```
!git clone https://bitbucket.org/jadslim/german-traffic-signs
```

```
Cloning into 'german-traffic-signs'...
remote: Counting objects: 6, done.
remote: Compressing objects: 100% (6/6), done.
remote: Total 6 (delta 0), reused 0 (delta 0)
Unpacking objects: 100% (6/6), done.
```

```
!ls german-traffic-signs
```

```
signnames.csv  test.p  train.p  valid.p
```

Importing all the libraries

```
import numpy as np
import matplotlib.pyplot as plt
import keras
from keras.models import Sequential
from keras.optimizers import Adam
from keras.layers import Dense
from keras.layers import Flatten, Dropout
from keras.utils.np_utils import to_categorical
from keras.layers.convolutional import Conv2D, MaxPooling2D
import random
import pickle
import pandas as pd
import cv2
```

```
np.random.seed(0)
```

Loading the data as train, test & valadition.

```
with open('german-traffic-signs/train.p', 'rb') as f:
    train_data = pickle.load(f)
with open('german-traffic-signs/valid.p', 'rb') as f:
    val_data = pickle.load(f)
# TODO: Load test data
with open('german-traffic-signs/test.p', 'rb') as f:
    test_data = pickle.load(f)

X_train, y_train = train_data['features'], train_data['labels']
X_val, y_val = val_data['features'], val_data['labels']
X_test, y_test = test_data['features'], test_data['labels']
```

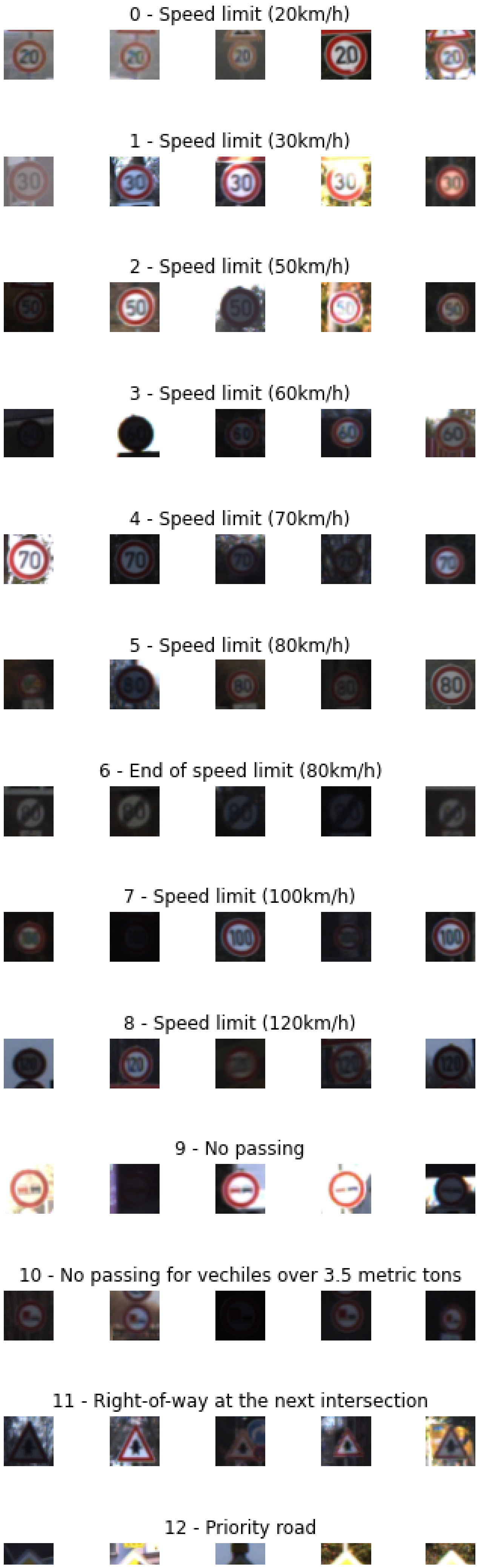
```
print(X_train.shape)
print(X_test.shape)
print(X_val.shape)
```

```
(34799, 32, 32, 3)
(12630, 32, 32, 3)
(4410, 32, 32, 3)
```

```
assert(X_train.shape[0] == y_train.shape[0]), "The number of images is not equal to the nu
assert(X_train.shape[1:] == (32,32,3)), "The dimensions of the images are not 32 x 32 x 3.
assert(X_val.shape[0] == y_val.shape[0]), "The number of images is not equal to the number
assert(X_val.shape[1:] == (32,32,3)), "The dimensions of the images are not 32 x 32 x 3."
assert(X_test.shape[0] == y_test.shape[0]), "The number of images is not equal to the numb
assert(X_test.shape[1:] == (32,32,3)), "The dimensions of the images are not 32 x 32 x 3."
```

