Flower classification using CNN models & Ensemble method

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***Abstract*—One of God's most exquisite creations, flowers come in countless varieties of species and hues. Numerous flowers can be seen everywhere. There are currently around 352,000 different species of flowers. One flower genre has lots of species. Plumeria has many species, such as Candy stripe, Vera Cruz Ros, Sundance, Thailand red, and many more. As a result, there are a lot of flowers, but people can't recognize which specific species and what is the current condition of the flower. To solve that problem, A strategy is suggested to solve the issue and identify the flower and its current status. Object recognition from a picture is currently quite promising with the use of machine learning algorithms, albeit there are still some difficulties. A method is put forth using CNN's classification of a Plumeria flower data set. We used vgg16, vgg19, and inception v3 and got 80%, 81%, and 81%, respectively, and after ensembling, the method gave us 81 % accuracy.**

Keywords: CNN,VGG-16,VGG-19,Inception V3,Flower Classification.

I. Introduction

In this paper, Convolutional neural networks are introduced to effectively detect flowers by only inputting an image of the target flower. We commonly witness a flower and become amazed by it. But It is nearly impossible for a casual observer with little understanding of flower species to identify them correctly. Their appearance in a broad range of colors and shapes makes it difficult to recognize a flower. The conventional approaches for classifying images typically extract the image's size, color, and texture features. It is easier to find information about any flower by browsing the internet. If the flower image or name is missing, no one can find any clear information about it. Using the CNN method, we are trying to recognize the state of a Plumeria flower. For this, we are trying to recognize the state of the flower, whether it is blooming, already bloomed, or rotten, by using machine learning algorithms. The flower is a glamorous and extraordinary reproductive part of a plant. So, Recognizing flowers can enable us to learn further details about the plant. The color and shape of flowers are their two most characteristic features. The model can be trained using those features to identify whether the flower is Pre-bloom, Bloom, or Post-Bloom. There are not enough methodologies yet constructed to identify the stages of any flower. People have tested in many ways to recognize different flower species, flower recognization but we are trying to categorize a flower into three stages. Thus our research methodology is to help everyone smoothly identify the flower in which state it belongs to. This study will help farmers easily identify flower states without any experts. In our study we present flower classification research, We have created an effective model for classifying plumeria flower images. To create this methodology, we applied a Convolutional neural network (CNN) to build the method. We have combined these three CNN models which are the Inception V3 model, VGG 16 model, and VGG 19 model, and we got the best prediction. We used our own dataset to predict the flower and got our result. This paper was organized as follows: To begin with Section I is an Introduction, and Section II is our study background

and related works. Following, In Section III, our proposed methodology is discussed. Section IV is for experimental Results and Discussion. Then, Section V is for the conclusion.

