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Detection of Crop Diseases using Deep Learning via Android Application

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ABSTRACT

Crops have ever been a primary source of food for humans as it provides us energy to carry out our everyday tasks. Every person requires food for his survival. During the early ages, the food requirement was far less as the human population was very less and sparse but after the fourth industrial revolution population explosion occurred due to which there was a sharp increase in population, and as a result, the food demand also spiked due to which shortage of food had occurred which still exists. This shortage was primarily caused due to two reasons-Increase in Agriculture destruction and a sharp increase in population. Deep learning has brought a new era of introducing intelligence to our artificial devices to imitate a task like humans without being programmed with pre-defined rules to do so. In this paper, we propose to integrate Deep learning to reduce the loss of crops due to crop infections caused by various microbes. We implement an Android solution operating in a mobile environment that integrates the Deep Learning Neural Network and provides an on-device image recognition of crop diseases. The deep learning model acquires an accuracy of 95% and is a modified MobileNetV2 model which is converted to a Siamese Network. This model is deployed as an Android Application with high performance and a higher accuracy while only consuming the resource of that device. Due to all the factors, this solution can be widely implemented due to its higher accuracy as well as it is cost-friendly.

Keywords : Deep Learning, Siamese Networks, Mobile Computing, Image Recognition, Smart Agriculture

I. INTRODUCTION

Crop Diseases has always been a threatening issue for agriculture caused due to various type of infectious microbes which can destroy almost complete agricultural produce. Microbes infect a large number of crops due to which a large amount of agricultural produce goes to waste every year.

Agriculture has ever since been a part of humans as a primary source for the generation of their food. Every human need's energy to survive and agriculture has met a lot of demand for providing that

energy. Evidence exists that humans were relying on agriculture for as long as 30,000 years. As the human population went on increasing so the cultivation of land began increasing spontaneously to meet the increasing demand for food. Due to this more and more land was coming under cultivation and due to this agricultural land started to come closer sharing common resources for a larger area due to which the crops became vulnerable to various types of microbial infections as the spreading pathway became common. Also due to the evolution of genetics, the further generation of crops had a degraded immunity to various evolved types of microbes which might also have been an important reason for an increase in crop diseases.

Another possible reason is the population explosion that occurred after the fourth industrial revolution. During the population explosion, there was a sharp rise in the population due to which there was a sudden increase in the consumer market whereas the producer market was falling short to meet the necessary food demands of the growing population leading to food scarcity. “Food grows according to Arithmetic Progression and Population grows by Geometric Progression”. Due to the above principle food always fell to meet the demands of the whole population and world hunger became an important issue. According to a WHO report, more than 820 million people sleep hungry every day.

Artificial intelligence is a new branch that also started growing as computers became more widely available to the public. It is the intelligence of humans which is imitated by machines to provide similar results.

This is an implementation of Neural Networks a part of deep learning in which an image of the diseased plant leaf is given as an input and an embedding is generated consisting of the distance between the input image and the trained data. It is a Siamese network a concept that allows for the generation of dynamic models to which new data can be easily recognized. This enables the machine to recognize the data for which it was never trained and allows the recognition of the new objects easily. It is a form of computer vision task in which the computer can recognize objects from the given input image. The model was trained using the modified version of the Plant Village Dataset consisting of 24000 colored images of 256 x 256 dimensions and consists of 24 categorized images of the leaves of the diseased plants.

Android is an operating system invented by Google in 2008 and powers most smartphones today. It is widely adopted and has a huge market due to its open-source nature.

Android-powered smartphones are available in various segments having costs as low as $55. Due to this Android smartphones can even be purchased by poor consumers further increasing its market. Due to a huge market, the processors, cameras, sensors, etc. also started to be developed for more accurate and speedy output which became an important reason for supporting AI on smartphones for various applications. On-device processing also became a reality on smartphones due to which results were quicker and security was increased. Google, the main contributor to the Android OS also started to develop various libraries and APIs for easy deployment of Deep Learning Models on Android along with an easy integration of those models in the application which further improved the quality of AI on smartphones.

