JOURNAL OF BASIC SCIENCE AND ENGINEERING

FIELDVISION: ENHANCING AGRICULTURE THROUGH CONVOLUTIONAL NEURAL NETWORKS

Mamtha Mohan[1], Pavitha U S[2], Suma K V[3], Krupa R[4], Preethi J Aradhaya[5]

[1,2,3] Department of Electronics and Communication Engineering, Ramaiah Institute of Technology, Bengaluru, India

[4,5]Department of Mechanical Engineering, Nitte Meenakshi Institute of Technology, Bangalore

*Corresponding author: mamtha.m@msrit.edu

ABSTRACT

Modern agricultural approaches now include precision farming as a crucial element, with smart agriculture devices providing essential data on crop disease, soil nutrient levels, and recommended fertilizer applications.This research presents a convolutional neural network (CNN) based smart agriculture system for nutrient analysis and crop suggestion based on soil photographs of five different types of soil: cinder, black, peat, yellow, and laterite. The suggested system consists of a nutrient analysis and crop recommendation model based on CNN, an image-capturing device, and a user interface. In order to accurately predict the best crop and fertilizer for a given soil type, the system uses an image-capturing device to take soil images. The CNN-based model is then used to process the images. This model is trained on a large dataset of soil images along with associated crop types, nutrient content, and recommended fertilizers. Farmers can interact with the system through the user interface to receive crop recommendations, nutrient analyses, and fertilizer recommendations based on the images of the soil that were collected.

Keywords: CNN, pH level,HTTP,IDE, smart farming

I. INTRODUCTION

Smartfarmingisamodernapproachtoagriculturethatutilizesadvancedtechnologytoincreaseyields,reduce costs, and improve the overall efficiency of farming operations. One aspect of smart farmingis the use of soil detection and crop recommendation using Convolutional Neural Networks (CNNs)[1].This involves using image recognition algorithms to analyze images of soil and crops and using thisdatato makerecommendationsonwhatcropsto plant,howtocareforthem,and whento harvest.Byusing these advanced techniques, farmers can make more informed decisions and optimize theirfarmingpractices tomaximizeyieldsandreducewaste.

Smart agriculture systems have been gaining traction in recent years due to the need to optimize cropproduction, reduce crop losses, and improve overall farm efficiency. One key technology used in smartagriculture is Convolutional Neural Networks (CNNs), which can analyze images of crops and soil to extractvaluable information for farmers. This report will explore how CNNs can be used in smart agriculture toanalyzesoilimages forcroprecommendation, nutrientsandsoiltype, rainfall, temperature,andcropillness.

By assisting farmers in making knowledgeable decisions about which crops to plant and how much fertilizer to use, the suggested approach can boost productivity and cut down on resource waste. Because of the system's adaptability, modern farming practices can be adopted in a variety of agricultural contexts, increasing their production and efficiency. About 6000 photos from the Kaggle soil image dataset were used. The Gaussian difference approach is used for image preparation.

The model receives data from the soil pictures. The proposed approach addressed the problem of class imbalance by using picture augmentation to obtain high accuracy. The InceptionV3 deep learning classification model analysis for our project's automated dirt picture detection. To demonstrate the resilience and dependability of the suggested strategy, a number of additional performance-related parameters have been provided.

Smart agriculture systems using CNNs provide more accurate and detailed information about soil type, nutrient content, and crop health. Traditional farming practices rely on manual testing and analysis of soil samples, which can be time-consuming, labor-intensive, and often provide limited information. In contrast, smart agriculture systems using CNNs can analyze soil images and other data to provide farmers with accurate and detailed information about soil composition, nutrient content, and crop health. Farmers can use this information to make better-informed decisions on pest control, soil management, and crop selection. [2] Smart agriculture systems using CNNs can provide real-time weather forecasts and make recommendations for irrigation and crop management practices. Conventional methods rely on subjective observations of weather patterns and crop health to make decisions about irrigation, fertilizer application, and pest control. This can lead to suboptimal crop yields, low-quality crops, and higher costs due to inefficient use of resources.

In contrast, smart agriculture systems using CNNs can analyze rainfall and temperature patterns to provide farmers with real-time weather forecasts and make recommendations for irrigation and crop management practices.By doing this, farmers may maximize crop yields and minimize losses brought on by unfavourable weather.Smart agriculture systems using CNNs can detect signs of crop illness and provide early warning to farmers, which can help them take preventive measures before the illness spreads to other crops. Traditional farming practices rely on visual observations to detect signs of crop illness, which can be difficult and time-consuming. In contrast, smart agriculture systems using CNNs can analyze crop images to detect signs of illness and provide early warning to farmers.

