Machine Learning Assignment 2

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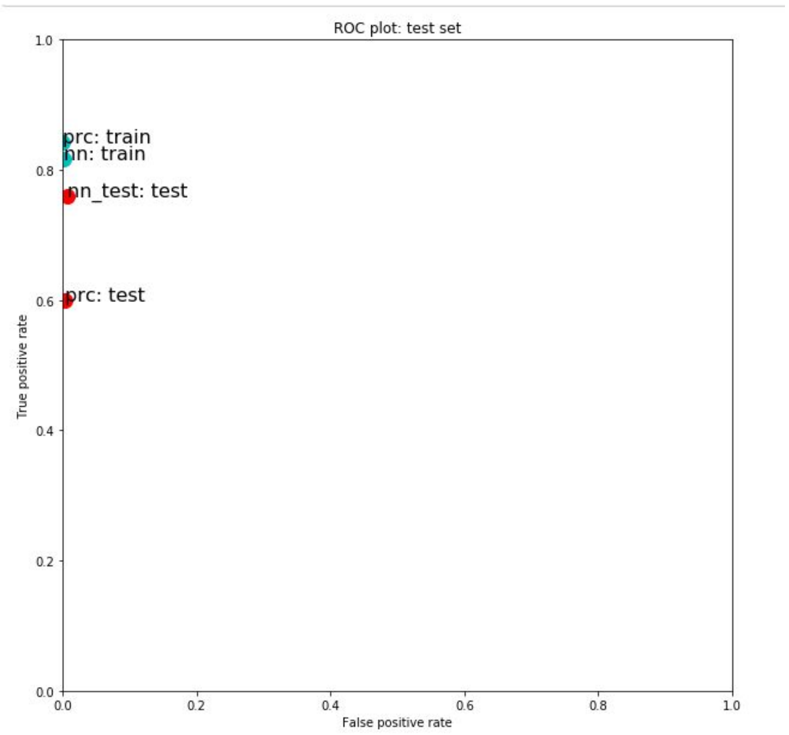
3.31.20 - 4.6.20
Flying Dollar Airport Assignment

Notes:

- Time of day - consider time of day as feature, as well as month, day of week, etc.
- Slope / angle of plane for take off/landing.
- Direction of the plane movement, whether inbound or outbound.
  - Landings on RWY 02
  - Departures on RWY 20
- Is the airplane in the foreground or background

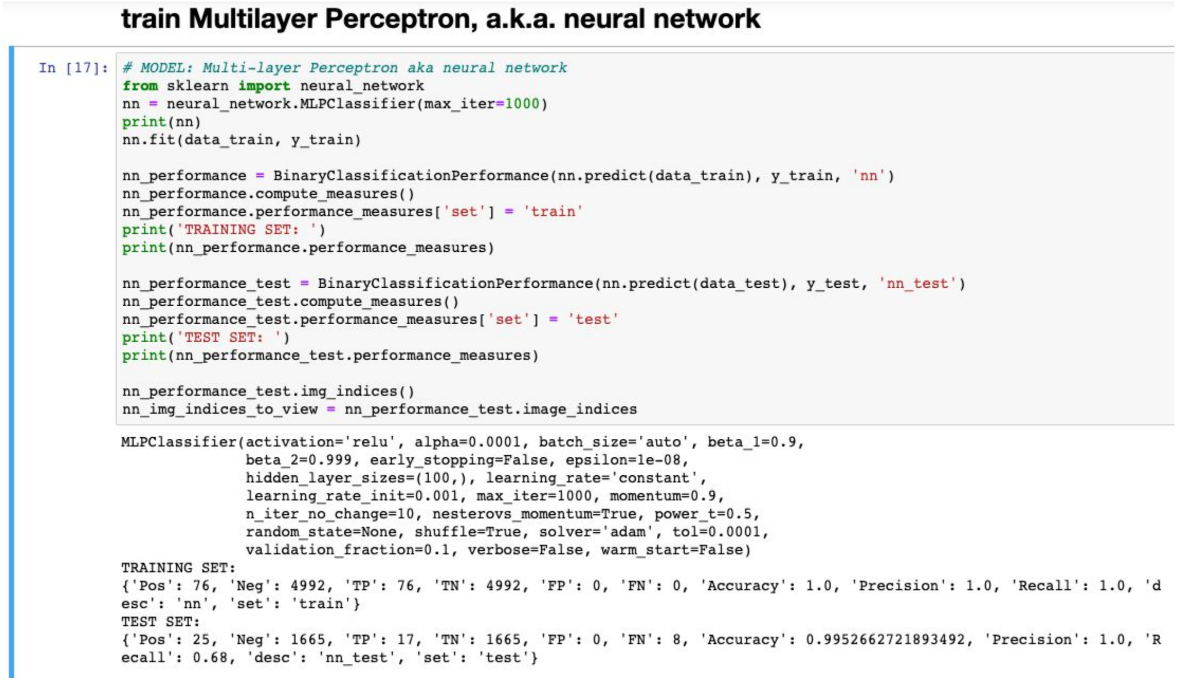
6758 and 101 contain airplanes.
1.49% of photos contain airplanes.

Starting around here after small adjustments.



