PLANT SPECIES RECOGNITION USING DEEP LEARNING

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***Abstract*—Machine learning is a sub-branch of artificial intelligence that aims to build systems and train models to improve input data. In the present situation, machine learning models are very crucial in each aspect like data analysis, and natural language processing in both science and healthcare. In other words, machine learning is a process of making computers learn from examples and improve their accuracy without any help of explicit instructions. In this paper, we will be dealing with the automatic identification of plant species recognition is carried out based on the color, texture, shape, and size of the plants. Accurate and efficient plant seedling classification is essential for various applications in agriculture and in biodiversity conservation. To address the challenges associated with the plant seedling classification, we will be introducing the plant seedling with the convolutional neural networks and image processing dataset with contains different plant species with the labeled images that are present in the dataset. We will be pre-processing and training data to get accuracy, confusion matrix, and overall performance.**

***Index Terms*—Normalization, accuracy graph, confusion matrix, convolutional neural network, image classification algorithm, plant seedlings,label encoder, pre-processing, model evaluation, Feature extraction.**

I. INTRODUCTION

The classification which is made on plants using deep learning is a method that will be identifying and categorize the plant species based on their colour, size, shape, texture, and other physical characteristics. It mainly involves the automatic classification and recognition of different plant species based on the labeled images using their seedling's growth rate under different climatic conditions and temperatures. The main objective of this project is to make an accurate and efficient system to identify and classify plants in the early stage of growth itself.

The project mainly involves the collection of different plant seedlings from different types of plants, which are encountered with their respective labels or species. The dataset which can be used can get collected from different laboratories, fields, and soon. The images which we are using can be captured by using RGB and infrared imaging. And we need to pre-process the dataset to remove the background noise because it should not cause any issues while we are performing the classification process.

In this project, we will be using deep learning algorithms like CNN (convolutional neural network) then we will train the dataset based on the features where it can help to distinguish

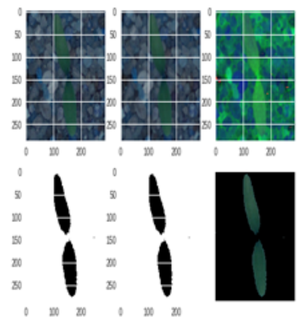

Fig. 1. Demonstrating the growth rate of the plant species.

the different types of plant species based on the different growth of their seedlings. The trained model is used to classify the new seedling's images based on their respective plant species. The model performance can be evaluated on the validation dataset to calculate or measure the accuracy and prediction.

One of the challenges in this plant seedling classification using deep learning is the appearance of the same species due to the different types of factors like soil conditions and growth rate. To overcome this type of challenge, we will be performing data augmentation techniques that can be applied to the trained dataset.

Therefore, making use of this plant classification using deep learning gives the ability to identify and classify the different plant species in the early growth stage. While there are many challenges in developing accurate and efficient plant seedlings classification, these deep learning techniques are continuously improving the performance of plant seedlings.

II. BACKGROUND

The background knowledge used in this plant seedling classification using deep learning includes different techniques and technologies which are listed below.

A. Computer vision

This vision is a field of study that ensures the computers analyze the visual data which is present around them. Computer vision techniques are important for image processing and analysis, which is needed for plant seedlings classification.

B. Deep Learning

Basically deep learning is a sub-field of machine learning that uses multiple layers to recognize the data. The techniques show a clear representation of classifying images.

C. Convolutional Neural Network

CNN is a type of deep algorithm that is mostly used in image classification tasks. This model is useful for recognizing and identifying plant species.

D. Dataset Preparation

Image datasets are crucial for training and evaluating the models for classification. The datasets should be prepared properly, with labeling each image based on the plant species they represent.

E. Data augmentation

The data augmentation techniques will increase the diversity of the training dataset, by creating different images through different techniques.

F. Model evaluation

The performance of this plant classification should be evaluated carefully to measure the overall accuracy and obtain the confusion matrix.

By making an understanding of these helpful concepts and techniques we can develop and implement the plant seedling classification by making use of deep learning.