This can help farmers take preventive measures before the illness spreads to other crops and reduce losses due to crop illness. Smart agriculture systems using CNNs can promote sustainable farming practices by optimizing resource use and reducing environmental impact. Conventional farming practices may rely on excessive use of water, fertilizer, and pesticides, which can lead to environmental degradation and reduce the land's long-term productivity. In contrast, smart agriculture systems using CNNs can provide farmers with real-time recommendations for resource management, which can help optimize resource use and reduce environmental impact. Smart agriculture systems using CNNs offer many advantages over conventional farming practices for crop recommendation, soil analysis, and weather forecasting. [3]

These systems can provide farmers with accurate and detailed information about soil type, nutrient content, and crop health, and make recommendations for crop selection, soil management, and pest control. Additionally, they can provide real-time weather forecasts and detect signs of crop illness, promoting sustainable farming practices and optimizing resource use. Farmers may ensure the long-term productivity of their land by optimizing crop yields, minimizing losses, and promoting sustainable farming practices through the use of CNN-based smart agricultural systems.

Objectives

The primary goals of the project are:

- To develop a smart agriculture system that uses CNN to analyze soil images and provide accurate recommendations for crop selection, soil management, and pest control.
- To provide farmers with real-time information about soil composition, nutrient content, and crop health using the CNN model. [5]
- To develop a web application that allows farmers to access and visualize the recommendations provided by the CNN model.
- To detect signs of crop illness and provide early warning to farmers using the CNN model [6].

II. METHODOLOGY

In this study, Convolutional Neural Network has been employed to enhance the capability of Smart Agricultural practices, which include the following:

a) SoilImageAnalysis for CropRecommendation

CNNs can analyze images of soil samples to identify the type of soil, its nutrients, and its properties.Subsequently,thisdatacanbeutilizedtosuggestthemostsuitablecropstocultivateinthatparticularsoil. Forexample, if the soil is rich in nitrogen and phosphorus, the CNN might recommend planting corn or wheat,while if the soil is alkaline, the CNN might recommend planting crops that prefer high pH, such as beets orasparagus. Additionally, the CNN can take into account other factors such as temperature, rainfall, andsunlighttofurtheroptimizecroprecommendations.

b) NutrientandSoilTypeAnalysis

Inadditiontocroprecommendation,CNNscanalsoanalyzesoilimagestodeterminethenutrientcontentandtype of soil. This information can help farmers make informed decisions about soil management practices,such as selecting the appropriate fertilizer or amending the soil to improve its nutrient content. The CNN canalsomonitorchangesinsoilnutrientlevelsovertimeand adjustrecommendationsaccordingly.

c) RainfallandTemperatureAnalysis

CNNscanbetrainedtoanalyzesatelliteimagestodeterminerainfallpatternsandtemperaturesinaparticulararea. This information can help farmers optimize irrigation and crop management practices based on currentweather conditions. For example, if the CNN detects a prolonged period of dry weather, it might recommendadjustingirrigationpracticesorplantingdrought-resistantcrops.

d) CropIllnessDetection

CNNs are able to recognize symptoms of stress or sickness by analyzing photographs of crops. Farmers can use this information to identify crop illnesses early on and take the necessary precautions to stop the disease from spreading. For example,the CNN might detect early signs of leaf wilting, which could indicate a fungal infection. The farmer couldthentakestepstotreattheinfectionbeforeitspreads tootherplants.

The architecture of the CNN used is discussed in following section.

InceptionV3Architecture:

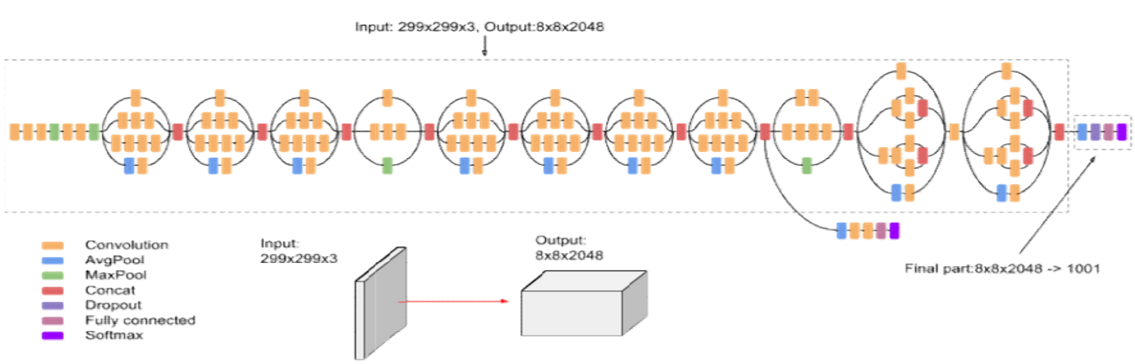


Fig1: InceptionV3Architecture

The figure1 shows the inception architecture:

- The Inception V3, an advanced Convolutional Neural Network (CNN) model, is employed for imageclassification.ItisanimprovediterationoftheoriginalInceptionV1model,alsoknown asGoogLeNet,whichwas createdbyaGoogleteamin2014.

