preprocessing

August 15, 2016

1 Training a cNN to detect roadsigns

In order to process roadsigns in the autonomous car of the Freie Universität, we want to train a convolutional (deep) neural network.

This network is supposed to distinguish between different classes of signs (stop, attention, train crossing etc) and the final model will then be integrated to the autonomos ROS structure.

This notebook shall download the dataset, read it in and then train the classifier. Afterwards, a validation of the training procedure will be done.

```
In [205]: import tensorflow as tf
          import numpy as np
          import matplotlib.pyplot as plt
          import matplotlib.image as mpimg
          from PIL import Image
          import urllib2, cStringIO, zipfile
          import csv
          import os
          import random
          from sklearn import preprocessing
          import warnings
          import scipy.misc as misc
          from scipy.ndimage import zoom
          import math
```

1.1 Set global parameters such as image size or channels

Options include: * Size of the images * Which color channels are used (RGB or YUV) * How many new images are artificially added? * How do we normalize the image?

```
In [2]: img_size = (32, 32)
```

1.2 Download the training dataset

```
In [3]: url = 'http://benchmark.ini.rub.de/Dataset/GTSRB_Final_Training_Images.zip'

        if not os.path.exists('GTSRB/Final_Training/Images'):
            try:
```

```
            remotezip = urllib2.urlopen(url)
            zipinmemory = cStringIO.StringIO(remotezip.read())
            zip = zipfile.ZipFile(zipinmemory)
            zip.extractall('.')
        except urllib2.HTTPError:
            pass
```

1.3 Download the test dataset

```
In [4]: #url = 'http://benchmark.ini.rub.de/Dataset/GTSRB_Final_Test_Images.zip'

        #if not os.path.exists('GTSRB/Final_Test/Images'):
        #    try:
        #        remotezip = urllib2.urlopen(url)
        #        zipinmemory = cStringIO.StringIO(remotezip.read())
        #        zip = zipfile.ZipFile(zipinmemory)
        #        zip.extractall('.')
        #    except urllib2.HTTPError:
        #        pass
```

