project_imbalanced_data

July 13, 2021

#imports

[57]:
```
from google.colab import drive
drive.mount('/content/drive', force_remount=True)
import matplotlib.pyplot as plt
import seaborn as sns
import keras
from keras.models import Sequential
from keras.layers import Dense, Conv2D , MaxPool2D , Flatten , Dropout
from keras.preprocessing.image import ImageDataGenerator
from keras.optimizers import Adam
from sklearn.metrics import classification_report,confusion_matrix
import tensorflow as tf
import cv2
import os
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn import metrics
from sklearn.neighbors import KNeighborsClassifier
from sklearn import svm
from sklearn.metrics import plot_confusion_matrix
from sklearn.metrics import mean_squared_error
```

```
Mounted at /content/drive
```

#Imbalanced Data

#generate data

[5]:
```
labels = ['pedestrian', 'regular']
img_size = 128

def get_data(data_dir):
    data = []
    for label in labels:
        path = os.path.join(data_dir, label)
        class_num = labels.index(label)
        for img in os.listdir(path):
```

```
            try:
                img_arr = cv2.imread(os.path.join(path, img))[...,::-1]␣
↪#convert BGR to RGB format
                resized_arr = cv2.resize(img_arr, (img_size, img_size)) #␣
↪Reshaping images to preferred size
                data.append([resized_arr, class_num])
            except Exception as e:
                print(e)
    return np.array(data)
```

[6]:
```
data = get_data('/content/drive/My Drive/machine learning/data')
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:16:
VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences
(which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths
or shapes) is deprecated. If you meant to do this, you must specify
'dtype=object' when creating the ndarray
  app.launch_new_instance()
```

#split to train and test

[7]:
```
train,test = train_test_split(data, test_size=0.33, random_state=42)
print(train.shape)
print(test.shape)
```

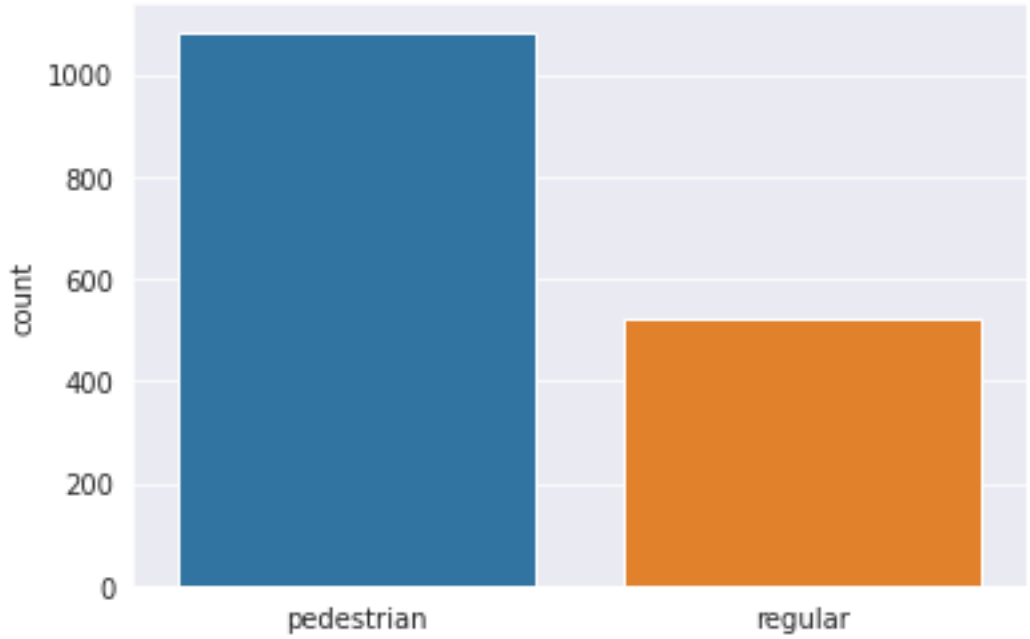
```
(1605, 2)
(792, 2)
```

#show the balance in the train

[8]:
```
l = []
for i in train:
    if(i[1] == 0):
        l.append("pedestrian")
    else:
        l.append("regular")
sns.set_style('darkgrid')
sns.countplot(l)
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarning:
Pass the following variable as a keyword arg: x. From version 0.12, the only
valid positional argument will be `data`, and passing other arguments without an
explicit keyword will result in an error or misinterpretation.
  FutureWarning
```

[8]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f907e5923d0>
```

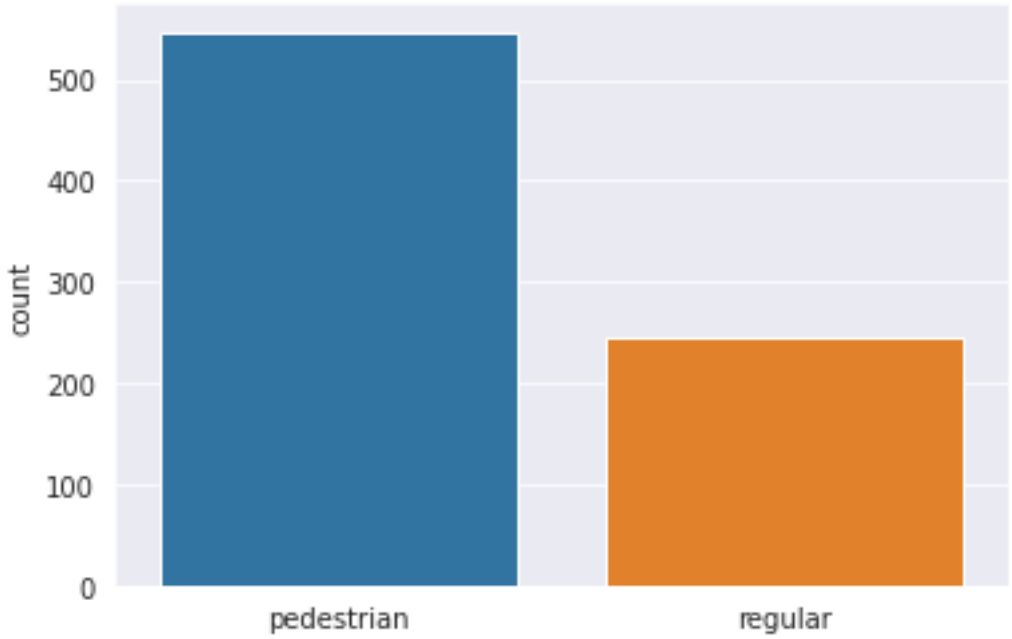


#show the balance in the test

[9]:
```
r = []
for i in test:
    if(i[1] == 0):
        r.append("pedestrian")
    else:
        r.append("regular")
sns.set_style('darkgrid')
sns.countplot(r)
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarning:
Pass the following variable as a keyword arg: x. From version 0.12, the only
valid positional argument will be `data`, and passing other arguments without an
explicit keyword will result in an error or misinterpretation.
  FutureWarning
```

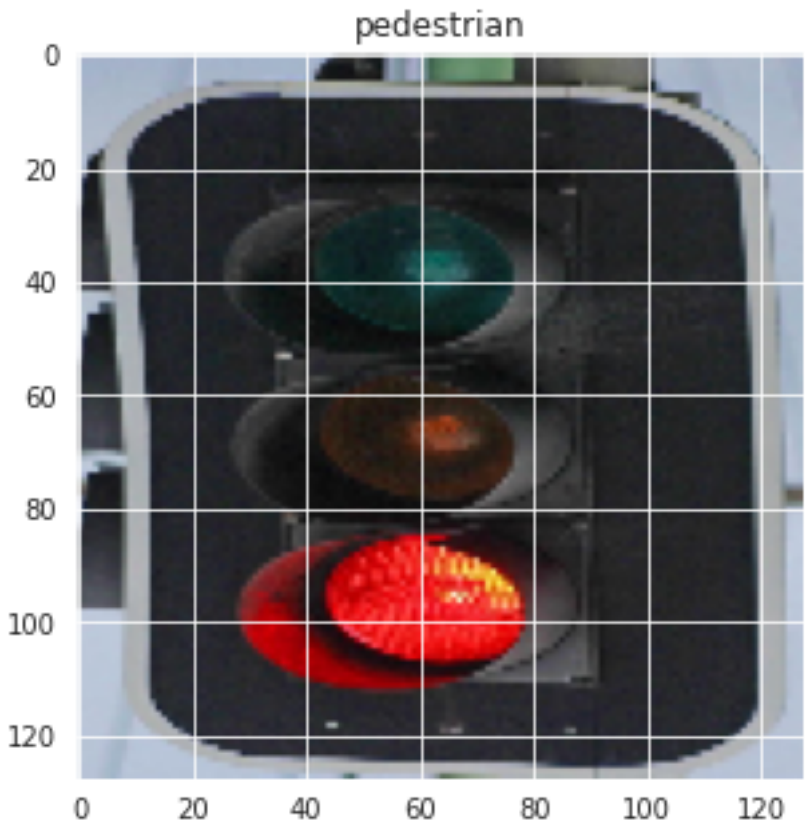
[9]: `<matplotlib.axes._subplots.AxesSubplot at 0x7f907e22a090>`



#dislpay some images from the data

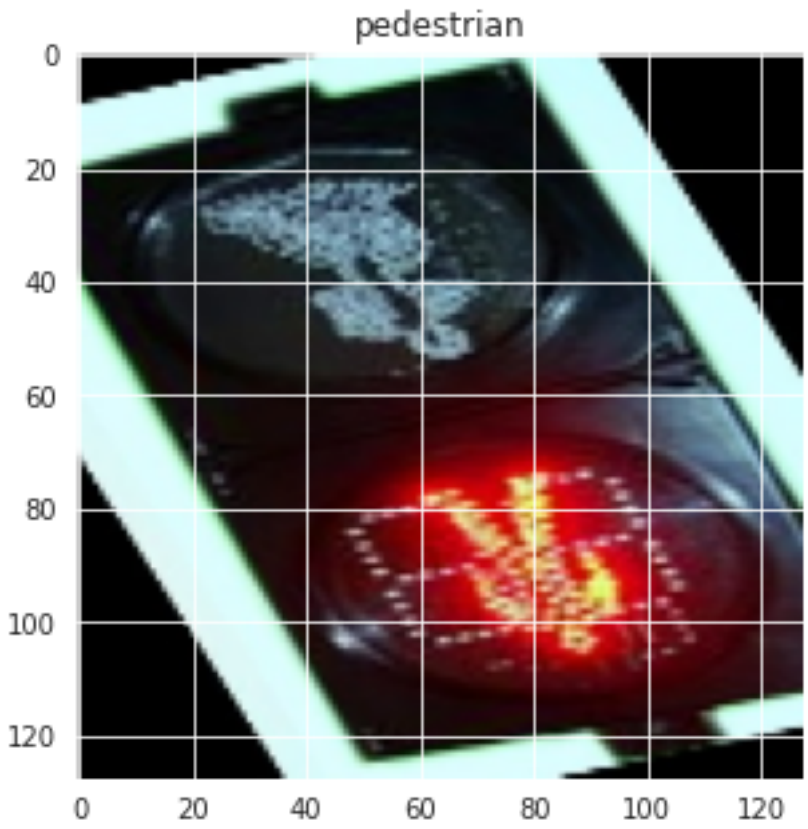
[10]:
```
plt.figure(figsize = (5,5))
plt.imshow(train[1][0])
plt.title(labels[train[0][1]])
```

[10]: Text(0.5, 1.0, 'pedestrian')



[11]:
```
plt.figure(figsize = (5,5))
plt.imshow(train[-1][0])
plt.title(labels[train[-1][1]])
```

[11]: Text(0.5, 1.0, 'pedestrian')



#preper the data

[12]:
```
x_train = []
y_train = []
x_test = []
y_test = []