II. Background and related works

Recognition of Flower Species is very difficult because flowers are similar in size and color. Classification of flower species will help the development of the pharmaceutical industry, food, and cosmetics industries. The authors used several methods to recognize the flower species. They got the highest accuracy by using Inception ResNetV2 (Acc: 92.25%). [2] It is challenging for humans to identify the right pharmaceutical plants. For that, An skilled botanist's intuition is needed. This paper author presents a CNN model based on Medicinal Plant Recognition. On their CNN model, they used several layers of Convolutional, Max Pooling, Batch normalization, Gaussian noise, and Dropout. Their proposed model gave almost 71.3 % of accuracy. [3] The authors used R-CNN to Detect the strawberry flowers in the outdoor field, Three types of R-CNN were used for this study. R-CNN model, Fast R-CNN model, and Faster R-CNN model. (The detection rate for these three models, R-CNN, Fast R-CNN, and Faster models, were 63.4 % accuracy, 76.7 % accuracy, and 86.1 % accuracy) [4] The authors mainly used the CNN model and compared it with another traditional algorithm. They used a CNN model in which has first five blocks are from FCN and 6-8 are from convolutional layers with 51 feature maps. They found the top accuracy 82.56 % [5] The authors used the CNN Inception V3 model with the help of transfer learning. Transfer learning methods were used to keep the last parameter of the model and remove the last layer of the present. The authors used both oxford-17,102 datasets for this classification and achieved 95% of accuracy. [6] There are millions of different species and colors of flowers that exist in the world. It takes a botanist who has advanced knowledge and abilities to recognize each of the flowers. The authors used CNN model to recognize the flowers and used several Convolutional layers, the ReLU activation function, Both Pooling layers were used max and average, and finally, they used fully connected(FC) layers. Their model attained an overall accuracy of 90 %, and 98.46 % accuracies were obtained on hibiscus flowers which were captured in real-time by a smartphone camera. [7] A significant area of study in image processing research and computer vision research is image classification. Authors of this paper used feature extraction to classify a flower during the segmentation period with the help of a multiple-layered Neural network. Several segmentation types were applied to classify flower images and achieved 68 % accuracy. [8] In this paper, The authors created a method for taking pictures in order to record observations about blooming plants. For an entire plant, their model gave 77% of accuracy when all the species' averaged accuracy levels were up at 97%. Flower frontal view generated 88% and top view 96% of accuracy. Inception-ResNet-v2 CNN model architecture was used to classify flowers and leaves [9] Rupinder Kaur, Anubha Jain, Sarvesh Kumar used an automated harvesting system implemented on the segmentation of flowers to understand and recognize sunflower plants by reading flowers' seeds and leaves. They used digital capturization, Data-set Formation analysis image, machine learning algorithm, and recognition and classification. By using these methods, they got an accuracy of 89 % to get an optimized classification of sunflower recognition through machine learning. [10] Authors have used the FCN method to segment the flower, which was performed for flower localization. They also used VGG-16 ImageNet CA for initializing their FCN and CNN model consequently. They also used Stochastic Gradient Descent(SGD) to optimize the parameters. [11] Ali Yazdizadeh, Zachary Patterson, Bilal Farooq developed an ensemble CNN method by using a series of CNN models and their study finds 85% of accuracy. [12] The author used CNN for image classification of fruits. They used CNN, deep learning for fruit classification. They got 94.94% accuracy With a 13-layer CNN model. [13]

III. Methodology

A. Data collection

Our data set contains three classes of Plumeria flowers. There are many kinds of Plumeria flowers. Such as Plumeria alba,Plumeria rubra,Plumeria pudica,Plumeria obtusa,Plumeria clusioides etc. A new data set using plumeria flowers was created for these different species of plumeria flowers. Some of our data were physically collected with the help of the smartphone, and some of The data were collected from different websites. We separated our whole data set into three different categories Bloom, pre-bloom, and post-bloom, and divided our data set for image training, validation, and testing. For training, we used 2991 flower images. For validating, we used 428 flower images. And for testing, a total of 854 flower images were used.

Fig. 1. Sample Images of Plumeria Dataset

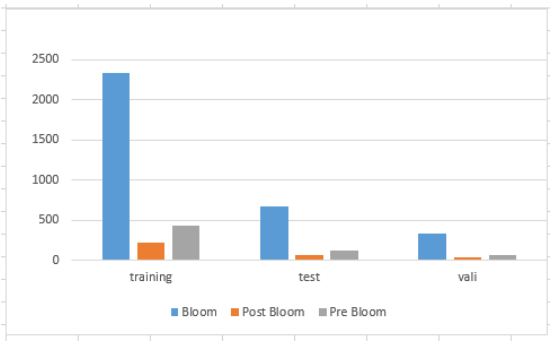

Fig. 2. Data set graph distribution by classes

B. Data Pre-Processing

When we collected the data, the shape and format of the data were different. All images were resized into 250x250 pixels, and the pictures were assembled into RGB. They were also converted into JPG. Data augmentation was used to avoid over-fitting. Eight augmentation techniques were applied to our data set:

1) Rotation (20)
2) Horizontal flip (True)
3) Vertical flip (True)
4) Shear Range(0.2)
5) Re-scale(1./255)
6) Height-Shift Range(0.2)
7) Zoom(0.2)
8) Width-shift Range(0.2)

