Where is Fido?
Using Machine Learning to Classify Dogs Breed

Junan Pan, Xuanye Guo, Sheng Wen Huang, Hyerin Kim, Wanying Zhou, Theerakorn Prasutchai, Matthew A. Lanham

Purdue University Krannert School of Management

pan132@purdue.edu; guo263@purdue.edu; huang666@purdue.edu; kim2407@purdue.edu; zhou633@purdue.edu; tprasutc@purdue.edu; lanhamm@purdue.edu

Abstract

This study investigates sophisticated image classification tools and predictive models to accurately predict a dog's breed. Image classification is applicable to various fields such as bio-diversity studies, facilitating auto-tagging, and image search. Image recognition has a vast number of applicable industries ranging from national security to marketing. From a marketing perspective, it creates a vast new knowledge base about consumers' identities, brand preferences, shopping habits which marketers could use to serve their customers better. In our study, we perform image classification using three machine learning models on 120 different dog breeds and compare the accuracy of each model to predict any breed within the 120 given breeds. By using TensorFlow with Inception model in Python, we found that a Convolutional Neural Network (CNN) developed by Google researchers performed the best result with a predictive accuracy around 90%. We tried other popular machine learning algorithms and compared those to the Inception model, discussed why we believe that the inception model performs so well and compared to the other techniques we investigated.

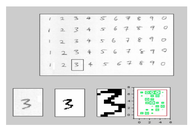
Introduction

- **What is image classification?**

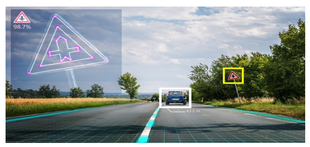
When you upload a picture of your friends, your lovely golden retriever and yourself on Facebook, those faces will be recognized and get automatically tagged - that's image classification.

- **Why important for business?**

Applying image recognition into your business will drive social sharing and improve user engagement since this technology allows you to extend beyond the boundaries of the mobile device and understand the user's physical world. You can provide something more tangible, which allows you to make a stronger, emotional connection with your users - for example, understanding their preferences. Since emotion is strongly connected to the memory, the odds are in your favor to make an impact that lasts.



Example 1. Character Recognition



Example 2. How self-driving car see the world?

Example 3. Better understanding your customers with image classification.

- **Research Questions**

➔ How well do these machine learning approaches predict dog breed when you feed any random images with dogs?

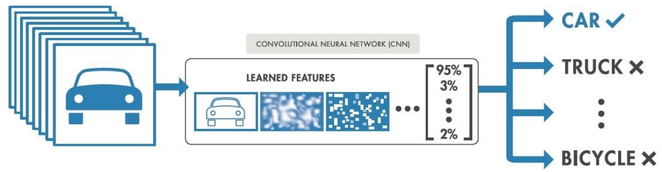
➔ How will image classification support business decisions?

Literature Review

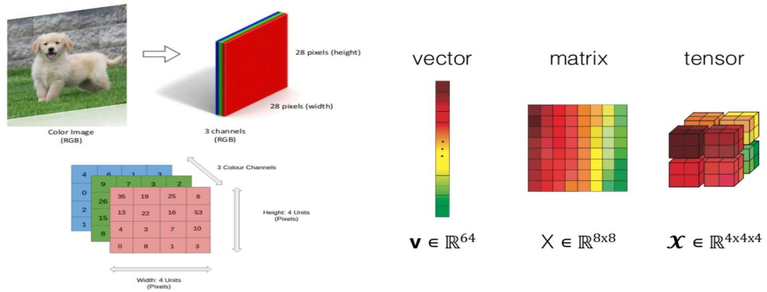
Literature Title	Literature Review	Improvement in Our Models
Dog Breed Classification Using Part Localization (Liu, 2012) **Going Deeper with Convolutions** (Christian, 2014)	The performance of fine-grained classification can be improved by using part localization since dog breeds are similar in common parts but different in shape and appearance.	Resize and crop the image in pre-processing steps.
Dog Breed Identification (LaRow, 2016)	The team picked the best model after comparing the accuracy of different machine learning models.	Test the accuracy using different machine learning models in Python and R.
Transfer Learning for Image Classification of Various Dog Breeds (Devikar, 2016)	Image Classification in CNN has proven to be highly efficient, but it requires a large training data set and substantial time for training to achieve higher accuracy.	Use 20,000+ images and train models in CNN with hundreds of epochs.
TensorFlow, A System for Large-scale Machine Learning (Abadi, 2016)	Using larger internal cluster with GPU can lead to fewer steps and high accuracy of the Inception model.	Install GPU version of TensorFlow to shorten training time & improve accuracy.
A Case Study on TensorFlow and Artificial Neural Networks (Vivekanandan, 2017)	TensorFlow performs very well on recognition problems, and the performance can be further improved by having more iterations.	Run our CNN models in TensorFlow and train them with hundreds of iterations.