III. Literature Survey

In the paper by Aravind Krishnaswamy Rangarajan et.al. [1], a model was developed using CNN models to detect six different tomato plant diseases from seven classes. The authors employed a transfer learning approach, utilizing AlexNet and VGG16 net. Results showed that the accuracy of classification achieved with AlexNet and VGG16 net was 97.49% and 97.23% respectively, using a dataset of 13,262 images. VGG16 net performed better than AlexNet in most cases, and both models achieved higher accuracy when a batch size of 373 (the maximum number of images in one of the classes) was used.

In their paper,Jing Wei Tan et al. [2] proposed a novel CNN model, which they named D-Leaf Plant Species Classification using Leaf Vein Morphometric. They employed RGB to grayscale conversion of images, followed by Sobel segmentation to identify the region of interest (ROI) from the images. The ROI was further skeletonized to obtain a clear vein architecture. For feature extraction, they utilized three CNN models, namely pre-trained AlexNet, fine-tuned AlexNet, and a newly designed D-Leaf model. These models, when combined with ANN classifiers, yielded the best accuracy compared to other classifiers. A comparison between AlexNet and D-Leaf models revealed that AlexNet is more complex than D-Leaf, and that a system with more convolutional layers necessitates a longer execution time.

The paper [3] presents a flower classification system using Deep CNN and data augmentation. Three machine learning algorithms were compared for classification purposes. The proposed system achieved high accuracy on Oxford-17 and Oxford-102 flower datasets. Esraa Hassan et al. [4] proposed a CNN-based classification algorithm using transfer learning and obtained an accuracy of 97%. Here computer vision techniques are used.

IV. DATASET

WE choose dataset from kaggle [8] For choosing the dataset for plant seedlings classification using deep learning is critical for measuring the accuracy and performance. The dataset used is the plant seedlings dataset which contains 4,270 images of 12 different plant species.

```
In [8]: train_Y['plant species'].value_counts()

Out[8]: Loose Silky-bent              654
        Common Chickweed              611
        Scentless Mayweed             516
        Small-flowered Cranesbill     496
        Fat Hen                       475
        Charlock                      390
        Sugar beet                    385
        Cleavers                      287
        Black-grass                   263
        Shepherds Purse               231
        Common wheat                  221
        Maize                         221
        Name: plant species, dtype: int64
```

Fig. 2. Demonstrating the dataset which we used in the project.

These are the different types of plant species we are using like maize, sugar beet, common wheat, loose silky-beet, common chickweed, Scentless Mayweed, and soon. And each different plant species is represented with the count label. so, the count label indicates the total no of species counts which are represented in the labeled images.

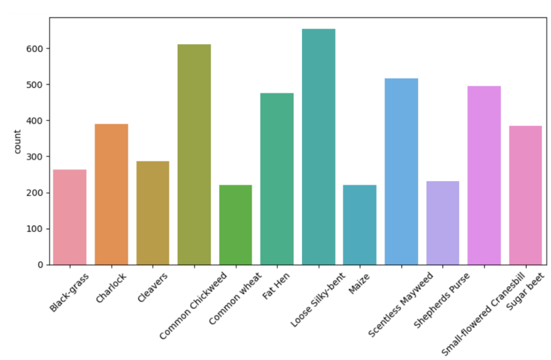

Fig. 3. This image describes the no of plant species and describes the count of each species.

V. TERMINOLOGY

A. MACHINE LEARNING

In machine learning, the dataset is divided into training and testing. A learning model is built by inputting the training data in multiple iterations. Once the model is built, the model is applied to the testing data to predict the output and calculate the accuracy of the model.

B. CONVOLUTIONAL NEURAL NETWORK

Convolutional Neural Network (Conv Net/CNN) is a Deep Learning algorithm that can take in an input image, assign performance (learnable weights and biases) to various aspects/objects in the image, and be able to differentiate one from the other. In the stage of pre-processing required in a Conv Net is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, Conv Nets can learn these filters/characteristics. A Conv Nets architecture was influenced by how the visual cortex is organized and is like the connectivity network of neurons in the human brain. Only in this constrained area of the visual field, known as the receptive field, do individual neurons react to stimuli. The entire visual field is covered by a series of such fields that overlap.