Some of the many changes made

Training on Neural Network:
Default: Relu and Max_iter=1000

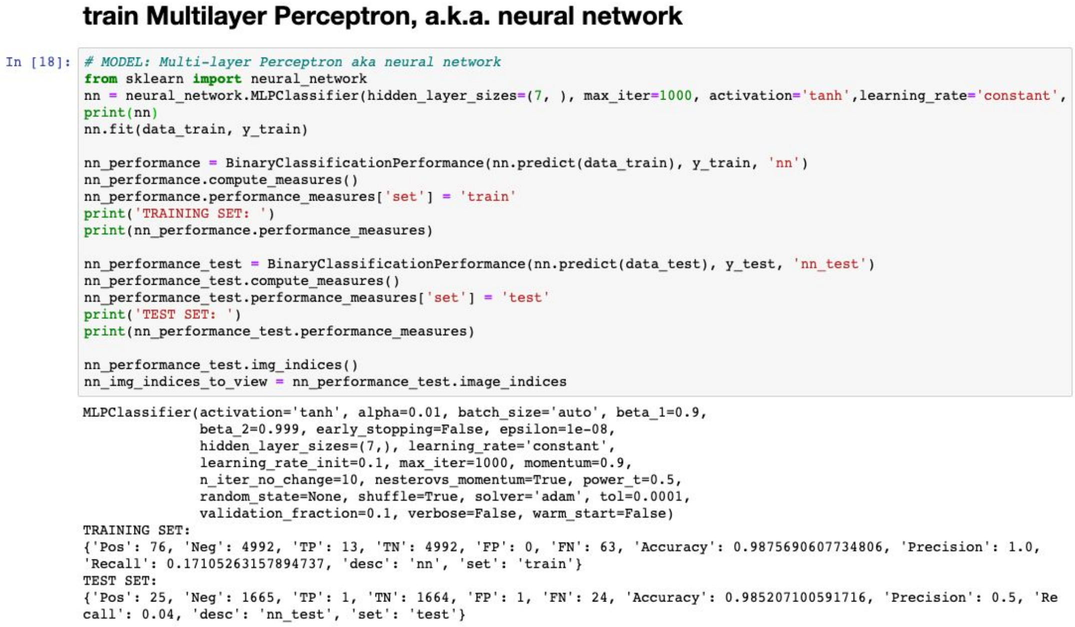


train Multilayer Perceptron, a.k.a. neural network

```
In [17]: # MODEL: Multi-layer Perceptron aka neural network
         from sklearn import neural_network
         nn = neural_network.MLPClassifier(max_iter=1000)
         print(nn)
         nn.fit(data_train, y_train)

         nn_performance = BinaryClassificationPerformance(nn.predict(data_train), y_train, 'nn')
         nn_performance.compute_measures()
         nn_performance.performance_measures['set'] = 'train'
         print('TRAINING SET: ')
         print(nn_performance.performance_measures)

         nn_performance_test = BinaryClassificationPerformance(nn.predict(data_test), y_test, 'nn_test')
         nn_performance_test.compute_measures()
         nn_performance_test.performance_measures['set'] = 'test'
         print('TEST SET: ')
         print(nn_performance_test.performance_measures)

         nn_performance_test.img_indices()
         nn_img_indices_to_view = nn_performance_test.image_indices
```

```
MLPClassifier(activation='relu', alpha=0.0001, batch_size='auto', beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(100,), learning_rate='constant',
              learning_rate_init=0.001, max_iter=1000, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='adam', tol=0.0001,
              validation_fraction=0.1, verbose=False, warm_start=False)
TRAINING SET:
{'Pos': 76, 'Neg': 4992, 'TP': 76, 'TN': 4992, 'FP': 0, 'FN': 0, 'Accuracy': 1.0, 'Precision': 1.0, 'Recall': 1.0, 'd
esc': 'nn', 'set': 'train'}
TEST SET:
{'Pos': 25, 'Neg': 1665, 'TP': 17, 'TN': 1665, 'FP': 0, 'FN': 8, 'Accuracy': 0.9952662721893492, 'Precision': 1.0, 'R
ecall': 0.68, 'desc': 'nn_test', 'set': 'test'}
```

Change Hidden Layer size to 7, activation function: tahn, learning rate= constant, learning rate init 0.1, alpha 0.1.