Methodology

All of our models are based on **Convolutional Neural network (CNN)** which is an essentially mathematical model to solve optimization problems. Convolutional Neural Network has successfully been applied to analyzing sequential data such as image or time-series data. It is made of neurons, the basic computation unit of neural networks, and usually results in lower RMSE for image classification problems.



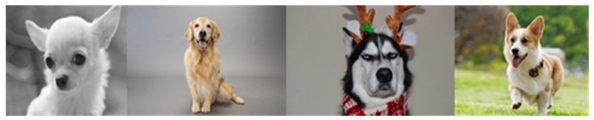
Tensorflow is used as the back-end library in developing our model since it's widely used for machine learning applications such as neural networks. It is designed for handling data that is kept in the tensor format. The image below shows how a color image data is stored as a tensor. The color code in the RGB format for each pixel will be stored and used to create a depth in the data frame, which could be treated as a tensor.



Finally, we trained 2 image classifiers, one in R and another in Python using an open source neural network library called Keras. Keras is capable of running on top of Tensorflow. For comparison purpose, we also trained a transfer learning classifier based on Inception V3 model which developed by Google for image classification.

Data

The original dataset was acquired from the *Stanford Dog Dataset*. It contains 20580 images of dog that were classified into 120 breeds of dog. There are approximately 150 images per breed.



Preprocessing

The color value in the color channel will be normalized using histogram equalization method in order to decrease variance. One of the requirements of using Convolutional Neural Network is that the image should be square. Thus, the images are cropped into square shapes at the middle of the image. Then, these images are downgraded to lower resolution images. It should be noted that there are many other ways to preprocess the image.

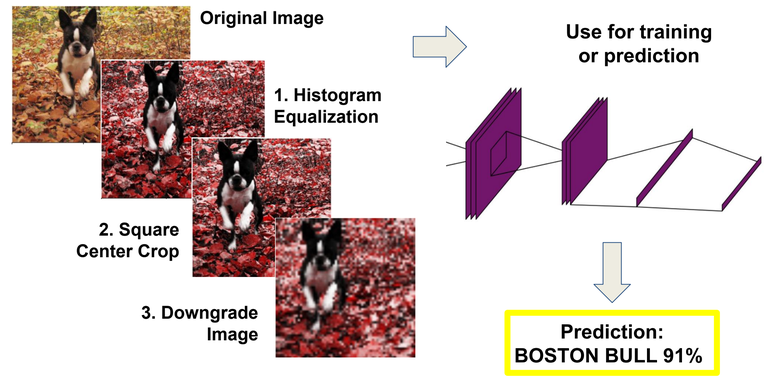
Model Design

The Keras models are trained using the sequential model in the Keras library. There are 3 layers of convolutional 2D layers. The inception model is trained from the original model itself.

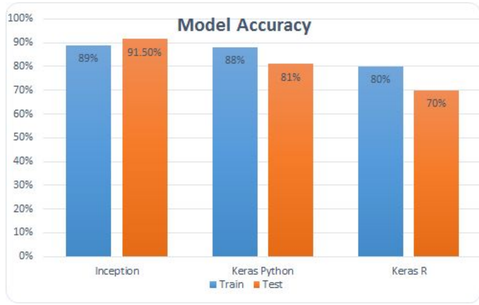
Model Evaluation

Classification accuracy of each model is used to evaluate our models. The models will predict the probability in each class of breed, then acquire the highest probability class as the prediction of the class.

Results



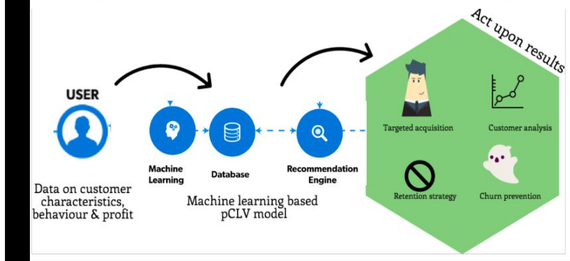
After re-train the Inception model several times, the model gives us an accuracy around 90%. The Keras model in Python performs within expectations and has an 81% accuracy. However, the Keras model in R performs worse than expected with about 70% accuracy. It is assumed that Keras should perform better in Python than R as Keras was made in the Python environment.



Conclusions

Using machine learning and **Convolutional Neural Network** to build predictive models in Python and R, we successfully classify visual imagery, 120 dog breeds, with more than 80% accuracy. Since machine learning has become a driving force behind technological advancements and image recognition is one of the most accessible applications of it, it's fueling a visual revolution.

Our high accuracy makes it possible to carry out our findings to solve real-world business:



- Identify products or services that customers prefer and then better position your brands around relevant content.
- Build Customer Lifetime Value model to help identify and retain a company's most valuable customers as well as enhance customer loyalty.

Acknowledgements

We thank Professor Matthew Lanham for constant guidance on this project.