for feature, label in train:
  x_train.append(feature)
  y_train.append(label)

for feature, label in test:
  x_test.append(feature)
  y_test.append(label)

# Normalize the data
x_train = np.array(x_train) / 255
x_test = np.array(x_test) / 255

x_train.reshape(-1, img_size, img_size, 1)
y_train = np.array(y_train)
```

```
x_test.reshape(-1, img_size, img_size, 1)
y_test = np.array(y_test)
```

[13]:
```
print(x_train.shape)
print(y_train.shape)
print(x_test.shape)
print(y_test.shape)
```

```
(1605, 128, 128, 3)
(1605,)
(792, 128, 128, 3)
(792,)
```

#do some random things on the data for better results

[14]:
```
datagen = ImageDataGenerator(
        featurewise_center=False,  # set input mean to 0 over the dataset
        samplewise_center=False,  # set each sample mean to 0
        featurewise_std_normalization=False,  # divide inputs by std of the␣
 ↪dataset
        samplewise_std_normalization=False,  # divide each input by its std
        zca_whitening=False,  # apply ZCA whitening
        rotation_range = 30,  # randomly rotate images in the range (degrees, 0␣
 ↪to 180)
        zoom_range = 0.2, # Randomly zoom image
        width_shift_range=0.1,  # randomly shift images horizontally (fraction␣
 ↪of total width)
        height_shift_range=0.1,  # randomly shift images vertically (fraction␣
 ↪of total height)
        horizontal_flip = True,  # randomly flip images
        vertical_flip=False)  # randomly flip images


datagen.fit(x_train)
```

#CNN model

[15]:
```
model = Sequential()
model.add(Conv2D(32,3,padding="same", activation="relu",␣
 ↪input_shape=(img_size,img_size,3)))
model.add(MaxPool2D())

model.add(Conv2D(32, 3, padding="same", activation="relu"))
model.add(MaxPool2D())

model.add(Conv2D(64, 3, padding="same", activation="relu"))
model.add(MaxPool2D())
```

```
model.add(Dropout(0.6))

model.add(Flatten())
model.add(Dense(128,activation="relu"))
model.add(Dense(2, activation="softmax"))

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 128, 128, 32)      896
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 64, 64, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 64, 64, 32)        9248
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 32, 32, 32)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 32, 32, 64)        18496
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 16, 16, 64)        0
_________________________________________________________________
dropout (Dropout)            (None, 16, 16, 64)        0
_________________________________________________________________
flatten (Flatten)            (None, 16384)             0
_________________________________________________________________
dense (Dense)                (None, 128)               2097280
_________________________________________________________________
dense_1 (Dense)              (None, 2)                 258
=================================================================
Total params: 2,126,178
Trainable params: 2,126,178
Non-trainable params: 0
_________________________________________________________________
```

[16]:
```
opt = Adam(lr=0.0001)
model.compile(optimizer = opt , loss = tf.keras.losses.
 ↪SparseCategoricalCrossentropy(from_logits=True) , metrics = ['accuracy'])
```

```
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/keras/optimizer_v2/optimizer_v2.py:375: UserWarning:
The `lr` argument is deprecated, use `learning_rate` instead.
  "The `lr` argument is deprecated, use `learning_rate` instead.")
```

[18]:
```
epochs = 15
```

```
history = model.fit(x_train,y_train,epochs = epochs , validation_data =␣
↪(x_test, y_test))
```

```
Epoch 1/15
51/51 [==============================] - 40s 789ms/step - loss: 0.1134 -
accuracy: 0.9620 - val_loss: 0.0815 - val_accuracy: 0.9760
Epoch 2/15
51/51 [==============================] - 41s 796ms/step - loss: 0.0971 -
accuracy: 0.9670 - val_loss: 0.0659 - val_accuracy: 0.9823
Epoch 3/15
51/51 [==============================] - 40s 784ms/step - loss: 0.0704 -
accuracy: 0.9769 - val_loss: 0.0482 - val_accuracy: 0.9886
Epoch 4/15
51/51 [==============================] - 40s 784ms/step - loss: 0.0508 -
accuracy: 0.9869 - val_loss: 0.0427 - val_accuracy: 0.9874
Epoch 5/15
51/51 [==============================] - 41s 805ms/step - loss: 0.0438 -
accuracy: 0.9850 - val_loss: 0.0331 - val_accuracy: 0.9937
Epoch 6/15
51/51 [==============================] - 39s 775ms/step - loss: 0.0377 -
accuracy: 0.9919 - val_loss: 0.0295 - val_accuracy: 0.9924
Epoch 7/15
51/51 [==============================] - 41s 796ms/step - loss: 0.0290 -
accuracy: 0.9938 - val_loss: 0.0232 - val_accuracy: 0.9962
Epoch 8/15
51/51 [==============================] - 40s 785ms/step - loss: 0.0265 -
accuracy: 0.9944 - val_loss: 0.0214 - val_accuracy: 0.9949
Epoch 9/15
51/51 [==============================] - 40s 778ms/step - loss: 0.0223 -
accuracy: 0.9944 - val_loss: 0.0168 - val_accuracy: 0.9962
Epoch 10/15
51/51 [==============================] - 40s 786ms/step - loss: 0.0135 -
accuracy: 0.9988 - val_loss: 0.0153 - val_accuracy: 0.9962
Epoch 11/15
51/51 [==============================] - 40s 779ms/step - loss: 0.0152 -
accuracy: 0.9963 - val_loss: 0.0192 - val_accuracy: 0.9937
Epoch 12/15
51/51 [==============================] - 40s 778ms/step - loss: 0.0137 -
accuracy: 0.9981 - val_loss: 0.0201 - val_accuracy: 0.9949
Epoch 13/15
51/51 [==============================] - 39s 774ms/step - loss: 0.0143 -
accuracy: 0.9969 - val_loss: 0.0148 - val_accuracy: 0.9975
Epoch 14/15
51/51 [==============================] - 40s 777ms/step - loss: 0.0104 -
accuracy: 0.9981 - val_loss: 0.0119 - val_accuracy: 0.9962
Epoch 15/15
51/51 [==============================] - 40s 780ms/step - loss: 0.0095 -
accuracy: 0.9981 - val_loss: 0.0134 - val_accuracy: 0.9962
```

#show results of CNN

[19]:
```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)

plt.figure(figsize=(15, 15))
plt.subplot(2, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(2, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```

