Cat Breed Classification Using Convolutional Neural Networks

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I. Domain Background

A. Cat Breed Classification

Cats have a variety of breeds, which come in a variety of colors, patterns, facial structure, fur length, etc. Currently the International Cat Association (TICA) recognizes a total of 71 cat breeds [1], so it can be difficult for a nonexpert to identify each of them. By building a machine learning model which taking a cat image as the input and yielding its breed probabilities, hopefully it can be helpful to identify the cat breeds more easily.

Fig. 1. Sample of labeled cat breeds in the *Oxford-IIIT Pet Dataset* [3]

In 2012, Parkhi et al. [2] investigated cat breed classification on the *Oxford-IIIT Pet Dataset* [3]. With the models built using some engineered features based on the combination of shape, appearance, and segmentation, the best accuracy achieved was 66.12%.

B. Convolutional Neural Network

Convolutional neural network (CNN) is a class of deep learning, that has been proven to be very successful in image classification tasks. In CNNs, the features are learned automatically in the process of training. When multiple classes share many similar features as in this cat breed classification problem, it can be difficult to engineer the features manually. Here, CNNs have potential to flexibly extract the features. Besides, by using CNNs, transfer learning can also be performed to transfer the knowledge of previously trained CNNs. Hussain et al. [4] found transfer learning could improve the accuracy of an image classification task.

II. Problem Statement

Considering there are lots of cat breeds, identifying the breeds can be difficult for a nonexpert. And considering the features between different breeds can be similar, building an image classifier for cat breed classification can be a challenging task. It can be difficult to do the feature engineering manually since the shape, color, pattern, or facial structure between different breeds can be similar. Incorrectly selecting the features can significantly affect the accuracy of the machine learning model.

This project will use CNNs to classify cat breeds from labeled images of cats.

III. Datasets

The *Oxford-IIIT Pet Dataset* [3] will be used for this project. It contains 37 classes of dogs and cats with roughly 200 images for each class, which consists of 12 cat breeds and 25 dog breeds (Fig. 2). Here only the cat breeds data will be used for the training and the evaluation.

Breed	Count
American Bulldog	200
American Pit Bull Terrier	200
Basset Hound	200
Beagle	200
Boxer	199
Chihuahua	200
English Cocker Spaniel	196
English Setter	200
German Shorthaired	200
Great Pyrenees	200
Havanese	200
Japanese Chin	200
Keeshond	199
Leonberger	200
Miniature Pinscher	200
Newfoundland	196
Pomeranian	200
Pug	200
Saint Bernard	200
Samyoed	200
Scottish Terrier	199
Shiba Inu	200
Staffordshire Bull Terrier	189
Wheaten Terrier	200
Yorkshire Terrier	200
Total	4978

1.Dog Breeds

Breed	Count
Abyssinian	198
Bengal	200
Birman	200
Bombay	200
British Shorthair	184
Egyptian Mau	200
Main Coon	190
Persian	200
Ragdoll	200
Russian Blue	200
Siamese	199
Sphynx	200
Total	2371

2.Cat Breeds

Family	Count
Cat	2371
Dog	4978
Total	7349

3.Total Pets

Fig. 2. Class distribution in the *Oxford-IIIT Pet Dataset* [3]

The dataset has variations in scale, pose, lighting, and background. Splitting of the dataset will be based on the provided splits for both training and testing data.

IV. Solution Statement

The proposed solution for the problem stated earlier is to apply CNNs that have been widely used for image classification tasks. Besides, transfer learning will also be applied in order to get a better evaluation result. By building a model with a better accuracy, hopefully it can better help us identify cat breeds on cat images.

V. Benchmark Model

For the benchmark, I will use the accuracy result (Table 1) from a paper entitled *Cats and Dogs* [2], which was trained and evaluated using the *Oxford-IIIT Pet Dataset*.

Table 1. Comparison of cat breed classification accuracy (yellow box) between different models defined in a paper entitled *Cats and Dogs* [2]

.	Shape	Appearance		Classification Accuracy (%)				
		layout type	using ground truth	family	breed (S. 4.2)		both (S. 4.3)	
				(S. 4.1)	cat	dog	hierarchical	flat
1	✓	–	–	94.21	NA	NA	NA	NA
2	–	Image	–	82.56	52.01	40.59	NA	39.64
3	–	Image+Head	–	85.06	60.37	52.10	NA	51.23
4	–	Image+Head+Body	–	87.78	64.27	54.31	NA	54.05
5	–	Image+Head+Body	✓	88.68	66.12	57.29	NA	56.60
6	✓	Image	–	94.88	50.27	42.94	42.29	43.30
7	✓	Image+Head	–	95.07	59.11	54.56	52.78	54.03
8	✓	Image+Head+Body	–	94.89	63.48	55.68	55.26	56.68
9	✓	Image+Head+Body	✓	95.37	66.07	59.18	57.77	59.21

VI. Evaluation Metrics

The evaluation metrics for this project is the accuracy of the model on the provided testing data, which is sum of the true predictions divided by the number of total predictions.

VII. Project Design

A. Data Preprocessing

- Retrieve the *Oxford-IIIT Pet Dataset*, and filter out the dog breeds data
- Clean the invalid and duplicate data if any
- Split the dataset into training and testing folders, based on the provided splits
- Explore the distribution of classes in both training and testing data
- Prepare image transformation to make the images have the same scaling and normalization with the pretrained models for transfer learning
- Add image augmentation

B. Modelling

- Train a Vanilla-CNN from scratch, and evaluate the trained model with the testing data.
- Train CNNs with pretrained models (transfer learning), and evaluate the trained models with the testing data.
- Try different architectures or hyperparameters to get a better accuracy score.

References

1. The International Cat Association. “Home Page.” TICA.org. Available: https://tica.org (accessed Jan. 18, 2020).
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4. Hussain, M., Bird, J.J., and Faria, D.R, “A Study on CNN Transfer Learning for Image Classification,” in UK Workshop on Computational Intelligence, 2018.