# Machine Learning Engineer Nanodegree
## Capstone Project

**CNN Project: Dog Breed Classifier**

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# Definition

## Project Overview

We human beings are always curious about everything. When one sees a dog, a question comes to his mind "What breed that dog is?". An average human being can only remember like 10-20 breeds of dogs. But there are many more breeds of dog present, in-fact we have 133 different breeds of dogs! But we have a solution. Apart from depending on human's recognition and remembering ability, we can use computers! Yes, this project is about classifying images of dogs into breeds they belong to.

This project uses machine learning to be able to classify dog breeds. More specifically Convolutional Neural Network is used for multiclass classification. We find many applications of image classification in real life like video moderation, self-driving cars and security surveillance.
Dog breed classification is a popular exercise in Deep Learning and various competitions are also held, like this one from kaggle.

## Problem Statement

The Goal is to provide an algorithm which can identify an image provided by the user to be a dog or human. If an image of a dog is provided then the dog breed is shown. If an image of a human is provided then resembling dog breed is shown.

The three main tasks are-

1. Implementation of human face detector.
2. Implementation of dog image detector
3. Finally identifying the breed of the dog using Deep Learning.

## Metrics

Metrics are used to monitor and measure the performance of a model. It tells us how well our model is performing. Two of the classification metrics used for the model are-
1. Accuracy and
2. Log loss

Accuracy is the simplest measure available for classification problems. It is the ratio of correct predictions by total number of predictions made.

$$accuracy = \frac{correct}{correct + incorrect}$$

The model achieved the accuracy of 78%.

# Analysis

## Data Exploration

The Images for dogs and humans are provided by Udacity.
Dog Images Dataset-
- There are a total of 8351 images provided which have been divided into train, test and validation.
- The sizes of images are not the same.
- 6680 images are present in train, 836 in test and 835 in valid directory.

- Each directory has 133 folders with names corresponding to each dog breed(Ex- Borzoi, Chinese_crested).
- The number of images provided for each breed is not the same.

Human Images Dataset-
- Total of 13233 images are provided for humans.
- The images are present in different folders corresponding to the name of the person( Ex- Bil_Cates).
- The size of each image is 250 x 250.
- The data is not balanced, some folders have only one image while others have more than one.
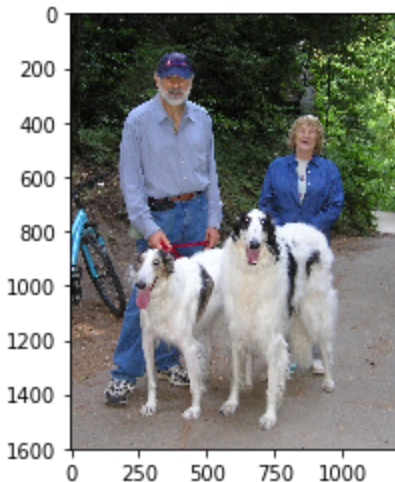
## Exploratory Visualization

Some of the sample images from human dataset are -



Some of the sample images from dog dataset are-
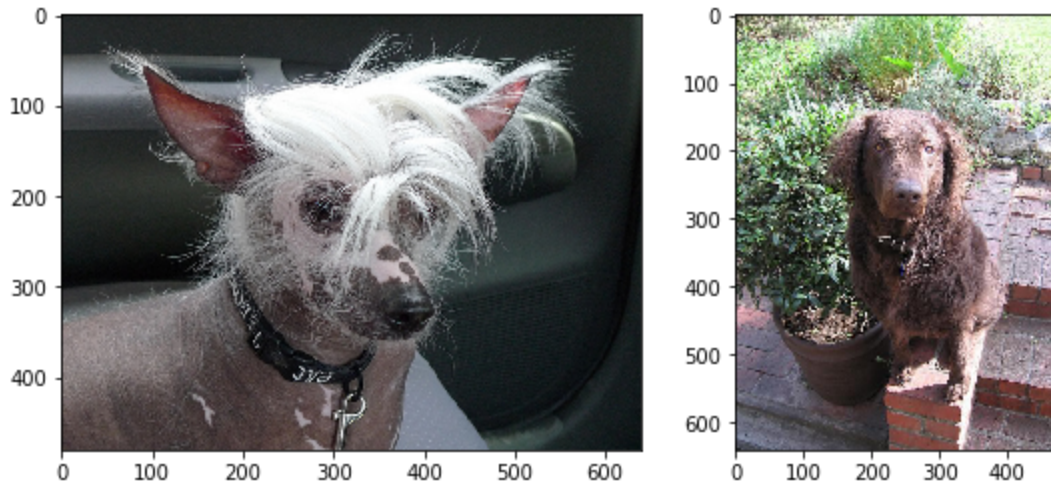
Some of the images of dogs are having humans present too. One example is given below.



