Design and Test a Model Architecture – Philip Lee

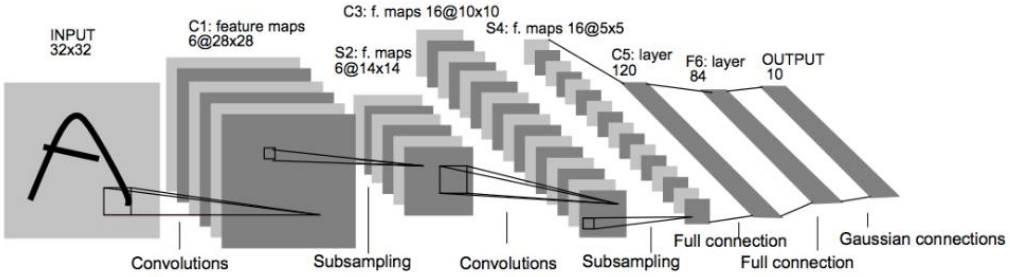
Preprocessing	*The submission describes the preprocessing techniques used and why these techniques were chosen.*

I chose the suggested normalization and RGB to grayscale conversions as suggested in the Youtube instruction session and Slack channel discussions. At first I was getting weird results and I realized I needed to convert the grayscale values so that they could take negative values. This fixed the wraparound problem I was having.

Model Architecture	*The submission provides details of the characteristics and qualities of the architecture, including the type of model used, the number of layers, and the size of each layer. Visualizations emphasizing particular qualities of the architecture are encouraged.*

I used the standard LeNet 5 architecture as I believed it to be sufficient for the job. It has 5 layers: 2 convolutional (32x32x1 -> 28x28x6 -> 14x14x6 -> 10x10x16 -> 5x5x16 -> 1x400 -> 1x120 -> 1x84 -> 1x43. There's a few max pooling and ReLU sprinkled in between.

From Yan LeCun's paper:



Model Training	*The submission describes how the model was trained by discussing what optimizer was used, batch size, number of epochs and values for hyperparameters.*

The model was trained using the standard Adam optimizer. This optimizes stochastic gradient descent without wasting CPU cycles and power. Batch size was 500, which I felt was a good balance of speed and effectiveness. Number of epochs was 50, as I felt like any more than that wasn't buying me more accuracy. Plus with a learning rate of 0.004, it was converging rather quickly. Any lower of a learning and it was taking too long, and higher rates started to get unstable. I initialized with mu = 0 and sigma = 0.1, and random variables to start out with a clean slate.

Solution Approach	*The submission describes the approach to finding a solution. Accuracy on the validation set is 0.93 or greater.*

I started off with the default LeNet 5 architecture and got acceptable 0.89 accuracies. Adding grayscale for ease of the machine learning algorithms raised it up about 2%. I found that with normalization I was able to get the required accuracy without further optimization.

I found that my accuracies were very close, indicating that th model was neither under or overfitted.

With more time I would have considered a different architecture, or duplicating data for slight rotations. Perhaps histogram normalization of the images for very dark or very light images would have helped. Finally, after getting the trained dataset saved, I applied it to 5 images from the web, which were successfully classified.

Test a Model on New Images

CRITERIA	MEETS SPECIFICATIONS
Acquiring New Images	*The submission includes five new German Traffic signs found on the web, and the images are visualized. Discussion is made as to particular qualities of the images or traffic signs in the images that are of interest, such as whether they would be difficult for the model to classify.* I chose a sampling of traffic signs of various shapes and types. I was eager to see if the model was going to classify these never-before seen images well so I chose well-lit traffic signs without occlusions or visual anomalies.
Performance on New Images	*The submission documents the performance of the model when tested on the captured images. The performance on the new images is compared to the accuracy results of the test set.* When I first started, it turns out that the images were not centered or square, and early errors resulted in 40% or 80% accuracy. Once I corrected the images for being square, I achieved 100% accuracy which is similar to the test set.
Model Certainty - Softmax Probabilities	The top five softmax probabilities of the predictions on the captured images are outputted. The submission discusses how certain or uncertain the model is of its predictions. When I output the softmax probabilities, the model was very confident in the predictions. All of them were 1.0 of the most-likely class. This is probably due to my well-lit, clear photos that I picked.