- InceptionV3hasachievedgoodclassificationperformance inseveralbiomedicalapplications.HencewetriedusingInceptionV3architecture inourmodel.

- Inception V3 is a convolution neural network that is 48 layers deep, a bit higher than the previousinceptionmodels.The efficiencyofthismodelistrulyremarkable.

- Eachlayerconsistsofconvolutionfilters, avgpool, andsomelayerscontainmaxpoolandeverylayerisfollowedbyacontacttocombinethe outputsofallthefilters.

- Thesearefollowedbyfullyconnectedlayersanda softmaxlayer.

A web application is a piece of software that operates on a web server and is accessible to users via a web browser on the internet. Web applications can be used for a wide range of purposes, including e-commerce,socialnetworking,contentmanagement,anddataanalysis.Forsoilanalysis,awebapplication [7]couldbedesignedto allowuserstouploadimagesofsoilsamplesandgetback resultsonthe soilproperties.Here'sa generaloverview ofhow sucha webapplicationcouldwork:

- Theuser accessesthewebapplicationusing awebbrowser.
- Theuserispresentedwithaformthatallowsthemtouploadanimageoftheir soilsample.
- Theuseruploadstheimage, andthewebapplicationprocessestheimagetoextractinformationaboutthe soilproperties.

Thewebapplicationpresentstheuserwiththeresultsoftheanalysis,whichcouldincludeinformationaboutsoiltype,nutrientcontent,pHlevels,andotherrelevantproperties [8]

Tools Used

1. Google colab

Google Colab is a cloud-based Jupyter notebook environment provided by Google, allowing users to write and execute Python code seamlessly in a web browser. It offers free access to powerful computing resources and facilitates collaborative coding and data analysis. [9]

2. Tensor flow

TensorFlow is a powerful open-source machine learning framework developed byGoogle. It provides a comprehensive ecosystem for building and deploying deeplearning models, enabling efficient computation on both CPUs and GPUs.

3. Keras

Keras is a popular deep learning library written in Python that provides a user-friendly interface for creating and training neural networks. It allows for efficient prototyping and supports both CPU and GPU computations.

4. PyCharm

PyCharm is a powerful integrated development environment (IDE) specificallydesigned for Python programming. It offers a wide range of features such as intelligent code completion, debugging tools, and support for version control systems. [10]

5. Language: Python

6. Jupyter Notebook

Using the interactive web application Jupyter Notebook, users may create and share documents with live code, equations, graphics, and narrative text. It is extensively utilized for activities related to scientific computing, machine learning, data analysis, and visualization.

7. Flask

Flask is a popular Python web framework known for its simplicity and flexibility.It allows developers to quickly build web applications with minimal boilerplate code and offers powerful tools for routing, templating, and handling HTTP requests. [11]

III. RESULTS AND DISCUSSION

The results are presented in three parts, starting with the Architecture results of Inception V3, followed by performance parameters and finally the screenshots of web App designed.

Summary of Inception V3

```
Layer (type)                 Output Shape              Param #
=================================================================
inception_v3 (Functional)    (None, 4, 4, 2048)        21802784

dropout (Dropout)            (None, 4, 4, 2048)        0

global_average_pooling2d (G  (None, 2048)              0
lobalAveragePooling2D)

flatten (Flatten)            (None, 2048)              0

batch_normalization_94 (Bat  (None, 2048)              8192
chNormalization)

dense (Dense)                (None, 512)               1049088

batch_normalization_95 (Bat  (None, 512)               2048
chNormalization)

dropout_1 (Dropout)          (None, 512)               0

dense_1 (Dense)              (None, 256)               131328

batch_normalization_96 (Bat  (None, 256)               1024
chNormalization)

dropout_2 (Dropout)          (None, 256)               0

dense_2 (Dense)              (None, 128)               32896

batch_normalization_97 (Bat  (None, 128)               512
chNormalization)

dropout_3 (Dropout)          (None, 128)               0

dense_3 (Dense)              (None, 64)                8256

dropout_4 (Dropout)          (None, 64)                0

batch_normalization_98 (Bat  (None, 64)                256
chNormalization)

dense_4 (Dense)              (None, 3)                 195

=================================================================
Total params: 23,036,579
Trainable params: 1,227,779
Non-trainable params: 21,808,800
_________________________________________________________________
```

Fig2: Summary of Inception V3

The Inception V3 model is trained using a batch size of 8 and 20 epochs, as shown in figure 2. We obtained a validation accuracy of 97.6% with a validation loss of 0.0001 and a training accuracy of 93.7% with a loss of 0.2081.

