Dog Breed Classifier Android Application

Report submitted in fulfillment of the requirements
for the Exploratory Project of

Second Year B.Tech.

by

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June 2020

Dedicated to

My parents, teachers,.....

Declaration

I certify that

1. The work contained in this report is original and has been done by myself and the general supervision of my supervisor.

2. The work has not been submitted for any project.

3. Whenever I have used materials (data, theoretical analysis, results) from other sources, I have given due credit to them by citing them in the text of the thesis and giving their details in the references.

4. Whenever I have quoted written materials from other sources, I have put them under quotation marks and given due credit to the sources by citing them and giving required details in the references.

Place: IIT (BHU) Varanasi
Date: 29 June 2020

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Certificate

*This is to certify that the work contained in this report entitled "**Dog Breed Classifier Android Application**" being submitted by **Kshitij Sharma (18075030), Kundan Kumar (18075033) and Madhur Sahu (18075038)** , carried out in the Department of Computer Science and Engineering, Indian Institute of Technology (BHU) Varanasi, is a bona fide work of our supervision.*

Place: IIT (BHU) Varanasi
Date: 29 June 2020

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Place: IIT (BHU) Varanasi

Date: 29 June 2020

Kshitij Sharma, Kundan Kumar and Madhur Sahu

Abstract

This Project deals with an application of **Deep Learning (Especially Convolutional Neural Network) and Image processing** to predict the breed of a dog out of more than 133 known breeds with more than 93 percent accuracy. We have developed a real time android app which collects image from camera of the user and shows probability percentages of top 3 breeds predicted by our trained model. The app uses a tensor flow model which was trained on more than 35000 images of dogs tagged with their breeds using **Transfer Learning**. The model consists of a deep web of several **Convolution and Pooling** layers. We have used **TensorFlow lite** module of android which interprets the input and output dimensions of the model and converts the image into the required dimensions. Our application takes input from camera or gallery and converts it to 224*224*3 **Byte Array** and calculates the prediction function using the trained model which is nothing but the probability distribution (an array of probabilities) for all breeds. The app shows you the breed names and probabilities of the three most likely breeds and if the input image is not of a dog, then it displays No dog detected.

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List of Symbols

Symbol	Description
Ψ	Field of Interest (FoI)
Ω	Boundary region of a FoI
b	Width of a region Ω
l	Length of a region Ω
ξ_i^k	Redundancy degree of a type i sensor for k-coverage of a FoI

Chapter 1

Introduction

1.1 Overview

Our Project deals with development of an android application that can identify the breed of a dog if the image of the dog is provided as input. It is an application of Deep Learning (Especially Convolutional Neural Network) and Image Classification. The app predicts the breed of a dog out of more than 133 known breeds with more than 93 percent accuracy. We have developed a real time android app which collects image from camera of the user and shows probability percentages of top 3 breeds predicted by the trained model. The app uses a tensor flow model which was trained on more than 35000 images of dogs tagged with their breeds using Transfer Learning. The model consists of a deep web of several Convolution and Pooling layers.The project includes Two major parts each of which consists of several steps (to be discussed in following chapters):

1. Designing and Training the CNN model using Transfer Learning

2. App Development using Android Studio

- **Designing and Training the CNN model using Transfer Learning:**

1. Designing a TensorFlow/keras model.
2. Setting up Working environment and directories
3. Downloading the Dataset
4. Setting partitions of the dataset for training, testing and validation.
5. Populating the training Data.
6. Storing the List of Labels in a directory
7. Create a CNN to Classify Dog Breeds
8. Training, testing and validation
9. Downloading the ".tflite" file of the trained model

- **App Development using Android Studio:**

1. Setting up working environment and the name of the app.
2. Designing the basic structure of the app.
3. Adding the activities and buttons accordingly
4. Setting up the Assets folder.
5. Asking permissions for access of camera and file manager
6. Defining the functions of buttons and activities.
7. TensorFlow interpreter interprets the input/output configuration of the model.
8. Converting the input into required format/pre-processing of image
9. Run the interpreter and show the results.

1.2 Motivation of the Research Work

We were really excited while doing the project work because of our specific interest in Machine learning. Learning Android development came out as another motivation for us. Learning new skills, creating something useful on our own and watching it working kept us motivated throughout the project.

Chapter 2

Designing and Training the CNN model using Transfer Learning

2.1 Designing a TensorFlow/keras model

Our project consists of a model based on deep learning. The model contains a deep web of an input layer of size =224*224*3, followed by several convolutions and pooling layers each of them are further activated with **ReLu** activation function. Finally, we have a fully connected layer of size equal to number of trained breeds which is activated by **SoftMax** function. The basic Design of the model is explained in the figure 2.1.

The Input Layer: A Byte Array of size 224*224*3

The Output Layer: A vector of size equal to number of breeds which stores probabilities of each breed.