II. LITERATURE SURVEY

Mango plants are highly sensitive to various types of fungal infections and specifically to Anthracnose. This creates a need to develop a highly effective

method that is also cost-effective to solve the problem. A multilayer Convolutional Neural Network can be used to provide immediate monitoring and control of the situation. This provides a higher amount of accuracy as compared to other models.[1]

Kamilaris and Prenafeta Boldu have presented various methods of deep learning that were adopted in agriculture. The size and variety are important aspects when working with deep learning in agriculture. Feature learning being a great advantage of Deep Learning has proved to be more useful than traditional Machine Learning models. Parallelization has also enabled to train of larger models with higher accuracy to enhance the performance of the model to be implemented for practical usages.[2]

Sun, Yang, He, Wu have proposed a Deep Learning Method to detect Northern Maize Leaf Blight under a complex field Environment using Deep Learning. This method has proposed three steps of dataset preprocessing which help to eliminate environmental factors negatively affecting the detection of disease of the model. It has successfully proved effective to solve the negative detection of disease due to the light intensity. An RPN is used to adjust the anchor box of diseased leaves which helps the RPN network to identify and delete the negative anchors which further improves the performance. The method achieves an accuracy of 91.83% mAP.[3]

Siamese Network proves to be a very effective method in Deep Learning where less data is available. A convolutional Siamese Network outperforms the traditional Convolutional Neural Networks. We can easily tune our network to generalize the recognition and then it can be capitalized to generalized the predictive power of the network to recognize new data and new classes. This eliminates the need to frequently retrain the network to generalize over new data as well as improves the approach of transfer learning for Deep Learning Networks. Siamese Networks have been proven highly useful for one-shot image recognition providing new results as compared to state-of-the-art classifier providing a human-level accuracy.[4]

Mobilenet V2 is a neural network architecture that is specially tailored and tuned for mobile resources. It provides a higher range accuracy while significantly reducing the number for operations and memory. This is achieved using the inverted residual with linear bottleneck. It takes a low dimensional representation which is expanded and then filtered with a lightweight depth-wise Convolutional Network.[5]. Depthwise Separable Convolution Network [6] are the key building block of the network which replaces a full Convolutional Network which splits the convolution operation into two separate layers thus reducing the total learning parameters. Due to this, the memory footprint of the model is highly reduced and thus it reduces the frequent main memory access by various embedded devices as it can be cached easily. Theoretically, the proposed block has a property to allow to separate the network expressiveness from its capacity.

Approach

We have proposed a system that will utilize the advantage of the widespread usage of Android smartphones to deploy a Neural Network that can recognize crop diseases at an early stage so that effective measures can be taken to prevent further damage.

The model will accept the input image and can process it on the device and immediately generate the output with details and solutions to eliminate the disease.

To develop an application, we first need to train a Siamese Neural Network model having low

computation parameters and operations but with a higher accuracy which can generalize between the various class identity of various image pairs. This model learns to identify the input pairs according to a probability that they belong to one class or different.
The model once ready would be deployed on a remote server from where the client devices can download it. Once the model is on the device it can be given an input image that would be scaled to its input dimensions whose result would be an embedding. The Euclidian distance [7] for the embedding can be compared with the stored embeddings of each class according to the plant species and the Euclidian distance below the fixed threshold will be the recognized class.

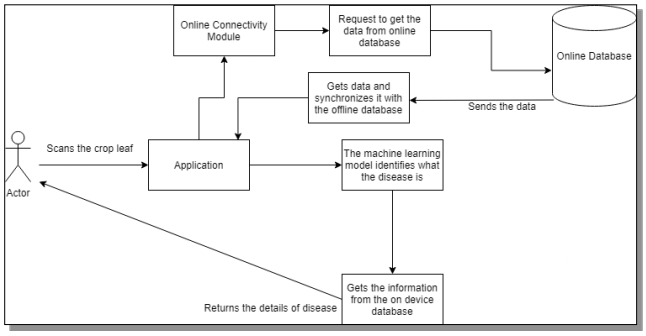

Fig -1 System Architecture

III. PROPOSED METHODOLOGY

a. Deep Learning Network

Mobilenet V2 is a neural network architecture developed by Google. It pushes the state of art for mobile visual recognition including classification and object detection. It introduces linear bottlenecks and shortcut connections between the bottlenecks to improve accuracy. This network can achieve high accuracy and can easily run in a constrained resource environment.

