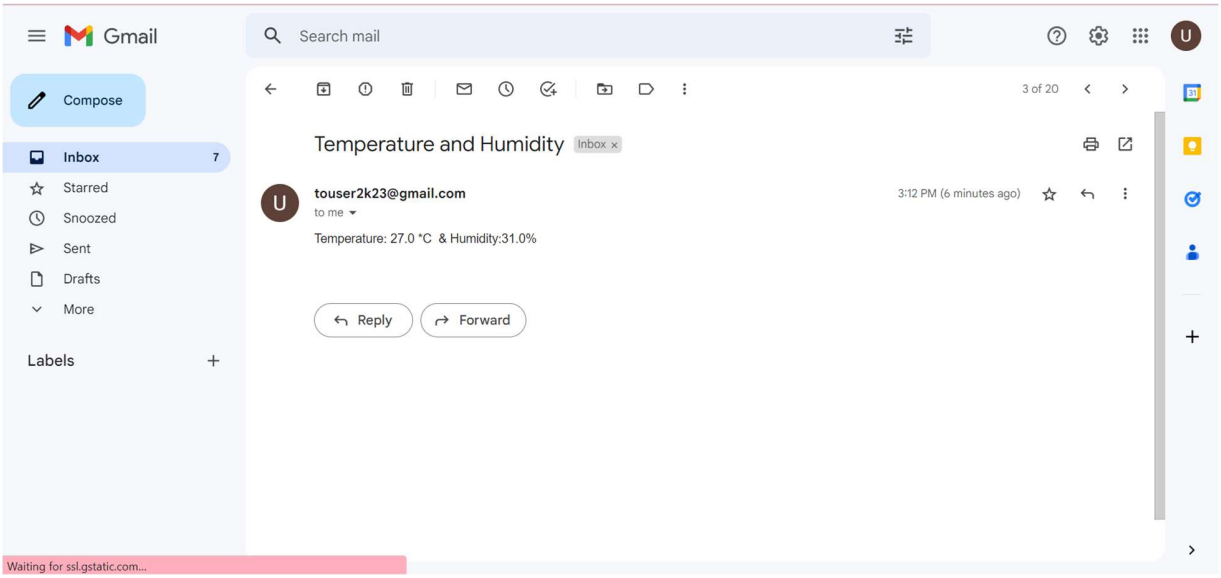
Output: Captured Image



4. SENDING THE INFORMATION TO MAIL

```
import os
import Adafruit_DHT
import time
import RPi.GPIO as GPIO
import smtplib
from email.message import EmailMessage
GPIO.setmode(GPIO.BCM)
sensor = Adafruit_DHT.DHT11
pin = 18
hum, temp = Adafruit_DHT.read_retry(sensor, pin)
if hum is None and temp is None:
    print("Failed to read, Try Again!")
else:
    print("Temperature: "+str(temp) + " *C " + " & Humidity:"+ str(hum) + "%")
raspi = 'touser2k23@gmail.com'
password = 'lgisesmrvwooblxn'
to =  'touser2k23@gmail.com'
fromras = raspi
msg = EmailMessage()
msg['Subject'] = "Temperature and Humidity"
msg['From'] = raspi
msg['To'] = 'touser2k23@gmail.com'
msg.set_content("Temperature: "+str(temp) + " *C " + " & Humidity:"+ str(hum) + "%")
server = smtplib.SMTP('smtp.gmail.com', 587)
server.ehlo()
server.starttls()
server.ehlo()
server.login(raspi, password)
print("Login Successfull")
server.send_message(msg)
server.quit()
print("Email has been sent")
```