2.2 Setting up Working environment and directories

The Whole training and testing work of the model was done on **Google Colab** through **Transfer Learning**. The reason behind this is the limitation of our personal

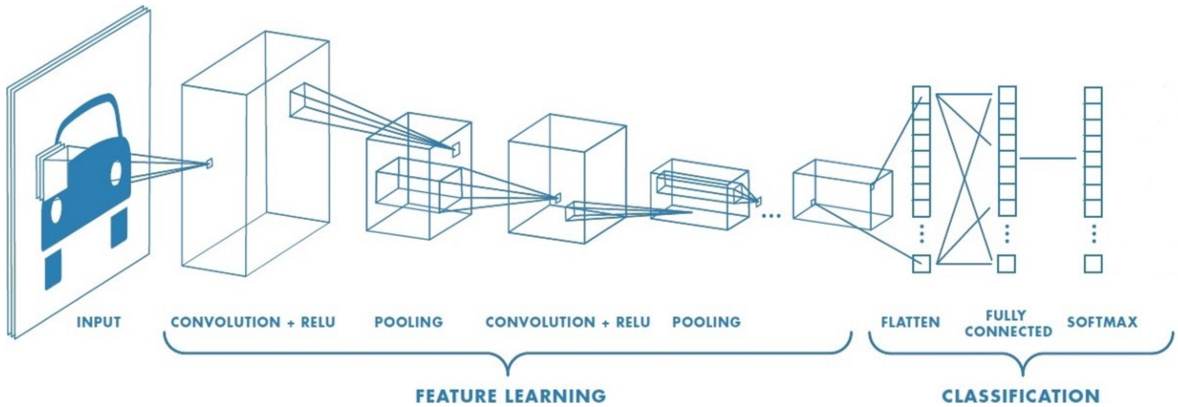


Figure 2.1 Basic Design of the model used in the project.

Systems and also the handy nature of the Transfer Learning as we don't need to install the required libraries and modules one by one. We only needed to setup the separate directories for train, test, validation dataset and also for storing labels.txt which contains a lexographic list of the breeds.

2.3 Downloading the Dataset

The Dataset we have used consists of more than 8000 images of dogs tagged with their breeds. The dataset was downloaded from cloud storage of **kaggle.com**.

2.4 Setting partitions of the dataset for training, testing and validation

We have used the following criteria of partition for different purposes:

Training: 80 percent of the total dataset was used for training (6400 images)

Testing: 10 percent of the total dataset was used for testing (800 images)

Validation: the rest 10 percent was used for validation (800 images)

Figure 2.2 Sample Dataset

2.5 Populating the training Data

8000 images are not enough for obtaining a decent accuracy of the model. We have to expand the training dataset in order to improve the performance and ability of the model to generalize. Population can be done using **ImageDataGenerator** class of the Keras deep learning library. We can populate the data by Flipping each image vertically and horizontally by changing the brightness of the image.

2.6 Storing the List of Labels in a directory

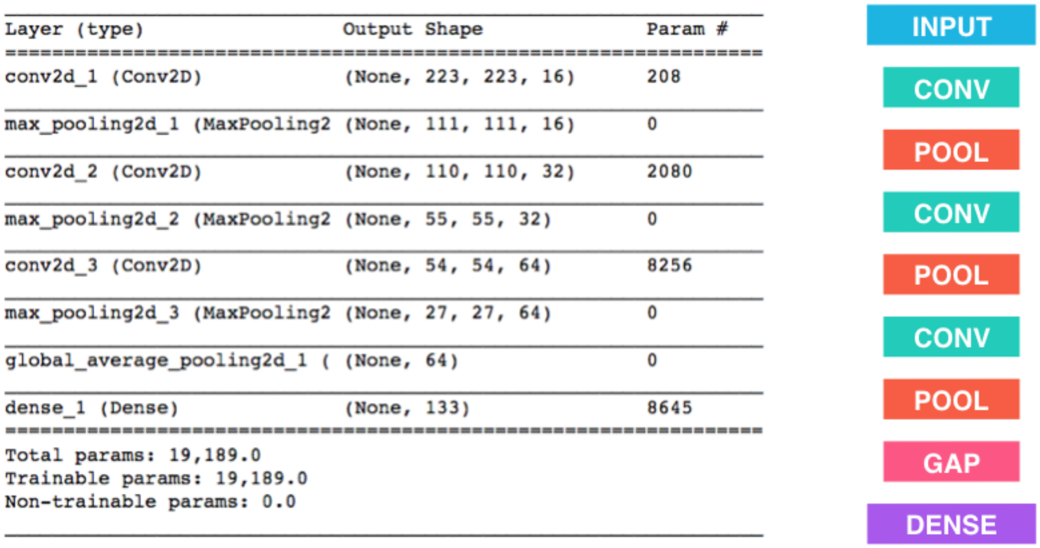
A file named labels.txt stores the list of all breeds in lexographical order.