Siamese Network is a concept introduced in the Facenet Paper [8]. The network can directly learn mappings of the images This allows the network to generalize over new data and can prove useful when the training data is very less.

Triplet Loss is a mathematical function that modifies a neural network to produce embeddings for the input image which is the mapping to the input image. It is motivated by the nearest neighbor classification. The loss function requires three input image anchors. An image anchor is an image that consist of the single object to be detected by the Neural Network. For this loss function, the triplet input selection must be performed carefully so as the anchor image and the positive anchor image are closer than the negative anchor images.

The Neural Network Model for the crop disease recognition will combine the advantages of MobileNet V2 and Siamese Networks to achieve an accurate result for the detection of crop disease using an image.
A pre-trained MobileNetV2 model will form the backbone of the neural network which does not include its top layer. This model produces a result of shape 7x7x1280 as output.

This model is modified to include a global average pooling layer [9] which reduces the dimensions of the MobileNet V2 output to maintain only the depth while reducing its width and height to 1 respectively. The output of the Global Average Pooling Layer is provided to a Dense layer which produces a 144-embedding vector. The output embedding vector is passed through a custom layer which calculates the L2 Norm of each value. The loss function used for training the Neural Network is Triplet Semi-Hard Loss. The optimization function used for training the model is Adam optimization. This model acquires an accuracy of 95% on the dataset.

During the training phase of the model, the computation graph consists of three different inputs

and consists of a single embedding as output. During inference, the graph is modified to include a single input image of dimensions 224x224x3 having a mean value of 0, as well as a standard deviation of 0.

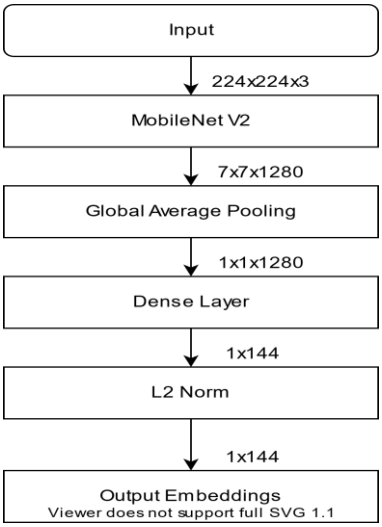

Fig -2 Architecture of the Neural Network

b. Android Smartphone

Android is an operating system developed by Google Inc. in 2008 and ever since its launch it has been a dominant OS for smartphones. This is highly contributed by its open-source nature. Android OS has evolved a lot with not only improving its Graphical User Interface but also supporting newer technologies and capabilities. This evolution formed a major reason for android hardware manufacturers to produce more new and powerful processors and other hardware components such as cameras, sensors, etc. This led to more processing power in small Android smartphones and having various sensors and cameras which have opened the scope for a broad range of new applications. Modern Android smartphone hardware is a million times more powerful than the Apollo 11 guidance computer.

IV. IMPLEMENTATION

We will develop a system that accepts an input image of the leaf of the diseased part of the crop and the system will provide the information of the detected disease and solutions to eliminate the disease. The input image will be first scaled to the appropriate input dimensions of the neural network. The Euclidian distance of the output embedding would be calculated, with the first vector being the result of the processed image and the second vector consisting of sub vectors of the stored pre-calculated embeddings of the crops having similar species. If more than one crop disease types are present in the species, the Euclidian distance is calculated for all the similar species crops which are stored in an output vector. The lowest value from the resulting vector is compared with the threshold and if it is lower than the threshold value, the disease is classified as a detected disease.

The embeddings of each species would be stored externally which would be obtained by inferring a random image of that species on the model. This helps in classifying the label of the recognized crop disease as well as helps in the recognition of new diseases without retraining of the model. The application will also provide details and treatment solutions for the recognized disease along with future steps to be taken. The complete inference will occur on the device along with the operation of calculation of the Euclidian distance.

