Traffic Sign Classifier

Introduction

Traffic Sign Classifier is trained on German Traffic signs dataset and classifies/recognizes new traffic images as one of the 43 traffic signs. Below are the steps to build Traffic Sign Classifier pipeline:

- Exploratory Data Analysis
- Data Augmentation
- Data Pre-processing
- Build Convolutitional Neural Network Architecture
- Train, validate, test and fine tune model and Network architecture
- Predict sign for new images and evaluate performance
- Visualize convolutional neural network to understand what each layer learns

Data Exploration and Summary

Data set consists of 34K training samples, 4.4K validation and 12.6k. There are 43 distinct traffic signs in the dataset.

Dataset Summary

```
Number of training examples      = 34799 (67%)
Number of validation examples    = 4410  (8.5%)
Number of testing examples       = 12630 (24.36%)
Image data shape = (32, 32, 3)
Number of classes = 43
```

Let's examine few of the traffic sign classes:

Observations

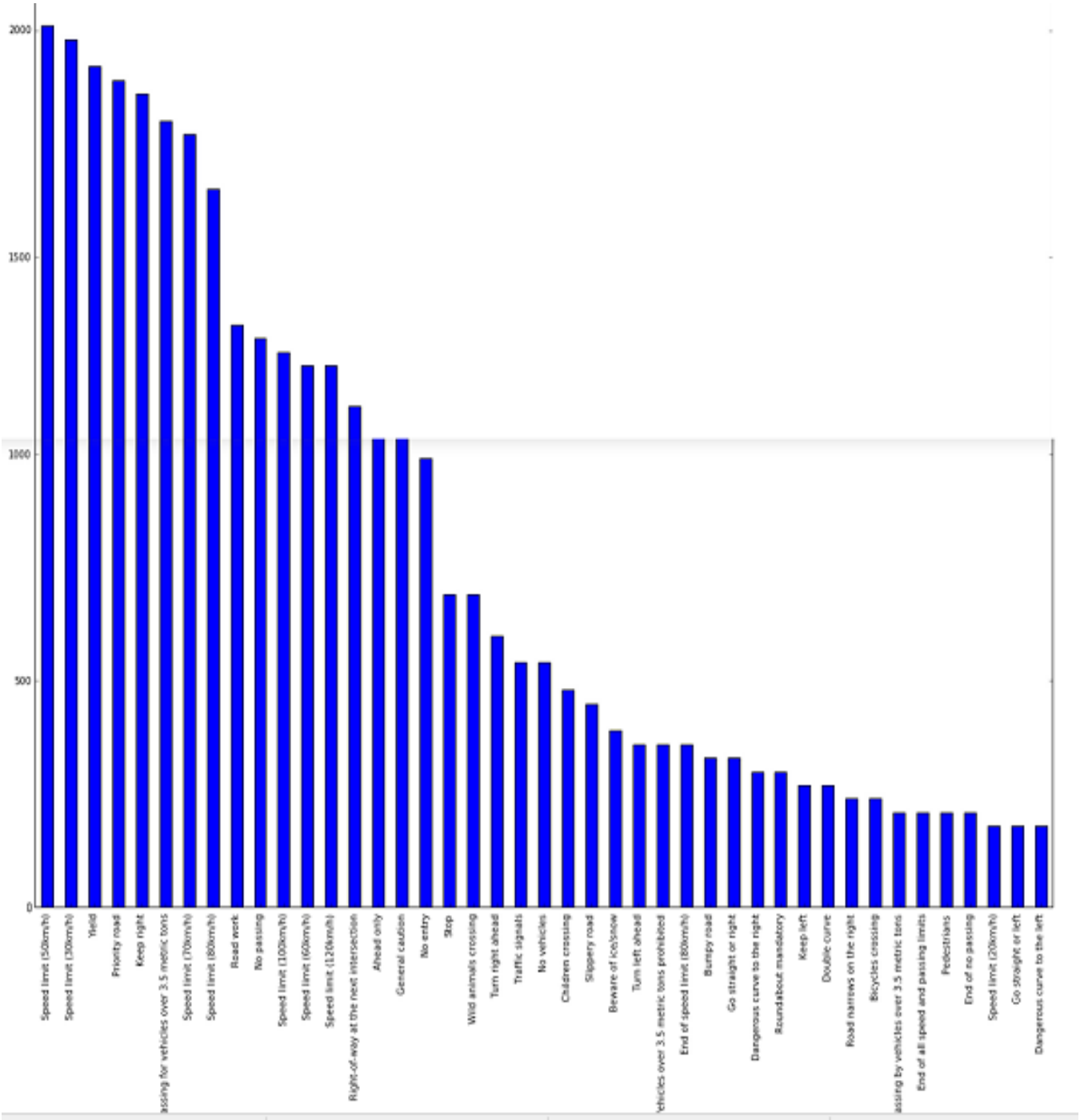
We can observe that traffic signs of the same appear differently due to following aspects

