```
!git clone https://github.com/pranit570/multiobstacle.git
```

```
Cloning into 'multiobstacle'...
remote: Enumerating objects: 9893, done.
remote: Counting objects: 100% (9893/9893), done.
remote: Compressing objects: 100% (9892/9892), done.
remote: Total 9893 (delta 1), reused 9893 (delta 1), pack-reused 0
Receiving objects: 100% (9893/9893), 123.30 MiB | 32.44 MiB/s, done.
Resolving deltas: 100% (1/1), done.
Checking out files: 100% (9931/9931), done.
```

```
!ls multiobstacle
```

```
driving_log.csv  IMG
```

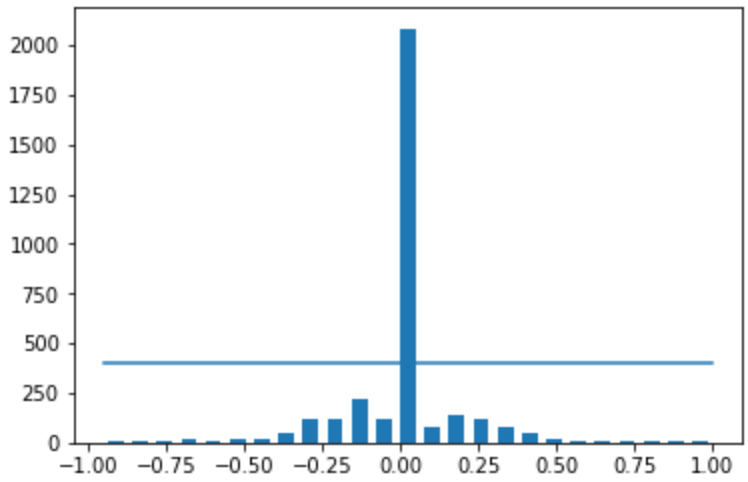
```
import os
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
import keras
from keras.models import Sequential
from keras.optimizers import Adam
from keras.layers import Conv2D, MaxPooling2D, Dropout, Flatten, Dense
from sklearn.utils import shuffle
from sklearn.model_selection import train_test_split
from imgaug import augmenters as iaa
import cv2
import pandas as pd
import ntpath
import random
```

```
datadir = 'multiobstacle'
columns = ['center', 'left', 'right', 'steering', 'throttle', 'reverse', 'speed']
data = pd.read_csv(os.path.join(datadir, 'driving_log.csv'), names = columns)
pd.set_option('display.max_colwidth', -1)
data.head()
```

	center	
0	C:\1jan2019pranitlenovo\data\mtechparul\final year dissertation\data\9oct19\multiobstacle\IMG\center_2019_10_09_04_40_46_944.jpg	C dissertation\data\9oct19\multio
1	C:\1jan2019pranitlenovo\data\mtechparul\final year dissertation\data\9oct19\multiobstacle\IMG\center_2019_10_09_04_40_47_026.jpg	C dissertation\data\9oct19\multio
2	C:\1jan2019pranitlenovo\data\mtechparul\final year dissertation\data\9oct19\multiobstacle\IMG\center_2019_10_09_04_40_47_099.jpg	C dissertation\data\9oct19\multio
3	C:\1jan2019pranitlenovo\data\mtechparul\final year dissertation\data\9oct19\multiobstacle\IMG\center_2019_10_09_04_40_47_168.jpg	C dissertation\data\9oct19\multio
4	C:\1jan2019pranitlenovo\data\mtechparul\final year dissertation\data\9oct19\multiobstacle\IMG\center_2019_10_09_04_40_47_236.jpg	C dissertation\data\9oct19\multio