Both Human and dog dataset are not balanced.

## Algorithms and Techniques

- OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library.The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements and much more.

Here OpenCV's implementation of Haar feature-based cascade classifiers is used to detect human faces in images.

- VGG16 is a pretrained CNN for classification and detection. It has been pretrained on Imagenet, which is a very large and popular dataset for classification and computer vision. It classifies the image into one of 1000 categories as mentioned [here](#).

  Here VGG16 is employed to check if the provided image is of a dog or not? This is done by checking the index of classification returned from the VGG16 model.

- Machine Learning is the ability of computers to learn from the given data and then make better classifications or predictions. Deep Learning is a subset of Machine Learning. It is inspired from the biological neural network in the human brain. It used artificial neural networks to learn from the data to be able to make predictions and classifications. A Convolutional Neural Network is a class of Deep Learning used for computer vision. It finds vast use in areas such as Youtube video classification, security cameras and image classification.

  In this project a CNN is used to identify the dog breed from the provide images. The CNN's job is to assign one of the 133 classes to The image.

- Transfer Learning is the method where models which are already pretrained on vast amount of inputs are tuned for other similar uses. This method is very useful because it saves the long time for training and also helps when we have comparatively less training data.

  In this project Resnet152 is used for transfer learning which is trained on ImageNet dataset. The accuracy from the model developed using transfer learning improved the accuracy drastically to 78% in just 7 epochs!

# Benchmark

The CNN model created from scratch achieves accuracy of 19% which is clearly better than a random guess(1 out of 133). So this serves as a proof of concept that the model is working.

The Final model created using transfer learning achieved accuracy of 78% which is satisfactory.

# Methodology

## Data Preprocessing
- The training, testing and validation images are cropped to dimension of 244x244 as required by the VGG16
- Images are Normalized from as the values obtained from [Pytorch's docs](#)
- Finally the images are converted into tensors.

## Implementation
A CNN is made from scratch using PyTorch which achieved an accuracy of 19% after training for 25 epochs.

A brief of the model architecture is as follows-
1. 3 Convolutional layers with kernel size 3.
2. The input_channel of the first layer is 3 and output of the last layer is 128. Pooling layer of(2,2) is applied to reduce input size.
3. 2 fully connected layers are used that produce  final output of 133.
4. Finally a dropout layer is used to avoid overfitting.

The loss function used is CrossEntropyLoss().

Finally a model is made by Transfer Learning using ResNet. The model was modified to produce the required dimension of 133. This model produced an accuracy of 78%. The model is trained on 7 epochs.Cross Entropy Loss and Stochastic Gradient Descent(SGD) is used.

## Refinement

The model created from scratch achieves accuracy of 19 which is above the expectation lower bound(10%). For a better model Transfer Learning is used.

The output of the Transfer Learning model is far better than the model created from scratch. Still I think some points for improvement are-
1. Training for more epochs(the current is only 7).
2. Applying Image Augmentation such as rotation or flip.
3. Use a different loss function.

# Results

## Model Evaluation and Validation

The model created from scratch obtained accuracy of 19% which is obviously better than a random guess(1/133).

```
Test Accuracy: 19% (166/836)
```

The model created using Transfer Learning obtained accuracy of 78%. This result is satisfactory.
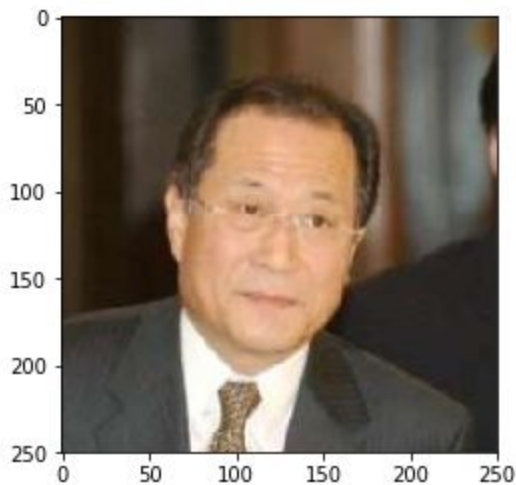
```
Test Accuracy: 78% (656/836)
```

Some of the final output from the model is provided below.

The resembling dog breed is -  Bichon frise



The resembling dog breed is -  Field spaniel



# Justification

The model created using scratch achieved accuracy of 19% which clearly shows that the model is working(better than a random guess).

Further, the final model achieved accuracy of 78% which is better than one created using scratch. So the use of the ResNet transfer learning model is justified.

## References

1. https://s3-us-west-1.amazonaws.com/udacity-aind/dog-project/dogImages.zip
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6. https://github.com/udacity/deep-learning-v2-pytorch/tree/master/project-dog-classification