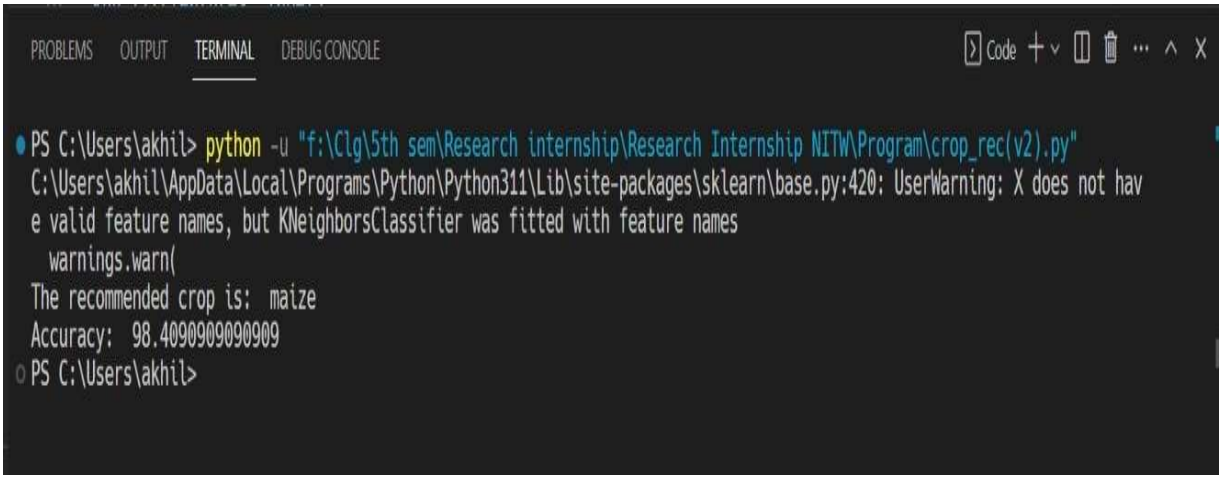
OUTPUT: INFORMATION SENT TO MAIL



5. CROP RECOMMENDATION CODE

```
import numpy as np
import pandas as pd
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
from sklearn.model_selection import train_test_split

dataset = pd.read_csv(r'F:\Clg\5th sem\Research internship\Research Internship NITW\Datasets\Crop_recommendation.csv')

features = dataset[["N", "P", "K", "temperature", "humidity", "ph", "rainfall"]]
label = dataset["label"]

X_train, X_test, y_train, y_test = train_test_split(features, label, test_size=0.2)

knn = KNeighborsClassifier(n_neighbors=5)

knn.fit(features, label)

input_values = [80, 40, 35, 30, 35, 9, 100]

pred_crop = knn.predict([input_values])
y_pred = knn.predict(X_test)

print("The recommended crop is: ", pred_crop[0])
accuracy = accuracy_score(y_test, y_pred)
print("Accuracy: ", accuracy*100)
```

OUTPUT : CROP RECCOMENDATION



12. Conclusion

Farming is the major source for the survival in this world, the future farming is moving towards the smarter technologies in order to increase the productivity with more efficiency. Machine learning techniques, and deep learning techniques have been showing a remarkable ability to properly detect and classify Soil, fertilizers and pests or plant diseases accordingly with respect to the given soil or crop.

In the present work, an attempt has been done to automate the Soil Testing, Soil Monitoring, Recognition of crop diseases or pests effected the crop by using the on-field images and giving pesticide recommendation through cloud to the farmer. The monitoring of the pH of the soil and soil temperature has been done with the very minimal cost. The values can be viewed by the farmer through mail or message which will be sent through cloud. Hence this system gives more accurate pH rate and temperature rate of the soil which play vital role in the agriculture. The temperature sensor, Humidity sensor and soil moisture sensor can be interfaced to the raspberry to assess any further data.

Future efforts could focus on creating mechanisms to facilitate and encourage the involvement of farmer in evolving technologies. The resulting system will be also a low in power consumption and provisional real time monitoring on the agriculture at minimal cost, so that farmer can afford it easily and can spend money on other products like pesticide or fertilizers.

It is a ready to use project model where the farmer can install it in his/her cultivating land. Installation process is quite easy and can be explained through video or written document format in different languages in block diagram. Farmer should be trained in such way that he/she should aware of all sensors and their information sent through cloud.

13. References

[1] Megha Raina, Dr. Archana Sharma - Intelligent Farming With Artificial Intelligence.5 May 2002

[2] Kiruba Shankari Arun Chinnappa, Lanka Ranawake, Saman Seneweera -Abiotic Stress Management for Resilient Agriculture - https://www.researchgate.net/publication/318652628_Abiotic_Stress_Management_for_Resilient_Agriculture. September 2017.