```
def path_leaf(path):
  head, tail = ntpath.split(path)
  return tail
data['center'] = data['center'].apply(path_leaf)
data['left'] = data['left'].apply(path_leaf)
data['right'] = data['right'].apply(path_leaf)
data.head()
num_bins = 25
samples_per_bin = 400
hist, bins = np.histogram(data['steering'], num_bins)
center = (bins[:-1]+ bins[1:]) * 0.5
plt.bar(center, hist, width=0.05)
plt.plot((np.min(data['steering']), np.max(data['steering'])), (samples_per_bin, samples_per_bin))
```

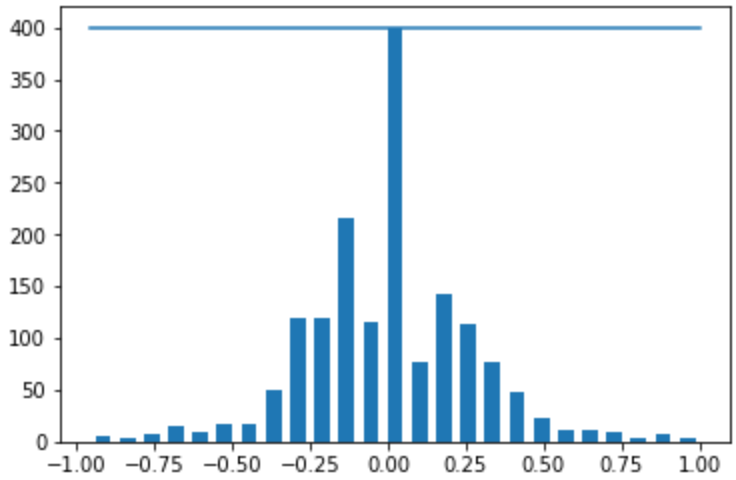
```
[<matplotlib.lines.Line2D at 0x7febb45ce470>]
```




```
print('total data:', len(data))
remove_list = []
for j in range(num_bins):
  list_ = []
  for i in range(len(data['steering'])):
    if data['steering'][i] >= bins[j] and data['steering'][i] <= bins[j+1]:
      list_.append(i)
  list_ = shuffle(list_)
```

```
  list_ = list_[samples_per_bin:]
  remove_list.extend(list_)

print('removed:', len(remove_list))
data.drop(data.index[remove_list], inplace=True)
print('remaining:', len(data))

hist, _ = np.histogram(data['steering'], (num_bins))
plt.bar(center, hist, width=0.05)
plt.plot((np.min(data['steering']), np.max(data['steering'])), (samples_per_bin, samples_per_bin))
```

```
total data: 3310
removed: 1683
remaining: 1627
[<matplotlib.lines.Line2D at 0x7febb464bb00>]
```



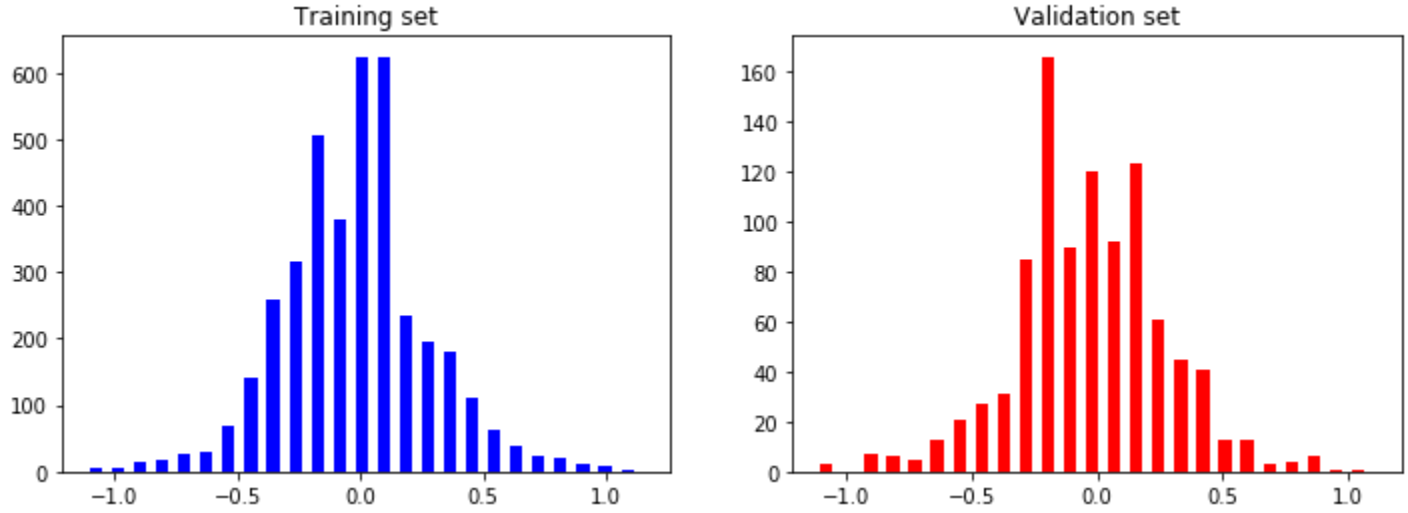

```
print(data.iloc[1])
def load_img_steering(datadir, df):
  image_path = []
  steering = []
  for i in range(len(data)):
    indexed_data = data.iloc[i]
    center, left, right = indexed_data[0], indexed_data[1], indexed_data[2],
    image_path.append(os.path.join(datadir, center.strip()))
    steering.append(float(indexed_data[3]))
    # left image append
    image_path.append(os.path.join(datadir,left.strip()))
    steering.append(float(indexed_data[3])+0.15)
    # right image append
    image_path.append(os.path.join(datadir,right.strip()))