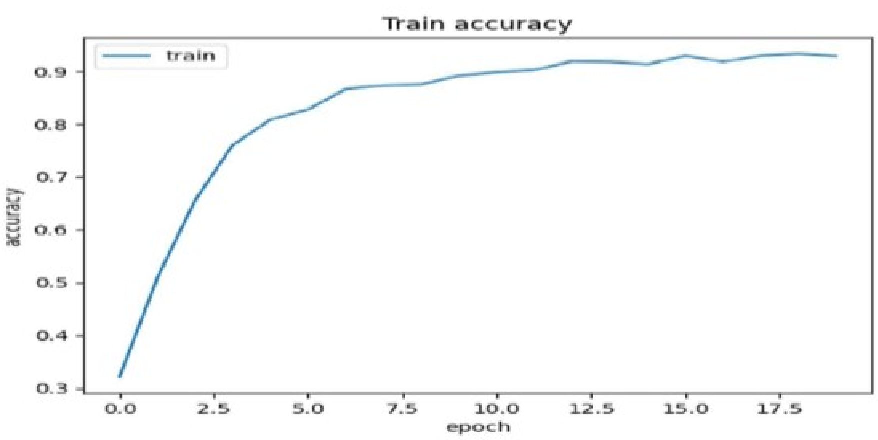


Fig 3: Train accuracy

The graph in Figure 3 above illustrates the relationship between accuracy and epochs. The Y-axis shows training accuracy, and the X-axis shows the number of epochs.

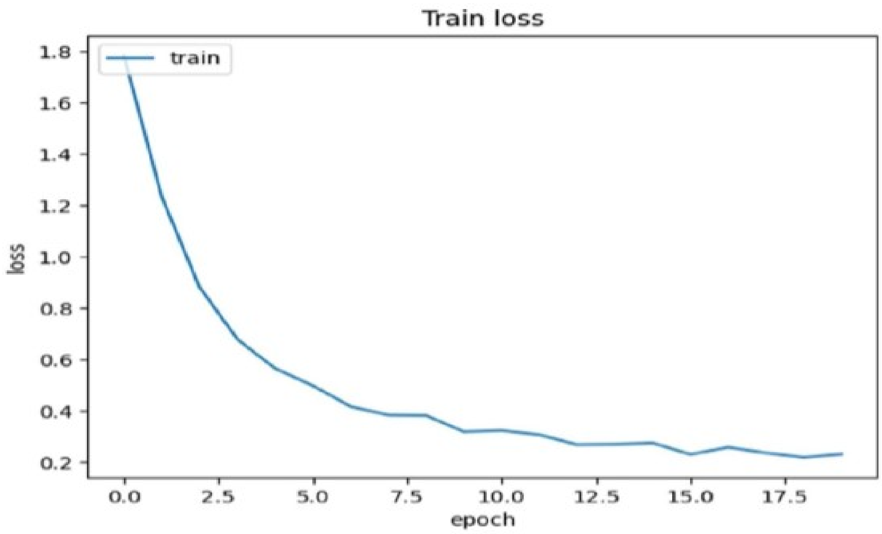


Fig 4: Train Loss

The graph in Figure 4 above illustrates the relationship between loss and epochs. The Y-axis shows training loss, and the X-axis shows the number of epochs.