2.7 Pre-Trained model for Dog Detection

The application uses a pretrained model **Xception** which classifies an image if it contains a dog. If the picture provided has no dog in it," No dog detected is displayed on the results screen else the breeds and their probability percentage is displayed on a Pie chart.

2.8 Creating a CNN to Classify Dog Breeds

The used CNN architecture has 3 convolutional layers alternating with maxpooling layers, 10layer which is then followed by a dense layer (the fully connected layer) to identify 133 breeds. The non-linearity used here is **ReLu** for each convolution and pooling layer and SoftMax for the fully connected layer. **SoftMax** maps each output of the last pooling layer to a value less than 1.0, the sum of all mappings is equal to 1.0 as we want to know the probability of each breed.



Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 223, 223, 16)	208
max_pooling2d_1 (MaxPooling2	(None, 111, 111, 16)	0
conv2d_2 (Conv2D)	(None, 110, 110, 32)	2080
max_pooling2d_2 (MaxPooling2	(None, 55, 55, 32)	0
conv2d_3 (Conv2D)	(None, 54, 54, 64)	8256
max_pooling2d_3 (MaxPooling2	(None, 27, 27, 64)	0
global_average_pooling2d_1 (	(None, 64)	0
dense_1 (Dense)	(None, 133)	8645

Total params: 19,189.0
Trainable params: 19,189.0
Non-trainable params: 0.0

Figure 2.3 Dimension of input, convolution, pooling and output layers

2.9 Training, testing and validation

We need to compile the model using a suitable Loss function and optimizer function. In this project we have used the rmsprop optimizer and the categorical crossentropy loss as per suggestions of Abhinav sir. model.compile(loss='categoricalcrossentropy', optimizer='rmsprop') The training was done on the batches of 32.The final accuracy after adjusting the Hyperparameters was close to 93 percent.Below is a snapshot of training and validation parameters:

2.10 Saving and Downloading the final model

Finally, we save the best weights obtained by training testing and validation in model.hdf5 format. But this file cannot be used directly in android studio. We need to convert this file into model.tflite format so that TensorflowLite module of android can interpret it. In the next chapter we will use this file to design the android app.

epoch	train_loss	valid_loss	error_rate	accuracy	time
0	0.627831	0.420220	0.126946	0.873054	01:46
1	0.565824	0.421033	0.130539	0.869461	01:45
2	0.500161	0.436525	0.135329	0.864671	01:46
3	0.431353	0.434656	0.135329	0.864671	01:45
4	0.300209	0.426703	0.129341	0.870659	01:44
5	0.248548	0.392488	0.108982	0.891018	01:45
6	0.176313	0.369094	0.113772	0.886228	01:45
7	0.117275	0.380862	0.108982	0.891018	01:45
8	0.109990	0.376605	0.107784	0.892216	01:46
9	0.085661	0.370920	0.101796	0.898204	01:46

Figure 2.4 Training Metrics

Chapter 3

App Development using Android Studio

3.1 Designing the basic structure of the app

We will design a simple two activity app: The welcome/main activity and the Results activity. The main activity will have a TextView containing the Title and short manual of the app. There will be Two buttons: one for camera and another for gallery. The camera button will take you to the camera view where you can see the breed of your dog without clicking the picture. The Gallery button will take you to the File manager where you can select the preclicked image of your dog. On the selection of image, you will be taken to the Results page where a TextView will show the results.

3.2 Adding the activities and buttons accordingly

We Create an empty activity and name it MainActivity . On the bottom of this activity we add two buttons one for camera and one for gallery .On the Top the activity A text View will show the title of the app and In the centre part of the activity we have a TextView containing info about the app. Below is a snapshot the main activity.