C. Proposed Method

The Convolutional Neural Network model (CNN) applied in this study are VGG-16 and VGG-19 and Inception V3(fig.3).The main goal was to determine the state of a Plumeria flower. These models were chosen because the basic structures of VGG16 and VGG19 each have sixteen weight layers and nineteen weight layers,respectively. [14]

1) VGG-16: Generally VGG-16 model has an Input layer, Several hidden layers, and an output layer. Hidden layers contain multiple layers like Convolutional layers, Max Pooling layers, Rectified Liner Unit (ReLU) layers, and Fully connected layers. [15] A fixed-size 250x250 RGB image set is also given on the inputs. We split the data set into three categories: Train, Test, and Validation. Figure 3 architecture consists of 2 Convolutional layers (250x250 and 64 filters). All Convolutional layers have a (3x3) kernel size. The model has (2x20) Max-Pooling with strides at (2x2) in each dimension. An activation function Rectified Linear Unit(ReLU 1) is used to improve the non-linearity property by removing non-negative values from an activation map.

$$ReLU\,function : f(x) = \left\{ \begin{matrix} 0, x < 0 \\ x, x > 0 \end{matrix} \right\} \quad (1)$$

Additionally, we included batch normalization, which normalizes each layer's input for each mini-batch. Batch

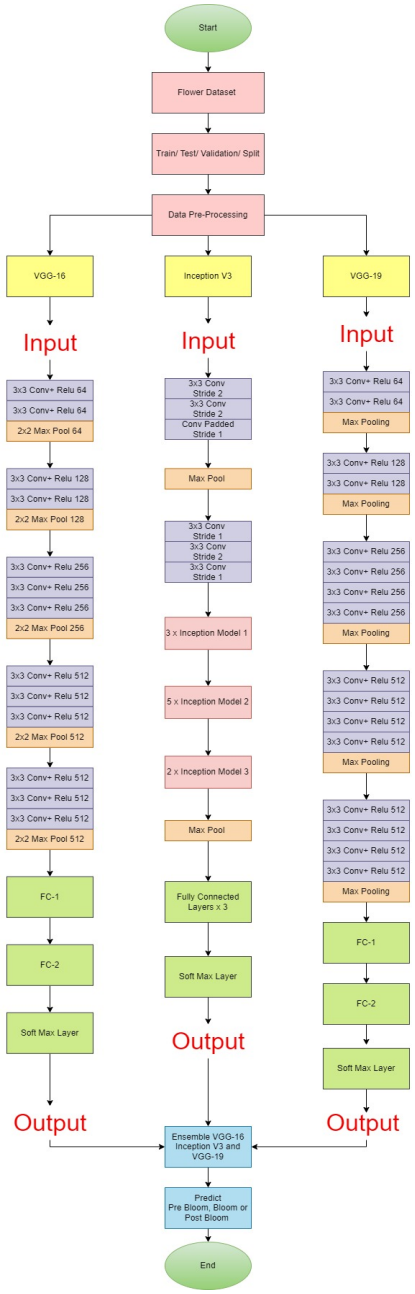

Fig. 3. Architecture Diagram

normalization helped us to improve the learning process. The output layer of the convolutional neural network displays the class probabilities. It is calculated using a "Softmax function(2)," also applied in our network.

$$Softmax : \sigma(z_i) = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}} \quad for\ i = 1, 2, \ldots, K \quad (2)$$

2) VGG-19: VGG-19 is another convolutional neural network we used to get the results. VGG19 contains the same basic architecture as VGG16 except for three additional convolutional layers.VGG-19 has 16 convolution

layers, 3 Fully connected layers,5 MaxPool layers, and 1 SoftMax layer. In VGG-19, there are two fully connected layers. In the first fully connected layers, we used 128 neurons, and in the second fully connected layers, we used 256 neurons, and max pooling layers were used as a handler to reduce the size of the volume. The final adjustment, dropout rate, made the network less sensitive to the particular weights of the neurons. We decided to use the "Adam" optimizer to learn the weights. The sparse categorical cross-entropy loss is applied as a loss function. Designing a deep neural network starts with a constant and modest convolution as the basis. [16]