[3] Syeda Iqra Hassan, Muhammad Mansoor Alam, Usman Illahi, Mohammed A. Al Ghamdi, Sultan H. Almotiri, Mazliham Mohd Su'ud – A systematic review on monitoring and advanced control strategies in smart agriculture. February 2021.

[4] Guijun Yang, Yanbo Huang, Chunjiang Zhao - Agri-BIGDATA: A smart pathway for crop nitrogen inputs. 8 August 2020.

[5] Jayme Garcia Arnal Barbedo - Detecting and Classifying Pests in Crops Using Proximal Images and Machine Learning. 24 June 2020.

[6] Varshitha D N, Savita Choudhary - An AI solution for Soil Fertility and Crop Friendliness Detection and Monitoring. 3 February 2021.

[7] Jiali Zha - Artificial Intelligence in Agriculture. 2020.

[8] Soumya Sri Attaluri, Nowshath K Batcha, Raheem Mafas - Crop Plantation Recommendation using Feature Extraction and Machine Learning Techniques. Novenber 2020.

[9] Shafiulla Shariff, Shwetha R B, Ramya O G, Pushpa H, Pooja K R - Crop Recommendation using Machine Learning Techniques. 2022.

[10] Nidhi H Kulkarni, Dr. G N Srinivasan, Dr. B M Sagar, Dr. N K Cauvery - Improving Crop Productivity Through A Crop Recommendation System Using Ensembling Technique. 2018.

[11] Sashant Suhag, Nidhi Singh, Sanskriti jadaun, Prashant Johri, Ayush Shukla, Nidhi Parashar - IoT based Soil Nutrition and Plant Disease Detection System for Smart Agriculture.2021.

[12] Sameer qazi (senior member, IEEE), Bilal A. Khawaja (senior member, IEEE) and Qazi Umar Farooq - IoT-Equipped and AI-Enabled Next Generation Smart Agriculture: A Critical Review, Current Challenges and Future Trends. February 17, 2022.

[13] E. Sowmiya, S. Sivaranjani - Smart System Monitoring on Soil Using Internet of Things (IoT). 02 February 2017.

[14] Laxmi Jadhav, Prof. Vidya Pai - Implementation & Testing of Soil Analysis in cultivation land using IoT. 06 June 2019.

[15] Prof. A V. Deorankar, Ashwini A. Rohankar - Soil Health Monitoring System using AI. January 2020.

[16] Joli Dutta, Jumi Dutta and Sukanya Gogoi - Smart farming: An opportunity for efficient monitoring and detection of pests and diseases.14 June 2020.

[17] Huong Thi Thanh Nguyen, Trung Minh Doan, Erkki Tomppo and Ronald E. McRoberts - Land Use/Land Cover Mapping Using Multitemporal Sentinel-2 Imagery and Four Classification. 26 April 2020.

[18] Sharma K.L, Srinivasa Rao Ch., Kotha Sammi Reddy – Soil Quality and Management. 11 April 2021.

[19] Basavaraj S. Anami, Naveen N. Malvade, Surendra Palaiah - Deep learning approach for recognition and classification of yield affecting paddy crop stresses using field images. 3 April 2020.

[20] Akshaya Gambhire, Shaikh Mohammad Bilal N. - Use of Artificial Intelligence in Agriculture.

[21] Tanha Talaviya , Dhara Shah, Nivedita Patel, Hiteshri Yagnik, Manan Shah - Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. 22 April 2020.

[22] Brownmang onwuka, Brown Mang - Effects of soil temperature on some soil properties and plant growth. January 12, 2018.

[23] Kiran Moraye, Aruna Pavate , Suyog Nikam and Smit Thakkar - Crop Yield Prediction Using Random Forest Algorithm for Major Cities in Maharashtra State. 2 March 2021.

[24] B. Lakshmi Praveena, A. Bhumika, A. Sindhuja, B. Tejaswini Mallika - Crop Prediction Using KNN Algorithm. 2022.