Image Recognition with Bayesian CNN for Simpsons Characters

Yu Zhu

1 Introduction

The Simpsons is a beloved American TV series, which has been broadcasted in more than 90 countries all over the world. It is easy to notice that almost all of the characters in Simpsons have yellow skin, because Simpsons creator Matt Groening made the characters yellow to grab the attention of channel surfers. He also designed the Simpson family to have distinctive hairstyles and headshapes. In this project, we propose Non-Bayesian Convolutional Neural Network (regularCNN) and Bayesian Convolutional Neural Network (BayesCNN), as well as other classical classification methods such as K-NN, Random Forest, SVM with RBF kernel to perform image classification for Simpsons charactors.

When dealing with image, we typically consider the feature as each the pixel, with or without transformations. However, the high dimensionality of the data can be quite challenging when we train the Artificial Neural Networks (ANNs) or some other machine learning methods. CNNs are exceptionally good at lowering the amount of parameters with convolutional layers without sacrificing model quality. And under different settings or combinations of the convolutional layers, CNNs can better extrapolate and identify the important patterns or edges in the data.

BayesCNN is a probablistic network that can learn from data with prior understandings. With Variational Inference that incorporates a probability distribution over the weights, it is capable of measuring the model uncertainty. We follow the methodology of *Bayes by Backprop* by Shridhar et al.[1].

2 The Data

The dataset is obtained from a Kaggle competition. It can be seen from figure 1 that some images have only one character, while a few of them have more than one characters. We removed those pictures in case the labels would be confusing.

In addition, by examining the raw data, we found out that there are over 20,000 images in training set with 47 different Simpsons characters, while around 1000 images in testing set with over 20 characters, and each character has about 50 test data. We plot a histogram 2 of the number of images for each character in training set, found out this number is very imbalance. Therefore, we decided to only use those characters with reasonably large images for the models to learn. Similar work has been done to test set. After the cleaning of raw data, we now have 13 characters with the largest amount of training images in both train and test set. They are shown in 1.

The maximum number of images we use to train our model for each character is 1000 (for example, 1354 images have been found for Lisa Simpson, we only use the first 1000 of them), to ensure our training data is balanced. Furthermore, the following data pre-processings are prepared:

- **Re-sizing:** Load the image as size of 64*64.
- **Normalization:** Normalize the data by dividing 255 (reduce the effect of illumination).
- **Reshaping:** Reshape the images into 3-D (height = 64, width = 64, canal = 3), and save another set of 1-D data (64*64*3) for k-NN, RF and SVM.
- **One-hot Encoding:** Encode labels to hot vectors as response variable for CNNs.

3 The Goal

The central goal for this project is to find out if BayesCNN can provide better performance in Simpsons character recognition via Accuracy measurement. We can explore different network architectures and see if it shows any influence to the convergence. Different priors can be applied for sensitivity checking. Furthermore, we will estimate the uncertainty [2] of the model. The tuning process for the network models can be quite complicated, and even if the prediction of BayesCNN is worse than other approaches, it is still helpful to gain some experience in training the network model under Bayesian framework and potentially obtain ideas of improvement.

Figure 1. Examples of Each Image Data

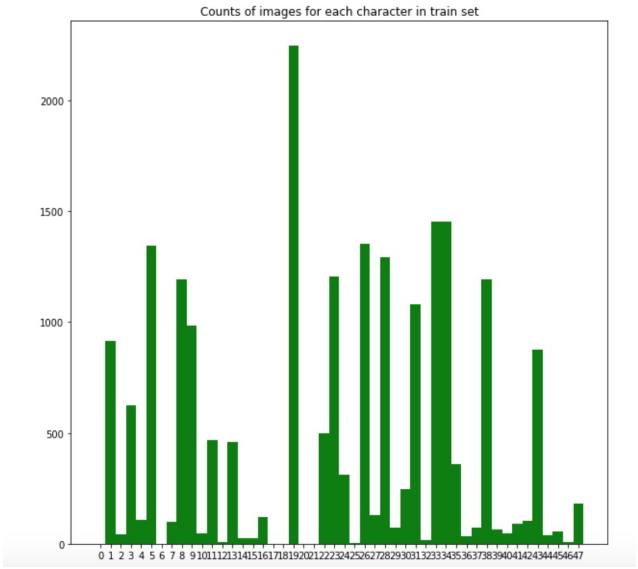

Figure 2. Counts of Images for Each Character in Train Set

Table 1. 13 Characters Picked For Further Use

label	Characters	counts(train set)
0	abrhm grampa simpson	913
1	bart simpson	1342
2	chls montgomery burns	1193
3	chief wiggum	986
4	homer simpson	2246
5	krusty the clown	1206
6	lisa simpson	1354
7	marge simpson	1291
8	milhouse van houten	1079
9	moe szyslak	1452
10	ned flanders	1454
11	principal skinner	1194
12	sideshow bob	877

References

[1] K. Shridhar, F. Laumann, and M. Liwicki, "A comprehensive guide to bayesian convolutional neural network with variational inference," 2019.

[2] K. Shridhar, F. Laumann, and M. Liwicki, "Uncertainty estimations by softplus normalization in bayesian convolutional neural networks with variational inference," 2018.