Neural Networks for Shape Recognition

1. Introduction:

Training artificial Neural networks has become the de facto method for image recognition problem, which is a very important topic in the machine learning field as it can support lots of interesting applications in many fields including medicine, art and finance. Recent years have seen an explosion of proprietary/open source projects aimed at building a better machine learning platform, such as scikit-learn, tensor-flow, and Teano, to name a few [1]. And as a result, we have seen more and more applications of machine learning in our daily interaction with technology---Alexa voice assistant, Apple photos and self-driving cars. For the task of image recognition, researchers have demonstrated steady progress against ImageNet[2], a benchmark problem for computer vision, and each year at the ImageNet competition, we witness a new construction of neural networks become the state-of-art: QuocNet[3], AlexNet[4], Inception(GoogleLeNet) [5], BN-Inception-v2[6]. The ImageNet is a database of 1000 different classes of images, like “Leopard, container ship and motor scooter”.

In this study, I developed a Convolution Neural Network(CNN) model using TensorFlow on the BabyAIShape Datasets[7]. The task is to distinguish between 3 basic shapes—rectangle, eclipse, and triangle—in 32 x 32 images with one shape and uniform colors (one for the shape, and one for the background). The motivation for this study is for one, it is a simple task for beginners to learn about artificial neural networks; second, the model can be used in many interesting applications, e.g. an app for teaching children basic intuition of shapes in early education.

The paper is divided into 5 sections. Section 2 introduces the dataset and how we prepare and process the dataset. In section 3, I explained the three 3 steps of training a neural network with TensorFlow and the architecture of my CNN. Section 4 discusses the decision on hyperparameters like learning rate and batch size, and the different types of optimization methods. In section 5, I provided the results of my model and discussed some thoughts on aspects of potential improvements.

1. Dataset

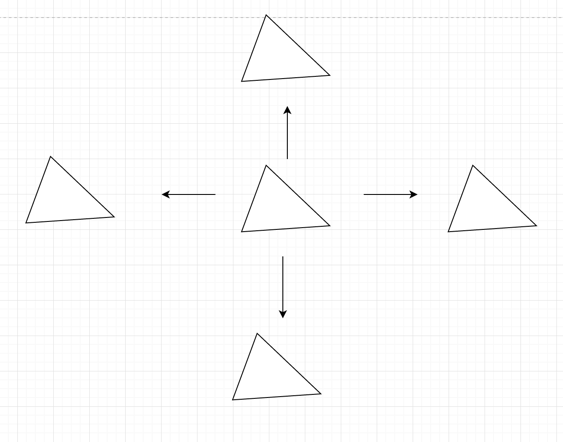
In this study, I have used publicly available dataset BabyAIShapeDatasets. Therer are several datasets in the link provided, but the particular dataset I have used is the shape2\_1cspo\_2\_3 dataset group, which is composed of 10000 samples of training data, 5000 samples of validation data and 5000 samples of testing data. In the github repo[9], you can find the corresponding python files responsible for generating the *amat* file, which is the file format later used by the CNN model. To generate the amat files, you need to install python[10], and then in the terminal (assuming you are using Mac OS), simply type in the following command:

$ python shapeset2\_1cspo\_2\_3.10000.train.py write\_formats amat

I also included the amat files inside the *input* folder for convenience. The .amat file is of ascii format. The value separator is the space (ascii code 0x20) It is organized as follows:

* The first line is the number of examples and the number of values per line (1031).
* On each subsequent line, the first 1024 values represent the gray tone of each pixel (or the color, depending on how you interpret it) as a floating point value between 0 and 1, inclusively (32 lines of 32 pixels). The next 7 values are:
* The shape: 0=rectangle, 1=ellipse and 2=triangle
* The color of the shape: this is actually an integer between 0 and 7. Divide by 7 to get the corresponding gray tone.
* The x coordinate of the centroid of the shape, between 0 (leftmost) and 256 (rightmost).
* The y coordinate of the centroid of the shape, between 0 (top) and 256 (bottom).
* The rotation angle of the shape, between 0 (no rotation) and 256 (full circle). This can probably not be learnt reliably because there the reference point is ambiguous (for instance, there is currently no way to know relatively to which side the triangle was rotated).
* The size of the shape, between 0 (a point) and 256 (the whole area). There is a lower bound and an upper bound.
* The elongation of the shape, between 0 (at least twice as wide as tall) and 256 (at least twice as tall as wide).
  1. Preprocessing the data

To preprocess the data, I first normalized the data since the color is merely a distraction when training a model to recognize shapes. By iterating over the normalize function, the pixels belong to the shape would have a value of 0.5, and the pixels of the background would have a value of -0.5. Since the training and validation data only has 15000 data points, it is too few to train an accurate model. To solve this problem, I flipped the image along the x-axis and y-axis and then translated the image to the left, right, top and bottom by 3 pixels to gain 24000 more sample data. At the end, I have a total of 30000 training and validation data combined for training.



1. Architecture
2. Optimizer
3. Results

References:

References:

1. Top 20 Python Machine Learning Open Source Projects in 2016: (*http://www.kdnuggets.com/2016/11/top-20-python-machine-learning-open-source-updated.html*)
2. ImageNet: (http://www.image-net.org/)
3. QuocNet: (<http://static.googleusercontent.com/media/research.google.com/en//archive/unsupervised_icml2012.pdf>)
4. AlexNet: (<http://www.cs.toronto.edu/~fritz/absps/imagenet.pdf)>
5. GoogleLeNet: (<https://arxiv.org/abs/1409.4842)>
6. BN-Inception-v2: (<https://arxiv.org/abs/1502.03167)>

Gradient Descent: ([*http://cs231n.github.io/optimization-1/*)](http://cs231n.github.io/optimization-1/))

1. BabyAIShapeDatasets: (<http://www.iro.umontreal.ca/~lisa/twiki/bin/view.cgi/Public/BabyAIShapesDatasets)>

Tasks:

Read what gradient descent is (45 mins)

Read through the blog(45 mins)

Batch size and learning rate are the hyper-parameters. We usually cross-validate learning rate, but not for batch size.