    steering.append(float(indexed_data[3])-0.15)
  image_paths = np.asarray(image_path)
  steerings = np.asarray(steering)
  return image_paths, steerings

image_paths, steerings = load_img_steering(datadir + '/IMG', data)
```

```
center      center_2019_10_09_04_40_47_099.jpg
left        left_2019_10_09_04_40_47_099.jpg
right       right_2019_10_09_04_40_47_099.jpg
steering    0
throttle    0
reverse     0
speed       1.26e-06
Name: 2, dtype: object
```

```
X_train, X_valid, y_train, y_valid = train_test_split(image_paths, steerings, test_size=0.2, random_sta
print('Training Samples: {}\nValid Samples: {}'.format(len(X_train), len(X_valid)))
```

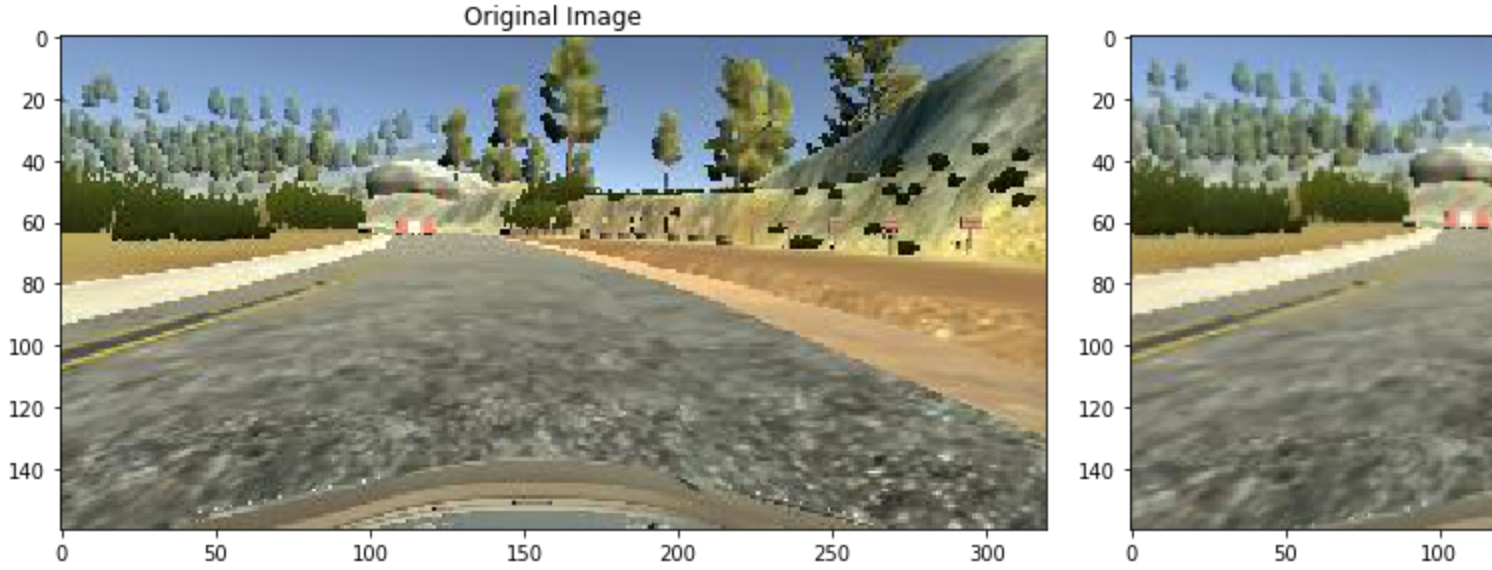
```
fig, axes = plt.subplots(1, 2, figsize=(12, 4))
axes[0].hist(y_train, bins=num_bins, width=0.05, color='blue')
axes[0].set_title('Training set')
axes[1].hist(y_valid, bins=num_bins, width=0.05, color='red')
axes[1].set_title('Validation set')
```

```
Training Samples: 3904
Valid Samples: 977
Text(0.5, 1.0, 'Validation set')
```



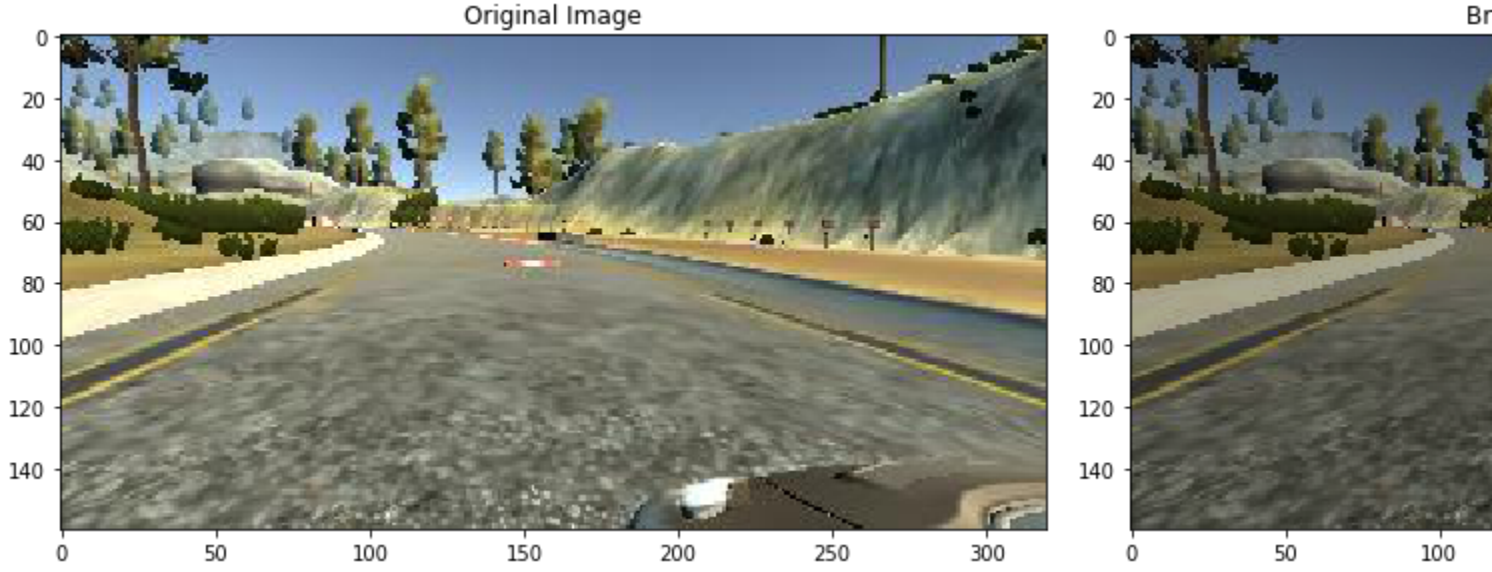

```
def zoom(image):
  zoom = iaa.Affine(scale=(1, 1.3))
  image = zoom.augment_image(image)
  return image
image = image_paths[random.randint(0, 1000)]
original_image = mpimg.imread(image)
zoomed_image = zoom(original_image)

fig, axs = plt.subplots(1, 2, figsize=(15, 10))
fig.tight_layout()

axs[0].imshow(original_image)
axs[0].set_title('Original Image')

axs[1].imshow(zoomed_image)
axs[1].set_title('Zoomed Image')
```

```
Text(0.5, 1.0, 'Zoomed Image')
```




```
#brightnessimage
def img_random_brightness(image):
    brightness = iaa.Multiply((0.2, 1.2))
    image = brightness.augment_image(image)
    return image
image = image_paths[random.randint(0, 1000)]
original_image = mpimg.imread(image)
brightness_altered_image = img_random_brightness(original_image)
fig, axs = plt.subplots(1, 2, figsize=(15, 10))
fig.tight_layout()
axs[0].imshow(original_image)