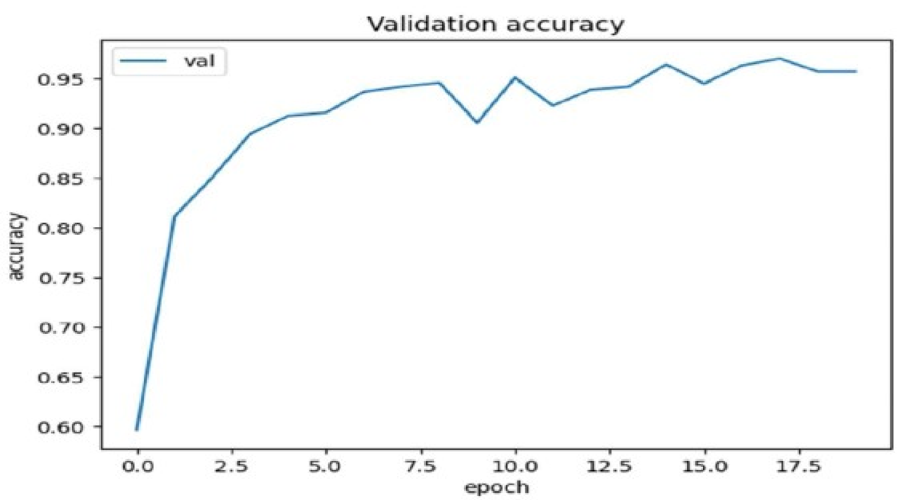


Fig 5: Validation accuracy

The graph in Figure 5 above illustrates the relationship between loss and epochs. The X-axis shows the number of epochs, while the Y-axis shows the correctness of the validation.

Fig 6: Relationshipbetweentrueand predicted class

The link between true and anticipated class is seen in the above matrix. Predicted classes are shown on the X-axis, and true classes are shown on the Y-axis.

Web Page:

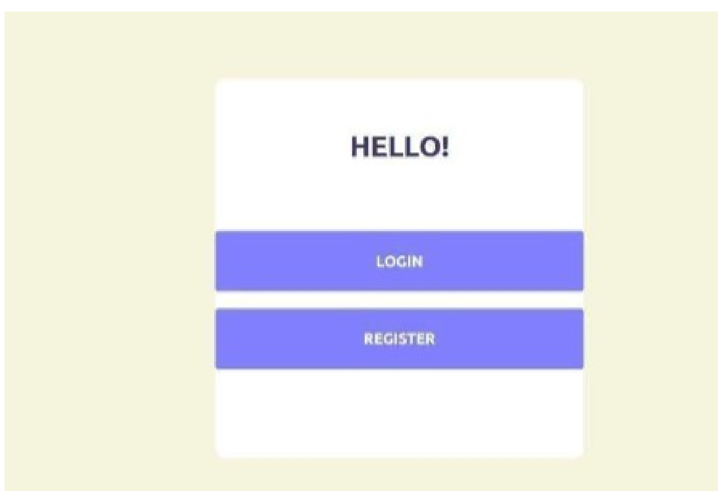
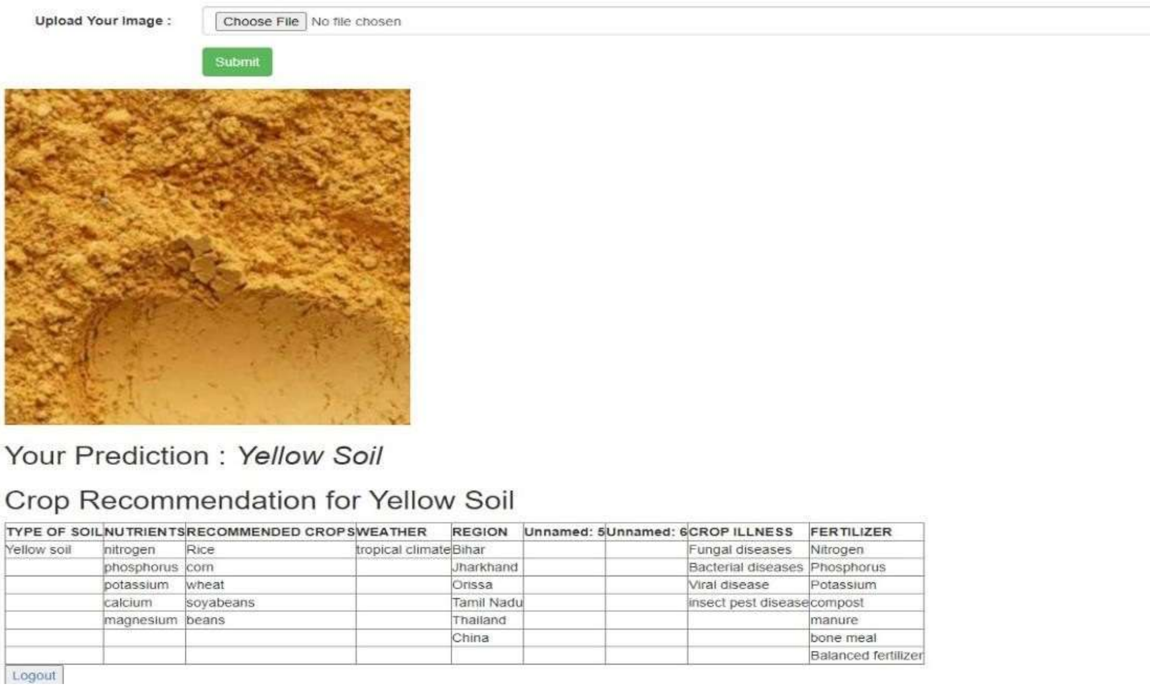
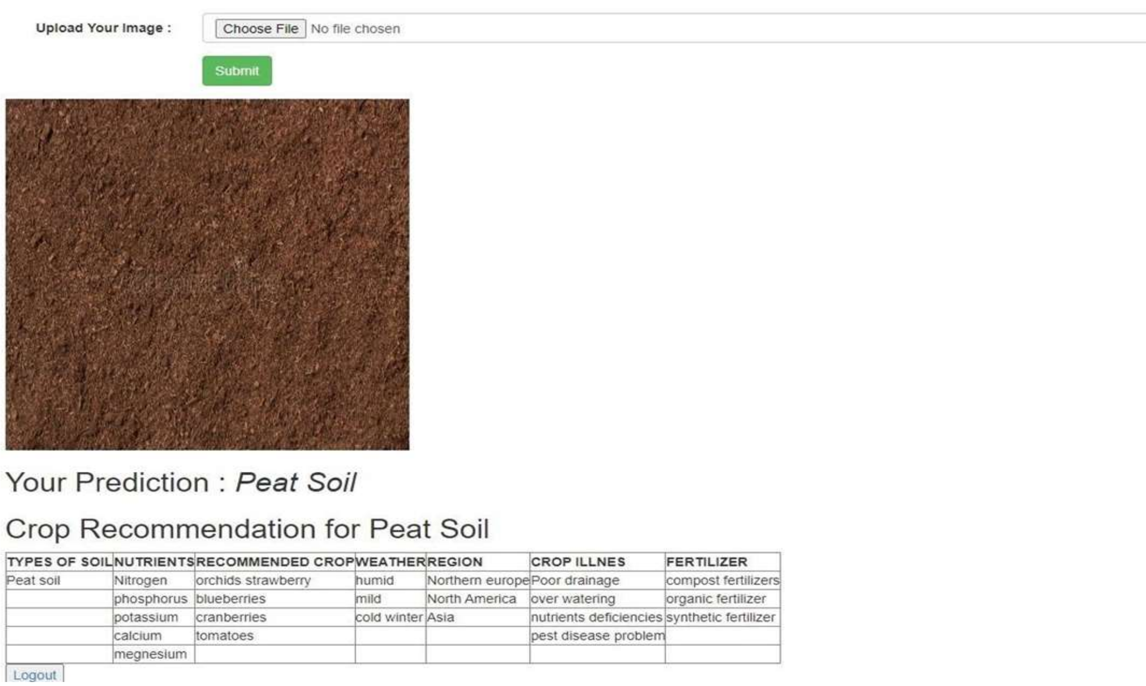