1.4 Read the data in and scale it to a fixed resolution

```
In [369]: def scale_image(img, scale_factor):
              scaled = misc.imresize(img, scale_factor)
              new_img = np.zeros_like(img)
              left_x = scaled.shape[0]/2.-img.shape[0]/2.
              right_x = scaled.shape[0]/2.+img.shape[0]/2.
              left_y = scaled.shape[1]/2.-img.shape[1]/2.
              right_y = scaled.shape[1]/2.+img.shape[1]/2.

              if rand_scale > 1: # scaled is larger than original img
                  new_img = scaled[math.ceil(left_x):math.ceil(right_x), math.ceil
              else: # scaled is smaller than original img
                  new_img[math.floor(-left_x):math.floor(right_x), math.floor(-left
              return new_img

          def scale_image_gs(img, scale_factor):
              scaled = misc.imresize(img, scale_factor)
              new_img = np.zeros_like(img)
              left_x = scaled.shape[0]/2.-img.shape[0]/2.
              right_x = scaled.shape[0]/2.+img.shape[0]/2.
              left_y = scaled.shape[1]/2.-img.shape[1]/2.
              right_y = scaled.shape[1]/2.+img.shape[1]/2.

              if rand_scale > 1: # scaled is larger than original img
                  new_img = scaled[math.ceil(left_x):math.ceil(right_x), math.ceil
              else: # scaled is smaller than original img
                  new_img[math.floor(-left_x):math.floor(right_x), math.floor(-left
```

```
    new_img = new_img.reshape(img_size[0], img_size[1], 1)
    return new_img

def getSingleImage(path, all_channels, normalize):
    # read image
    img = Image.open(path) # the 1th column is the filename
    img_resized = img.resize((img_size[0], img_size[1]), Image.LINEAR)
    del img
    np_img = np.array(img_resized.convert('YCbCr'))
    del img_resized
    Y_channel = np_img[:,:,0]

    if normalize:
        scaler = preprocessing.MinMaxScaler(feature_range=(0, 255), copy=
        scaler.transform(Y_channel)

    if not all_channels:
        return Y_channel.reshape(img_size[0], img_size[1], 1)
    else:
        np_img[:,:,0] = Y_channel
        return np_img

def read_training_set(rootpath, train_test_split, all_channels=True, norm
    '''Reads traffic sign data for German Traffic Sign Recognition Benchm

    Arguments: path to the traffic sign data, for example './GTSRB/Traini
    Returns:   list of images, list of corresponding labels'''

    training_images = [] # images
    training_labels = [] # corresponding labels

    test_images = [] # images
    test_labels = [] # corresponding labels

    # loop over all 43 classes
    with warnings.catch_warnings(): #ignore warnings from sklearn
        warnings.simplefilter("ignore")
        for c in range(0,43):
            prefix = rootpath + '/' + format(c, '05d') + '/' # subdirecto
            gtFile = open(prefix + 'GT-'+ format(c, '05d') + '.csv') # ar
            gtReader = csv.reader(gtFile, delimiter=';') # csv parser for
            gtReader.next() # skip header

            # loop over all images in current annotations file
            for row in gtReader:
                np_img = getSingleImage(prefix + row[0], all_channels, no

                if random.random() <= train_test_split:
```

```
                    test_images.append(np_img)
                    test_labels.append(row[7])
                else:
                    training_images.append(np_img)
                    training_labels.append(row[7])
            gtFile.close()
            print "Loaded images from class " + str(c)
        return (training_images, training_labels, test_images, test_label

    def read_test_set(rootpath):

        images = [] # images
        gtFile = open(rootpath + '/GT-final_test.test.csv') # annotations fi
        gtReader = csv.reader(gtFile, delimiter=';') # csv parser for annotat
        gtReader.next() # skip header

        # loop over all images in current annotations file
        for row in gtReader:
            print "Filename: " + rootpath + '/' + row[0]
            np_img = getSingleImage(rootpath + '/' + row[0]) # the 1th column
            images.append(np_img)
        gtFile.close()

        return (images, labels)
```

```
In [382]: trainImg, trainLabels, testImg, testLabels = read_training_set('GTSRB/Fir
```

```
Loaded images from class 0
Loaded images from class 1
Loaded images from class 2
Loaded images from class 3
Loaded images from class 4
Loaded images from class 5
Loaded images from class 6
Loaded images from class 7
Loaded images from class 8
Loaded images from class 9
Loaded images from class 10
Loaded images from class 11
Loaded images from class 12
Loaded images from class 13
Loaded images from class 14
Loaded images from class 15
Loaded images from class 16
Loaded images from class 17
Loaded images from class 18
Loaded images from class 19
Loaded images from class 20
```