3) Inception V3: Convolutional neural network's classification model includes Inception-v3.The Inception-V3 model is an updated form of the Inception series model. The Inception - V3 features a complex design with several simultaneous convolutional layers, although it only has a few parameters. Because there are fewer parameters utilized, the model may be implemented in one with fewer memory requirements and run faster. [17] Inception – V3 is the 48-layered convolutional neural network model. The image size of the flower was 250x250. Like other CNN models on the Inception V3 model, we used convolutional, max pool, and finally three fully connected(FC) layers. In the first FC layer, we used 512 neurons, and in the second fully connected(FC) layer, we used 256 neurons, and dropout was the same as 0.1 only. In the third fully connected layer, we used 128 neurons, and the dropout was 0.1
4) Ensemble method: In Ensemble learning, different models are trained using the same Dataset, predictions are made using each model, and then the predictions are combined in some way to provide the final prediction. Ensemble models are complex machine learning methods that improve performance overall by combining outcomes from many models. [18] In terms of accuracy, ensemble models outperform any single CNN model. [19] That's why we chose this technique. During our study, we used three CNN models and emsembled them. To boost classification accuracy, ensemble approaches often involve training with several types of CNN models and then combining their output results by using a voting technique or averaging technique. [20] Those CNN models are VGG-16 model, VGG-19 model, and Inception V3 model. These models were used to predict the state of a plumeria flower if it is Bloom, Pre Bloom, or Post Bloom. During our project, we ran each model, then trained and predicted them. After completion, we saved each model in hdf5 file format. During the approach of our Ensemble method, we loaded three models individually to list them together, and we also predicted them. The amax NumPy function is used to generate an array's maximum value. It picked each model's highest values to set the final result.
5) Experiment Setup: In this section, we discuss the experimental environment, implementation, and necessary library needed to complete our project.

Implementation: We implemented all the experiments related to this study by using the latest version of python Python, which is 3.9.5. We also used the TensorFlow library developed by google engineers version (2.6.0) and the latest version of Keras, which is 2.6.0; they were all set up on a traditional computer that could run the Nvidia GeForce GTX 1660Ti GPU. additionally, our computer has a Random-access memory (RAM) capacity of 16.0 GB, which holds a 3.70 GHz-4.60GHz Intel® Core™ i5-9600K Processor with 16 threads and 9 MB Intel® Smart Cache.

Importing the necessary libraries: We used various libraries, such as Numpy. Numpy was used to convert the image into the array. Pandas were used to achieve better performance. We used other libraries such as Matplotlib, os,cv2, pickle, seaborn, and visual-keras. Our projects were done using the anaconda software and jupytar notebook on our computer's local environment.

IV. Result and Discussion

In this section, we have discussed our performance, accuracy, and loss. In the first section, we will discuss the accuracy of the VGG-16, VGG-19, and Inception V3 models. At last, we will discuss these three models using Ensemble methods to make our final result, including our loss.

A. Result of VGG-16 Architecture :

During VGG-16 model training (From fig.4,5,6), we train the data set with 30 epochs. It takes 94 seconds to run the first epoch, and the rest of the epoch runs for 55 seconds. It took 28 minutes and 15 seconds to complete the whole training. Then after training VGG-16, we get 81% of accuracy.

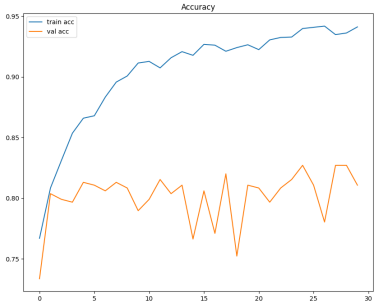

Fig. 4. VGG-16 model's Accuracy graph

B. Result of VGG-19 Architecture :

During VGG-19 model training(From fig.7,8,9), we train the data set with 30 epochs. It takes 147 seconds to run the first epoch, and the rest of the epoch runs for 64 seconds. It took 34 minutes to complete the whole training. Then after training VGG-19, we get almost 80% of accuracy value.