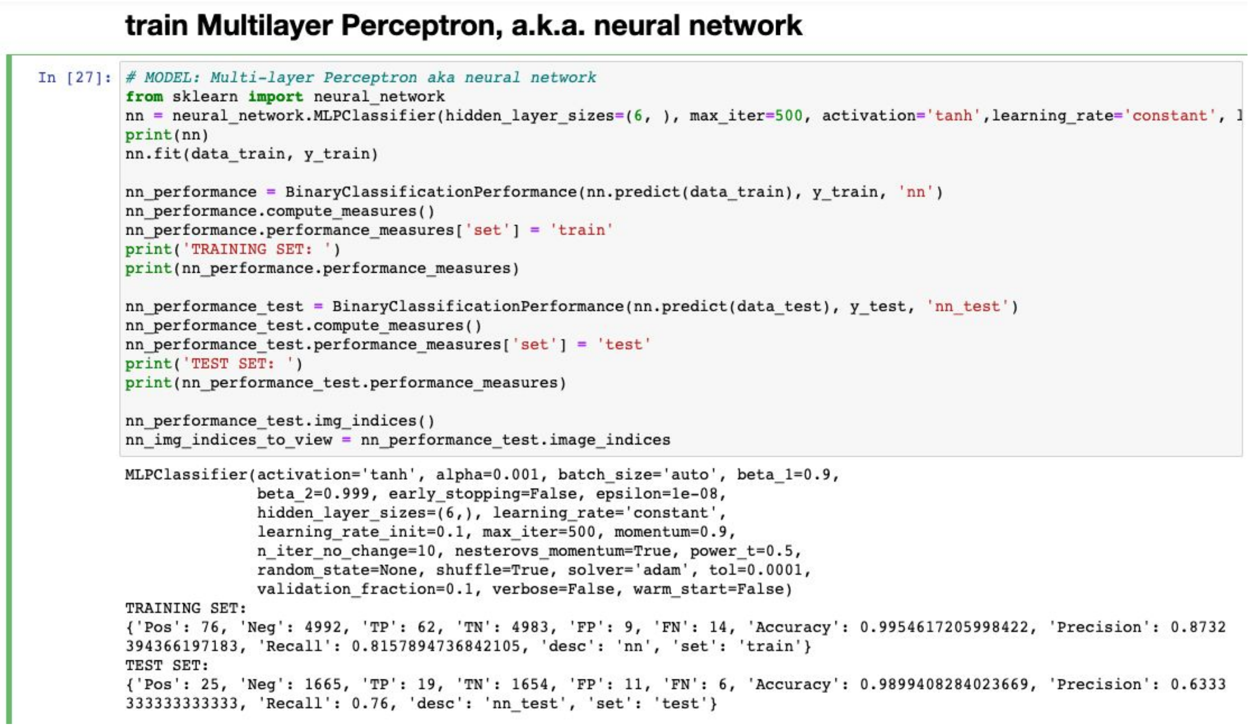


train Multilayer Perceptron, a.k.a. neural network

```
In [18]: # MODEL: Multi-layer Perceptron aka neural network
         from sklearn import neural_network
         nn = neural_network.MLPClassifier(hidden_layer_sizes=(7, ), max_iter=1000, activation='tanh',learning_rate='constant',
         print(nn)
         nn.fit(data_train, y_train)

         nn_performance = BinaryClassificationPerformance(nn.predict(data_train), y_train, 'nn')
         nn_performance.compute_measures()
         nn_performance.performance_measures['set'] = 'train'
         print('TRAINING SET: ')
         print(nn_performance.performance_measures)

         nn_performance_test = BinaryClassificationPerformance(nn.predict(data_test), y_test, 'nn_test')
         nn_performance_test.compute_measures()
         nn_performance_test.performance_measures['set'] = 'test'
         print('TEST SET: ')
         print(nn_performance_test.performance_measures)

         nn_performance_test.img_indices()
         nn_img_indices_to_view = nn_performance_test.image_indices
```

```
MLPClassifier(activation='tanh', alpha=0.01, batch_size='auto', beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(7,), learning_rate='constant',
              learning_rate_init=0.1, max_iter=1000, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='adam', tol=0.0001,
              validation_fraction=0.1, verbose=False, warm_start=False)
TRAINING SET:
{'Pos': 76, 'Neg': 4992, 'TP': 13, 'TN': 4992, 'FP': 0, 'FN': 63, 'Accuracy': 0.9875690607734806, 'Precision': 1.0,
'Recall': 0.17105263157894737, 'desc': 'nn', 'set': 'train'}
TEST SET:
{'Pos': 25, 'Neg': 1665, 'TP': 1, 'TN': 1664, 'FP': 1, 'FN': 24, 'Accuracy': 0.985207100591716, 'Precision': 0.5, 'Re
call': 0.04, 'desc': 'nn_test', 'set': 'test'}
```

Hidden layer size= 6, Max iter=500, activation function ‘tanh’



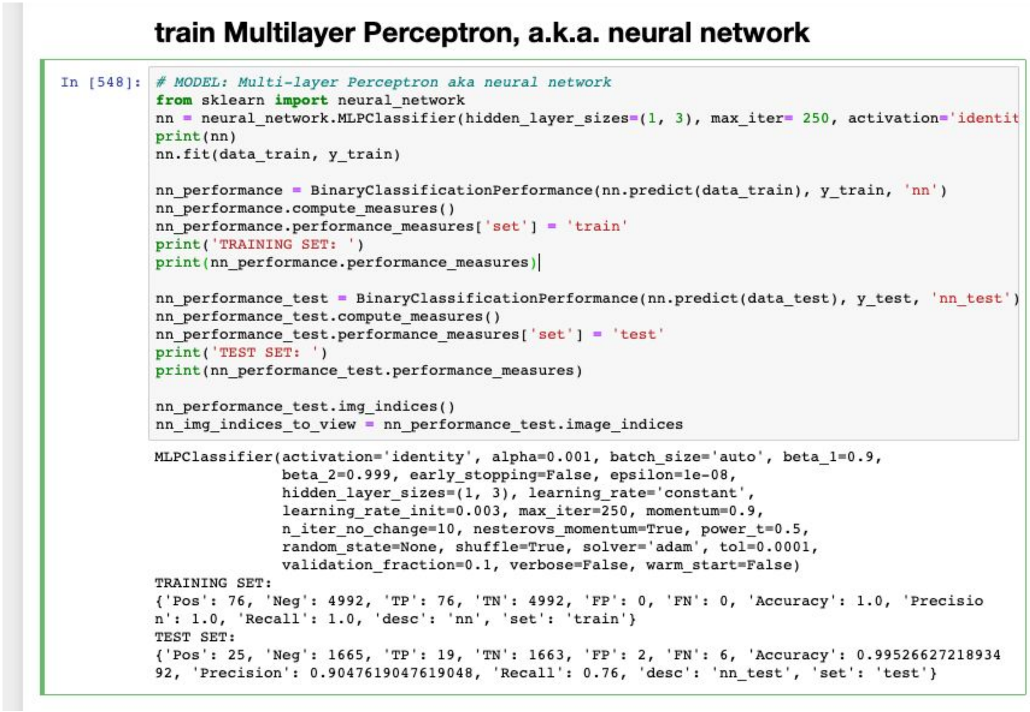
train Multilayer Perceptron, a.k.a. neural network

In [27]:

```
# MODEL: Multi-layer Perceptron aka neural network
from sklearn import neural_network
nn = neural_network.MLPClassifier(hidden_layer_sizes=(6, ), max_iter=500, activation='tanh',learning_rate='constant', l
print(nn)
nn.fit(data_train, y_train)

nn_performance = BinaryClassificationPerformance(nn.predict(data_train), y_train, 'nn')
nn_performance.compute_measures()
nn_performance.performance_measures['set'] = 'train'
print('TRAINING SET: ')
print(nn_performance.performance_measures)

nn_performance_test = BinaryClassificationPerformance(nn.predict(data_test), y_test, 'nn_test')
nn_performance_test.compute_measures()
nn_performance_test.performance_measures['set'] = 'test'
print('TEST SET: ')
print(nn_performance_test.performance_measures)

nn_performance_test.img_indices()
nn_img_indices_to_view = nn_performance_test.image_indices
```

```
MLPClassifier(activation='tanh', alpha=0.001, batch_size='auto', beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(6,), learning_rate='constant',
              learning_rate_init=0.1, max_iter=500, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='adam', tol=0.0001,
              validation_fraction=0.1, verbose=False, warm_start=False)
TRAINING SET:
{'Pos': 76, 'Neg': 4992, 'TP': 62, 'TN': 4983, 'FP': 9, 'FN': 14, 'Accuracy': 0.9954617205998422, 'Precision': 0.8732
394366197183, 'Recall': 0.8157894736842105, 'desc': 'nn', 'set': 'train'}
TEST SET:
{'Pos': 25, 'Neg': 1665, 'TP': 19, 'TN': 1654, 'FP': 11, 'FN': 6, 'Accuracy': 0.9899408284023669, 'Precision': 0.6333
333333333333, 'Recall': 0.76, 'desc': 'nn_test', 'set': 'test'}
```

Hidden Layers to 1, 3, Max_iter to 250, activation functio to identity, etc.