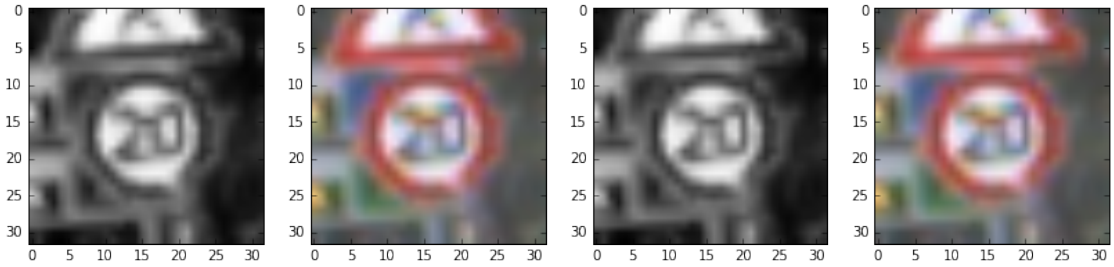
```
Loaded images from class 21
Loaded images from class 22
Loaded images from class 23
Loaded images from class 24
Loaded images from class 25
Loaded images from class 26
Loaded images from class 27
Loaded images from class 28
Loaded images from class 29
Loaded images from class 30
Loaded images from class 31
Loaded images from class 32
Loaded images from class 33
Loaded images from class 34
Loaded images from class 35
Loaded images from class 36
Loaded images from class 37
Loaded images from class 38
Loaded images from class 39
Loaded images from class 40
Loaded images from class 41
Loaded images from class 42
```

```
In [383]: fig = plt.figure(figsize=(14,8))
          path = 'GTSRB/Final_Training/Images/00000/00000_00000.ppm'
          plt.subplot(1, 4, 1)
          img1 = getSingleImage(path, False, False)
          print img1.shape
          plt.imshow(img1.squeeze(), cmap='Greys_r')
          plt.subplot(1, 4, 2)
          img2 = getSingleImage(path, True, False)
          print img2.shape
          x = misc.toimage(img2, high=255, low=0, mode='YCbCr')
          plt.imshow(x)
          plt.subplot(1, 4, 3)
          img3 = getSingleImage(path, False, True)
          print img3.shape
          plt.imshow(img3.squeeze(), cmap='Greys_r')
          plt.subplot(1, 4, 4)
          img4 = getSingleImage(path, True, True)
          print img4.shape
          x = misc.toimage(img4, high=255, low=0, mode='YCbCr')
          plt.imshow(x)
```

```
(32, 32, 1)
(32, 32, 3)
(32, 32, 1)
```

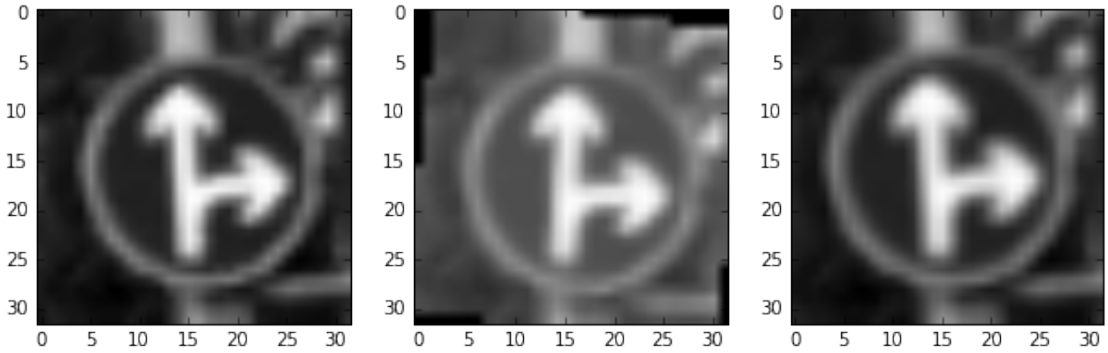
```
(32, 32, 3)
```

Out[383]: <matplotlib.image.AxesImage at 0x7f9004de4290>



In [384]:
```
fig = plt.figure(figsize=(14,8))
rand_index = random.randrange(0, len(trainImg)-1)
rand_angle = (random.random()*15.) * (-1)**(random.random() > 0.5)
rand_scale = 1 + random.random()*0.2 * (-1)**(random.random() > 0.5)
print rand_angle, rand_scale
plt.subplot(1, 4, 1)
print trainImg[rand_index].shape
if trainImg[rand_index].shape[2] > 1:
    x = misc.toimage(trainImg[rand_index], mode='YCbCr')
    plt.imshow(x)
else:
    plt.imshow(trainImg[rand_index].squeeze(), cmap='Greys_r')
    plt.subplot(1,4,2)

if trainImg[rand_index].shape[2] > 1:
    rotated = misc.imrotate(trainImg[rand_index], rand_angle)
    print rotated.shape
    y = misc.toimage(rotated, mode='YCbCr')
    plt.imshow(y)
else:
    rotated = misc.imrotate(trainImg[rand_index].squeeze(), rand_angle)
    plt.imshow(rotated, cmap='Greys_r')
plt.subplot(1,4,3)
if trainImg[rand_index].shape[2] > 1:
    scaled = scale_image(trainImg[rand_index], rand_scale)
    z = misc.toimage(scaled, mode='YCbCr')
    plt.imshow(z)
else:
    scaled = scale_image_gs(trainImg[rand_index].squeeze(), rand_scale)
    plt.imshow(scaled.squeeze(), cmap='Greys_r')
```

```
-6.45592929182 1.04140350241
(32, 32, 1)

/usr/local/lib/python2.7/dist-packages/ipykernel/__main__.py:24: VisibleDeprecation
```



```
In [385]: print "Number of training images: " + str(len(trainImg))
          print "Number of training labels: " + str(len(trainLabels))
          print "Number of testing images: " + str(len(testImg))
          print "Number of testing labels: " + str(len(testLabels))
          print "Train Test Ratio: " + str(len(trainImg) / (len(testImg)*100.))
```

```
Number of training images: 35318
Number of training labels: 35318
Number of testing images: 3891
Number of testing labels: 3891
Train Test Ratio: 0.0907684399897
```