[20]:
```
predictions = model.predict_classes(x_test)
predictions = predictions.reshape(1,-1)[0]
print(classification_report(y_test, predictions, target_names = ['pedestrain␣
↪(Class 0)','regular (Class 1)']))
```

```
/usr/local/lib/python3.7/dist-packages/keras/engine/sequential.py:450:
UserWarning: `model.predict_classes()` is deprecated and will be removed after
```

```
2021-01-01. Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if
your model does multi-class classification   (e.g. if it uses a `softmax` last-
layer activation).* `(model.predict(x) > 0.5).astype("int32")`,   if your model
does binary classification   (e.g. if it uses a `sigmoid` last-layer
activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```

	precision	recall	f1-score	support
pedestrain (Class 0)	1.00	1.00	1.00	547
regular (Class 1)	0.99	1.00	0.99	245
accuracy			1.00	792
macro avg	1.00	1.00	1.00	792
weighted avg	1.00	1.00	1.00	792

#KNN model

[21]:
```
x_train = x_train.reshape(x_train.shape[0],x_train.shape[1]*x_train.
↪shape[2]*x_train.shape[3])
x_train.shape
```

[21]:
```
(1605, 49152)
```

[22]:
```
x_test = x_test.reshape(x_test.shape[0],x_test.shape[1]*x_test.shape[2]*x_test.
↪shape[3])
x_test.shape
```

[22]:
```
(792, 49152)
```

[23]:
```
knn_1 = KNeighborsClassifier(n_neighbors=1)
knn_1.fit(x_train,y_train)
knn_2 = KNeighborsClassifier(n_neighbors=2)
knn_2.fit(x_train,y_train)
knn_3 = KNeighborsClassifier(n_neighbors=3)
knn_3.fit(x_train,y_train)
knn_4 = KNeighborsClassifier(n_neighbors=4)
knn_4.fit(x_train,y_train)
knn_5 = KNeighborsClassifier(n_neighbors=5)
knn_5.fit(x_train,y_train)
# knn_9 = KNeighborsClassifier(n_neighbors=9)
# knn_9.fit(x_train,y_train)
```

[23]:
```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=5, p=2,
                     weights='uniform')
```

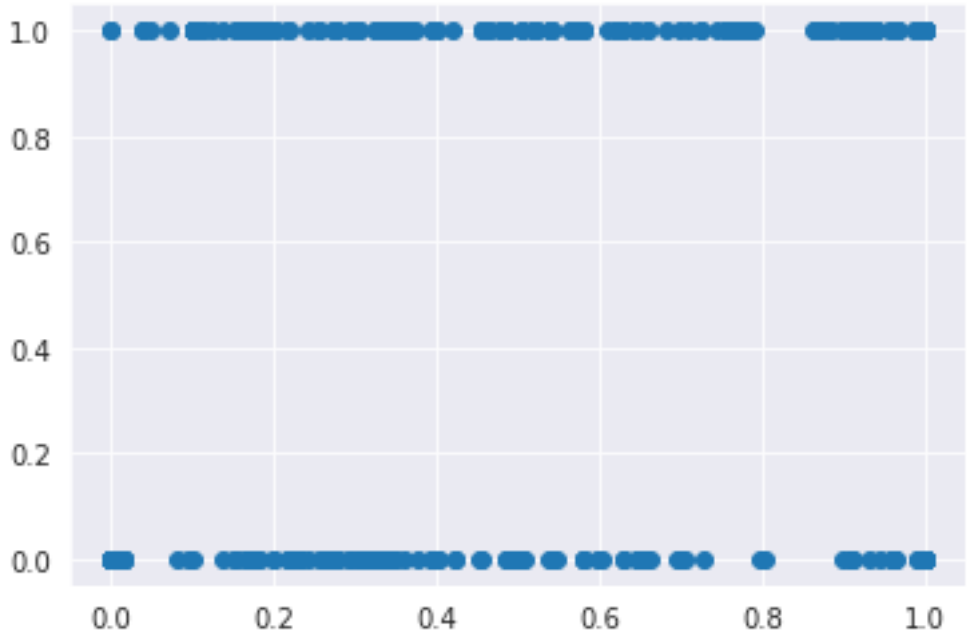
#show results of KNN

[24]:
```
score1 = knn_1.score(x_test, y_test)
score2 = knn_2.score(x_test, y_test)
score3 = knn_3.score(x_test, y_test)
score4 = knn_4.score(x_test, y_test)
score5 = knn_5.score(x_test, y_test)
print("1 neighbour: " ,score1)
print("2 neighbours: " ,score2)
print("3 neighbours: " ,score3)
print("4 neighbours: " ,score4)
print("5 neighbours: " ,score5)
```

```
1 neighbour:  0.9785353535353535
2 neighbours:  0.9406565656565656
3 neighbours:  0.946969696969697
4 neighbours:  0.9154040404040404
5 neighbours:  0.9356060606060606
```

[25]:
```
plt.scatter(x_test[:,1],knn_1.predict_proba(x_test)[:,1])
```

[25]: <matplotlib.collections.PathCollection at 0x7f90774c2e50>



#Logistic regression Model

[26]:
```
logisticRegr = LogisticRegression()
result = logisticRegr.fit(x_train, y_train)
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_logistic.py:940:
```

```
ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

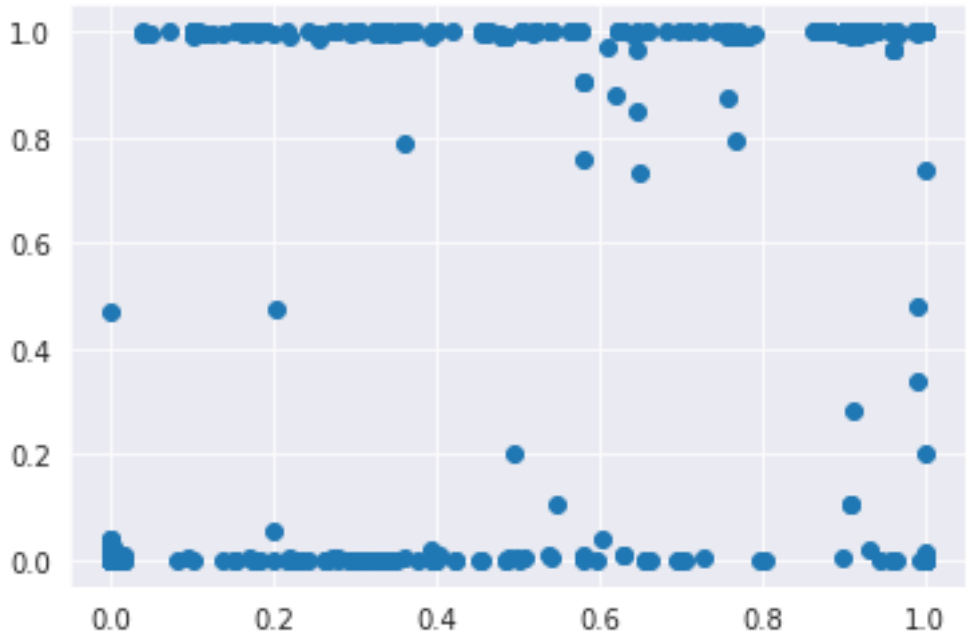
#show results of Logistic Regression

[27]:
```
score = logisticRegr.score(x_test, y_test)
print(score)
```

```
0.9873737373737373
```

[28]:
```
plt.scatter(x_test[:,1],logisticRegr.predict_proba(x_test)[:,1])
```

[28]:
```
<matplotlib.collections.PathCollection at 0x7f90775cc610>
```



#SVM model

[29]:
```
svm = svm.SVC(kernel='linear',probability=True) # Linear Kernel
svm.fit(x_train, y_train)
```

[29]:
```
SVC(C=1.0, break_ties=False, cache_size=200, class_weight=None, coef0=0.0,
    decision_function_shape='ovr', degree=3, gamma='scale', kernel='linear',
    max_iter=-1, probability=True, random_state=None, shrinking=True, tol=0.001,
    verbose=False)
```

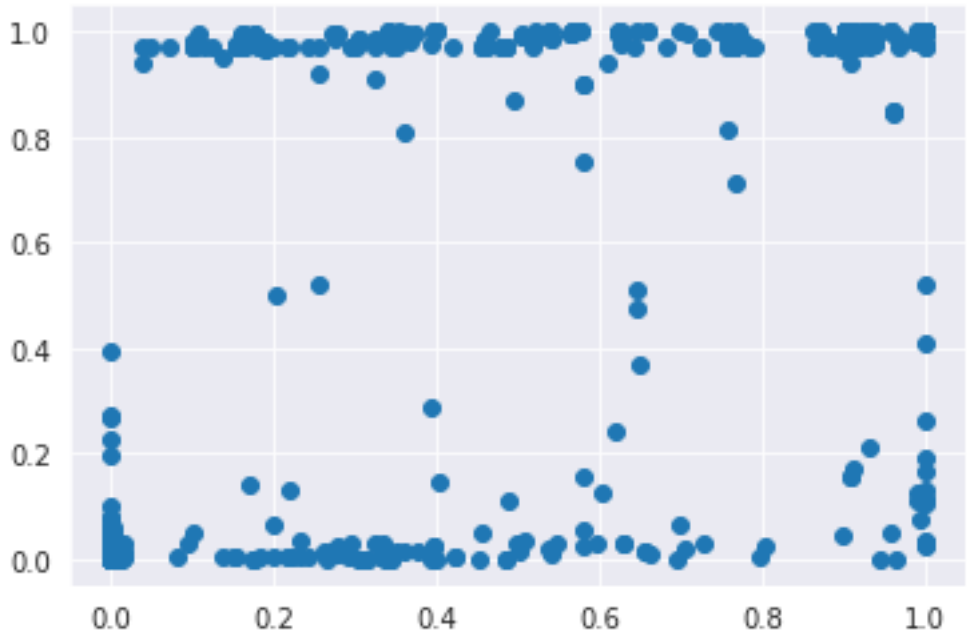
#show results of SVM

[30]:
```
y_pred = svm.predict(x_test)
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
print("Precision:",metrics.precision_score(y_test, y_pred))
print("Recall:",metrics.recall_score(y_test, y_pred))
```

```
Accuracy: 0.9886363636363636
Precision: 0.9916666666666667
Recall: 0.9714285714285714
```