- Lighting conditions
- Brightness
- Angle or position
- Sharpness
- Size
- Color

It will be interesting to observe the distribution of the traffic sign classes:

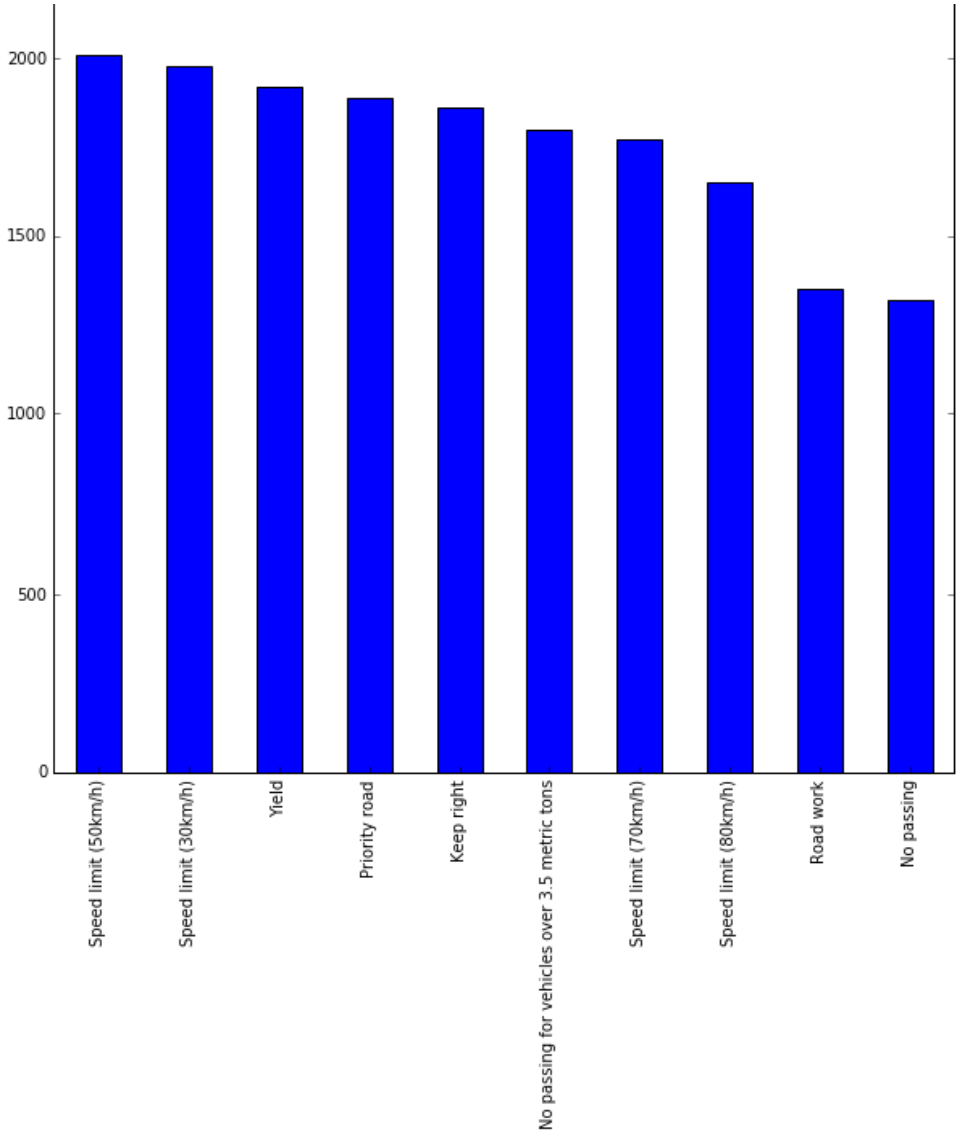
Traffic Sign Distribution

Below is the distribution of the traffic signs. Obviously, the classes are skewed with many traffic sings with less than 500 traffic signs.