1.5 Permute the training data randomly and make it a big matrix

```
In [386]: permutation = np.random.permutation(len(trainImg))
          train_set = np.array([trainImg[idx] for idx in permutation], dtype=np.flo
          train_labels = [trainLabels[idx] for idx in permutation]
          test_set = np.array(testImg, dtype=np.float32)
          test_labels = testLabels
```

1.6 Transform labels to one-hot-vectors and make it a matrix

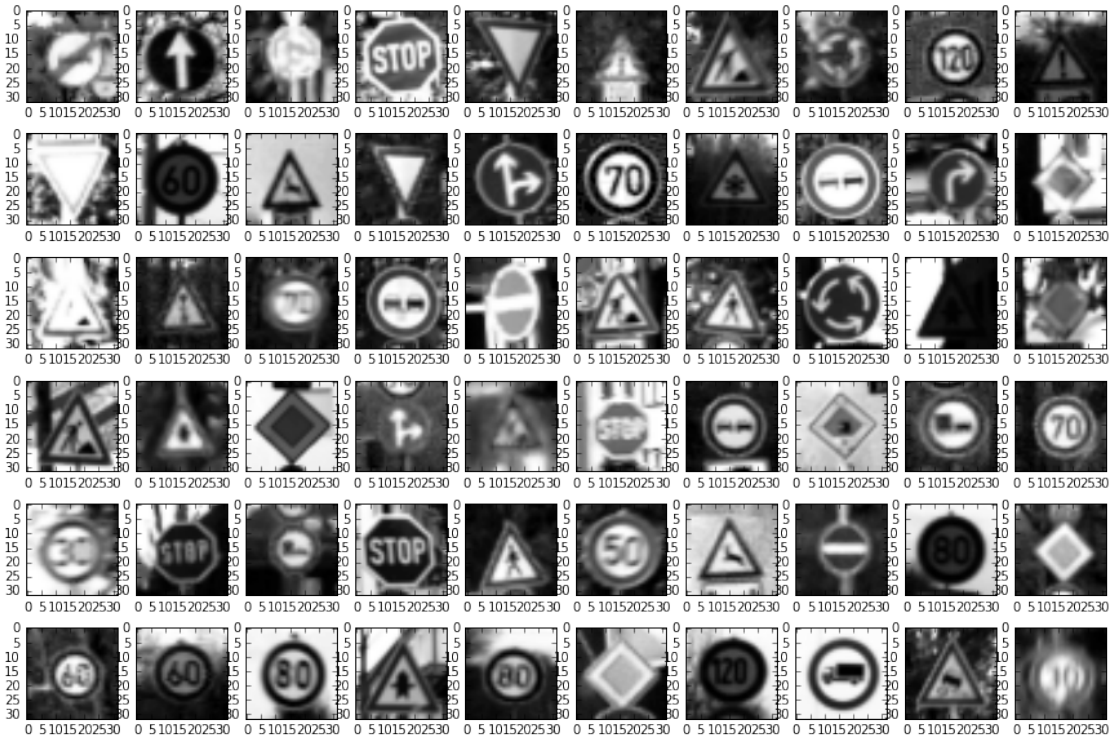
```
In [387]: train_labels_oh = []
          number_of_classes = 43
          for label in train_labels:
              new_label = np.zeros(number_of_classes)
              new_label[int(label)] = 1
```

```
        train_labels_oh.append(new_label)
    train_labels = np.array(train_labels_oh, dtype=np.float32)

    test_labels_oh = []
    for label in test_labels:
        new_label = np.zeros(number_of_classes)
        new_label[int(label)] = 1
        test_labels_oh.append(new_label)
    test_labels = np.array(test_labels_oh, dtype=np.float32)
```

