Traffic Sign Recognition

Writeup

The goals / steps of this project are the following:

- Load the data set (see below for links to the project data set)
- Explore, summarize and visualize the data set
- Design, train and test a model architecture
- Use the model to make predictions on new images
- Analyze the softmax probabilities of the new images
- Summarize the results with a written report

Data Set Summary & Exploration

1. Provide a basic summary of the data set. In the code, the analysis should be done using python, numpy and/or pandas methods rather than hardcoding results manually.

- The size of training set is 34799
- The size of validation set is 4410
- The size of testing set is 12630
- The shape of a traffic sign image is 32x32x3
- The number of unique classes is 43

2. Include an exploratory visualization of the data set.

A bar chart showing how the instances are distributed across classes is shown in Fig. 1. We can see that the data set is imbalanced. Thus, augmentation of the dataset by adding images to the classes can increase prediction accuracy.

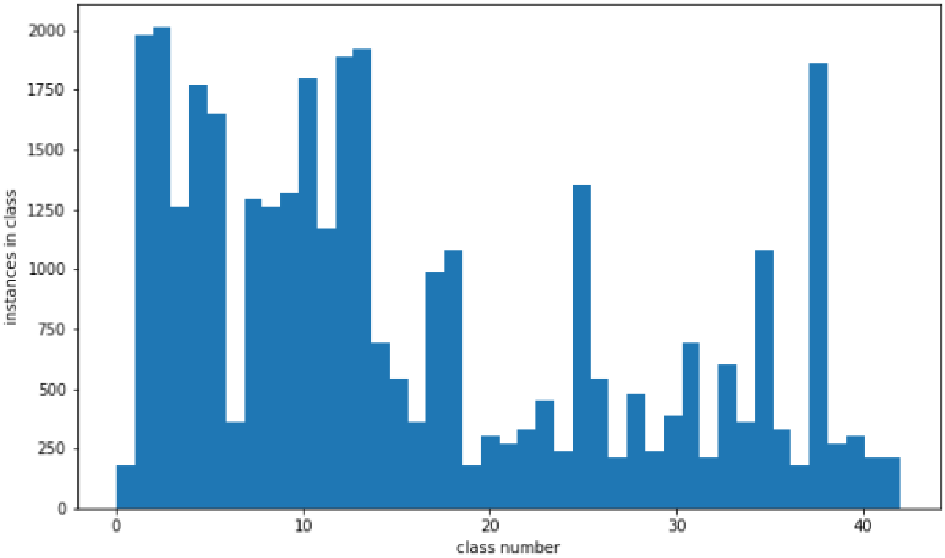

Fig. 1. Histogram of instances in classes

Figure 2 demonstrates examples of images in the training data set.

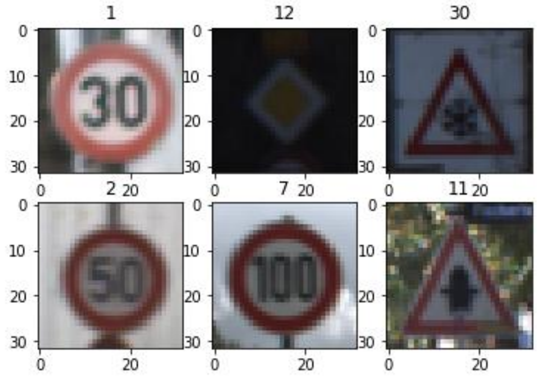

Fig 2. Example of images in the training data set

Design and Test a Model Architecture

1. Describe how you preprocessed the image data. What techniques were chosen and why did you choose these techniques? Consider including images showing the output of each preprocessing technique. Pre-processing refers to techniques such as converting to grayscale, normalization, etc.

I normalized data because it speeds up learning and leads to faster convergence. Even though the data set was quite imbalanced, I decided to train the CNN without augmenting the data. Also the data was shuffled to make the training batches uncorrelated.

2. Describe what your final model architecture looks like including model type, layers, layer sizes, connectivity, etc.) Consider including a diagram and/or table describing the final model.

Layer	Description
Input	32x32x3 RGB image
Convolution	5x5, 1x1 stride, valid padding, 28x28x6 output
ReLU	
Max pooling	2x2, 2x2 stride, 14x14x6 outputs
Convolution	5x5, 1x1 stride, valid padding, 10x10x16 output
ReLU	
Max pooling	2x2, 2x2 stride, 5x5x16 output
Fully connected	Input: 400, output: 120
ReLU	
Fully connected	Input: 120, output: 84
ReLU	
Fully connected	Input: 83, output: 43
Softmax	

3. Describe how you trained your model. The discussion can include the type of optimizer, the batch size, number of epochs and any hyperparameters such as learning rate.

To train the model, I used Adam optimization algorithm. The batch size was 128 and 70 epochs were used. The learning rate was set to 0.001.

4. Describe the approach taken for finding a solution and getting the validation set accuracy to be at least 0.93.

The validation accuracy of 0.945 was achieved.

The test set accuracy is 0.929.

The LeNet architecture was used. I decided that it is relevant to the traffic sign classification since it was originally used to classify images of digits, which is close to our task. The validation and test accuracy are quite high and can be increased by balancing the training data set and futher tuning hyperparameters. So, the chosen LeNet model works well in this application.

Test a Model on New Images

1. Choose five or more German traffic signs found on the web and provide them in the report. For each image, discuss what quality or qualities might be difficult to classify.

I used 7 traffic sign images which were obtained from Google Street view of Munich.

a) b) c)

d) e) f) g)

Fig. 3. New images used for testing. a) yield, b) keep right, c) go straight or right, d) bicycles crossing, e) road work, f) priority road, g) speed limit 60 km/h

Images a-f might be difficult to classify because of heterogeneous background. Sign g is strongly illuminated which can cause difficulties in classification.

2. Discuss the model's predictions on these new traffic signs and compare the results to predicting on the test set. At a minimum, discuss what the predictions were, the accuracy on these new predictions, and compare the accuracy to the accuracy on the test set

Image	Prediction
a) yield	yield
b) keep right	keep right

c) go straight or right	go straight or right
d) bicycles crossing	turn right ahead
e) road work	road work
f) priority road	priority road
g) speed limit 60 km/h	priority road

The model was able to correctly guess 5 out of 7 traffic signs, which gives an accuracy of 71.4%. The code which demonstrates this is in the 18th cell of the notebook.

3. *Describe how certain the model is when predicting on each of the five new images by looking at the softmax probabilities for each prediction. Provide the top 5 softmax probabilities for each image along with the sign type of each probability.*

The code for making predictions on my final model is located in the 18th cell of the notebook.

For image number 1, the model is sure that it is a stop sign. The probability is 100%.

For the second image the probability of the sign to be “keep right” is 100%, which is correct.

The third image was classified correctly as well with the probability of 100% that it is a “go straight or right” sign.

The top 5 classification probabilities for image 4 (bicycles crossing) are in the table below.

Probability	Prediction
≈ 1	Turn right ahead
$0.12 \cdot 10^{-6}$	Priority road
$0.89 \cdot 10^{-9}$	Keep left
$0.21 \cdot 10^{-13}$	Go straight or left
$0.5 \cdot 10^{-14}$	Traffic signals

The 5th and 6th images were correctly classified with 100% probabilities.

The 7th image (speed limit 60km/h) was not classified correctly.

Probability	Prediction
0.94	Priority road
0.063	Keep right
$0.799 \cdot 10^{-4}$	Speed limit (20km/h)
$0.22 \cdot 10^{-7}$	Speed limit (30km/h)
$0.14 \cdot 10^{-7}$	Slippery road