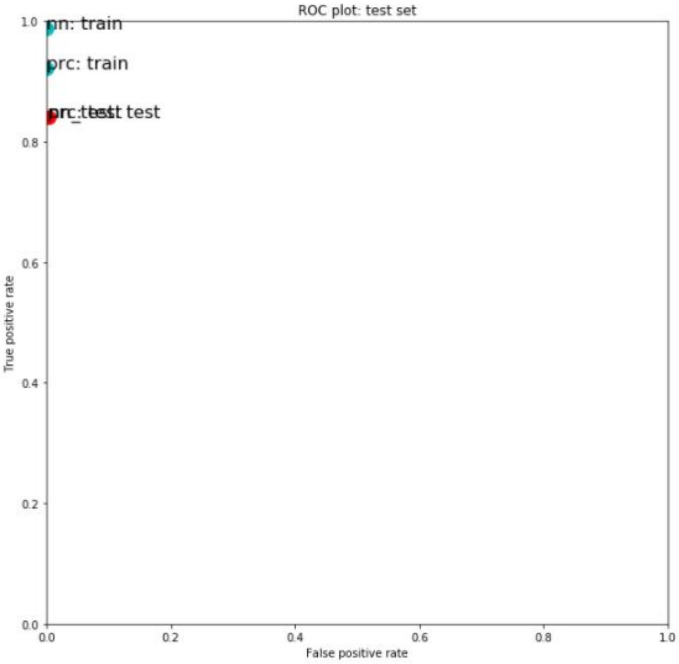


train Multilayer Perceptron, a.k.a. neural network

```
In [548]: # MODEL: Multi-layer Perceptron aka neural network
          from sklearn import neural_network
          nn = neural_network.MLPClassifier(hidden_layer_sizes=(1, 3), max_iter= 250, activation='identit
          print(nn)
          nn.fit(data_train, y_train)

          nn_performance = BinaryClassificationPerformance(nn.predict(data_train), y_train, 'nn')
          nn_performance.compute_measures()
          nn_performance.performance_measures['set'] = 'train'
          print('TRAINING SET: ')
          print(nn_performance.performance_measures)

          nn_performance_test = BinaryClassificationPerformance(nn.predict(data_test), y_test, 'nn_test')
          nn_performance_test.compute_measures()
          nn_performance_test.performance_measures['set'] = 'test'
          print('TEST SET: ')
          print(nn_performance_test.performance_measures)

          nn_performance_test.img_indices()
          nn_img_indices_to_view = nn_performance_test.image_indices
```

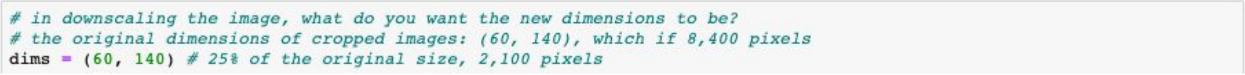
```
MLPClassifier(activation='identity', alpha=0.001, batch_size='auto', beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(1, 3), learning_rate='constant',
              learning_rate_init=0.003, max_iter=250, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='adam', tol=0.0001,
              validation_fraction=0.1, verbose=False, warm_start=False)
TRAINING SET:
{'Pos': 76, 'Neg': 4992, 'TP': 76, 'TN': 4992, 'FP': 0, 'FN': 0, 'Accuracy': 1.0, 'Precisio
n': 1.0, 'Recall': 1.0, 'desc': 'nn', 'set': 'train'}
TEST SET:
{'Pos': 25, 'Neg': 1665, 'TP': 19, 'TN': 1663, 'FP': 2, 'FN': 6, 'Accuracy': 0.99526627218934
92, 'Precision': 0.9047619047619048, 'Recall': 0.76, 'desc': 'nn_test', 'set': 'test'}
```

Seeing big improvements in all the adjustments:

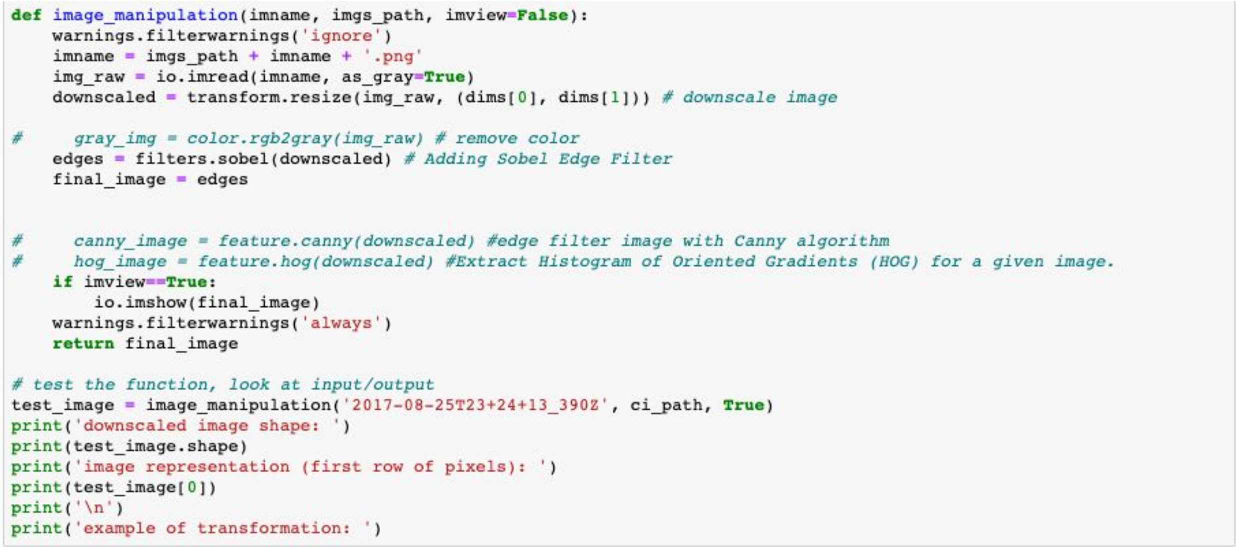


Adding A Sobel Filter:

Increasing Dims back to higher resolution and adding Sobel Edge Filter

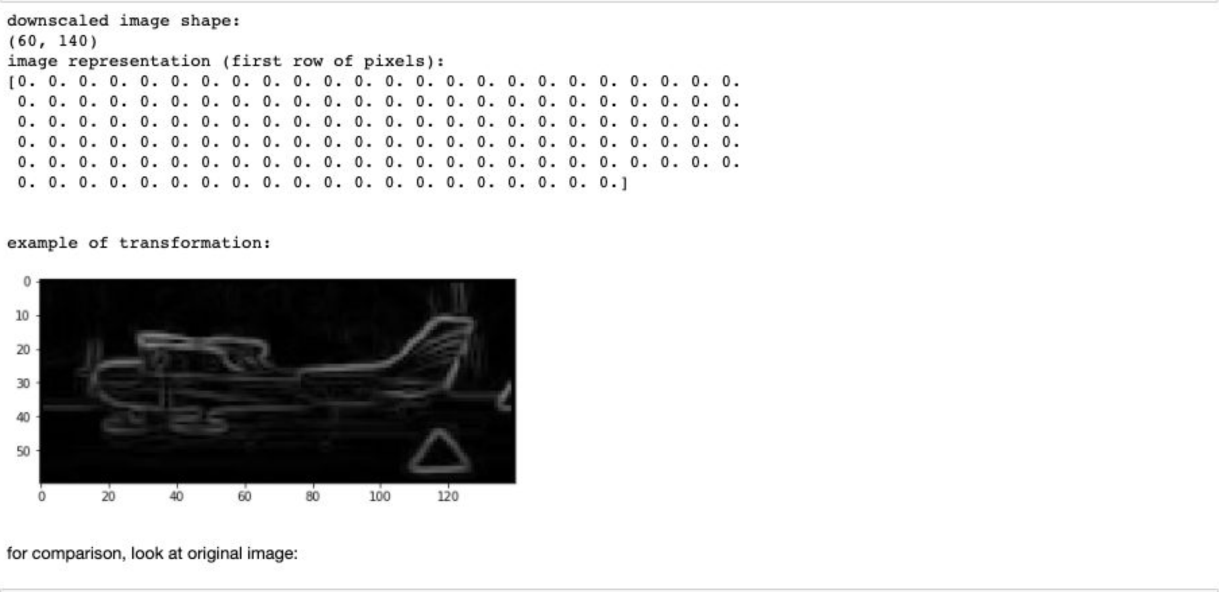


```
# in downscaling the image, what do you want the new dimensions to be?
# the original dimensions of cropped images: (60, 140), which if 8,400 pixels
dims = (60, 140) # 25% of the original size, 2,100 pixels
```



```
def image_manipulation(imname, imgs_path, imview=False):
    warnings.filterwarnings('ignore')
    imname = imgs_path + imname + '.png'
    img_raw = io.imread(imname, as_gray=True)
    downscaled = transform.resize(img_raw, (dims[0], dims[1])) # downscale image

#     gray_img = color.rgb2gray(img_raw) # remove color
    edges = filters.sobel(downscaled) # Adding Sobel Edge Filter
    final_image = edges


#     canny_image = feature.canny(downscaled) #edge filter image with Canny algorithm
#     hog_image = feature.hog(downscaled) #Extract Histogram of Oriented Gradients (HOG) for a given image.
    if imview==True:
        io.imshow(final_image)
    warnings.filterwarnings('always')
    return final_image

# test the function, look at input/output
test_image = image_manipulation('2017-08-25T23+24+13_390Z', ci_path, True)
print('downscaled image shape: ')
print(test_image.shape)
print('image representation (first row of pixels): ')
print(test_image[0])
print('\n')
print('example of transformation: ')
```

Tried Sobel filter with image shape of 60, 140 / 30,70 / 15,35 Overfitting on 60, 140, but perceptron performed well.

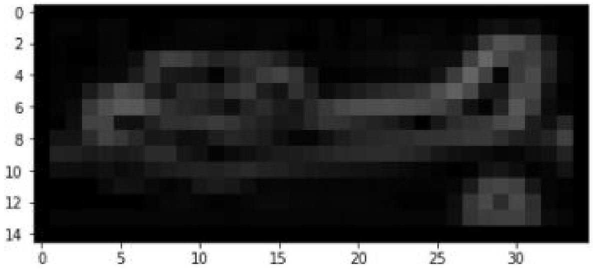


```
downscaled image shape:
(60, 140)
image representation (first row of pixels):
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]


example of transformation:
```

for comparison, look at original image:

Low Resolution Sobel Filter at (15, 35)