[31]:
```
plt.scatter(x_test[:,1],svm.predict_proba(x_test)[:,1])
```

[31]:
```
<matplotlib.collections.PathCollection at 0x7f9077204210>
```



[32]:
```
svm_preds = svm.predict(x_test)
knn_preds = knn_1.predict(x_test)
logistic_preds = logisticRegr.predict(x_test)
```

#Combine all models to see if it is improving results

[33]:
```
# predictions
adaboost_preds = []

for x in range(len(predictions)):
  preds = []
  preds.append(svm_preds[x])
  preds.append(knn_preds[x])
  preds.append(logistic_preds[x])
  preds.append(predictions[x])
  adaboost_preds.append(max(set(preds), key = preds.count))
```

#results of the combined models

[34]:
```
print("Accuracy:",metrics.accuracy_score(y_test, adaboost_preds))
print("Precision:",metrics.precision_score(y_test, adaboost_preds))
print("Recall:",metrics.recall_score(y_test, adaboost_preds))
```

```
Accuracy: 0.9924242424242424
Precision: 1.0
Recall: 0.9755102040816327
```

[35]:
```
target_names = ['pedestrian', 'regular']
print(classification_report(y_test, adaboost_preds, target_names=target_names))
```

```
              precision    recall  f1-score   support

  pedestrian       0.99      1.00      0.99       547
     regular       1.00      0.98      0.99       245

    accuracy                           0.99       792
   macro avg       0.99      0.99      0.99       792
weighted avg       0.99      0.99      0.99       792
```

[36]:
```
print(mean_squared_error(y_test, adaboost_preds, multioutput='raw_values'))
```

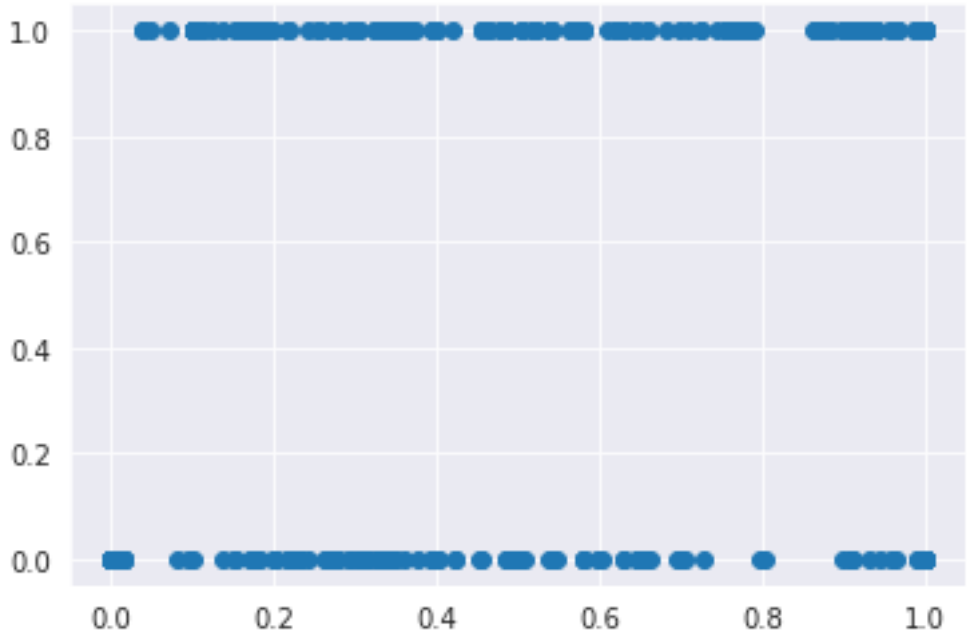
```
[0.00757576]
```

[37]:
```
print(confusion_matrix(y_test, adaboost_preds))
```

```
[[547   0]
 [  6 239]]
```

[38]:
```
plt.scatter(x_test[:,1],adaboost_preds)
```

[38]:
```
<matplotlib.collections.PathCollection at 0x7f90770c7c90>
```



#Balanced Data

#Generate Data

[39]:
```
labels = ['pedestrian', 'regular']
img_size = 128

def get_data(data_dir):
    data = []
    for label in labels:
        path = os.path.join(data_dir, label)
        class_num = labels.index(label)
        for img in os.listdir(path):
            try:
                img_arr = cv2.imread(os.path.join(path, img))[...,::-1]␣
 ↪#convert BGR to RGB format
                resized_arr = cv2.resize(img_arr, (img_size, img_size)) #␣
 ↪Reshaping images to preferred size
                data.append([resized_arr, class_num])
            except Exception as e:
                print(e)
    return np.array(data)
```

[40]:
```
data = get_data('/content/drive/My Drive/machine learning/balanced data')
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:16:
VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences
```

```
(which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths
or shapes) is deprecated. If you meant to do this, you must specify
'dtype=object' when creating the ndarray
  app.launch_new_instance()
```

#Split to train and test

[41]:
```
train,test = train_test_split(data, test_size=0.33, random_state=42)
print(train.shape)
print(test.shape)
```

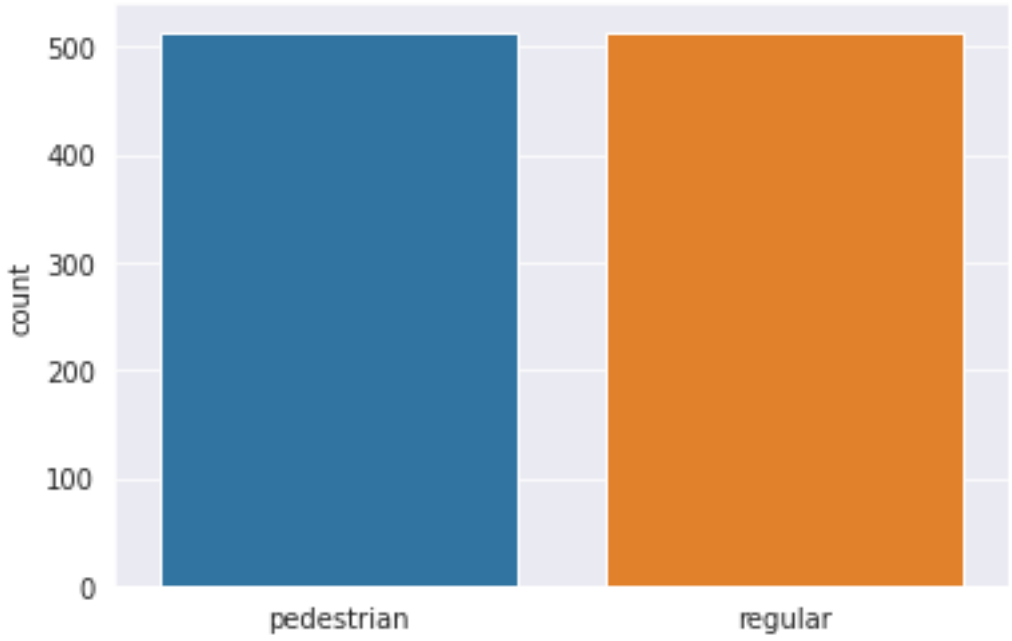
```
(1027, 2)
(507, 2)
```

#Show the balance in the train

[42]:
```
l = []
for i in train:
    if(i[1] == 0):
        l.append("pedestrian")
    else:
        l.append("regular")
sns.set_style('darkgrid')
sns.countplot(l)
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarning:
Pass the following variable as a keyword arg: x. From version 0.12, the only
valid positional argument will be `data`, and passing other arguments without an
explicit keyword will result in an error or misinterpretation.
  FutureWarning
```