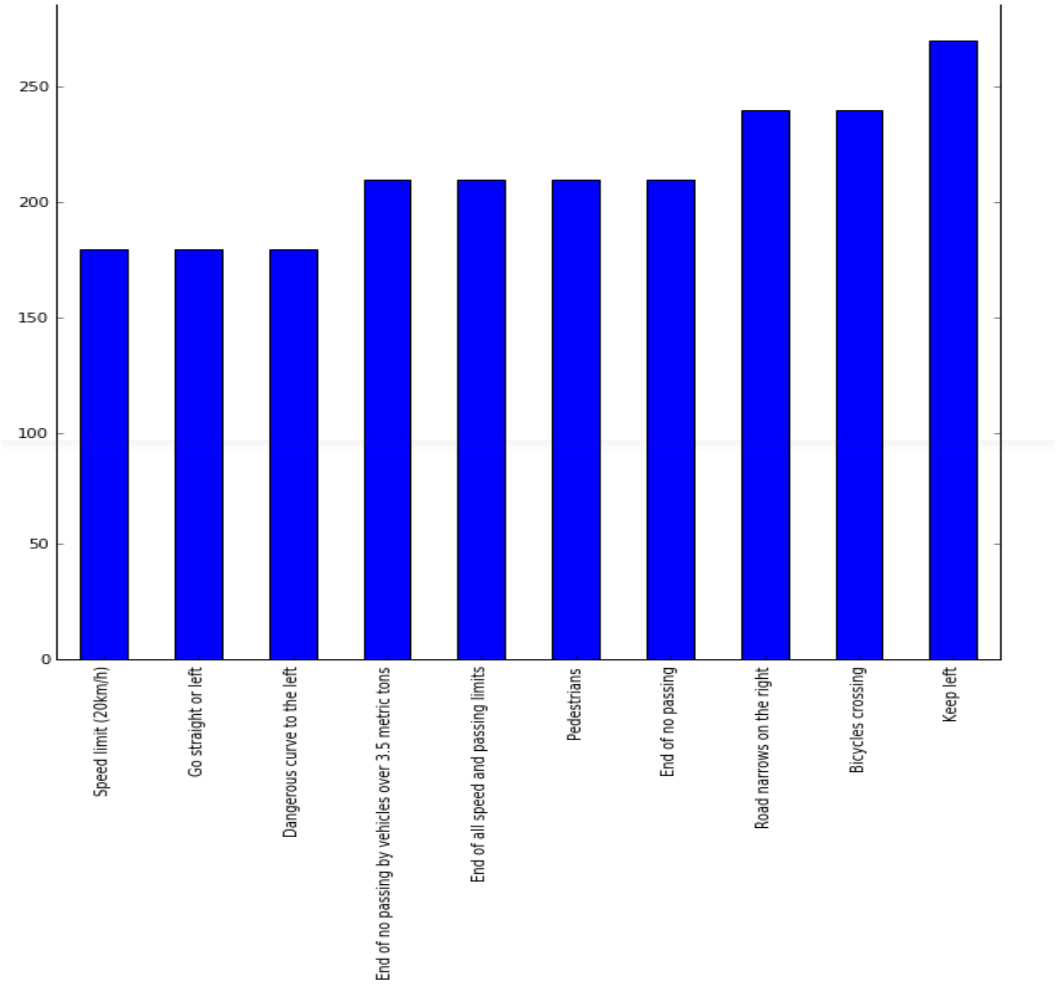


Top 10

Below are the top 10 traffic signs by number of examples:


2000
1500
1000
500
0
Speed limit (50km/h)
Speed limit (30km/h)
Yield
Priority road
Keep right
No passing for vehicles over 3.5 metric tons
Speed limit (70km/h)
Speed limit (80km/h)
Road work
No passing

Bottom 10



Summary Statistics

count	43.000000
mean	809.279070
std	626.750855
min	180.000000
25%	285.000000
50%	540.000000
75%	1275.000000
max	2010.000000

Given the that lower quartile has only 285 images, we can augment the number of examples for these classes by faking the data. I applied rule of augmenting the traffic sign class by adding 400 images per class. Combinations of random rotation, translation, sharpening or histogram equalization.