axs[0].set_title('Original Image')
axs[1].imshow(brightness_altered_image)
axs[1].set_title('Brightness altered image ')
```

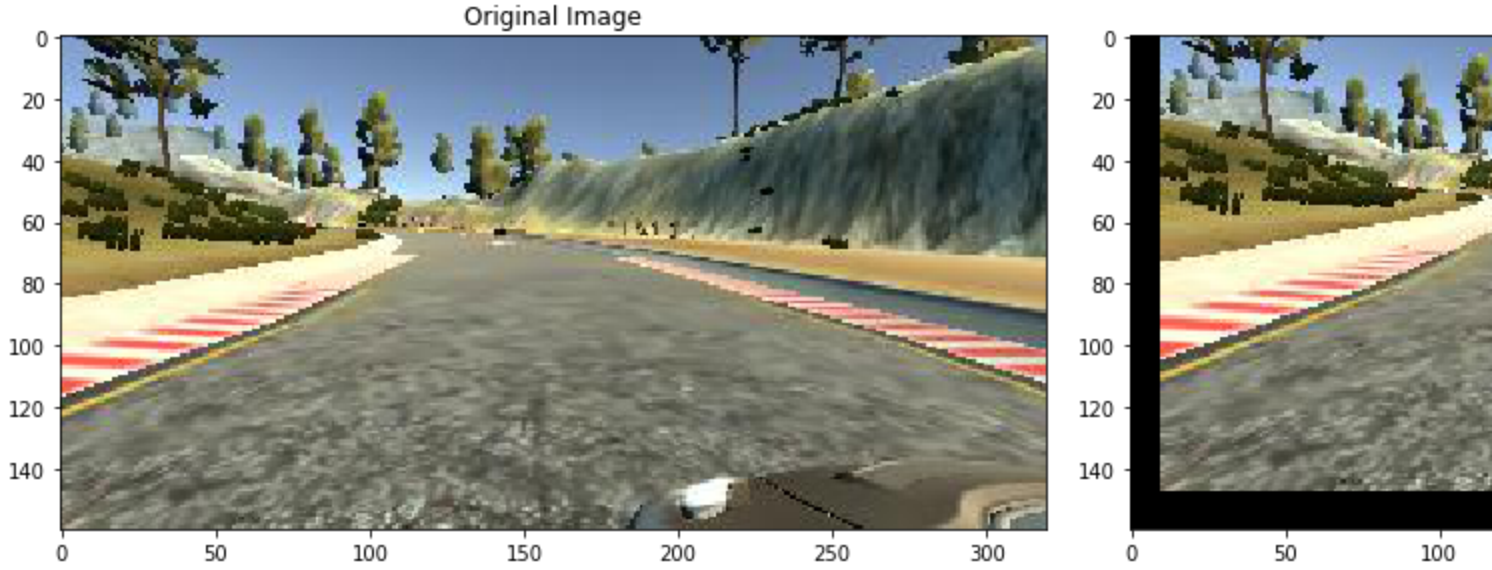
```
Text(0.5, 1.0, 'Brightness altered image ')
```




```
#panimage
def pan(image):
```

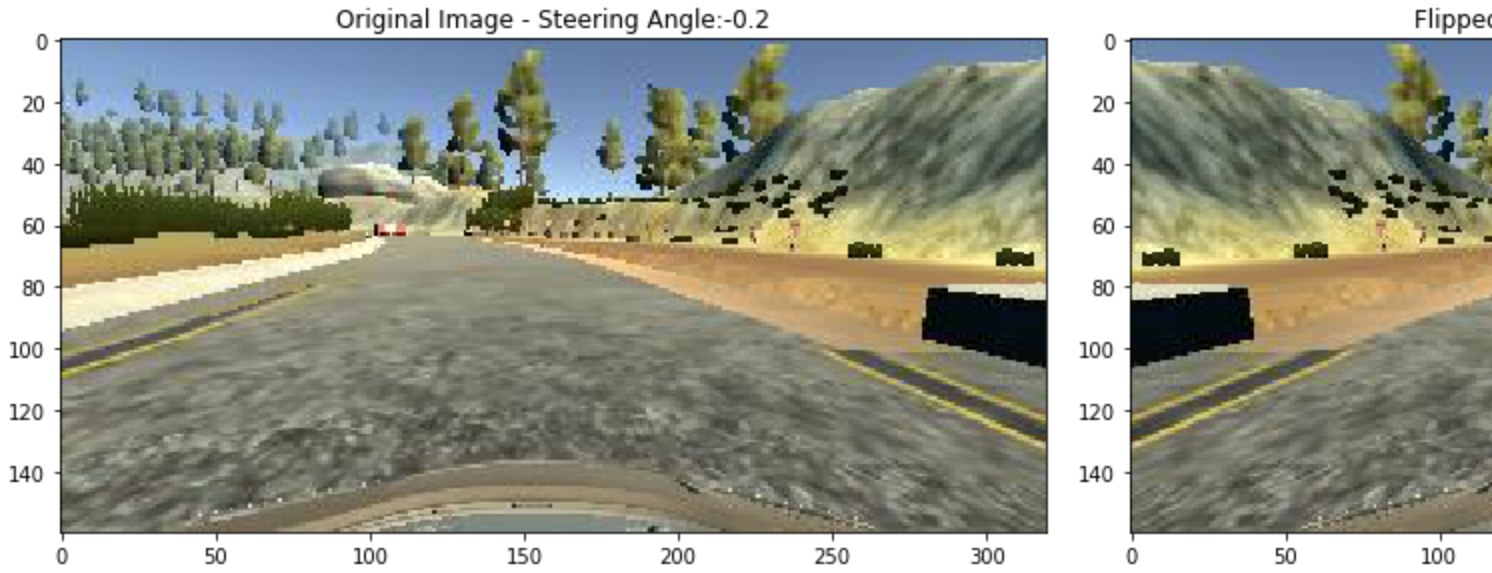
```
  pan = iaa.Affine(translate_percent= {"x" : (-0.1, 0.1), "y": (-0.1, 0.1)})
  image = pan.augment_image(image)
  return image
image = image_paths[random.randint(0, 1000)]
original_image = mpimg.imread(image)
panned_image = pan(original_image)
fig, axs = plt.subplots(1, 2, figsize=(15, 10))
fig.tight_layout()
axs[0].imshow(original_image)
axs[0].set_title('Original Image')
axs[1].imshow(panned_image)
axs[1].set_title('Panned Image')
```

```
Text(0.5, 1.0, 'Panned Image')
```

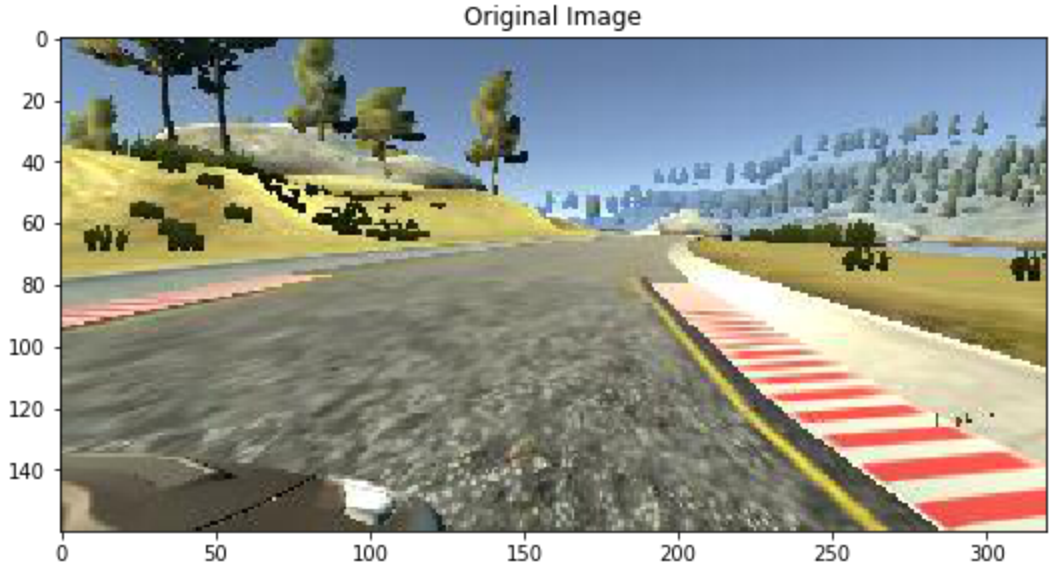



```
#flipimage
def img_random_flip(image, steering_angle):
    image = cv2.flip(image,1)
    steering_angle = -steering_angle
    return image, steering_angle
random_index = random.randint(0, 1000)
image = image_paths[random_index]
steering_angle = steerings[random_index]
original_image = mpimg.imread(image)
flipped_image, flipped_steering_angle = img_random_flip(original_image, steering_angle)
fig, axs = plt.subplots(1, 2, figsize=(15, 10))
fig.tight_layout()
axs[0].imshow(original_image)
axs[0].set_title('Original Image - ' + 'Steering Angle:' + str(steering_angle))
axs[1].imshow(flipped_image)
axs[1].set_title('Flipped Image - ' + 'Steering Angle:' + str(flipped_steering_angle))
```

```
Text(0.5, 1.0, 'Flipped Image - Steering Angle:0.2')
```




```
#augmentedimage
def random_augment(image, steering_angle):
    image = mpimg.imread(image)
    if np.random.rand() < 0.5:
      image = pan(image)
    if np.random.rand() < 0.5:
      image = zoom(image)
    if np.random.rand() < 0.5:
      image = img_random_brightness(image)
    if np.random.rand() < 0.5:
      image, steering_angle = img_random_flip(image, steering_angle)