[42]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f907754b250>
```

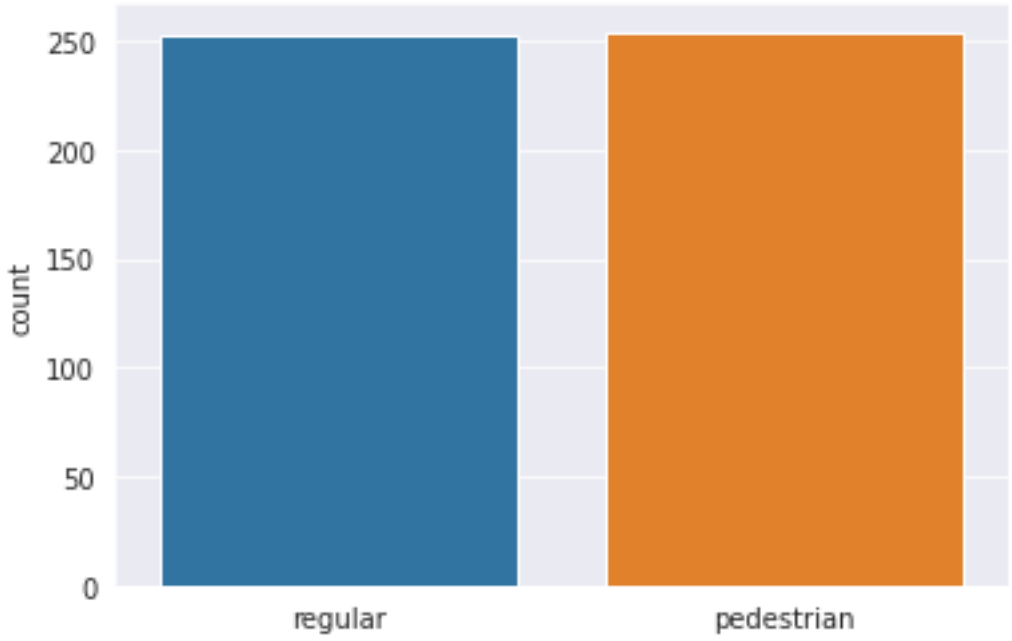


#Show the balance in the test

[43]:
```
r = []
for i in test:
    if(i[1] == 0):
        r.append("pedestrian")
    else:
        r.append("regular")
sns.set_style('darkgrid')
sns.countplot(r)
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarning:
Pass the following variable as a keyword arg: x. From version 0.12, the only
valid positional argument will be `data`, and passing other arguments without an
explicit keyword will result in an error or misinterpretation.
  FutureWarning
```

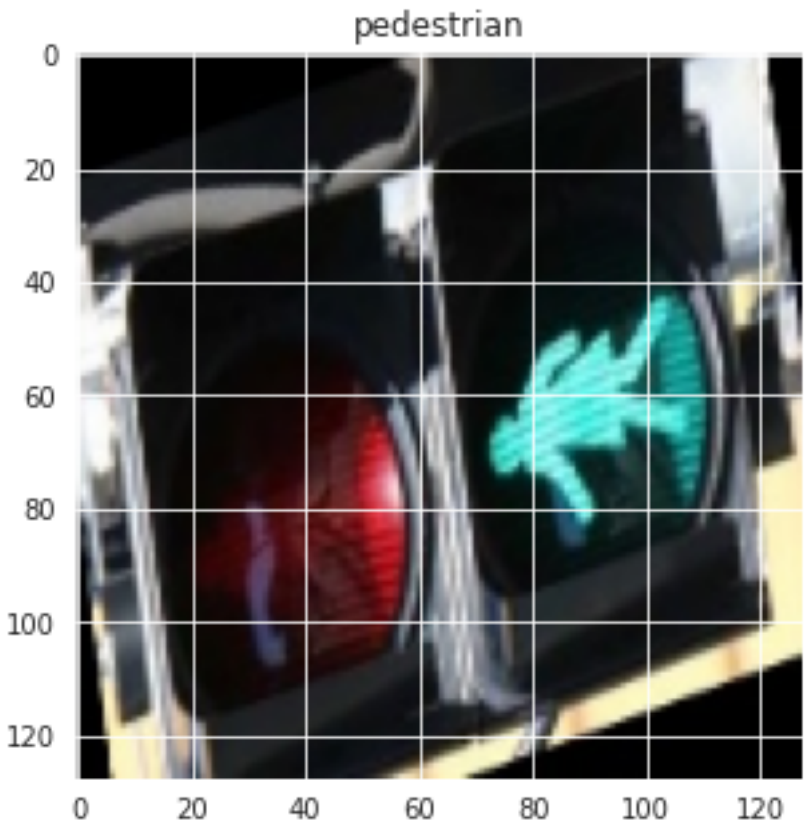
[43]: `<matplotlib.axes._subplots.AxesSubplot at 0x7f9073112210>`

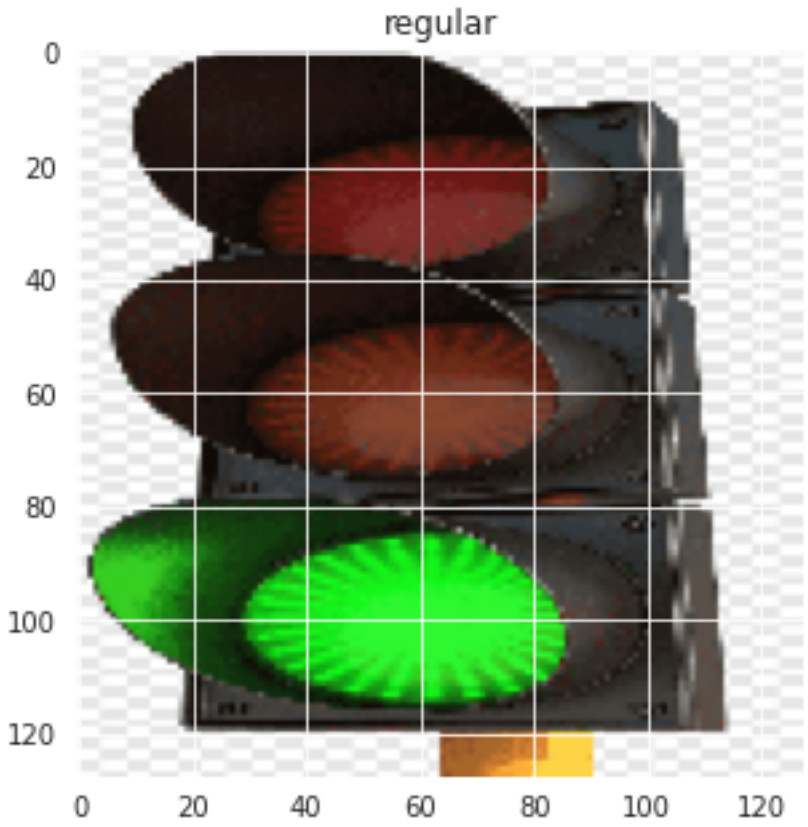


#Dislpay some images from the data

[44]:
```
plt.figure(figsize = (5,5))
plt.imshow(train[1][0])
plt.title(labels[train[0][1]])

plt.figure(figsize = (5,5))
plt.imshow(train[-1][0])
plt.title(labels[train[-1][1]])
```

[44]:
```
Text(0.5, 1.0, 'regular')
```


pedestrian
0
20
40
60
80
100
120
0
20
40
60
80
100
120



#Preper the data

[45]:
```
x_train_list = []
y_train = []
x_test_list = []
y_test = []

for feature, label in train:
  x_train_list.append(feature)
  y_train.append(label)

for feature, label in test:
  x_test_list.append(feature)
  y_test.append(label)

# Normalize the data
x_train = np.array(x_train_list)/255
x_test = np.array(x_test_list)/255
# img = Image.fromarray(x_train[4])
# img.save('my.png')
# img.show()
```

```
x_train.reshape(-1, img_size, img_size, 1)
y_train = np.array(y_train)

x_test.reshape(-1, img_size, img_size, 1)
y_test = np.array(y_test)

print(x_train.shape)
print(y_train.shape)
print(x_test.shape)
print(y_test.shape)
```

```
(1027, 128, 128, 3)
(1027,)
(507, 128, 128, 3)
(507,)
```

#Do some random things on the data for better results

[46]:
```
datagen = ImageDataGenerator(
        featurewise_center=False,  # set input mean to 0 over the dataset
        samplewise_center=False,  # set each sample mean to 0
        featurewise_std_normalization=False,  # divide inputs by std of the␣
↪dataset
        samplewise_std_normalization=False,  # divide each input by its std
        zca_whitening=False,  # apply ZCA whitening
        rotation_range = 30,  # randomly rotate images in the range (degrees, 0␣
↪to 180)
        zoom_range = 0.2, # Randomly zoom image
        width_shift_range=0.1,  # randomly shift images horizontally (fraction␣
↪of total width)
        height_shift_range=0.1,  # randomly shift images vertically (fraction␣
↪of total height)
        horizontal_flip = True,  # randomly flip images
        vertical_flip=False)  # randomly flip images


datagen.fit(x_train)
```

#CNN model

[47]:
```
class CNN:

    def __init__(self, x_train, y_train, x_test, y_test, img_size):
        self.x_train = x_train
        self.y_train = y_train
        self.x_test = x_test
        self.y_test = y_test
        self.img_size = img_size
```

```
        self.model = self.model()

    def model(self):
        model = Sequential()
        model.add(Conv2D(32, 3, padding="same", activation="relu",␣
↪input_shape=(self.img_size, self.img_size, 3)))
        model.add(MaxPool2D())

        model.add(Conv2D(32, 3, padding="same", activation="relu"))
        model.add(MaxPool2D())

        model.add(Conv2D(64, 3, padding="same", activation="relu"))
        model.add(MaxPool2D())
        model.add(Dropout(0.6))

        model.add(Flatten())
        model.add(Dense(128, activation="relu"))
        model.add(Dense(2, activation="softmax"))

        model.summary()
        return model

    def run(self):

        opt = Adam(lr=0.0001)
        self.model.compile(optimizer=opt, loss=tf.keras.losses.
↪SparseCategoricalCrossentropy(from_logits=True),
                           metrics=['accuracy'])

        epochs = 15
        history = self.model.fit(self.x_train, self.y_train, epochs=epochs,␣
↪validation_data=(self.x_test, self.y_test))