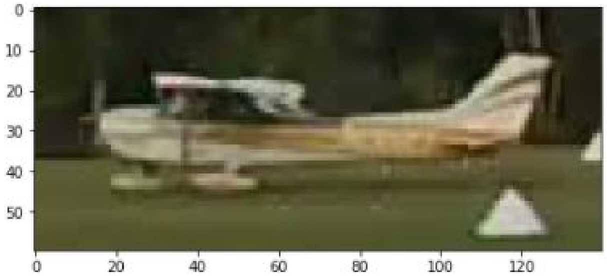
```
example of transformation:
```

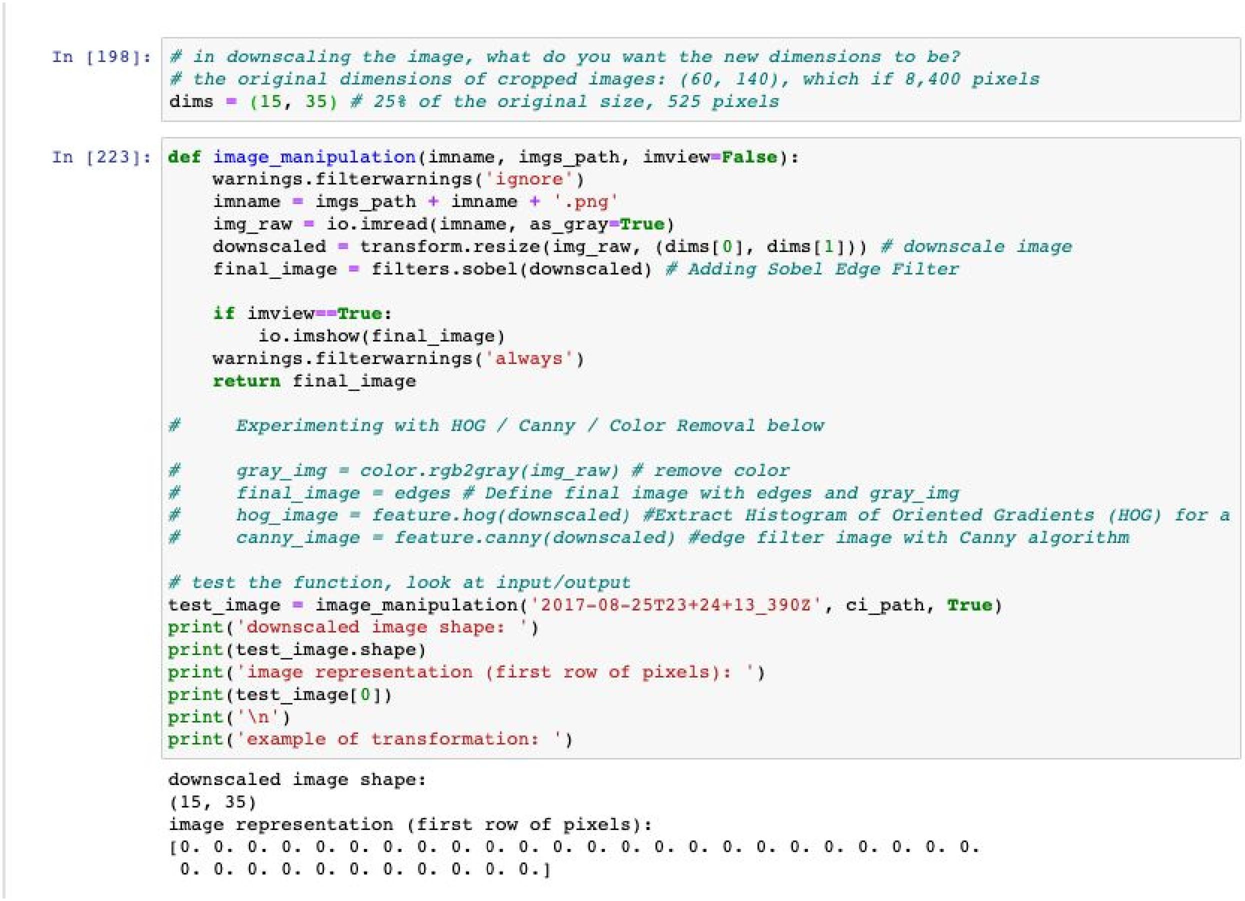


for comparison, look at original image:

```
In [200]: this_imname = ci_path + '2017-08-25T23+24+13_390Z.png'
          io.imshow(io.imread(this_imname))
```

```
Out[200]: <matplotlib.image.AxesImage at 0x1c1812ab50>
```



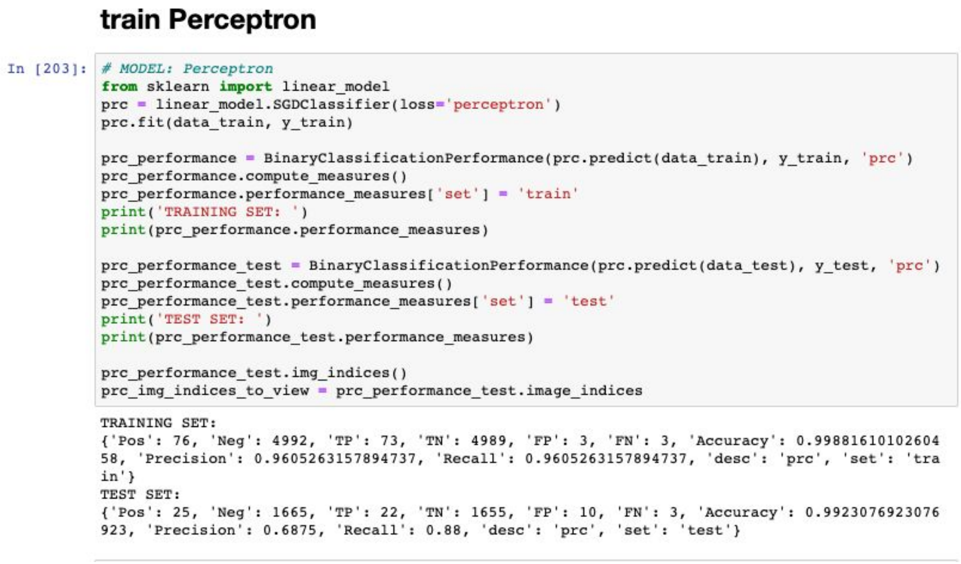


```
In [198]: # in downscaling the image, what do you want the new dimensions to be?
          # the original dimensions of cropped images: (60, 140), which if 8,400 pixels
          dims = (15, 35) # 25% of the original size, 525 pixels
```

```
In [223]: def image_manipulation(imname, imgs_path, imview=False):
              warnings.filterwarnings('ignore')
              imname = imgs_path + imname + '.png'
              img_raw = io.imread(imname, as_gray=True)
              downscaled = transform.resize(img_raw, (dims[0], dims[1])) # downscale image
              final_image = filters.sobel(downscaled) # Adding Sobel Edge Filter

              if imview==True:
                  io.imshow(final_image)
              warnings.filterwarnings('always')
              return final_image

          #     Experimenting with HOG / Canny / Color Removal below

          #     gray_img = color.rgb2gray(img_raw) # remove color
          #     final_image = edges # Define final image with edges and gray_img
          #     hog_image = feature.hog(downscaled) #Extract Histogram of Oriented Gradients (HOG) for a
          #     canny_image = feature.canny(downscaled) #edge filter image with Canny algorithm

          # test the function, look at input/output
          test_image = image_manipulation('2017-08-25T23+24+13_390Z', ci_path, True)
          print('downscaled image shape: ')
          print(test_image.shape)
          print('image representation (first row of pixels): ')
          print(test_image[0])
          print('\n')
          print('example of transformation: ')
```

```
downscaled image shape:
(15, 35)
image representation (first row of pixels):
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
```

Perceptron:

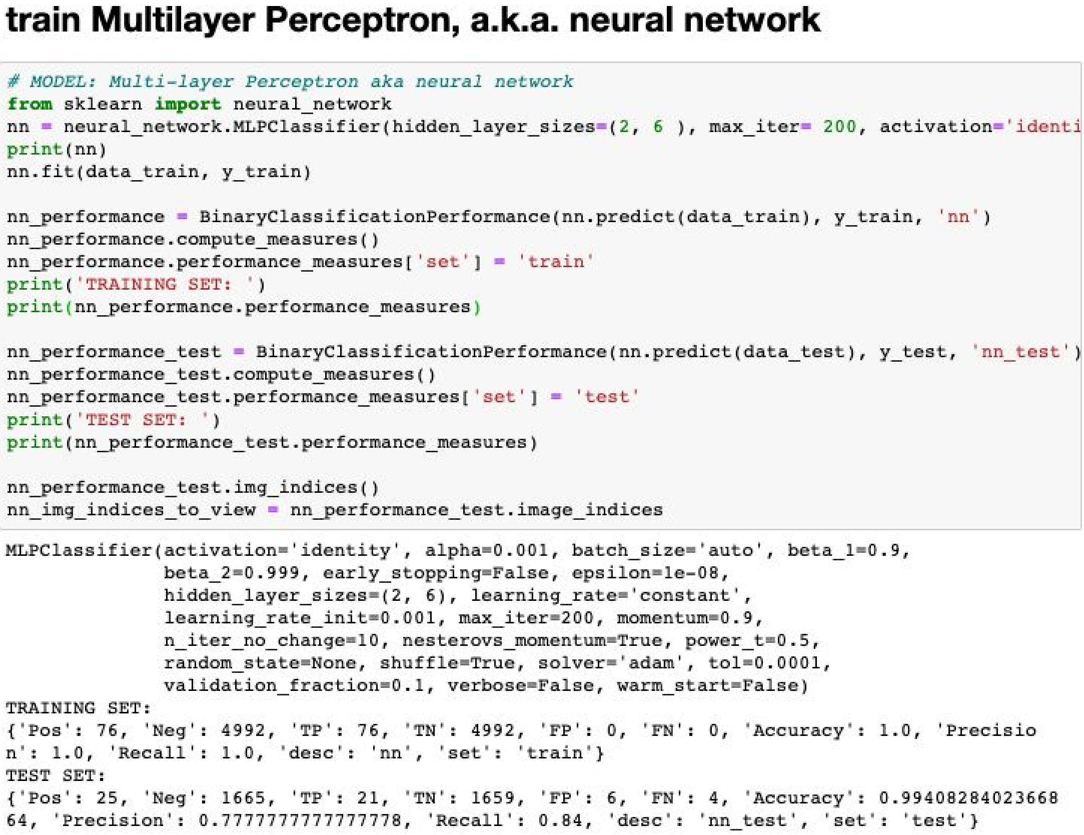


train Perceptron

```
In [203]: # MODEL: Perceptron
          from sklearn import linear_model
          prc = linear_model.SGDClassifier(loss='perceptron')
          prc.fit(data_train, y_train)

          prc_performance = BinaryClassificationPerformance(prc.predict(data_train), y_train, 'prc')
          prc_performance.compute_measures()
          prc_performance.performance_measures['set'] = 'train'
          print('TRAINING SET: ')
          print(prc_performance.performance_measures)

          prc_performance_test = BinaryClassificationPerformance(prc.predict(data_test), y_test, 'prc')
          prc_performance_test.compute_measures()
          prc_performance_test.performance_measures['set'] = 'test'
          print('TEST SET: ')
          print(prc_performance_test.performance_measures)

          prc_performance_test.img_indices()
          prc_img_indices_to_view = prc_performance_test.image_indices
```

```
TRAINING SET:
{'Pos': 76, 'Neg': 4992, 'TP': 73, 'TN': 4989, 'FP': 3, 'FN': 3, 'Accuracy': 0.99881610102604
58, 'Precision': 0.9605263157894737, 'Recall': 0.9605263157894737, 'desc': 'prc', 'set': 'tra
in'}
TEST SET:
{'Pos': 25, 'Neg': 1665, 'TP': 22, 'TN': 1655, 'FP': 10, 'FN': 3, 'Accuracy': 0.9923076923076
923, 'Precision': 0.6875, 'Recall': 0.88, 'desc': 'prc', 'set': 'test'}
```

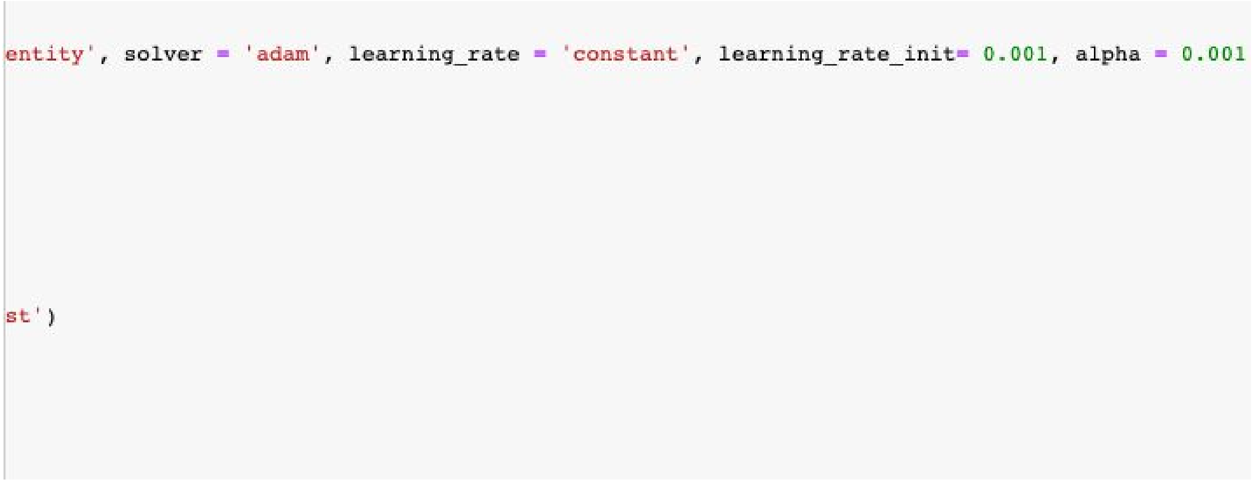
Change to Layer Sizes of NN, change to activation function, and learning rate, and solver.