Training vs Testing vs Validation Distribution

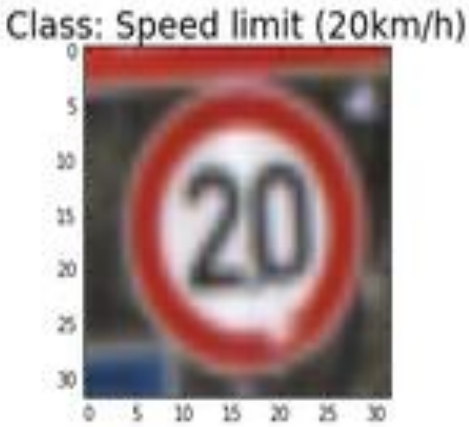
Data Augmentation

Given the imbalanced data set, we can augment the dataset by generating fake images. Images can be generated through following operations:

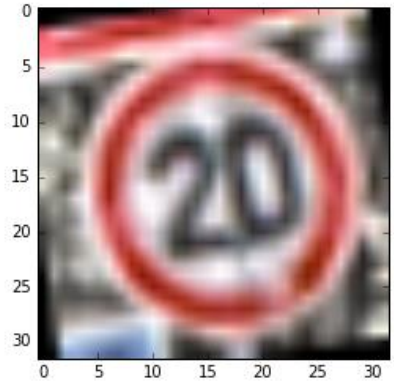
- Rotation
- Translation

- Histogram Equalization
- Sharpening

I have generated fake images by transforming the images through series of few of the above set of operations. Below are few examples of such augmented images:

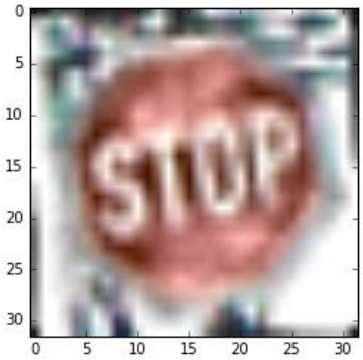


Original Image



Augmented Image

Original Image



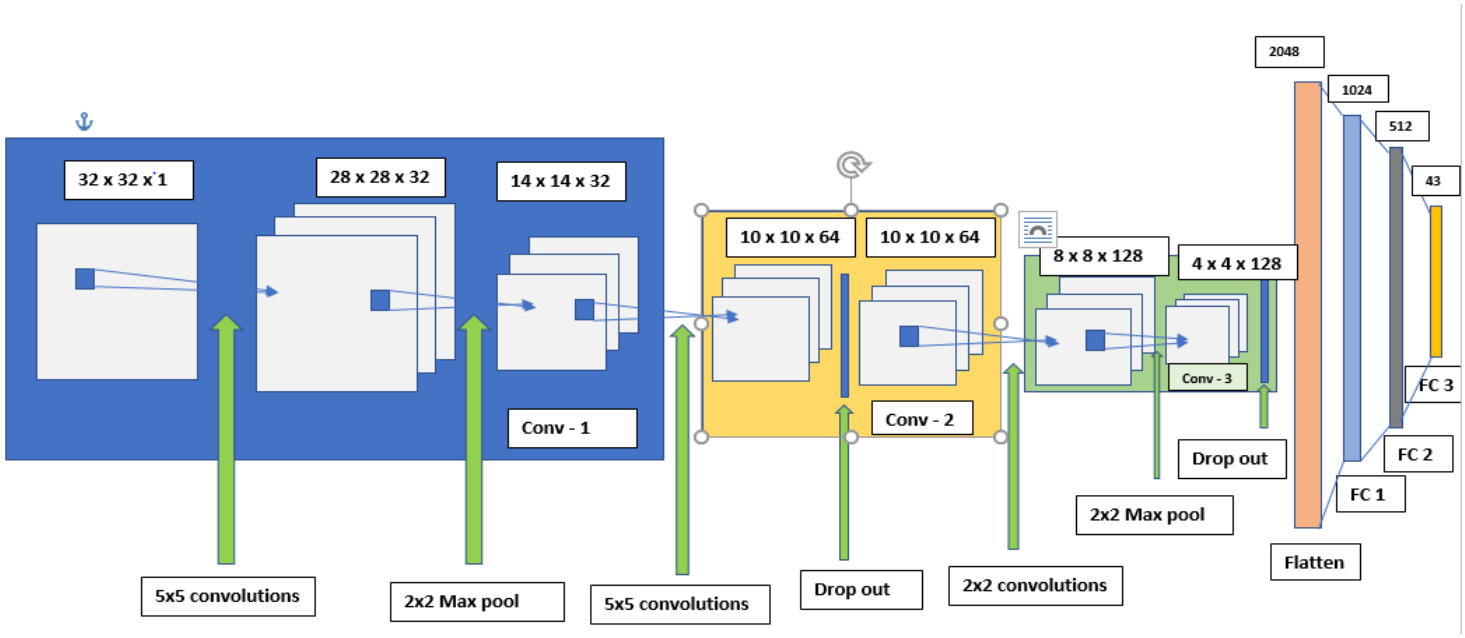
Augmented Image

Data Pre-processing

Below were the data pre-processing tests done:

a) Convert to gray scale
b) Normalize data set to be in the range of [0, 1]

Model Architecture



Layer	Description	Input	Output
Input Layer	32 x 32 x 1 after conversion to grayscale	32x32x3	32x32x1
Conv - 1	32 5x5 filters	32x32x1	28x28x32
Max pool - 1	2x2 Maxpool	28x28x32	14x14x32
Conv - 2	64 5x5 filters	14x14x32	10x10x64
Dropout	Dropout layer	10x10x64	10x10x64
Conv - 3	128 2x2 Filters	10x10x64	8x8x128
Max pool - 2	2x2 Maxpool	8x8x128	4x4x128
Dropout	Dropout layer	4x4x128	4x4x128
Flatten Layer	Flatten droput layer	4x4x128	2048
FC 1 Layer	Fully connected layer 1	2048	1024
FC 2 Layer	Fully connected layer 2	1024	512
FC 3 Layer	Fully connected layer 3	512	43