        """#show results of CNN"""
        acc = history.history['accuracy']
        val_acc = history.history['val_accuracy']
        loss = history.history['loss']
        val_loss = history.history['val_loss']

        epochs_range = range(epochs)

        plt.figure(figsize=(15, 15))
        plt.subplot(2, 2, 1)
        plt.plot(epochs_range, acc, label='Training Accuracy')
        plt.plot(epochs_range, val_acc, label='Validation Accuracy')
        plt.legend(loc='lower right')
        plt.title('Training and Validation Accuracy')
```

```
        plt.subplot(2, 2, 2)
        plt.plot(epochs_range, loss, label='Training Loss')
        plt.plot(epochs_range, val_loss, label='Validation Loss')
        plt.legend(loc='upper right')
        plt.title('Training and Validation Loss')
        plt.show()

        predictions = self.model.predict_classes(x_test)
        predictions = predictions.reshape(1, -1)[0]
        print(classification_report(self.y_test, predictions,␣
↪target_names=['pedestrain (Class 0)', 'regular (Class 1)']))
        return predictions
```

#KNN model

[48]:
```
class KNN:

    def __init__(self, x_train, y_train, x_test, y_test):
        self.x_train = x_train
        self.y_train = y_train
        self.x_test = x_test
        self.y_test = y_test

    def run(self):
        knn_1 = KNeighborsClassifier(n_neighbors=1)
        knn_1.fit(self.x_train, self.y_train)
        knn_2 = KNeighborsClassifier(n_neighbors=2)
        knn_2.fit(self.x_train, self.y_train)
        knn_3 = KNeighborsClassifier(n_neighbors=3)
        knn_3.fit(self.x_train, self.y_train)
        knn_4 = KNeighborsClassifier(n_neighbors=4)
        knn_4.fit(self.x_train, self.y_train)
        knn_5 = KNeighborsClassifier(n_neighbors=5)
        knn_5.fit(self.x_train, self.y_train)

        """#show results of KNN"""

        score1 = knn_1.score(self.x_test, self.y_test)
        score2 = knn_2.score(self.x_test, self.y_test)
        score3 = knn_3.score(self.x_test, self.y_test)
        score4 = knn_4.score(self.x_test, self.y_test)
        score5 = knn_5.score(self.x_test, self.y_test)
        print("1 neighbour: ", score1)
        print("2 neighbours: ", score2)
        print("3 neighbours: ", score3)
        print("4 neighbours: ", score4)
```

```
        print("5 neighbours: ", score5)

        plt.scatter(self.x_test[:, 1], knn_1.predict_proba(self.x_test)[:, 1])
        return knn_1
```

#Logistic Regression

[49]:
```
class logisticRegression:

    def __init__(self, x_train, y_train, x_test, y_test):
        self.x_train = x_train
        self.y_train = y_train
        self.x_test = x_test
        self.y_test = y_test

    def run(self):
        logisticRegr = LogisticRegression()
        result = logisticRegr.fit(self.x_train, self.y_train)

        """#show results of Logistic Regression"""

        score = logisticRegr.score(self.x_test, self.y_test)
        print(score)

        plt.scatter(self.x_test[:, 1], logisticRegr.predict_proba(self.x_test)[:
↪, 1])
        return logisticRegr
```

#SVM model

[50]:
```
class SVM:

    def __init__(self, x_train, y_train, x_test, y_test):
        self.x_train = x_train
        self.y_train = y_train
        self.x_test = x_test
        self.y_test = y_test

    def run(self):
        SVM = svm.SVC(kernel='linear', probability=True)  # Linear Kernel
        SVM.fit(self.x_train, self.y_train)

        """#show results of SVM"""

        y_pred = SVM.predict(self.x_test)
        print("Accuracy:", metrics.accuracy_score(self.y_test, y_pred))
        print("Precision:", metrics.precision_score(self.y_test, y_pred))
        print("Recall:", metrics.recall_score(self.y_test, y_pred))
```

```
        plt.scatter(self.x_test[:, 1], SVM.predict_proba(self.x_test)[:, 1])
        return SVM
```

#Adaboost model (combining all models)

[51]:
```
class adaboost:

    def __init__(self, x_test, y_test, cnn, knn, lgr, svm):
        self.x_test = x_test
        self.y_test = y_test
        self.cnn = cnn
        self.knn = knn
        self.lgr = lgr
        self.svm = svm

    def run(self):
        cnn_preds = self.cnn
        cnn_acc = metrics.accuracy_score(self.y_test, cnn_preds)
        svm_preds = self.svm.predict(self.x_test)
        svm_acc = metrics.accuracy_score(self.y_test, svm_preds)
        knn_preds = self.knn.predict(self.x_test)
        knn_acc = metrics.accuracy_score(self.y_test, knn_preds)
        logistic_preds = self.lgr.predict(self.x_test)
        logistic_acc = metrics.accuracy_score(self.y_test, logistic_preds)

        # predictions
        adaboost_preds = []

        for x in range(len(self.cnn)):
            preds = 0.
            if svm_preds[x] == 0:
                preds += svm_acc * -1
            else:
                preds += svm_acc * 1
            if knn_preds[x] == 0:
                preds += knn_acc * -1
            else:
                preds += knn_acc * 1
            if logistic_preds[x] == 0:
                preds += logistic_acc * -1
            else:
                preds += logistic_acc * 1
            if cnn_preds[x] == 0:
                preds += cnn_acc * -1
            else:
                preds += cnn_acc *1
```

```
            if preds >= 0:
                adaboost_preds.append(1)
            else:
                adaboost_preds.append(0)


        """#results of the combined models"""

        print("Accuracy:", metrics.accuracy_score(self.y_test, adaboost_preds))
        print("Precision:", metrics.precision_score(self.y_test,␣
↪adaboost_preds))
        print("Recall:", metrics.recall_score(self.y_test, adaboost_preds))

        target_names = ['pedestrian', 'regular']
        print(classification_report(self.y_test, adaboost_preds,␣
↪target_names=target_names))

        print(mean_squared_error(self.y_test, adaboost_preds,␣
↪multioutput='raw_values'))

        print(confusion_matrix(self.y_test, adaboost_preds))

        plt.scatter(x_test[:, 1], adaboost_preds)
```

#Find Errors

[52]:
```
def findErrors(x_test, y_test, algo,isCnn= False):
    lst = []
    if(isCnn):
        for idx, prediction, label in zip(enumerate(x_test), algo, y_test):
            if prediction != label:
                lst.append(idx[0])
    else:
        for idx, prediction, label in zip(enumerate(x_test), algo.
↪predict(x_test), y_test):
            if prediction != label:
                lst.append(idx[0])
    # npArr = np.array(lst, dtype=int)
    print("list: ", lst)
    return np.array(lst, dtype=int)
    # np.save = ('sum.npy', npArr)
```

#Run models

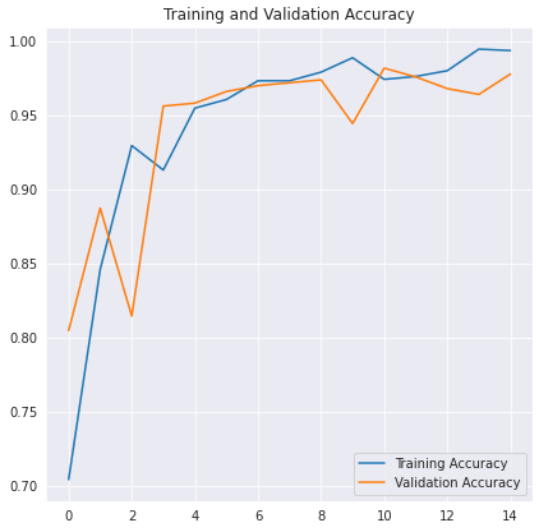
#CNN Results

[53]:
```
img_size = 128
```

```
print("\n CNN \n")
CNN = CNN(x_train, y_train, x_test, y_test, img_size).run()
```

```
 CNN

Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_3 (Conv2D)            (None, 128, 128, 32)      896
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 64, 64, 32)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 64, 64, 32)        9248
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 32, 32, 32)        0
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 32, 32, 64)        18496
_________________________________________________________________
max_pooling2d_5 (MaxPooling2 (None, 16, 16, 64)        0
_________________________________________________________________
dropout_1 (Dropout)          (None, 16, 16, 64)        0
_________________________________________________________________
flatten_1 (Flatten)          (None, 16384)             0
_________________________________________________________________
dense_2 (Dense)              (None, 128)               2097280
_________________________________________________________________
dense_3 (Dense)              (None, 2)                 258
=================================================================
Total params: 2,126,178
Trainable params: 2,126,178
Non-trainable params: 0
_________________________________________________________________
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/keras/optimizer_v2/optimizer_v2.py:375: UserWarning:
The `lr` argument is deprecated, use `learning_rate` instead.
  "The `lr` argument is deprecated, use `learning_rate` instead.")