1.7 Show some of the images

```
In [388]: %matplotlib inline
          num_of_plotted_imgs = 60
          imgs_per_line = 10
          random_images = [random.randrange(train_set.shape[0]) for i in xrange(num
          print train_set[random_images[0]].shape
          print random_images
          fig = plt.figure(figsize=(15, 10))
          for i in xrange(num_of_plotted_imgs):
              fig.add_subplot(num_of_plotted_imgs / imgs_per_line, imgs_per_line, i

              if train_set[random_images[i]].shape[2] == 1: #only y channel
                  plt.imshow(train_set[random_images[i]].squeeze(), cmap='Greys_r')
              else:
                  x = misc.toimage(train_set[random_images[i]], mode='YCbCr')
                  plt.imshow(x)
          plt.show()
```

```
(32, 32, 1)
[14230, 27151, 6182, 6414, 34692, 11577, 30373, 9974, 12794, 1396, 13824, 8409, 196
```



1.8 Add images with random rotations and scales

To further improve the quality of the classifier, add some more images. These new training images are derived from previous data by rotating and translating randomly.

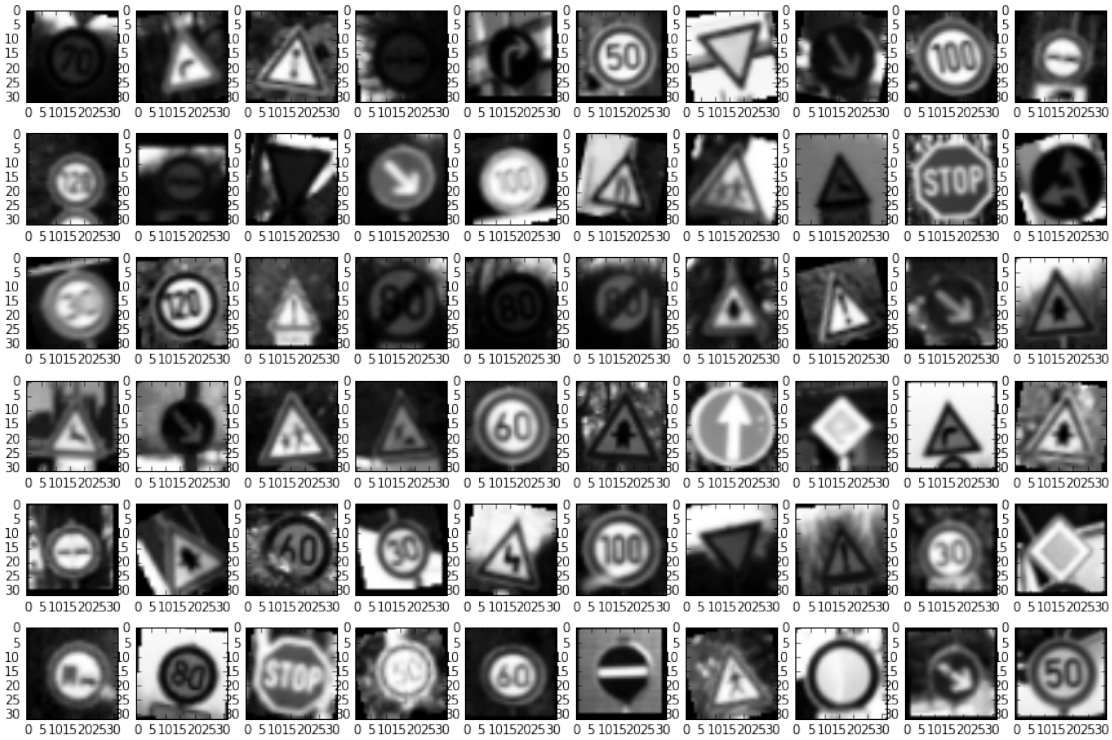
```
In [392]: desired_number_of_images = 100000
          print train_set.shape[0]
          additional_images = []
          additional_labels = []
          for i in xrange(train_set.shape[0], desired_number_of_images):
              rand_index = random.randrange(0, train_set.shape[0])
              rand_img = train_set[rand_index]
              if random.random() > 0.5: # rotate
                  rand_angle = (random.random()*15.) * (-1)**(random.random() > 0.5
                  if rand_img.shape[2] > 1:
                      additional_images.append(misc.imrotate(rand_img, rand_angle))
                  else:
                      additional_images.append(misc.imrotate(rand_img.squeeze(), ra
              else:
                  rand_scale = 1 + random.random()*0.1 * (-1)**(random.random() > 0
                  if rand_img.shape[2] > 1:
                      additional_images.append(scale_image(rand_img, rand_scale))
                  else:
```

```
                    additional_images.append(scale_image_gs(rand_img.squeeze(), r
                additional_labels.append(train_labels[rand_index])