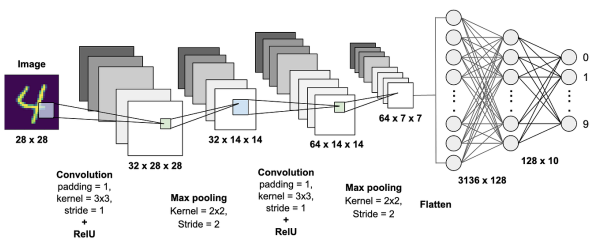

Fig. 4. An CNN sequence to classify hand-written digits. [7]

C. POOLING LAYER

The pooling layer, like the convolutional layer, oversees shrinking the convolved feature through dimensionality reduction, the amount of computing power needed to process the data will be reduced. Furthermore, it aids in properly training the model by allowing the extraction of dominating characteristics that are rotational and positional invariant.
Max pooling and Average pooling are the two different types of pooling. The maximum value from the area of the image that the kernel has covered is returned by Max pooling. The average of all the values from the area of the image covered by the kernel is what is returned by average pooling, on the other hand.

D. ACTIVATION FUNCTION

An activation function decides whether a neuron should be activated or not. This means that it will decide whether the neuron's input to the network is important or not in the process of prediction using simpler mathematical operations.
The activation function in a neural network oversees converting the node's summed weighted input into the activation of the node or output for that input.
If the input is positive, the rectified linear activation function, or ReLU for short, will output the input directly, if it is negative, it will be output zero. Because a model that utilizes it is simpler to train and frequently performs better, it has evolved into the standard activation function for many kinds of neural networks.

E. CONFUSION MATRIX

A confusion matrix is a tabular representation used in machine learning to evaluate the performance of a classification model by comparing the predicted labels against the actual labels of a dataset. It is commonly used in binary classification problems where the output can be classified as either "positive" or "negative".

F. IMAGE DATA GENERATOR

The ImageDataGenerator is a function that is used in deep learning such as Keras, and TensorFlow which are basically used for data augmentation during training. Many techniques like rotation and, flipping are performed.
This Generator immediately loads the images in the directory and gets converts them into tensors and augments them. It is a tool for maintaining all large datasets, which helps improve performance, precision, and robustness.

G. LABEL ENCODER

This label encoder is a type of pre-processing method that we use in machine learning, where it converts categorical information into numerical information. This label encoder is easy and effective to use for categorical variables. Mainly this label encoder is available in the python libraries like sci-kit-learn, tensor flow, and soon.

VI. MODULES/PACKAGES

A. PANDAS

Pandas are a tool that we use in machine learning, with the help of this package we will be pre-processing the data and analyzing it. This panda's package is used to handle all the errors and the missing values that are present in the data and the data-related issues will be cleared by using this package in machine learning.
Import pandas as pd.
With the above representation, we will be representing this package.

B. NUMPY

The package NumPy is a Python library, which is used in machine learning. All mathematical operations are performed by using this package. Here we will be manipulating and pre-processing the data. The package is used for large and complex datasets. Overall, this package provides a framework for all the datasets.
Import numpy as np.
With the above representation, we will be representing this package.

C. SKLEARN

Sklearn or Scikit-learn is the most common library we will be using for machine learning. This package involves many machine learning algorithms like linear regression, random forest, and soon. This package is easy and efficient to use.
Import sklearn
With the above representation, we will be representing this package.

D. MATPLOTLIB

Matplotlib is a popular library we will be using this package for the creation of data visualizations for 2D and 3D. By making use of this library, we will be plotting the graphs among the data provided. Along with pandas and numpy, we will be integrating this matplotlib package.
Import matplotlib.pyplot as plt

E. SEABORN

Basically, the Seaborn is a type of Python data visualization library that is used in machine learning that is used to create data visualizations. Upon the matplot library, this package is used. This seaborn is used in different plots that are present in machine learning.

VII. METHODOLOGY

The methodology for plant classification basically involves the below following steps:

- Data Collection
- Data pre-processing
- Feature Extraction
- Training the model
- Evaluation
- Deployment

A. Data Collection

In this data Collection, the dataset contains the image of plant classification. The images are described from different angles and different positions, and they specify plant seedlings. The dataset we consider is a supervised learning dataset with 12 unique class labels. And total training dataset consists of 4,270 images.