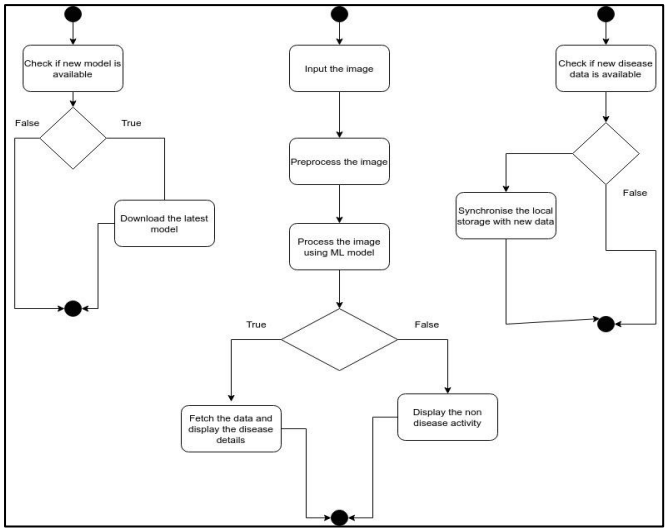

Fig -3 Activity Diagram for the system

c. Modules

1. **Triplet Pair Generator**-Generation of triplet pairs consisting of an anchor, the positive anchor, and a negative anchor of a species. This pair must be such that the argmax and argmin of the negative anchor image must be large than that of the anchor image.The method for the generation of triplets is offline triplet mining [10] process due to the small size of the dataset.
2. **Data preprocessor**-Preprocessing all the data according to the input shape required by the model as well as normalization of input values according to the deviation and mean values. It includes the initialization of all the hyperparameters of the network as well as the initialization of all the weights and bias values.
3. **Custom Network generation**-The custom Neural network must be formed. A pre-trained MobilenetV2 model must be taken without the top layers. A global average pooling layer and a dense layer consisting of 144 embedding values as output must be added to the network.
4. **Neural Network Training**-The neural network is fed with the triplet pairs of the input dataset. All three images are given as input to the network and the network embeddings having a shape of batch_sizex144 are produced as output.
5. **L2 Norm calculation**-The L2 Norm of the output embedding must be calculated which is the resultant output for the neural network.
6. **Embedding classifier** -Classifies the embeddings of the model and assigns the label to the predicted embeddings.
7. **Details Displayer**-Based on the class of the disease detected by the model it displays the details on how to prevent the disease and other solutions to contain the disease. It also provides solutions on the future steps that can be taken to reduce its impact.
8. **Input graph modifier**-After the training of the model the graph is modified to accept only one input image. During inference, only a single image of the diseased crop will be provided as input to the neural network so the graph must be modified to accept only one input.
9. **Mobile Inference**-It optimizes the neural network to operate on mobile resource constraints with high performance and lower latency. This helps the neural network to consume fewer resources and faster computations for image recognition which is crucial in a mobile environment.

Algorithms

1. **L2 Norm**-This algorithm calculates the L2 Norm of the output embeddings of the neural network. It is a function from a complex vector that behaves like a distance from the origin. It obeys scaling. It helps to generalize the output vector over the origin. It is also known as Euclidian Norm.
2. **Siamese Network**-This is a category of neural network proposed in the Facenet paper that produces allows a network to generalize over mappings of the input rather than classifying the image labels. This allows the network to generalize new data easily without retraining for the new data.

3. **Triplet Semi-Hard Loss**-It is a category of Triplet Loss where the loss function generates a positive distance and also tries to increase the Euclidian distance of the negative anchor from the primary anchor and reduce the Euclidian distance between the positive anchor and primary anchor.

V. CONCLUSION

This system aims to reduce the impact caused by infectious microbes to destroy agricultural produce. Effective steps being taken before large destruction can help to save a large amount of agricultural produce which can help in reducing world hunger. It will not only display the disease caused to the user but will also provide details and solutions to help the crops fight the infection and also some regular practices to be followed to prevent such diseases.

Due to the neural network's capacity to operate in a resource-constrained environment and be mobile-friendly, it is easily deployable on Android Smartphones which already have a huge base. This will help the widespread usage and cost-effective solution for farmers to integrate the power of Deep Learning for their application and protect the destruction of their crops. As the application runs on the device the application can be used even in remote parts where internet connectivity can be a problem and also reduces the risk of data theft.

With all these methods we can highly improve the quality of agricultural produce and also reduce world hunger which will add a greater step towards world hunger elimination.

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