Epoch 1/15

/usr/local/lib/python3.7/dist-packages/tensorflow/python/keras/backend.py:4930:
UserWarning: "`sparse_categorical_crossentropy` received `from_logits=True`, but
the `output` argument was produced by a sigmoid or softmax activation and thus
does not represent logits. Was this intended?"
  '"`sparse_categorical_crossentropy` received `from_logits=True`, but '

33/33 [==============================] - 26s 762ms/step - loss: 0.6447 -
accuracy: 0.6136 - val_loss: 0.4559 - val_accuracy: 0.8047
```

```
Epoch 2/15
33/33 [==============================] - 25s 762ms/step - loss: 0.4132 -
accuracy: 0.8057 - val_loss: 0.2872 - val_accuracy: 0.8876
Epoch 3/15
33/33 [==============================] - 25s 759ms/step - loss: 0.2323 -
accuracy: 0.9364 - val_loss: 0.3566 - val_accuracy: 0.8146
Epoch 4/15
33/33 [==============================] - 25s 756ms/step - loss: 0.2655 -
accuracy: 0.8803 - val_loss: 0.1607 - val_accuracy: 0.9566
Epoch 5/15
33/33 [==============================] - 25s 761ms/step - loss: 0.1205 -
accuracy: 0.9659 - val_loss: 0.1321 - val_accuracy: 0.9586
Epoch 6/15
33/33 [==============================] - 25s 745ms/step - loss: 0.1221 -
accuracy: 0.9529 - val_loss: 0.1168 - val_accuracy: 0.9665
Epoch 7/15
33/33 [==============================] - 24s 744ms/step - loss: 0.0890 -
accuracy: 0.9772 - val_loss: 0.1029 - val_accuracy: 0.9704
Epoch 8/15
33/33 [==============================] - 25s 769ms/step - loss: 0.0855 -
accuracy: 0.9718 - val_loss: 0.1028 - val_accuracy: 0.9724
Epoch 9/15
33/33 [==============================] - 26s 800ms/step - loss: 0.0746 -
accuracy: 0.9796 - val_loss: 0.0845 - val_accuracy: 0.9744
Epoch 10/15
33/33 [==============================] - 28s 855ms/step - loss: 0.0652 -
accuracy: 0.9867 - val_loss: 0.1081 - val_accuracy: 0.9448
Epoch 11/15
33/33 [==============================] - 27s 815ms/step - loss: 0.0619 -
accuracy: 0.9747 - val_loss: 0.0722 - val_accuracy: 0.9822
Epoch 12/15
33/33 [==============================] - 26s 804ms/step - loss: 0.0647 -
accuracy: 0.9713 - val_loss: 0.0874 - val_accuracy: 0.9763
Epoch 13/15
33/33 [==============================] - 27s 831ms/step - loss: 0.0549 -
accuracy: 0.9808 - val_loss: 0.0756 - val_accuracy: 0.9684
Epoch 14/15
33/33 [==============================] - 26s 797ms/step - loss: 0.0339 -
accuracy: 0.9923 - val_loss: 0.0753 - val_accuracy: 0.9645
Epoch 15/15
33/33 [==============================] - 26s 792ms/step - loss: 0.0243 -
accuracy: 0.9957 - val_loss: 0.0697 - val_accuracy: 0.9783
```




```
/usr/local/lib/python3.7/dist-packages/keras/engine/sequential.py:450:
UserWarning: `model.predict_classes()` is deprecated and will be removed after
2021-01-01. Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if
your model does multi-class classification   (e.g. if it uses a `softmax` last-
layer activation).* `(model.predict(x) > 0.5).astype("int32")`,   if your model
does binary classification   (e.g. if it uses a `sigmoid` last-layer
activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```

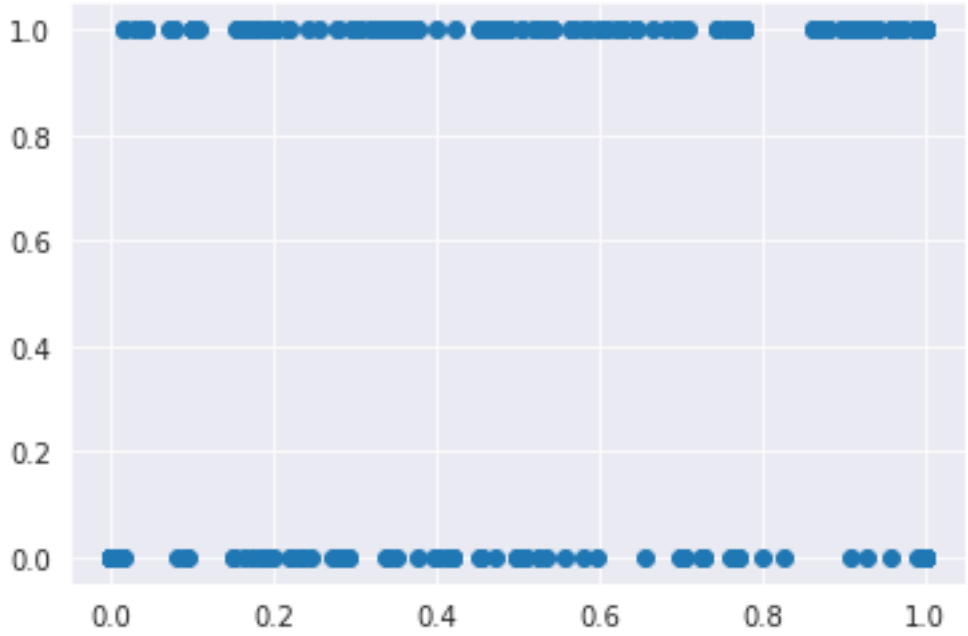
	precision	recall	f1-score	support
pedestrain (Class 0)	0.97	0.99	0.98	254
regular (Class 1)	0.99	0.96	0.98	253
accuracy			0.98	507
macro avg	0.98	0.98	0.98	507
weighted avg	0.98	0.98	0.98	507

#KNN Results

[54]:
```
x_train = x_train.reshape(x_train.shape[0], x_train.shape[1] * x_train.shape[2]␣
 ↪* x_train.shape[3])
x_test = x_test.reshape(x_test.shape[0], x_test.shape[1] * x_test.shape[2] *␣
 ↪x_test.shape[3])

print("\n KNN \n")
KNN = KNN(x_train, y_train, x_test, y_test).run()
```

```
 KNN
```

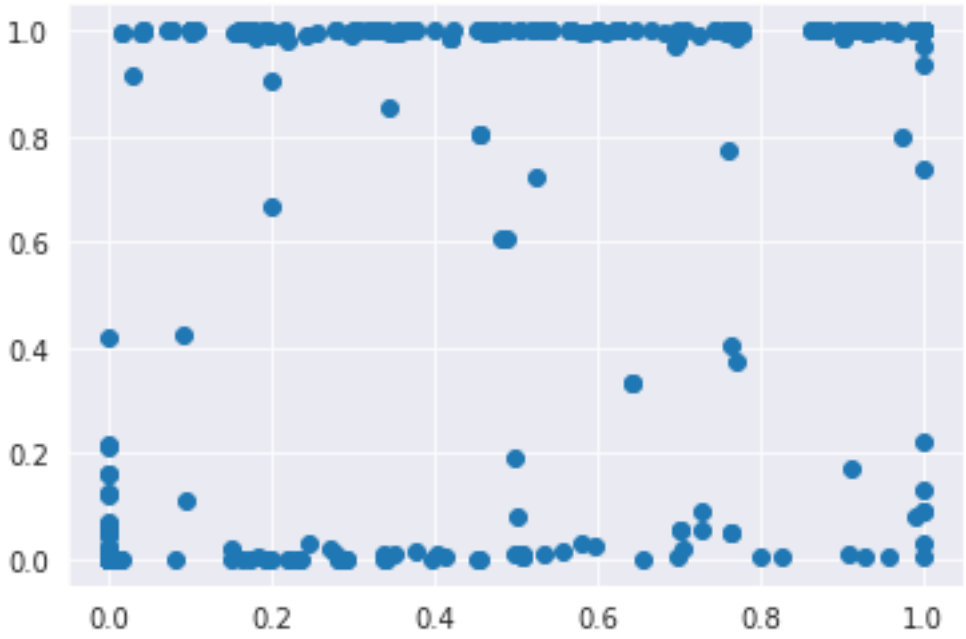
```
1 neighbour:  0.9684418145956607
2 neighbours:  0.9250493096646942
3 neighbours:  0.9349112426035503
4 neighbours:  0.903353057199211
5 neighbours:  0.9230769230769231
```



#Logistic Regression Results

[55]:
```
print("\n Logistic Regression \n")
LGR = logisticRegression(x_train, y_train, x_test, y_test).run()
```