B. Data Pre-processing

The steps we used are Image resizing, Image Normalization, and Label Encoding.
We resized the images to 256 x 256 pixels. Pixel values were normalized in a range [0-1] This normalization gives better training results. Label encoder is used to convert categorical values of plant species labels to numerical values. During the training phase, we used a real-time data augmentation technique to reduce overfitting. This technique is useful because we have an imbalanced dataset.
The selected augmentation techniques were rotation range of 0° to 180°, zooming in a range of 0-10%, height-shift, and width-shift in a range of 0-10%, and horizontal flip and vertical flip. We split our dataset randomly in the ratio of 80% and 20% split, 80% for training the model, and 20% for validation data.

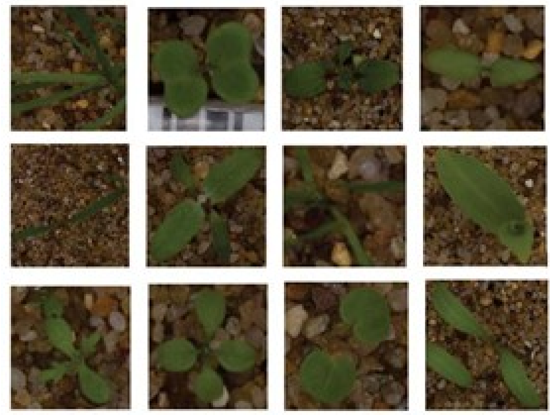

Fig. 5. 12 different plant species in the dataset.

C. Feature Extraction

Features are extracted from the pre-processed images which remove all the noise and dirty data so that it will be helpful for the classification process to classify the images. We will be training the model by using the CNN model.
Here we applied the feature extraction process by creating a Boolean mask and applied it to every image in the dataset to remove the background from every image so that the training results can be better.

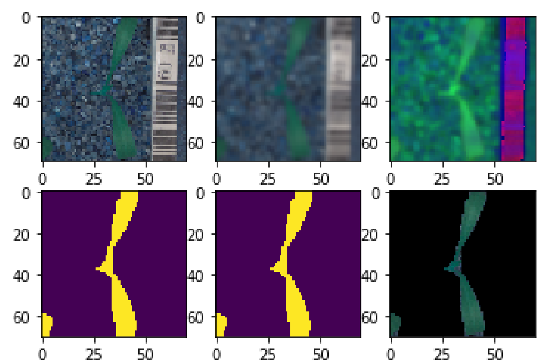

Fig. 6. Mask used to remove background.

D. Model Selection

The chosen model is a Convolutional Neural Network (CNN) Sequential model in Keras, which consists of multiple layers including Conv2D, MaxPooling2D, Dropout, Batch Normalization, and Dense layers.
The architecture of the model includes three sets of Conv2D and MaxPooling2D layers with different filters and kernel sizes, followed by Dense layers with activation, batch normalization, and dropout. The final output layer has a SoftMax activation function with 12 classes for classification.

E. Training the model

After splitting the training data, we had 3800 data for training and 950 data for validation. We took 20 epochs for fitting the data into the model. The batch size was set to 20 for better learning. Adam was used as an optimization function with a .0001 learning rate. We used categorical cross-entropy as a loss function as we had multi-class data.

F. Evaluation

The trained model is evaluated on validation dataset to assess validation performance and accuracy.
After evaluation the model, we got the accuracy of 80.2% accuracy and we generated accuracy and loss plots and generated confusion matrix from true and predicted labels.