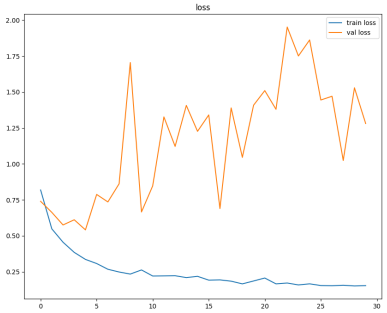

Fig. 5. Loss of VGG-16

```
Epoch 29/30
2991/2991 [==============================] - 55s 18ms/step - loss: 0.1515 - accuracy: 0.9361 - val_loss: 1.5293 - val_accuracy:
0.8271
Epoch 30/30
2991/2991 [==============================] - 55s 18ms/step - loss: 0.1536 - accuracy: 0.9412 - val_loss: 1.2888 - val_accuracy:
0.8107
```

Fig. 6. Last two epochs of VGG-16

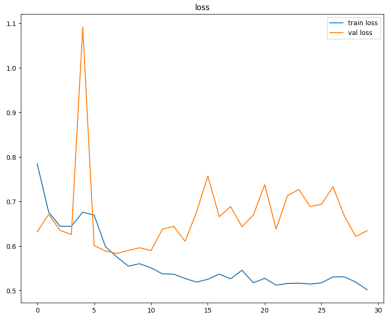

Fig. 8. Loss of VGG-19

```
Epoch 29/30
2991/2991 [==============================] - 67s 22ms/step - loss: 0.5190 - accuracy: 0.8519 - val_loss: 0.6215 - val_accuracy:
0.8014
Epoch 30/30
2991/2991 [==============================] - 65s 22ms/step - loss: 0.5018 - accuracy: 0.8566 - val_loss: 0.6344 - val_accuracy:
0.8014
```

Fig. 9. Last two epochs of VGG-19

C. Result of Inception V3 Architecture :

During Inception V3 model training(From fig.10,11,12), we train the data set with 30 epochs. It takes 117 seconds to run the first epoch, and the rest of the epoch runs for 62 seconds. It took 32 minutes to complete the whole training. Then after training Inception V3, we get 81 % of accuracy.

D. Result of Ensemble Approach and Predction

The result from this ensemble approach satisfies our expectations. we ensembled VGG-16, VGG-19, and Inception V3, we got 81% accuracy from VGG-16,80% from VGG-19, and 80% from inception v3.finally our ensemble method gives us almost 81% accuracy. Based on this performance, we tried to predict the plumeria flower state.

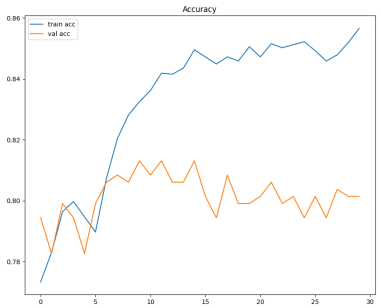

Fig. 7. VGG-19 model's Accuracy graph

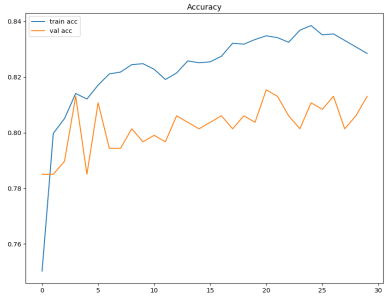

Fig. 10. Inception V3 model's Accuracy graph

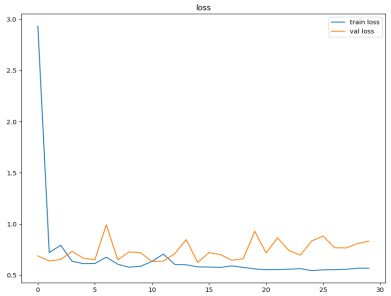

Fig. 11. Loss of Inception V3

```
Epoch 29/30
2991/2991 [==============================] - 62s 21ms/step - loss: 0.5690 - accuracy: 0.8308 - val_loss: 0.8097 - val_accuracy:
0.8061
Epoch 30/30
2991/2991 [==============================] - 62s 21ms/step - loss: 0.5688 - accuracy: 0.8285 - val_loss: 0.8328 - val_accuracy:
0.8111
```