Fig 6: Login page



TYPE OF SOIL	NUTRIENTS	RECOMMENDED CROPS	WEATHER	REGION	Unnamed: 5	Unnamed: 6	CROP ILLNESS	FERTILIZER
Yellow soil	nitrogen	Rice	tropical climate	Bihar			Fungal diseases	Nitrogen
	phosphorus	corn		Jharkhand			Bacterial diseases	Phosphorus
	potassium	wheat		Orissa			Viral disease	Potassium
	calcium	soyabeans		Tamil Nadu			insect pest disease	compost
	magnesium	beans		Thailand				manure
				China				bone meal
								Balanced fertilizer

Fig 7: Crop recommendation for yellow soil



TYPES OF SOIL	NUTRIENTS	RECOMMENDED CROP	WEATHER	REGION	CROP ILLNES	FERTILIZER
Peat soil	Nitrogen	orchids strawberry	humid	Northern europe	Poor drainage	compost fertilizers
	phosphorus	blueberries	mild	North America	over watering	organic fertilizer
	potassium	cranberries	cold winter	Asia	nutrients deficiencies	synthetic fertilizer
	calcium	tomatoes			pest disease problem	
	megnesium					

Fig 8: Crop recommendation for peat soil

Upload Your Image : Choose File No file chosen

Submit

Your Prediction : *Laterite Soil*

Crop Recommendation for Laterite Soil

TYPE OF SOIL	NUTRIENTS	RECOMMENDED CROP	WEATHER	REGION	CROP ILLNESS	FERTILIZER
Laterite soil	Iron oxide mineral	Rubber	highly humidity	Brazil	Weeds	organic
	Aluminum	oil palms		Indonesia	Insect	inorganic
	phosphorus	cashew nuts		India	Fungal	balanced fertilizers
	zinc	pineaaple		Ghana	Bacterial disease	
	copper	Tea				
	magnanese					
	nitrogen					
	potassium					