VIII. RESULTS

The accuracy plot obtained is

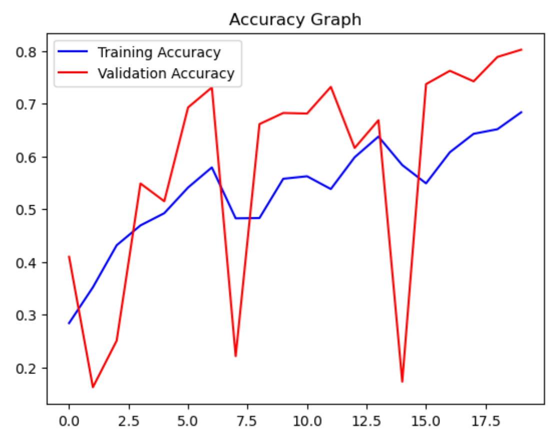

Fig. 7. Accuracy plot

The loss plot obtained is

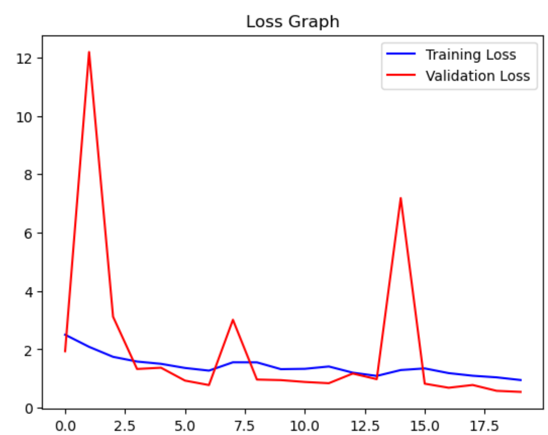

Fig. 8. Loss plot

We obtained the accuracy of 80.2%

The confusion matrix obtained after generating predicted and true labels are:

We tested our model with test data and made the prediction with different images in test data

```
[20]: score, accuracy = model.evaluate(X_test,Y_test)
      print('Validation score:', score,'   Validation accuracy:', accuracy)        ###Accuracy

30/30 [==============================] - 175s 6s/step - loss: 0.5453 - accuracy: 0.8021
Validation score: 0.5453482866287231    Validation accuracy: 0.8021052479743958
```

Fig. 9. Accuracy obtained

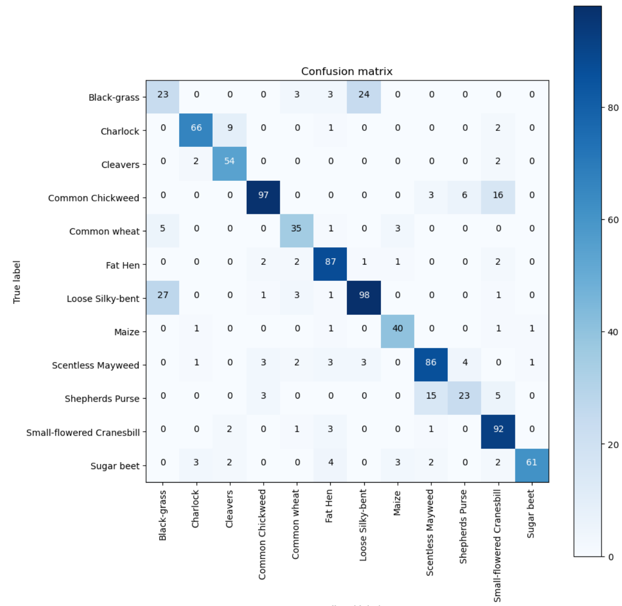

Fig. 10. Demonstrates the confusion matrix for true label and predicted label for 12 different species

IX. IMPLEMENTATION DIFFICULTIES

- As the dataset we selected is large, the time took for training the model is high.
- And we have access to the less labeled data in the training dataset.
- The samples in the classes are different so there is class imbalance and model training and accuracy is effected
- Since we used dataset where palnt seedlings images are at early growth stage so it affected the accuracy
- Since we dont have GPU, it also affect our model training

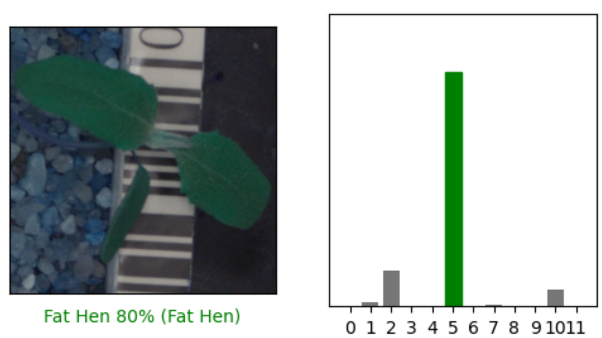

Fig. 11. Demonstrates prediction with test data.

X. CONTRIBUTIONS

- Naga Satwika Kakarla-pre-processed the steps like data augmentation and normalization. An introduction in the documentation.
- Priyanka Reddy Mainampati-Trained the model and calculate the accuracy. And implementation and literature survey in the documentation.
- Nikhil Kumar Reddy Apur- Generated the performance metrics like confusion matrix and loss graph. And results and conclusion in the documentation.

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