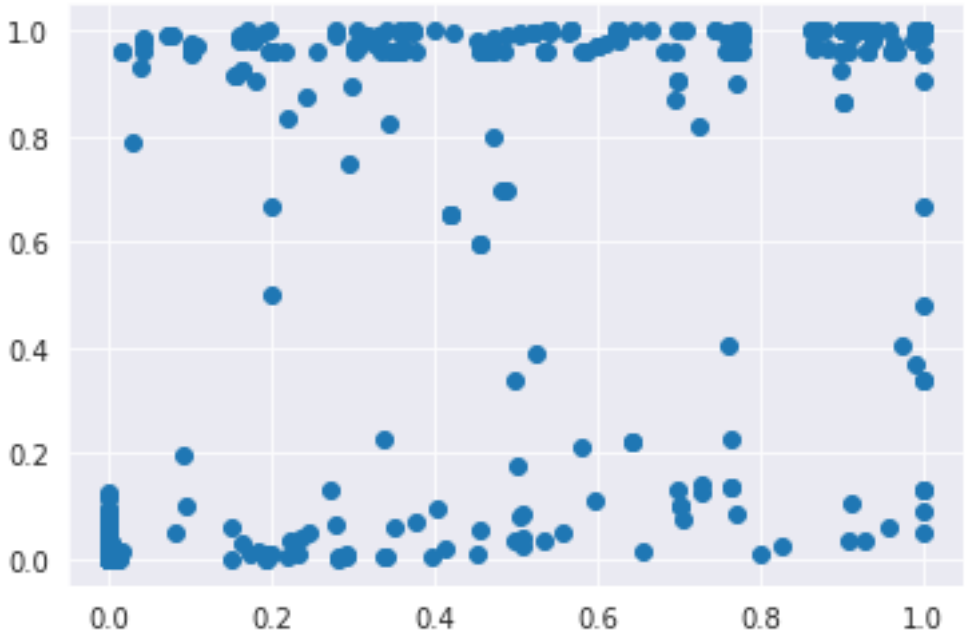
```
 Logistic Regression


/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_logistic.py:940:
ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)

0.9664694280078896
```



#SVM Results

[58]:
```
print("\n SVM \n")
SVM = SVM(x_train, y_train, x_test, y_test).run()
```

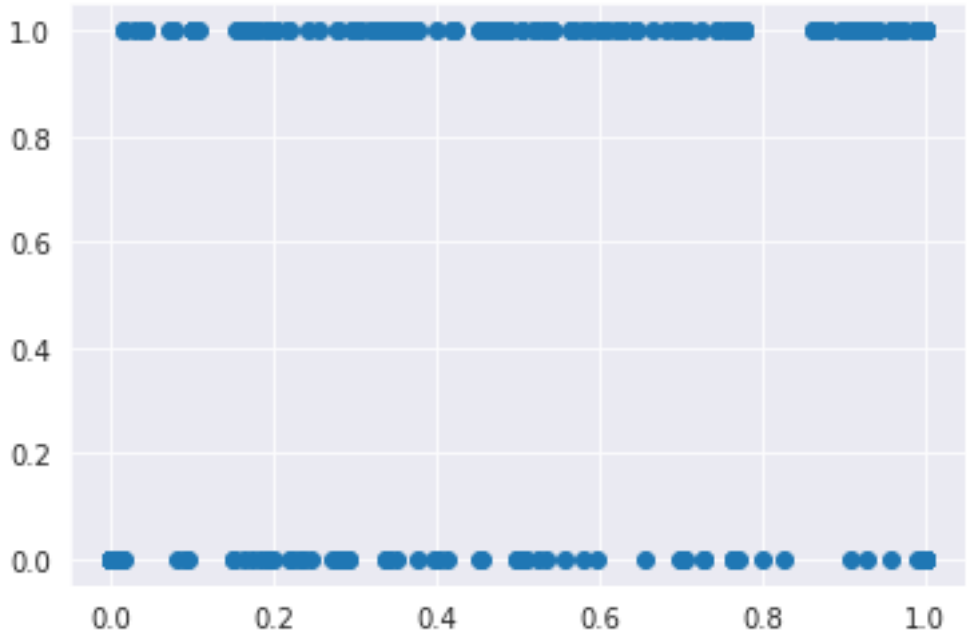
```
 SVM

Accuracy: 0.9644970414201184
Precision: 0.9757085020242915
Recall: 0.9525691699604744
```



#Adaboost Results

[59]:
```
print("\n Adaboost \n")
adb = adaboost(x_test, y_test, CNN, KNN, LGR, SVM)
adb.run()
```

```
 Adaboost

Accuracy: 0.980276134122288
Precision: 0.9879518072289156
Recall: 0.9723320158102767
              precision    recall  f1-score   support

  pedestrian       0.97      0.99      0.98       254
     regular       0.99      0.97      0.98       253

    accuracy                           0.98       507
   macro avg       0.98      0.98      0.98       507
weighted avg       0.98      0.98      0.98       507

[0.01972387]
[[251   3]
 [  7 246]]
```



[75]:
```
new_data = get_data('/content/drive/My Drive/machine learning/new_data')
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:16:
VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences
(which is a list-or-tuple of lists-or-tuples-or ndarrays with different lengths
or shapes) is deprecated. If you meant to do this, you must specify
'dtype=object' when creating the ndarray
  app.launch_new_instance()
```

[85]:
```
x = []
y = []

for feature, label in new_data:
  x.append(feature)
  y.append(label)

# Normalize the data
x = np.array(x) / 255

x.reshape(-1, img_size, img_size, 1)
y = np.array(y)
```

[87]:
```
cnn_preds = model.predict_classes(x)
cnn_acc = metrics.accuracy_score(y, cnn_preds)
print(cnn_preds)
print(cnn_acc)
```

```
[1 1 0 0 0 1 0 1 1 0]
0.6

/usr/local/lib/python3.7/dist-packages/keras/engine/sequential.py:450:
UserWarning: `model.predict_classes()` is deprecated and will be removed after
2021-01-01. Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if
your model does multi-class classification   (e.g. if it uses a `softmax` last-
layer activation).* `(model.predict(x) > 0.5).astype("int32")`,   if your model
does binary classification   (e.g. if it uses a `sigmoid` last-layer
activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```

[94]:
```
x_ = x.reshape(x.shape[0],x.shape[1]*x.shape[2]*x.shape[3])
x_.shape
```

[94]: (10, 49152)

[95]:
```
svm_preds = SVM.predict(x_)
svm_acc = metrics.accuracy_score(y, svm_preds)
knn_preds = KNN.predict(x_)
knn_acc = metrics.accuracy_score(y, knn_preds)
logistic_preds = LGR.predict(x_)
logistic_acc = metrics.accuracy_score(y, logistic_preds)
```

[96]:
```
print("SVM" , svm_acc)
print("KNN" ,knn_acc)
print("Logistic Regression" ,logistic_acc)
```

```
SVM 0.8
KNN 0.6
Logistic Regression 0.6
```

[97]:
```
adb = adaboost(x_, y, cnn_preds, KNN, LGR, SVM)
adb.run()
```

```
Accuracy: 0.7
Precision: 0.6666666666666666
Recall: 0.8
              precision    recall  f1-score   support

  pedestrian       0.75      0.60      0.67         5
     regular       0.67      0.80      0.73         5

    accuracy                           0.70        10
   macro avg       0.71      0.70      0.70        10
weighted avg       0.71      0.70      0.70        10

[0.3]
[[3 2]
```

```
[1 4]]
```

```
      ␣
↪---------------------------------------------------------------------------

       ValueError                                Traceback (most recent call␣
↪last)

       <ipython-input-97-5742f352dcf4> in <module>()
         1 adb = adaboost(x_, y, cnn_preds, KNN, LGR, SVM)
   ----> 2 adb.run()


       <ipython-input-51-1c29ab7cadb8> in run(self)
        59         print(confusion_matrix(self.y_test, adaboost_preds))
        60
   ---> 61         plt.scatter(x_test[:, 1], adaboost_preds)


       /usr/local/lib/python3.7/dist-packages/matplotlib/pyplot.py in␣
↪scatter(x, y, s, c, marker, cmap, norm, vmin, vmax, alpha, linewidths, verts,␣
↪edgecolors, plotnonfinite, data, **kwargs)
      2814         verts=verts, edgecolors=edgecolors,
      2815         plotnonfinite=plotnonfinite, **({"data": data} if data is not
   -> 2816         None else {}), **kwargs)
      2817     sci(__ret)
      2818     return __ret


       /usr/local/lib/python3.7/dist-packages/matplotlib/__init__.py in␣
↪inner(ax, data, *args, **kwargs)
      1563     def inner(ax, *args, data=None, **kwargs):
      1564         if data is None:
   -> 1565             return func(ax, *map(sanitize_sequence, args), **kwargs)
      1566
      1567         bound = new_sig.bind(ax, *args, **kwargs)


       /usr/local/lib/python3.7/dist-packages/matplotlib/cbook/deprecation.py␣
↪in wrapper(*args, **kwargs)
       356                 f"%(removal)s.  If any parameter follows {name!r},␣
↪they "
       357                 f"should be pass as keyword, not positionally.")
   --> 358         return func(*args, **kwargs)
       359
       360     return wrapper
```

```
      /usr/local/lib/python3.7/dist-packages/matplotlib/axes/_axes.py in␣
↪scatter(self, x, y, s, c, marker, cmap, norm, vmin, vmax, alpha, linewidths,␣
↪verts, edgecolors, plotnonfinite, **kwargs)
     4389         y = np.ma.ravel(y)
     4390         if x.size != y.size:
  -> 4391             raise ValueError("x and y must be the same size")
     4392
     4393         if s is None:


      ValueError: x and y must be the same size
```