Logout

Fig 9: Crop recommendation for Laterite soil

Upload Your Image : Choose File No file chosen

Submit

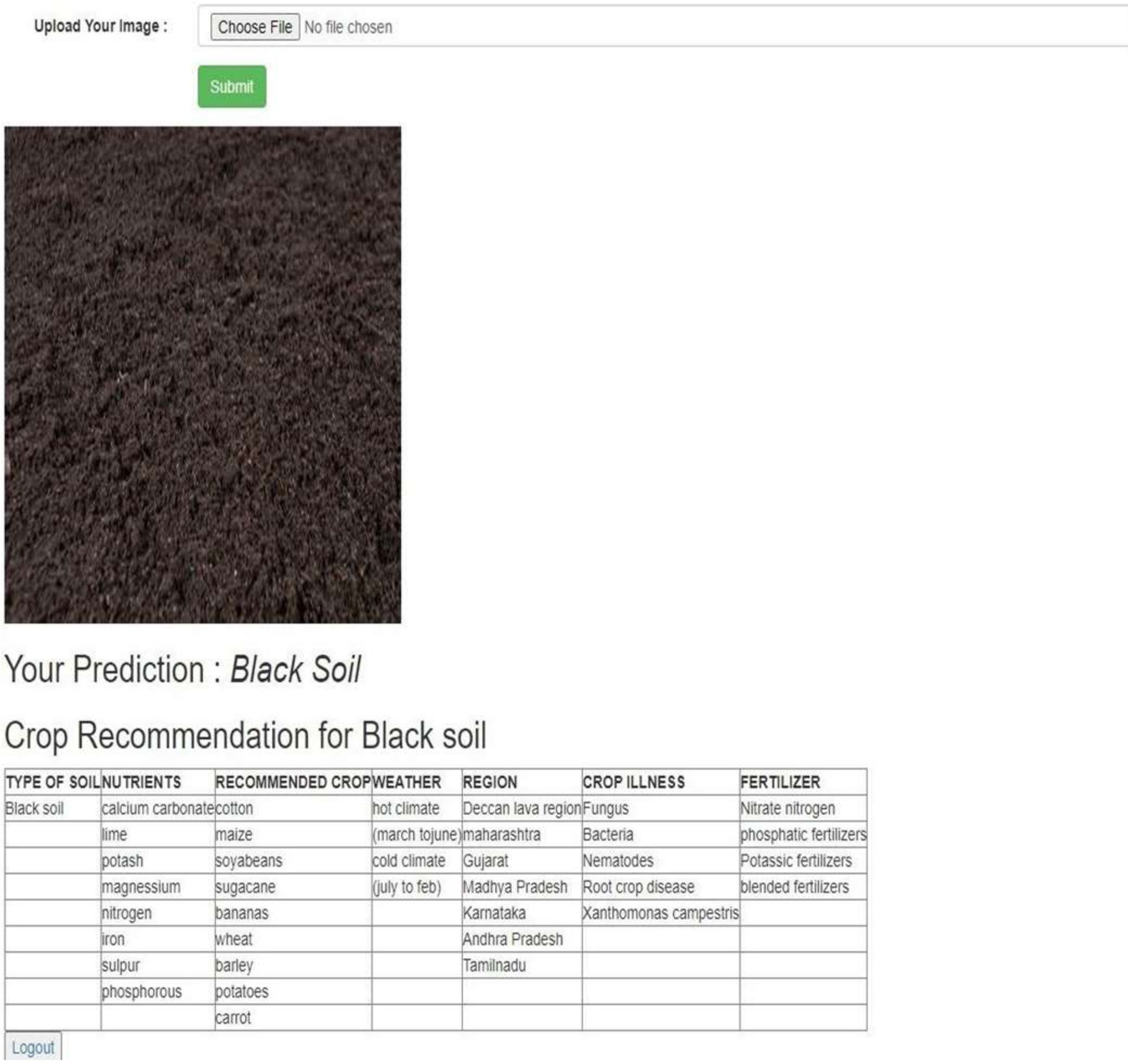
Your Prediction : *Cinder Soil*

Crop Recommendation for Cinder Soil

TYPES OF SOIL	NUTRIENTS	RECOMMRNDED CROP	WEATHER	REGION	CROP ILLNESS	FERTILIZER
Cinder soil	Nitrogen	Leafy greens	moderate humidity	Hwaii	Nutrient deficiency	Organic fertilizer
	Phosphorus	Root vegetables		The Galapagos Islands	Poor drainage	synthetic fertilizer
	Potassium	Cruciferous vegetables		The Canary Islands	pest and disease problem	balanced fertilizer
	Calcium	Herbs		The Azores	drought stress	
	Magnesium	Flowers		The Philippines		
	Sulfur	Apple		The Lesser Antilles		
		Pears		The Aegean Islands		
				The Caribbean		