Visualising the data

```
data = pd.read_csv('german-traffic-signs/signnames.csv')
num_of_samples=[]

cols = 5
num_classes = 43

fig, axs = plt.subplots(nrows=num_classes, ncols=cols, figsize=(5,50))
fig.tight_layout()

for i in range(cols):
    for j, row in data.iterrows():
      x_selected = X_train[y_train == j]
      axs[j][i].imshow(x_selected[random.randint(0,(len(x_selected) - 1)), :, :], cmap=plt
      axs[j][i].axis("off")
      if i == 2:
        axs[j][i].set_title(str(j) + " - " + row["SignName"])
        num_of_samples.append(len(x_selected))
```


0 - Speed limit (20km/h)
1 - Speed limit (30km/h)
2 - Speed limit (50km/h)
3 - Speed limit (60km/h)
4 - Speed limit (70km/h)
5 - Speed limit (80km/h)
6 - End of speed limit (80km/h)
7 - Speed limit (100km/h)
8 - Speed limit (120km/h)
9 - No passing
10 - No passing for vechiles over 3.5 metric tons
11 - Right-of-way at the next intersection
12 - Priority road

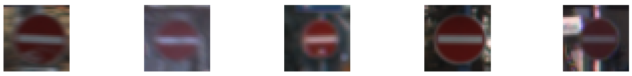
13 - Yield

14 - Stop

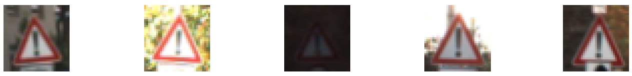
15 - No vechiles

16 - Vechiles over 3.5 metric tons prohibited

17 - No entry

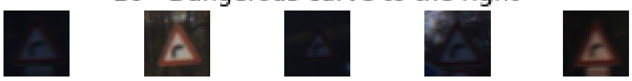


18 - General caution



19 - Dangerous curve to the left

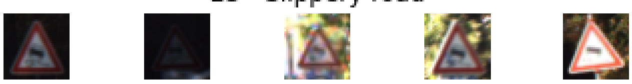
20 - Dangerous curve to the right



21 - Double curve

22 - Bumpy road

23 - Slippery road



24 - Road narrows on the right

25 - Road work

26 - Traffic signals

27 - Pedestrians

28 - Children crossing

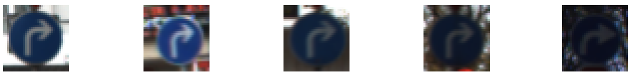
29 - Bicycles crossing

30 - Beware of ice/snow

31 - Wild animals crossing

32 - End of all speed and passing limits

33 - Turn right ahead

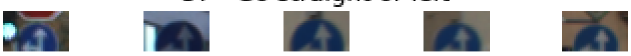