    return image, steering_angle
ncol = 2
nrow = 10
fig, axs = plt.subplots(nrow, ncol, figsize=(15, 50))
fig.tight_layout()
for i in range(10):
  randnum = random.randint(0, len(image_paths) - 1)
  random_image = image_paths[randnum]
  random_steering = steerings[randnum]
  original_image = mpimg.imread(random_image)
  augmented_image, steering = random_augment(random_image, random_steering)
  axs[i][0].imshow(original_image)
  axs[i][0].set_title("Original Image")
  axs[i][1].imshow(augmented_image)
  axs[i][1].set_title("Augmented Image")
```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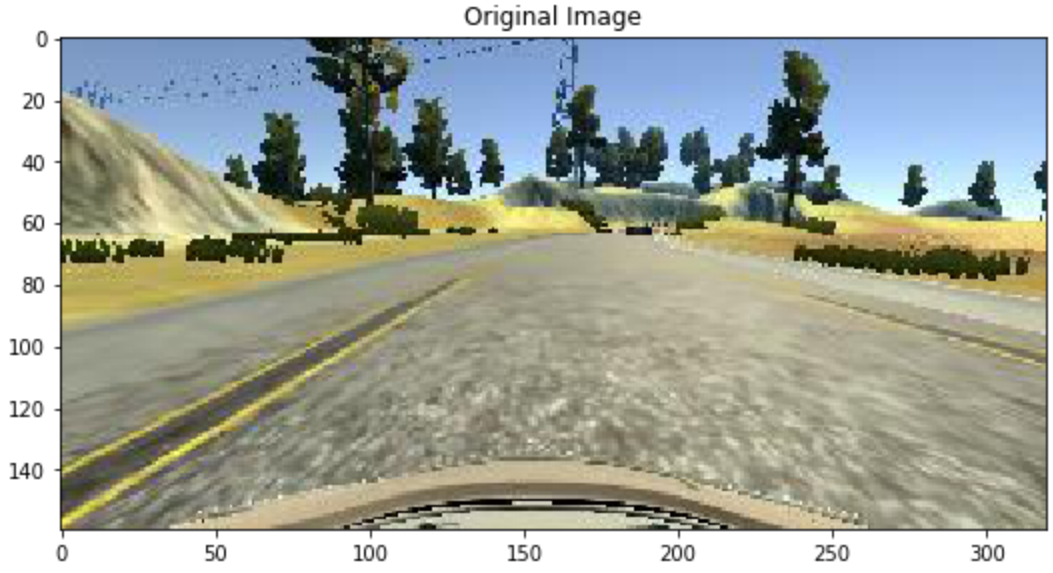
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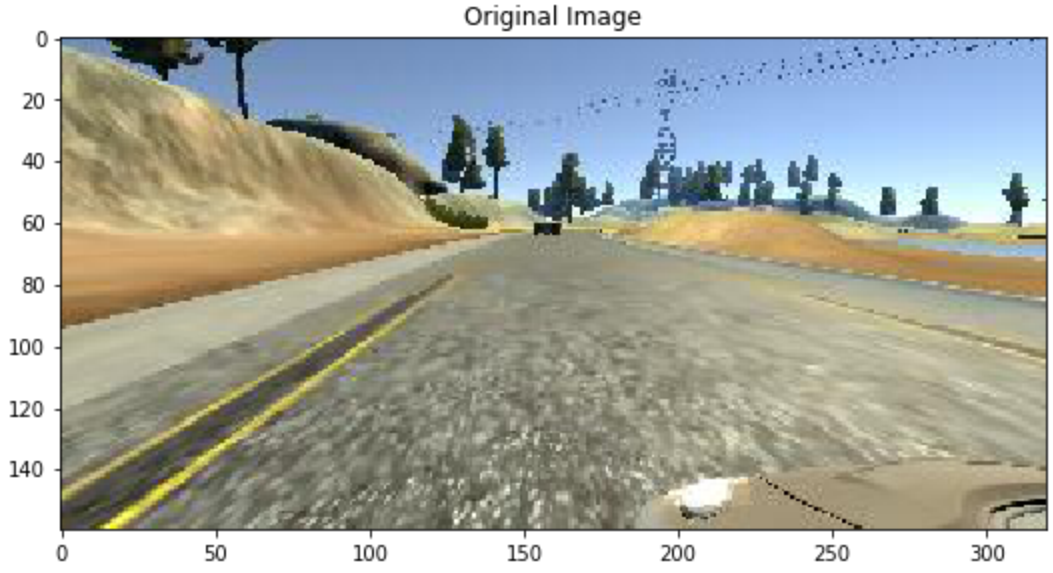
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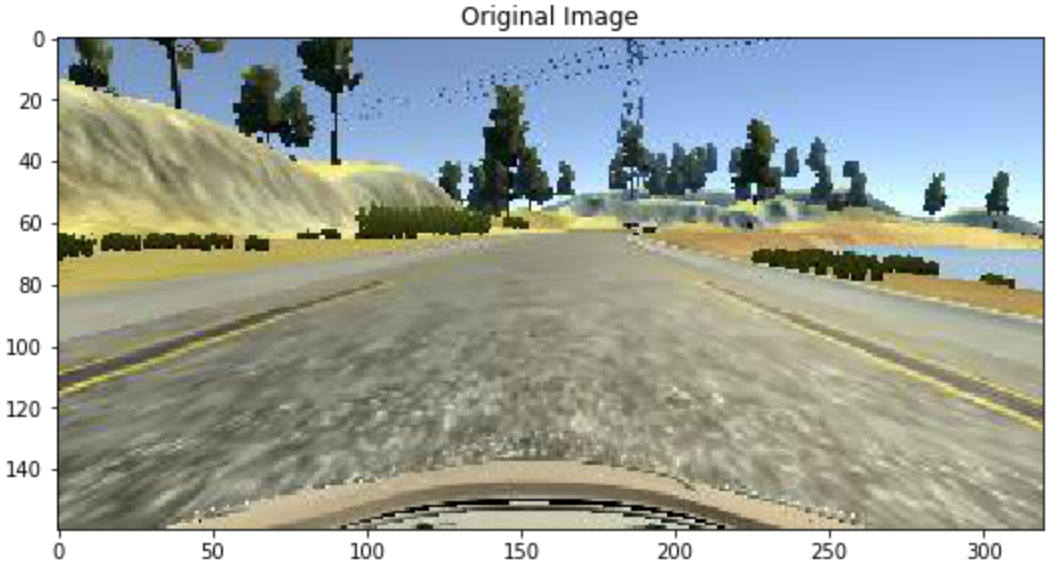
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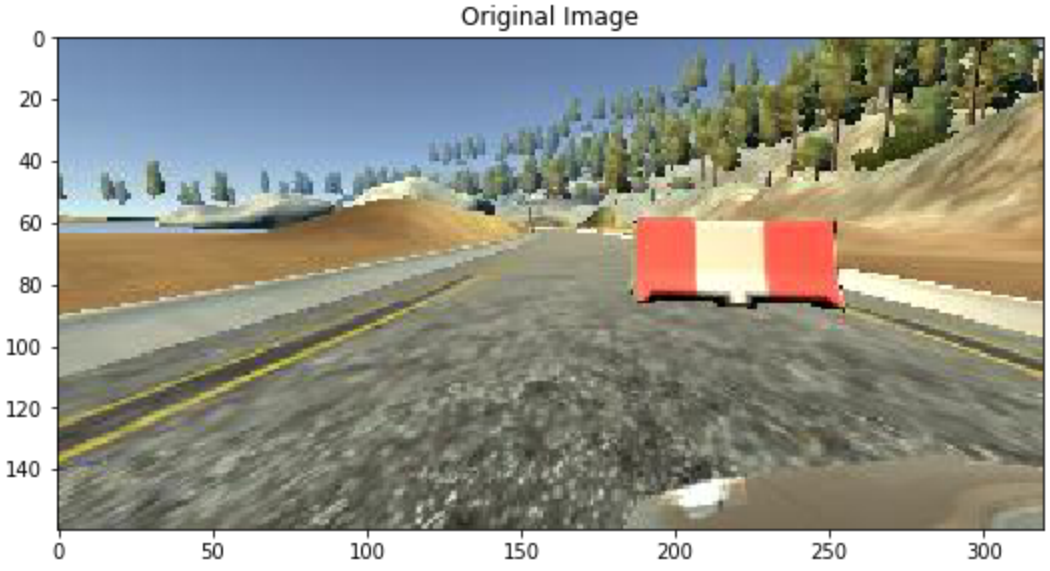
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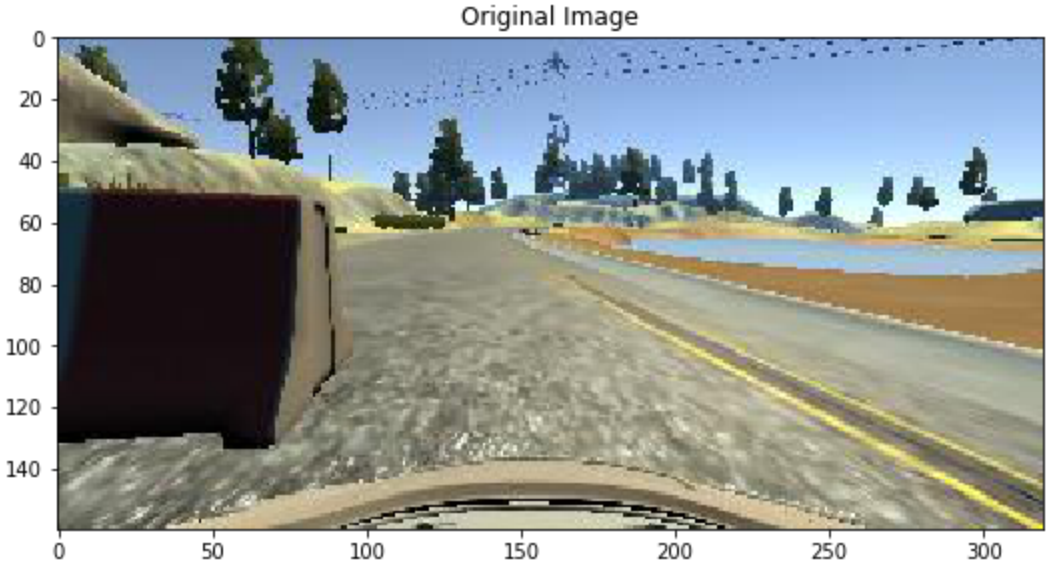
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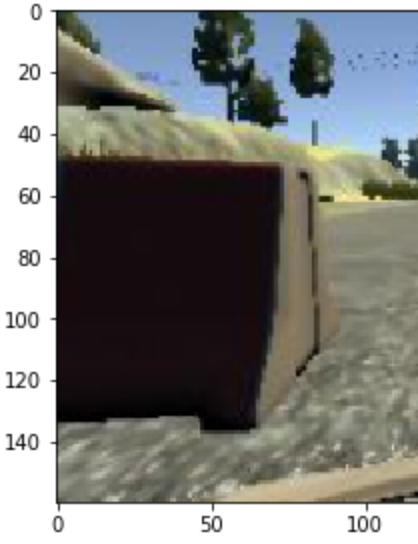
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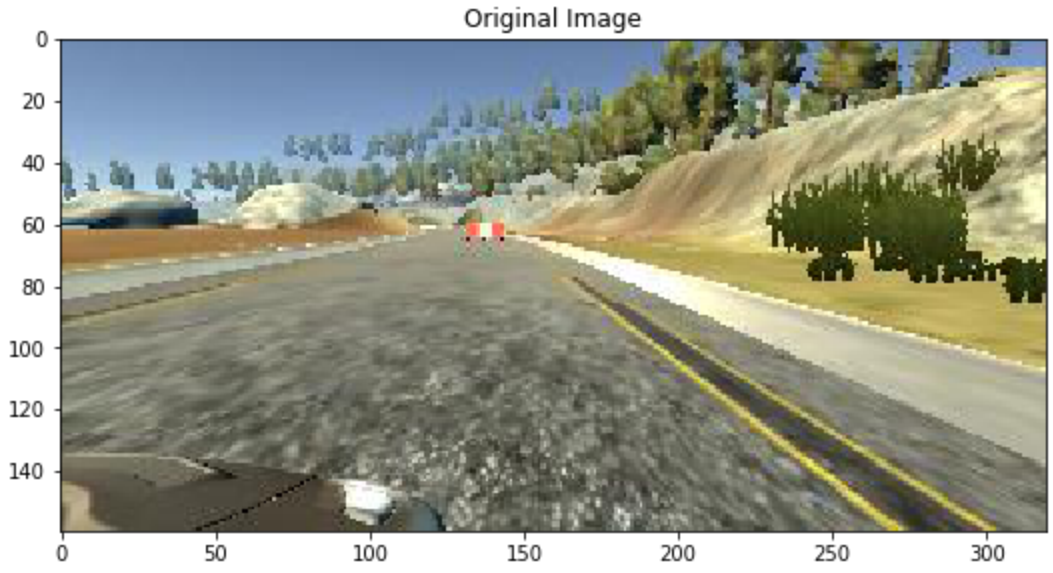
Original Image
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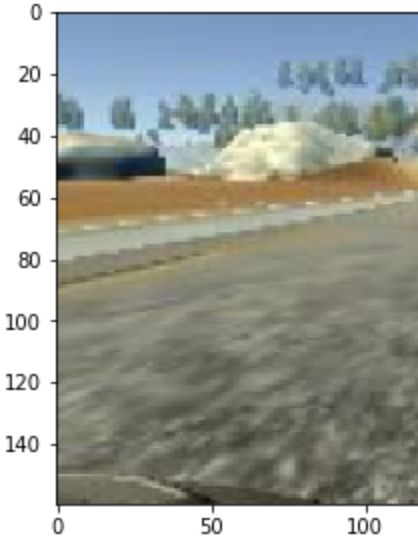
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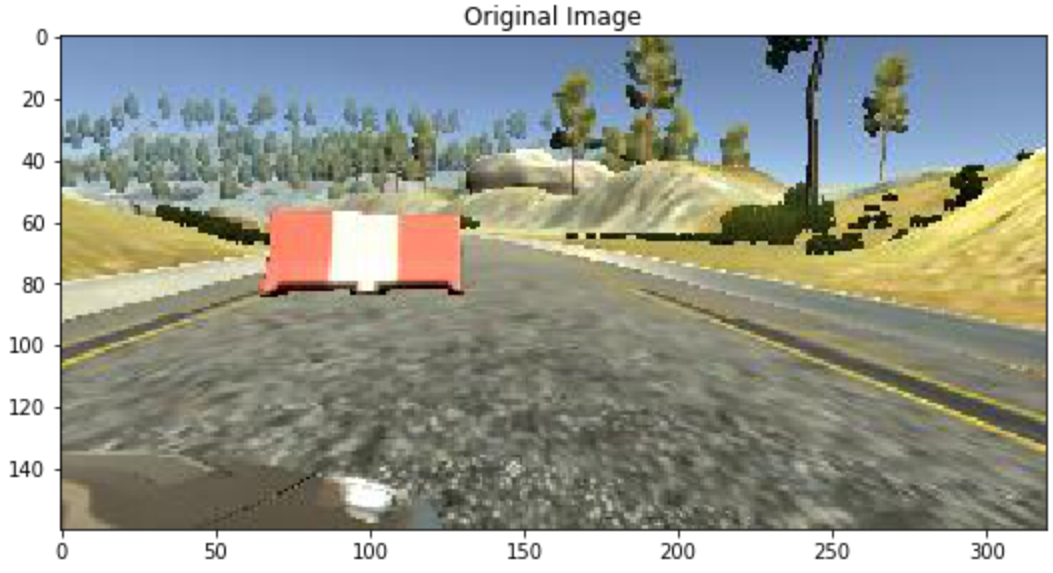
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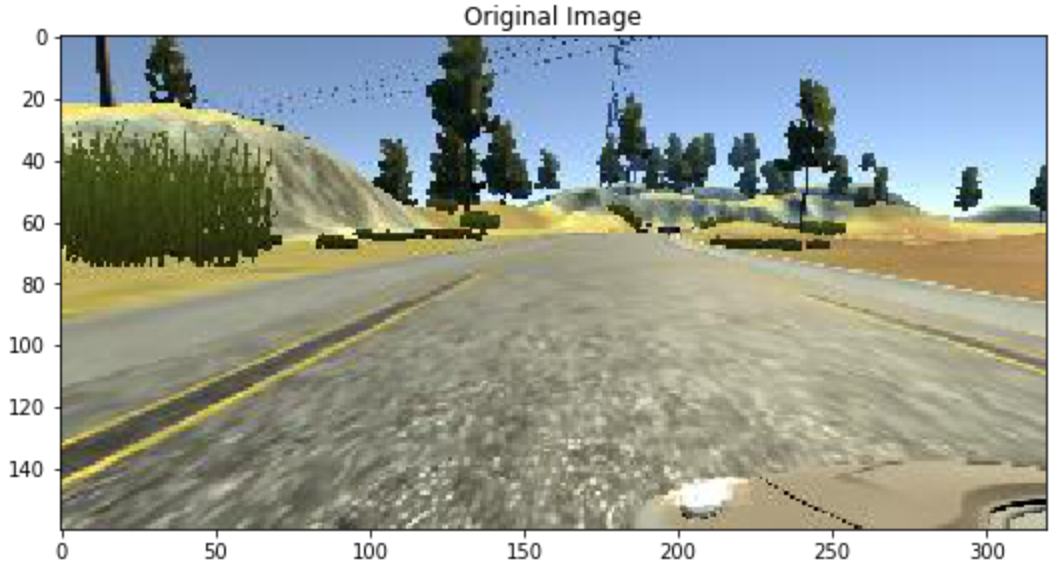
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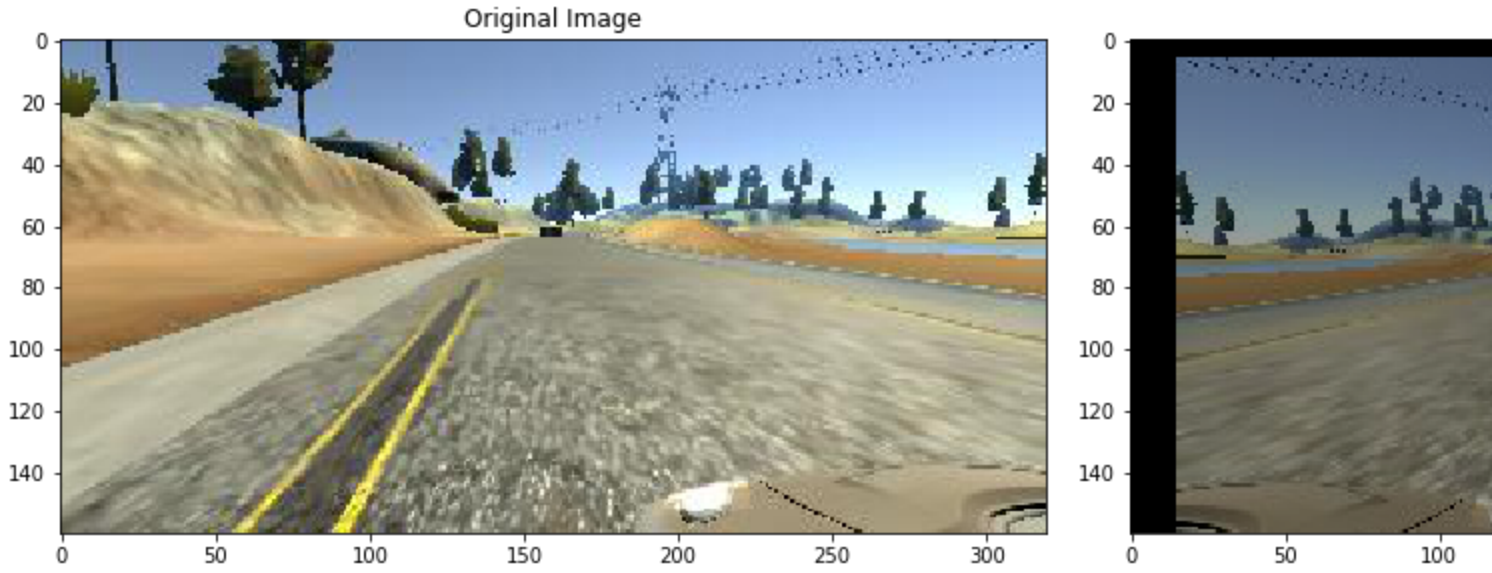
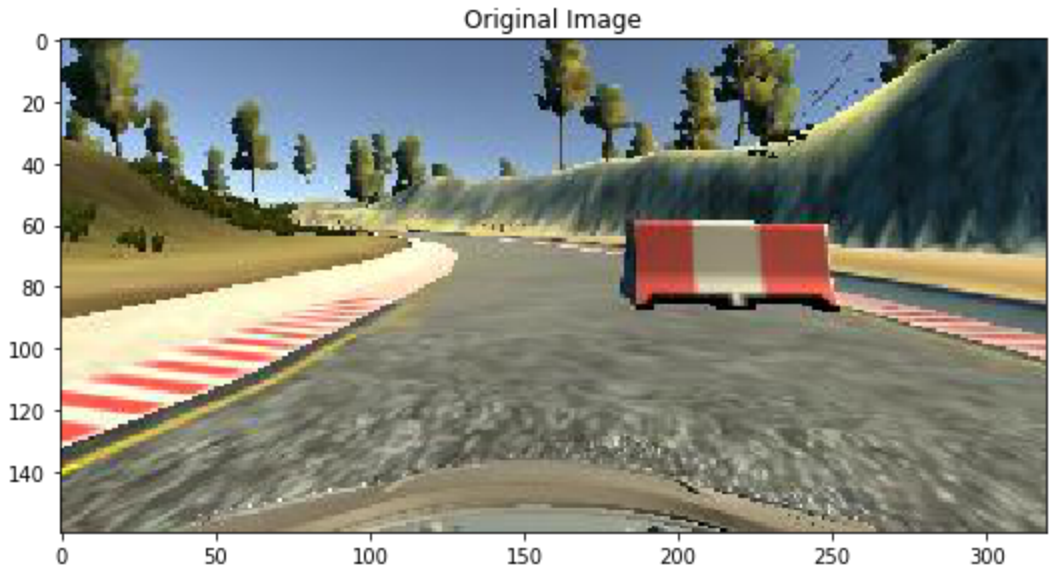
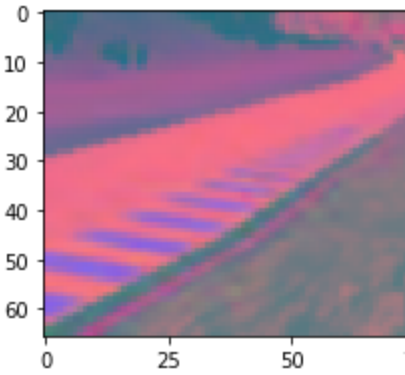



```
def img_preprocess (img):
    img = img[55:135,:,:]
    img = cv2.cvtColor(img, cv2.COLOR_RGB2YUV)
    img = cv2.GaussianBlur(img, (3, 3), 0)
    img = cv2.resize(img, (200, 66))
    img = img/255
    return img


image = image_paths[150]
original_image = mpimg.imread(image)
preprocessed_image = img_preprocess(original_image)