Logout

Fig 10: Crop recommendation for cinder soil



TYPE OF SOIL	NUTRIENTS	RECOMMENDED CROP	WEATHER	REGION	CROP ILLNESS	FERTILIZER
Black soil	calcium carbonate	cotton	hot climate	Deccan lava region	Fungus	Nitrate nitrogen
	lime	maize	(march tojune)	maharashtra	Bacteria	phosphatic fertilizers
	potash	soyabeans	cold climate	Gujarat	Nematodes	Potassic fertilizers
	magnessium	sugacane	(july to feb)	Madhya Pradesh	Root crop disease	blended fertilizers
	nitrogen	bananas		Karnataka	Xanthomonas campestris	
	iron	wheat		Andhra Pradesh		
	sulpur	barley		Tamilnadu		
	phosphorous	potatoes				
		carrot				

Fig 11: Crop recommendation for Black soil

The figure 7,8,9,10 and 11 shows the crop recommendation for the particular soil type,weather,region,illness and fertilizer details.

IV. CONCLUSION AND FUTURE SCOPE

Inception V3 has been deployed for predicting soil composition, nutrient content, and crop health. Farmers who use smart agricultural solutions on their farms can reduce water consumption by up to 85% and energy consumption by up to 50%. They also claim a 40% increase in crop output at a 40% decrease in fertilizer and chemical treatment costs, as well as a 60% decrease in losses due to human error. Web App can be conveniently used for to access and visualize the recommendations.

The implementation of CNN can be optimized and customized for better computation efficiency and low latency. Also, information database provided to the farmers can be expanded to accommodate disease prediction and better agricultural practices.

References:

1. Weixiao Xu 1, Lin Sun, Cheng Zhen, Bo Liu ,Zhengyi Yang and Wenke Yang 5." Deep Learning-Based Image Recognition of AgriculturalPests".15th December2022. doi:https://doi.org/10.3390/app122412896.

2. Mingyuan Xin, 1andYong Wang, "Image Recognition of Crop Diseases and Insect Pests Based on Deep Learning".28 Apr 2021.Doi: https://doi.org/10.1155/2021/5511676.

3. Lili Li; Shujuan Zhang; Bin Wang. "Plant Disease Detection and Classification by Deep Learning—A Review". 08 April 2021. DOI:10.1109/ACCESS.2021.3069646.

4. T. Ojha, S. Misra, and N. S. Raghuwanshi, "Internet of Things for Agricultural Applications: The Stateof the Art," in IEEE Internet of Things Journal, vol. 8, no.14, pp. 10973-10997, 15 July 15, 2021, doi:10.1109/JIOT.2021.3051418.

5. Yuanhui Yu," Research Progress of Crop Disease Image Recognition Based on Wireless Network Communication and Deep Learning". 14 Oct 2021.doi: https://doi.org/10.1155/2021/7577349.

6. M. Ayaz, M. Ammad-Uddin, Z. Sharif, A. Mansour, and E. -H. M. Aggoune, "Internet-of-Things (IoT)-Based Smart Agriculture: Toward Making the Fields Talk," in IEEE Access, vol. 7, pp. 129551- 129583, 2019, doi: 10.1109/ACCESS.2019.2932609.

7. Diclehan Karakaya, Oguzhan Ulucan & Mehmet Turkan "Electronic Nose and Its Applications": A Survey. Int. J. Autom.Comput. 28 Dec 2019.

8. K. L. Krishna, O. Silver, W. F. Malende and K. Anuradha, "Internet of Things application for implementation of smart agriculture system," (IoTin Social, Mobile, Analytics, and Cloud) (I- SMAC), 2017, pp. 54-59, doi: 10.1109/I- SMAC.2017.8058236.

9. Chetan Dwarkani M, Ganesh Ram R, Jagannathan S, and R. Priyatharshini, "Smart farming system using sensors for agricultural task automation," 2015 IEEE Technological Innovation in ICT for Agriculture and Rural Development (TIAR), 2015, pp. 49-53, doi: 10.1109/TIAR.2015.7358530.

10. ChiranjeeviMuppala*,VelmathiGuruviah." Machinevisiondetectionofpests, diseases and weeds:

A review".April ,09, 2020. doi: 10.25081/jp. 2020.v12.6145.

11. Siyuan Yuan; Xiaonan Luo; Ruishu Xu." Crop disease recognition based on deep learning", 19th December 2022, DOI: 10.1109/ICDH57206.2022.00017.