34 - Turn left ahead

35 - Ahead only

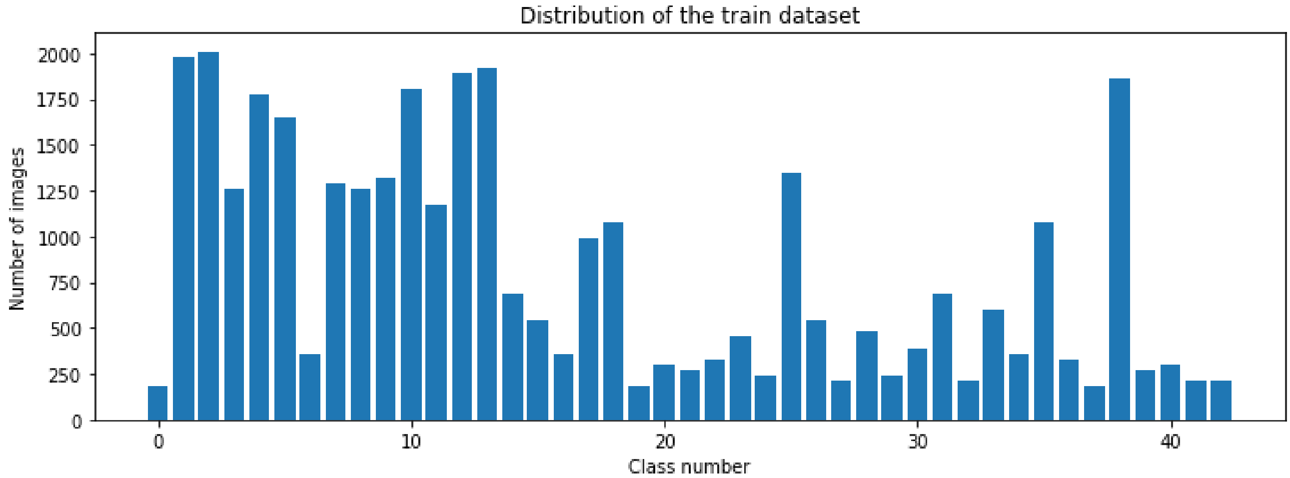
36 - Go straight or right

37 - Go straight or left




```
print(num_of_samples)
plt.figure(figsize=(12, 4))
plt.bar(range(0, num_classes), num_of_samples)
plt.title("Distribution of the train dataset")
plt.xlabel("Class number")
plt.ylabel("Number of images")
plt.show()
```

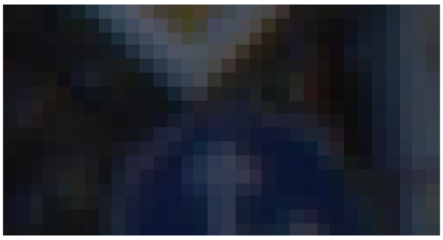
```
[180, 1980, 2010, 1260, 1770, 1650, 360, 1290, 1260, 1320, 1800, 1170, 1890, 1920, 69
```



Using OpenCV2 for preprocessing the image.

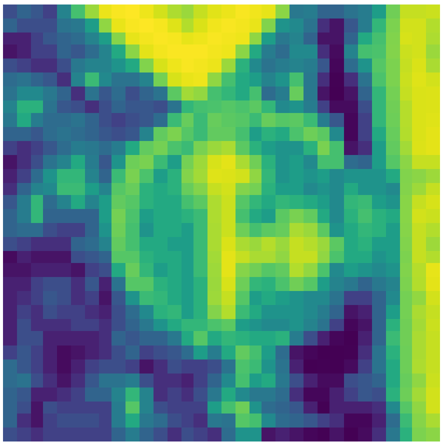
```
import cv2

plt.imshow(X_train[1000])
plt.axis("off")
print(X_train[1000].shape)
print(y_train[1000])
def grayscale(img):
    img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    return img
```

```
(32, 32, 3)
36
```



```
img = grayscale(X_train[1000])
plt.imshow(img)
plt.axis("off")
print(img.shape)
def equalize(img):
    img = cv2.equalizeHist(img)
    return img
img = equalize(img)
plt.imshow(img)
plt.axis("off")
print(img.shape)
```

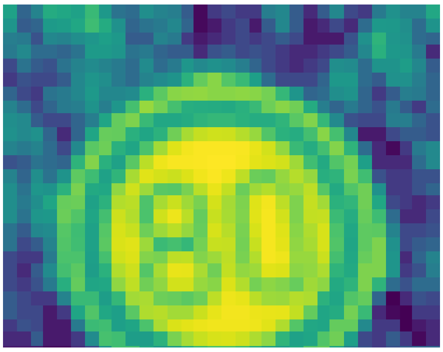
```
(32, 32)
(32, 32)
```



```
def preprocess(img):
    img = grayscale(img)
    img = equalize(img)
    img = img/255
    return img
```

```
X_train = np.array(list(map(preprocess, X_train)))
X_test = np.array(list(map(preprocess, X_test)))
X_val = np.array(list(map(preprocess, X_val)))

plt.imshow(X_train[random.randint(0, len(X_train) - 1)])
plt.axis('off')
print(X_train.shape)
```

```
(34799, 32, 32)
```

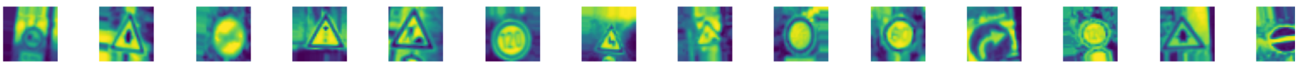


```
X_train = X_train.reshape(34799, 32, 32, 1)
X_test = X_test.reshape(12630, 32, 32, 1)
X_val = X_val.reshape(4410, 32, 32, 1)
```