Training, Validation and Testing

Results

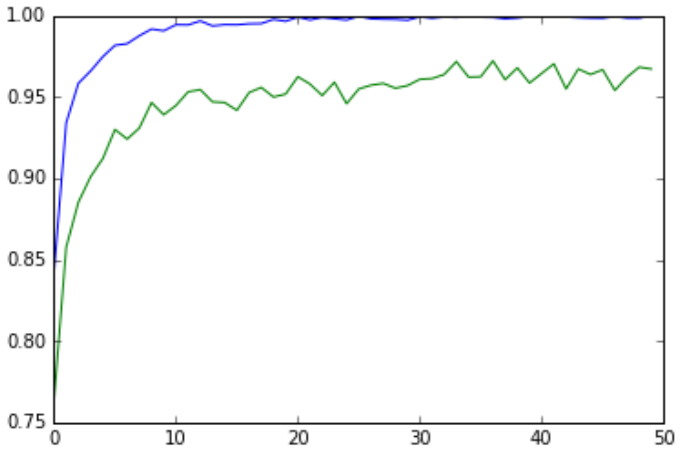
a) With Data Augmentation

Stage	Accuracy
Training	1.000
Validation	0.968
Testing	0.956

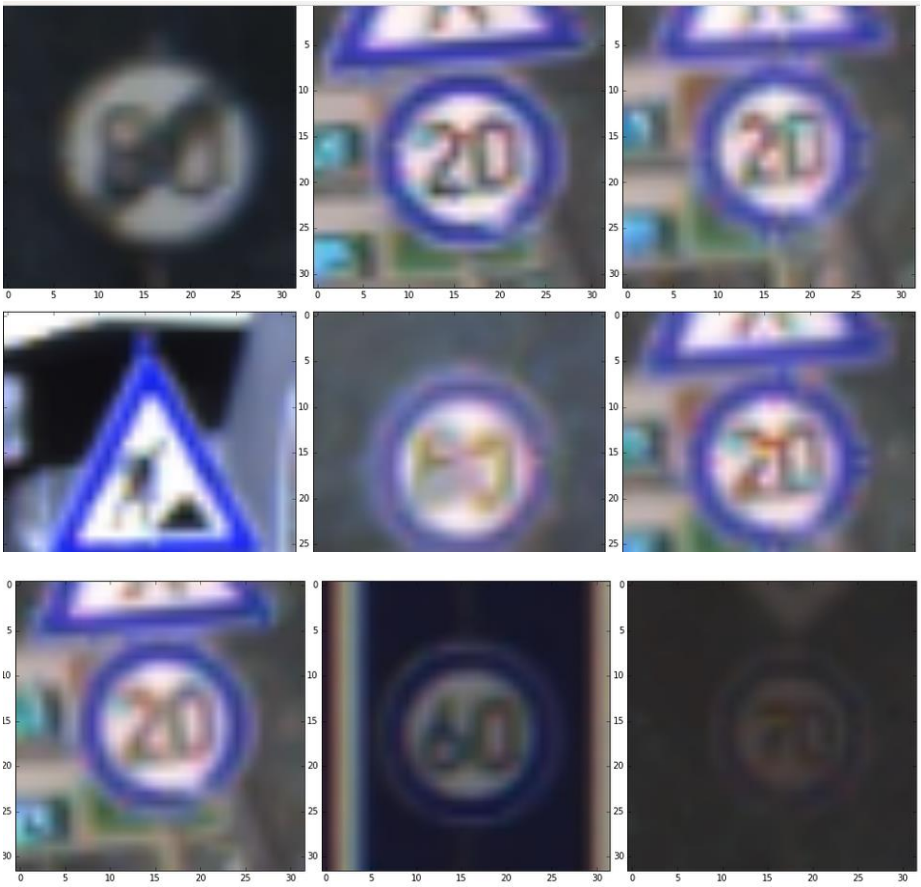
b) Without Data Augmentation

Stage	Accuracy
Training	0.990
Validation	0.963
Testing	0.950

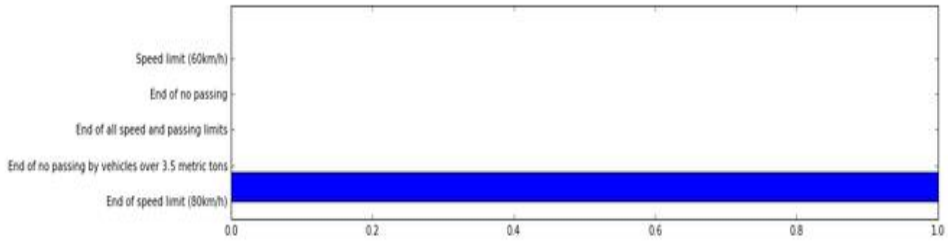
Training vs Validation Accuracy



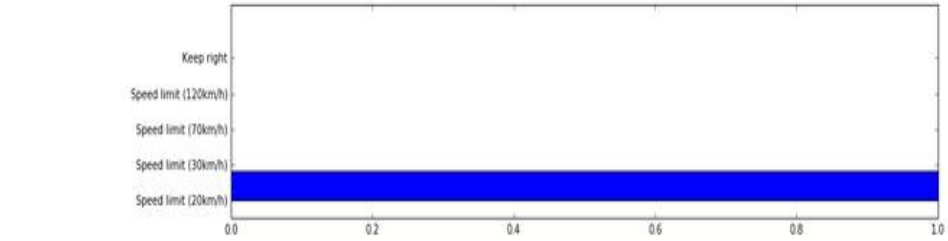
Predicting Sign of New Images



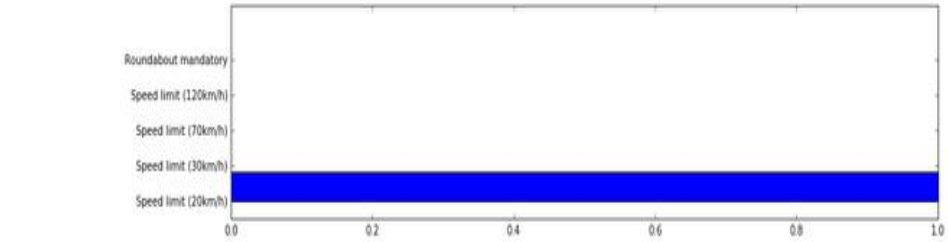
Actual class: Speed limit (80km/h)