fig, axs = plt.subplots(1, 2, figsize=(15, 10))
fig.tight_layout()
axs[0].imshow(original_image)
axs[0].set_title('Original Image')
axs[1].imshow(preprocessed_image)
axs[1].set_title('processed Image')
```

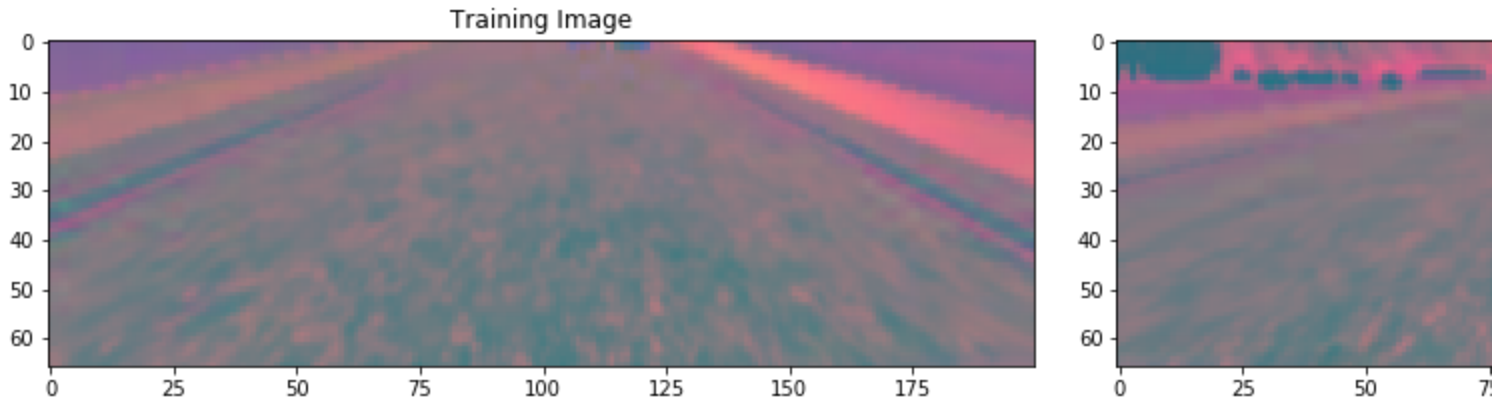
```
Text(0.5, 1.0, 'processed Image')
```






```
#batchgenerator
def batch_generator(image_paths, steering_ang, batch_size, istraining):

  while True:
    batch_img = []
    batch_steering = []

    for i in range(batch_size):
      random_index = random.randint(0, len(image_paths) - 1)

      if istraining:
        im, steering = random_augment(image_paths[random_index], steering_ang[random_index])

      else:
        im = mpimg.imread(image_paths[random_index])
        steering = steering_ang[random_index]

      im = img_preprocess(im)
      batch_img.append(im)
      batch_steering.append(steering)
    yield (np.asarray(batch_img), np.asarray(batch_steering))


x_train_gen, y_train_gen = next(batch_generator(X_train, y_train, 1, 1))
x_valid_gen, y_valid_gen = next(batch_generator(X_valid, y_valid, 1, 0))
fig, axs = plt.subplots(1, 2, figsize=(15, 10))
fig.tight_layout()
axs[0].imshow(x_train_gen[0])
axs[0].set_title('Training Image')
axs[1].imshow(x_valid_gen[0])
axs[1].set_title('Validation Image')
```

```
Text(0.5, 1.0, 'Validation Image')
```




```
def nvidia_model():
  model = Sequential()
  model.add(Conv2D(24, 5, 5, subsample=(2, 2), input_shape=(66, 200, 3), activation='elu'))
  model.add(Conv2D(36, 5, 5, subsample=(2, 2), activation='elu'))
  model.add(Conv2D(48, 5, 5, subsample=(2, 2), activation='elu'))
  model.add(Conv2D(64, 3, 3, activation='elu'))
  model.add(Conv2D(64, 3, 3, activation='elu'))
  #model.add(Dropout(0.5))
  model.add(Flatten())
  model.add(Dense(100, activation = 'elu'))
  #model.add(Dropout(0.5))
  model.add(Dense(50, activation = 'elu'))
  #model.add(Dropout(0.5))
  model.add(Dense(10, activation = 'elu'))
  #model.add(Dropout(0.5))