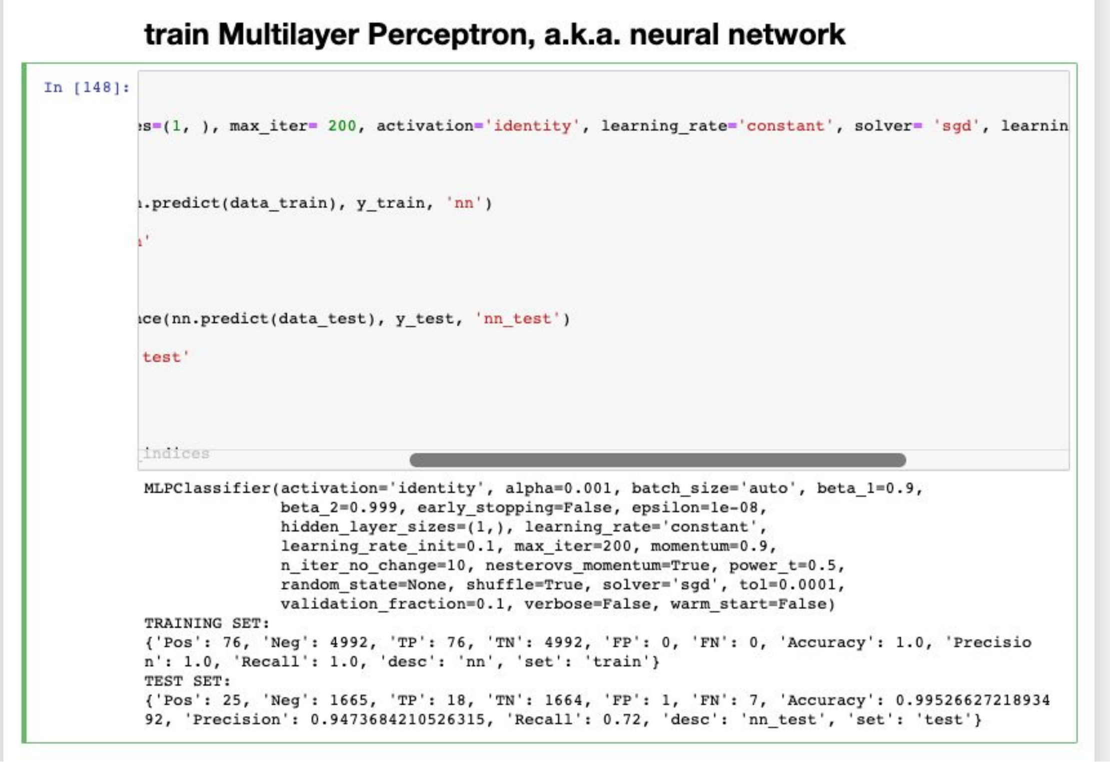
train Multilayer Perceptron, a.k.a. neural network

```
In [211]: # MODEL: Multi-layer Perceptron aka neural network
          from sklearn import neural_network
          nn = neural_network.MLPClassifier(hidden_layer_sizes=(2, 6 ), max_iter= 200, activation='identi
          print(nn)
          nn.fit(data_train, y_train)

          nn_performance = BinaryClassificationPerformance(nn.predict(data_train), y_train, 'nn')
          nn_performance.compute_measures()
          nn_performance.performance_measures['set'] = 'train'
          print('TRAINING SET: ')
          print(nn_performance.performance_measures)

          nn_performance_test = BinaryClassificationPerformance(nn.predict(data_test), y_test, 'nn_test')
          nn_performance_test.compute_measures()
          nn_performance_test.performance_measures['set'] = 'test'
          print('TEST SET: ')
          print(nn_performance_test.performance_measures)

          nn_performance_test.img_indices()
          nn_img_indices_to_view = nn_performance_test.image_indices
```

```
MLPClassifier(activation='identity', alpha=0.001, batch_size='auto', beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(2, 6), learning_rate='constant',
              learning_rate_init=0.001, max_iter=200, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='adam', tol=0.0001,
              validation_fraction=0.1, verbose=False, warm_start=False)
TRAINING SET:
{'Pos': 76, 'Neg': 4992, 'TP': 76, 'TN': 4992, 'FP': 0, 'FN': 0, 'Accuracy': 1.0, 'Precisio
n': 1.0, 'Recall': 1.0, 'desc': 'nn', 'set': 'train'}
TEST SET:
{'Pos': 25, 'Neg': 1665, 'TP': 21, 'TN': 1659, 'FP': 6, 'FN': 4, 'Accuracy': 0.99408284023668
64, 'Precision': 0.7777777777777778, 'Recall': 0.84, 'desc': 'nn_test', 'set': 'test'}
```



```
entity', solver = 'adam', learning_rate = 'constant', learning_rate_init= 0.001, alpha = 0.001









st')
```



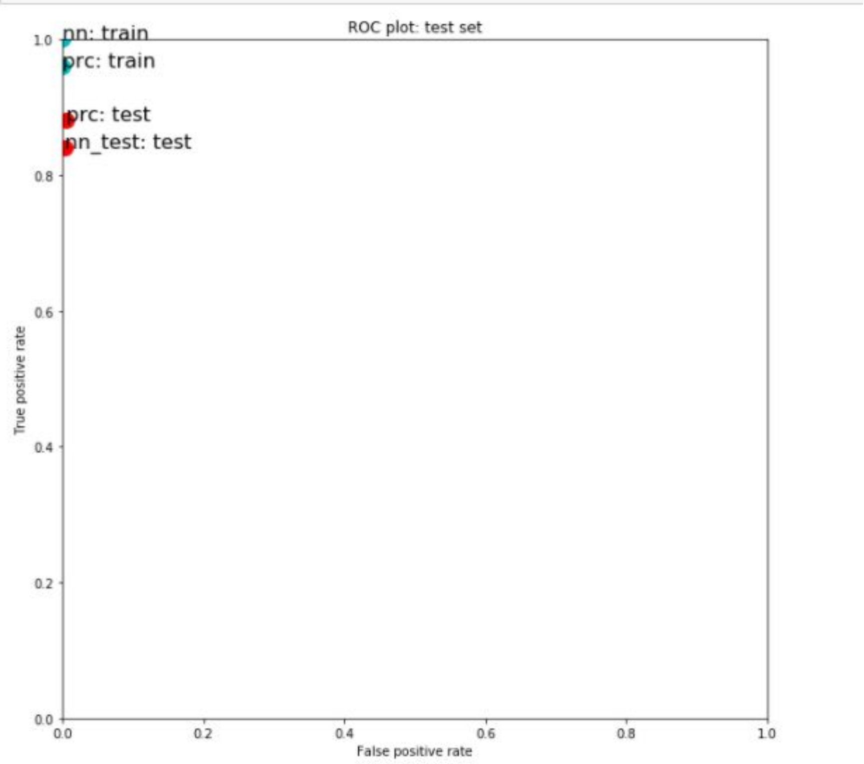
train Multilayer Perceptron, a.k.a. neural network

In [148]:

```
es=(1, ), max_iter= 200, activation='identity', learning_rate='constant', solver= 'sgd', learnin

.predict(data_train), y_train, 'nn')
'


ce(nn.predict(data_test), y_test, 'nn_test')
 test'


indices
```

```
MLPClassifier(activation='identity', alpha=0.001, batch_size='auto', beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(1,), learning_rate='constant',
              learning_rate_init=0.1, max_iter=200, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='sgd', tol=0.0001,
              validation_fraction=0.1, verbose=False, warm_start=False)
TRAINING SET:
{'Pos': 76, 'Neg': 4992, 'TP': 76, 'TN': 4992, 'FP': 0, 'FN': 0, 'Accuracy': 1.0, 'Precisio
n': 1.0, 'Recall': 1.0, 'desc': 'nn', 'set': 'train'}
TEST SET:
{'Pos': 25, 'Neg': 1665, 'TP': 18, 'TN': 1664, 'FP': 1, 'FN': 7, 'Accuracy': 0.99526627218934
92, 'Precision': 0.9473684210526315, 'Recall': 0.72, 'desc': 'nn_test', 'set': 'test'}
```

Submission on Training and Testing Sets.
4/6/20


ROC plot: test set
nn: train
prc: train
prc: test
nn_test: test
True positive rate
False positive rate