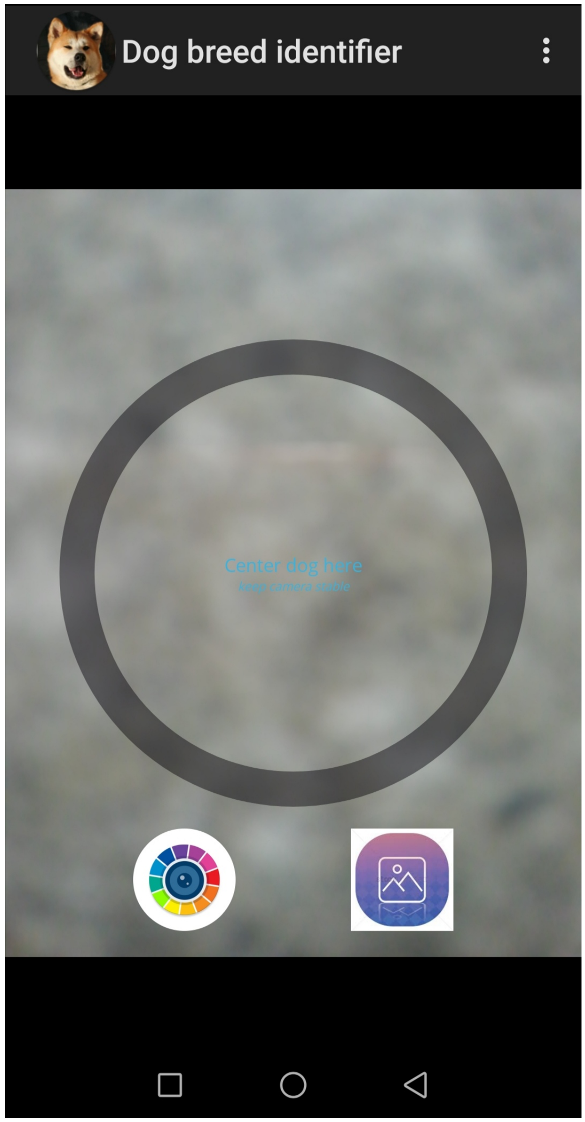


Figure 3.1 Main activity

3.3 Setting up the Assets folder

In the res folder of the project we create an Assets Folder in which we keep the model.tflite and labels.txt file downloaded earlier.

3.4 Asking permissions for access of camera and file manager

We need to ask for the permission to access camera and file manager from the user. For this we need to add a few lines of code in AndroidManifest.xml file of the app.

3.5 TensorFlow interpreter interprets the input output configuration of the model

Now comes the use of TensorFlow Lite module of android to interpret the model. The interpreter returns the input and output dimensions of the model. In our project input shape is 224*224*3 and output shape is 125*1.

3.6 Converting the input into required format/pre-processing of image

The input image can be of any size depending upon the device configurations, so we need to convert the input image to 224*224*3 byte array. The image taken from camera is of bitmap object type and that from gallery is of Uri object type. We can do the conversions easily by the help of Converters present in android.

3.7 Run the interpreter and show the results.

Finally, we have to pass the byte array to the TensorFlow interpreter. The interpret simply calculates the SoftMax values using the saved model (model.tflite) and returns the final probability distribution in a vector of shape 125*1. We have to define a function that sorts this array and find the index of the top three probabilities. Using these indices, we can refer to the names of the breeds listed in labels.txt. Now the app is ready to run.

Chapter 4

Result and Conclusions

1. The accuracy of the model which we have trained is 93 Percent.

2. The size of the dataset which we use to train our model plays a major role in deciding the accuracy of the model. Larger the dataset, more experienced the model and hence more the accuracy.

3. Activation function such as ReLu function, plays an important role here as it adds the non-linearity to our model. The SoftMax function helps provide our predicted result on the scale of 0 to 1.

4. We have used pre-trained Imagenet classifier which determines whether the image contains any Dog or not.

5. We have used pre-trained model Xception because it's accuracy was highest.

6. We have tested the application on 5 different pre-trained models ,the accuracy ,Inference time model size before and after conversion to tflite is listed in the following tables and some snapshots of our Application.:

Model	Accuracy	Inference time(Mobile CPU)	Inference time(Mobile GPU)
VGG_16	70.81 %	232 ms	185 ms
VGG_19	72.13 %	230 ms	182 ms
Inception	81.10 %	241 ms	197 ms
Xception	92.87 %	267 ms	213 ms
Resnet_50	82.66 %	257 ms	201 ms

Table 4.1 Model Accuracy and Inference Time on mobile comparison

Model	Accuracy	Inference time(Computer CPU)	Inference time(Computer GPU)
VGG_16	70.81 %	176 ms	120 ms
VGG_19	72.13 %	173 ms	126 ms
Inception	81.10 %	186 ms	141 ms
Xception	92.87 %	207 ms	179 ms
Resnet_50	82.66 %	190 ms	152 ms

Table 4.2 Model Inference Time on Computer comparison

Model	Size(Before Conversion to tflite)	Size(After Conversion to tflite)
VGG_16	551 kb	268 kb
VGG_19	552 kb	268 kb
Inception	2148 kb	1066 kb
Xception	2148 kb	1066 kb
Resnet_50	2148 kb	1066 kb

Table 4.3 Model Size comparison

Figure 4.1 Snapshot 2

Figure 4.2 Snapshot 3

Bibliography

Figures:

Fig 2.1 Basic Design of the model used in the project

https://blog.floydhub.com/building-your-first-convnet/

Fig 2.2 Sample Dataset

https://medium.com/nanonets/how-to-easily-build-a-dog-breed-imageclassification- model-2fd214419cde

Learning material:

https://www.tensorflow.org/lite

https://kaggle.com/

https://towardsdatascience.com/

https://www.coursera.org/