            additional_images = np.asarray(additional_images, dtype=np.float32)
            additional_labels = np.asarray(additional_labels, dtype=np.float32)
            print additional_images.shape
            print additional_labels.shape
```

```
50000


/usr/local/lib/python2.7/dist-packages/ipykernel/__main__.py:24: VisibleDeprecation
/usr/local/lib/python2.7/dist-packages/ipykernel/__main__.py:26: VisibleDeprecation


(50000, 32, 32, 1)
(50000, 43)
```

```
In [393]: num_of_plotted_imgs = 60
          imgs_per_line = 10
          random_images = [random.randrange(additional_images.shape[0]) for i in xr
          print additional_images[random_images[0]].shape
          print random_images
          fig = plt.figure(figsize=(15, 10))
          for i in xrange(num_of_plotted_imgs):
              fig.add_subplot(num_of_plotted_imgs / imgs_per_line, imgs_per_line, i

              if additional_images[random_images[i]].shape[2] == 1: #only y channel
                  plt.imshow(additional_images[random_images[i]].squeeze(), cmap='G
              else:
                  x = misc.toimage(additional_images[random_images[i]], mode='YCbCr
                  plt.imshow(x)
          plt.show()
```

```
(32, 32, 1)
[25438, 27804, 45999, 22880, 24929, 29298, 33523, 14082, 5596, 37789, 9869, 20328,
```



```
In [394]: train_set = np.concatenate((train_set, additional_images), axis=0)
          train_labels = np.concatenate((train_labels, additional_labels), axis=0)
          print train_set.shape
          print train_labels.shape
```

```
(100000, 32, 32, 1)
(100000, 43)
```

1.9 Pickle the images to a file that can easily be loaded

```
In [395]: import pickle
          train_name = 'train_data_gray_norm_aug.pkl'
          with open(train_name, 'w') as f:
              pickle.dump([train_set, train_labels], f, pickle.HIGHEST_PROTOCOL)

          test_name = 'test_data_gray_norm_aug.pkl'
          with open(test_name, 'w') as f:
              pickle.dump([test_set, test_labels], f, pickle.HIGHEST_PROTOCOL)
```

```
In [201]: angles = []
          for i in range(1000):
              angles.append((random.random()*15.) * (-1)**(random.random() > 0.5))
          print np.sum(np.array(angles) > 0)
          print np.sum(np.array(angles) < 0)
```

```
491
509
```

In [ ]: