

Udacity Machine Learning Engineer Nanodegree

Capstone Project Proposal

# Dog Breed Classification with Convolutional Neural Networks

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## **Domain background**

Computer vision is an active research area with applications in medicine, production quality control, and autonomous navigation. It enables automatic extraction and analysis of information from images that can be used to make a medical diagnosis, estimate the quality of a product, or direct a moving vehicle. Image classification through computer vision helps automate a process that can be costly, time-consuming, and could require specific domain knowledge by training a machine learning model, usually a convolutional neural network (CNN), that can label images with high accuracy. For this project, a CNN will be trained to differentiate between dog breeds.

## **Problem Statement**

According to a Reader's Digest article, there are at least 195 dog breeds in the world (Gould, 2020). That can make labeling a dog with the correct breed a challenging task, which makes it a perfect candidate as a computer vision problem. The goal of this project is to train a CNN model that can identify the dog breed with high accuracy. The model will also detect if an image of a human face was passed instead of a dog. In that case, it will return the dog breed with the most resemblance. If neither a human face nor a dog are detected in the image, the model will return an appropriate notification.

## **Datasets and Inputs**

The dataset used in the project is provided by Udacity and consists of 13,233 human and 8,351 dog images. The dog images are already split into 6680 training, 835 validation, and 836 testing images in individual folders with a relatively balanced split among the 133 represented breeds. All images are in color, so they all have 3 channels in depth. The images are of different sizes, which will need to be taken into consideration while performing image transformations. The dog images will be used for training, validating, and testing the CNNs used for classification. The human images will be used to test the model's ability to detect a face and return the breed that it resembles the most.

## **Solution statement**

The solution is to build a dog detection function and a CNN that will be able to predict the detected dog's breed with high accuracy. Two CNNs will be tested on the classification task: one that is built from scratch, and another that is built using transfer learning by fine-tuning an existing model and adding a new fully-connected layer for classification.

## Benchmark model

The target accuracy is 10% for a new CNN and 60% for the CNN built using transfer learning. Both benchmarks are set by Udacity.

## Evaluation metrics

The solutions will be evaluated using prediction accuracy where a prediction is correct if the model's output for the most likely breed matches the actual breed.

## Project design

The project will consist of the following steps:

1. Import training, validation, and testing datasets.
2. Create a human face detection function.
3. Create a dog detection function.
4. Create a new CNN for dog classification that achieves at least 10% accuracy.
  - The initial approach will be to build a CNN in PyTorch consisting of several convolutional layers with ReLU activation and max pooling layers in-between and two fully-connected layers for classification at the end.
5. Fine tune an existing CNN for dog classification that achieves at least 60% accuracy.
  - This will be done by replacing the last layers of VGG-19 and ResNet-50 models, training them on the data, and measuring the performance.
6. Write the algorithm to put the previous steps together:
  - Check if the image contains a dog. If so, return the breed.
  - If no dog is detected, check for a human face.
  - If a human face is detected, return the breed with the most resemblance.
  - If neither a human face nor a dog are detected, return a message stating so.
7. Test the algorithm on sample images and evaluate the performance.

## References

Gould, Wendy Rose. "How Many Breeds of Dogs Are There in the World?" *Reader's Digest*, Reader's Digest, 26 Feb. 2020, [www.rd.com/article/how-many-dog-breeds-in-the-world/](http://www.rd.com/article/how-many-dog-breeds-in-the-world/).