  model.add(Dense(1))

  optimizer = Adam(lr=1e-3)
  model.compile(loss='mse', optimizer=optimizer)
  return model


model = nvidia_model()
print(model.summary())
```

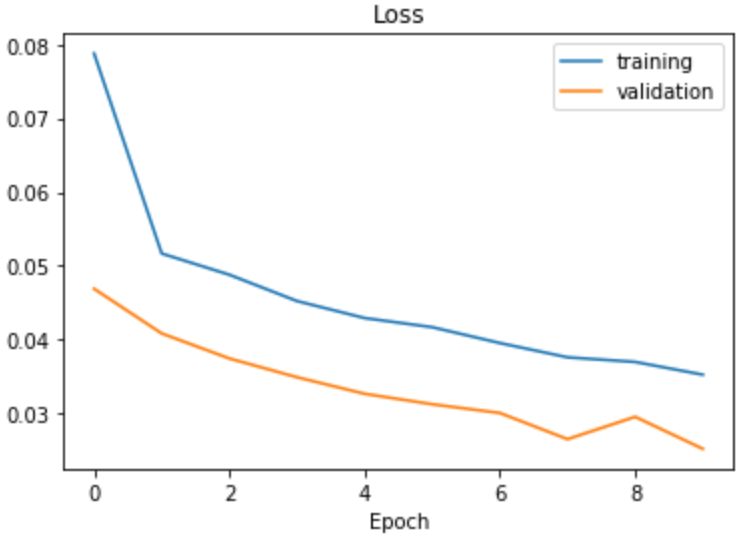
```
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_11 (Conv2D)           (None, 31, 98, 24)        1824
_________________________________________________________________
conv2d_12 (Conv2D)           (None, 14, 47, 36)        21636
_________________________________________________________________
conv2d_13 (Conv2D)           (None, 5, 22, 48)         43248
_________________________________________________________________
conv2d_14 (Conv2D)           (None, 3, 20, 64)         27712
_________________________________________________________________
conv2d_15 (Conv2D)           (None, 1, 18, 64)         36928
_________________________________________________________________
flatten_3 (Flatten)          (None, 1152)              0
_________________________________________________________________
dense_9 (Dense)              (None, 100)               115300
_________________________________________________________________
dense_10 (Dense)             (None, 50)                5050
_________________________________________________________________
dense_11 (Dense)             (None, 10)                510
_________________________________________________________________
dense_12 (Dense)             (None, 1)                 11
=================================================================
Total params: 252,219
Trainable params: 252,219
Non-trainable params: 0
_________________________________________________________________
None
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:3: UserWarning: Update your `Conv2D`
  This is separate from the ipykernel package so we can avoid doing imports until
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:4: UserWarning: Update your `Conv2D`
  after removing the cwd from sys.path.