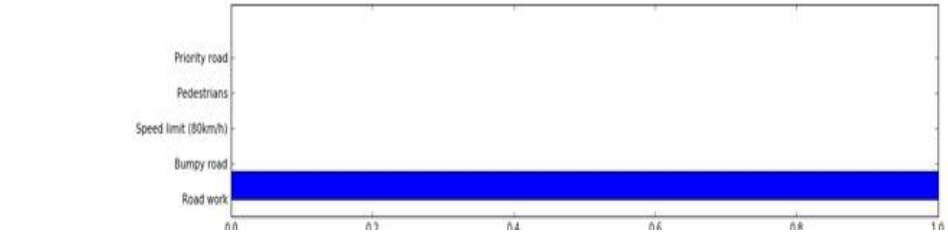
Actual class: Speed limit (20km/h)



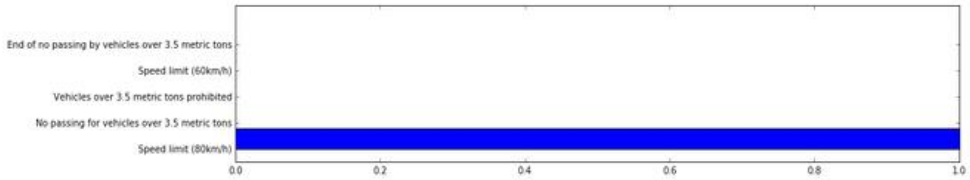
Actual class: Speed limit (20km/h)



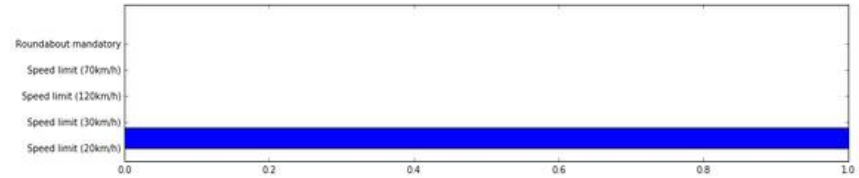
Actual class: Road work



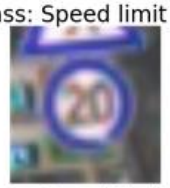
Actual class: Speed limit (60km/h)

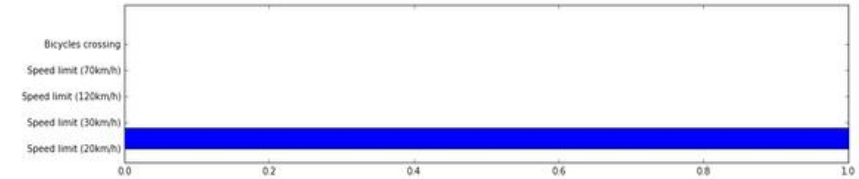


Actual class: Speed limit (20km/h)

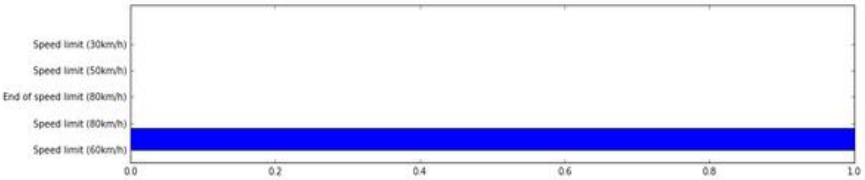


Actual class: Speed limit (20km/h)





Actual class: Speed limit (60km/h)



Actual class: Speed limit (70km/h)

Actual class: Speed limit (70km/h)