Applying the preprocessing function to every image in dataset

```
from keras.preprocessing.image import ImageDataGenerator

datagen = ImageDataGenerator(width_shift_range=0.1,
                            height_shift_range=0.1,
                            zoom_range=0.2,
                            shear_range=0.1,
                            rotation_range=10.)

datagen.fit(X_train)
batches = datagen.flow(X_train, y_train, batch_size = 15)
X_batch, y_batch = next(batches)

fig, axs = plt.subplots(1, 15, figsize=(20, 5))
fig.tight_layout()

for i in range(15):
    axs[i].imshow(X_batch[i].reshape(32, 32))
    axs[i].axis("off")

print(X_batch.shape)
```

```
(15, 32, 32, 1)
```



```
y_train = to_categorical(y_train, 43)
y_test = to_categorical(y_test, 43)
y_val = to_categorical(y_val, 43)
```

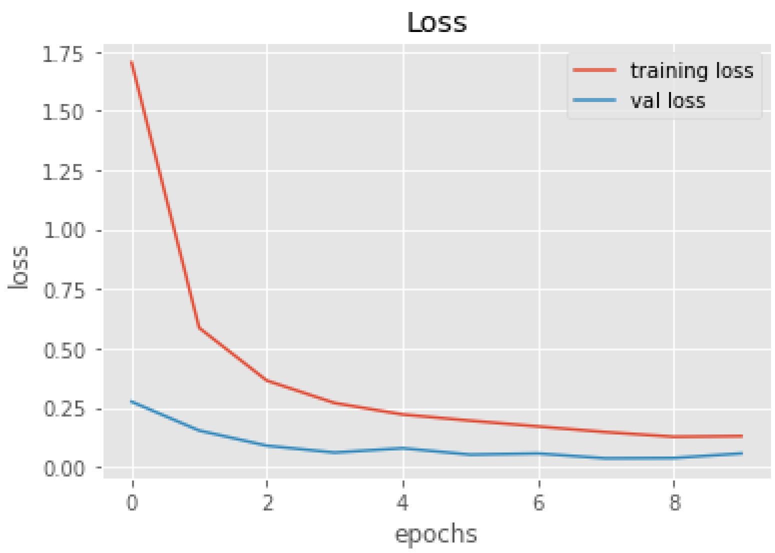
Defining the CNN model. I have taken inspiration from the traditional LeNet architecture as I am curious how this old model performs on such a huge dataset.

```
def modified_model():
  model = Sequential()
  model.add(Conv2D(60, (5, 5), input_shape=(32, 32, 1), activation='relu'))
  model.add(Conv2D(60, (5, 5), activation='relu'))
  model.add(MaxPooling2D(pool_size=(2, 2)))

  model.add(Conv2D(30, (3, 3), activation='relu'))
  model.add(Conv2D(30, (3, 3), activation='relu'))
  model.add(MaxPooling2D(pool_size=(2, 2)))

  model.add(Flatten())
  model.add(Dense(500, activation='relu'))
  model.add(Dropout(0.5))
  model.add(Dense(43, activation='softmax'))

  model.compile(Adam(lr = 0.001), loss='categorical_crossentropy', metrics=['accuracy'])
  return model


model = modified_model()
print(model.summary())

history = model.fit_generator(datagen.flow(X_train, y_train, batch_size=50),
                            epochs=10,
                            validation_data=(X_val, y_val), shuffle = 1)
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d (Conv2D)              (None, 28, 28, 60)        1560      
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 24, 24, 60)        90060     
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 12, 12, 60)        0         
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 10, 10, 30)        16230     
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 8, 8, 30)          8130      
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 4, 4, 30)          0         
_________________________________________________________________
flatten (Flatten)            (None, 480)               0         
_________________________________________________________________
dense (Dense)                (None, 500)               240500    
_________________________________________________________________
dropout (Dropout)            (None, 500)               0         
_________________________________________________________________
```

```
import matplotlib.pyplot as plt
plt.figure(0)
plt.plot(history.history['loss'], label='training loss')
plt.plot(history.history['val_loss'], label='val loss')
plt.title('Loss')
plt.xlabel('epochs')
plt.ylabel('loss')
plt.legend()
```

```
<matplotlib.legend.Legend at 0x7fa745cf3a58>
```




```
696/696 [==============================] - 19s 27ms/step - loss: 0.1293 - accuracy: (
```

```
plt.figure(1)
plt.plot(history.history['accuracy'], label='training accuracy')
plt.plot(history.history['val_accuracy'], label='val accuracy')
plt.legend(['training','test'])
plt.title('Accuracy')
plt.xlabel('epoch')
plt.ylabel('loss')
plt.legend()
```