Fig. 12. Last two epochs of Inception V3

From fig.13, our Ensemble method correctly predicted this flower as bloom. During prediction, this picture produced three arrays for model 1. These are 0.85, 0.07, and 0.06. Model 2 also made three arrays, these are 0.99,0.007, and 0.01. Model 3 also gives us three arrays, which are 0.84, 0.08, and 0.068. Then we used amax function to get the highest value which is 0.99. Similarly, fig.14 correctly predicts as bloom.

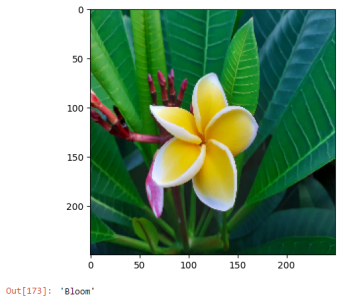

Fig. 13. Predicted Bloom

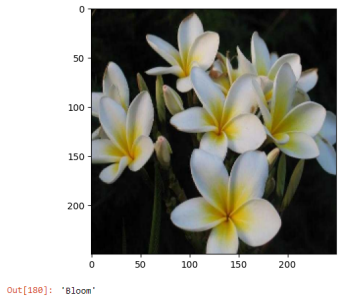

Fig. 14. Predicted Bloom

Like previous Bloom predictions, during our Ensemble approach, Pre-bloom prediction also generates three arrays from each of the models. We got a total of nine arrays from three models. These arrays are 0.85,0.07,0.06 and 0.9997,0.005,0.0005 and 0.00003,0.00004,0.9999. After applying the amax function, our ensemble method correctly predicts this flower(fig 15) as pre-bloom. Similarly, other flowers also generated a total of nine arrays from three different models. After applying the amax function, fig 16 also correctly predicted it as pre-bloom.

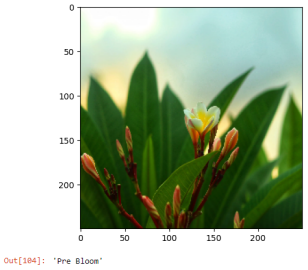

Fig. 15. Predicted Pre Bloom

Fig. 16. Predicted Pre-Bloom

Like earlier Bloom and Pre-Bloom predictions, during our Ensemble approach, Post-Bloom prediction generates three arrays from each model. We got a total of nine arrays from three models. These arrays are 0.857,0.077,0.0652 and 0.0003,0.9999,0.0001 and 0.8474,0.8406,0.068. After applying the amax function, our ensemble method correctly predicts this flower (fig.17,18) as post-bloom. Similarly, other flowers are also predicted as post-bloom.

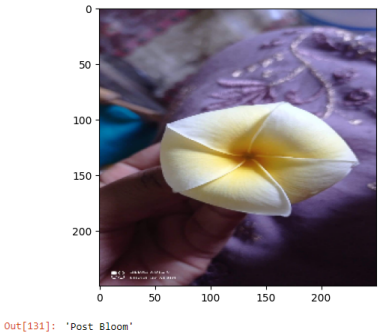

Fig. 17. Predicted Post-Bloom

Fig. 18. Predicted Post-Bloom

V. Conclusion

In this study, we presented an ensemble Convolutional neural network(CNN) method to identify the Plumeria flower state. For this work, we collected our own Data set. We developed an Ensemble method by using three different CNN models. We ran our CNN models separately and got different results. Then, The CNN model's output results were merged. Finally, our method's highest accuracy is approximately 81%. This research aids in the detection of flowers. It can also be used for harvesting and flower business. Our collection of Data set was small in order to get better accuracy. We have to collect a bigger data set and different types of flower data set. Finally, In the future, based on this concept, we intend to create a mobile application to identify the different classes of flower states.

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