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:5: UserWarning: Update your `Conv2D`
  """
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:6: UserWarning: Update your `Conv2D`

/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:7: UserWarning: Update your `Conv2D`
  import sys
```

```
history = model.fit_generator(batch_generator(X_train, y_train, 100, 1),
                              steps_per_epoch=300,
                              epochs=10,
                              validation_data=batch_generator(X_valid, y_valid, 100, 0),
                              validation_steps=200,
                              verbose=1,
                              shuffle = 1)
```

```
Epoch 1/10
300/300 [==============================] - 409s 1s/step - loss: 0.0788 - val_loss: 0.0469
Epoch 2/10
300/300 [==============================] - 402s 1s/step - loss: 0.0517 - val_loss: 0.0409
Epoch 3/10
300/300 [==============================] - 400s 1s/step - loss: 0.0488 - val_loss: 0.0375
Epoch 4/10
300/300 [==============================] - 403s 1s/step - loss: 0.0452 - val_loss: 0.0349
Epoch 5/10
300/300 [==============================] - 402s 1s/step - loss: 0.0429 - val_loss: 0.0327
Epoch 6/10
300/300 [==============================] - 402s 1s/step - loss: 0.0417 - val_loss: 0.0313
Epoch 7/10
300/300 [==============================] - 396s 1s/step - loss: 0.0395 - val_loss: 0.0301
Epoch 8/10
300/300 [==============================] - 398s 1s/step - loss: 0.0376 - val_loss: 0.0265
Epoch 9/10
300/300 [==============================] - 399s 1s/step - loss: 0.0370 - val_loss: 0.0296
Epoch 10/10
300/300 [==============================] - 398s 1s/step - loss: 0.0353 - val_loss: 0.0252
```

```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.legend(['training', 'validation'])
plt.title('Loss')
plt.xlabel('Epoch')
```

```
Text(0.5, 0, 'Epoch')
```




```
model.save('multiobstaclenodrop.h5')
```

```
from google.colab import files
files.download('model.h5')
```