```
import numpy as np
from sklearn.model_selection import train_test_split
from  sklearn.datasets import fetch_lfw_people
from sklearn.manifold import TSNE


import pandas as pd
import matplotlib.pyplot as plt
from sklearn.decomposition import PCA
import seaborn as sns
from time import time
```

```
/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19: FutureWarnin
  import pandas.util.testing as tm
```

```
lfw_dataset = fetch_lfw_people(min_faces_per_person=100)
```

```
Downloading LFW metadata: https://ndownloader.figshare.com/files/5976012
Downloading LFW metadata: https://ndownloader.figshare.com/files/5976009
Downloading LFW metadata: https://ndownloader.figshare.com/files/5976006
Downloading LFW data (~200MB): https://ndownloader.figshare.com/files/5976015
```

```
_, h, w = lfw_dataset.images.shape
X1 = lfw_dataset.data
y1 = lfw_dataset.target
target_names = lfw_dataset.target_names

X_train, X_test, y_train, y_test = train_test_split(X1, y1, test_size=0.3,random_state=42)


cols = [ 'pixel'+str(i) for i in range(X1.shape[1]) ]
df = pd.DataFrame(X1,columns=cols)
df['y'] = y1
df['label'] = df['y'].apply(lambda i: str(i))
X, y = None, None
print('Size of the dataframe: {}'.format(df.shape))
```

```
Size of the dataframe: (1140, 2916)
```

```
target_names.shape
```

```
(5,)
```

```
n_components = 100
pca = PCA(n_components=n_components, whiten=True,random_state=42).fit(X_train)
print('Total explained variance by principal components: {}'.format(pca.explained_variance
```

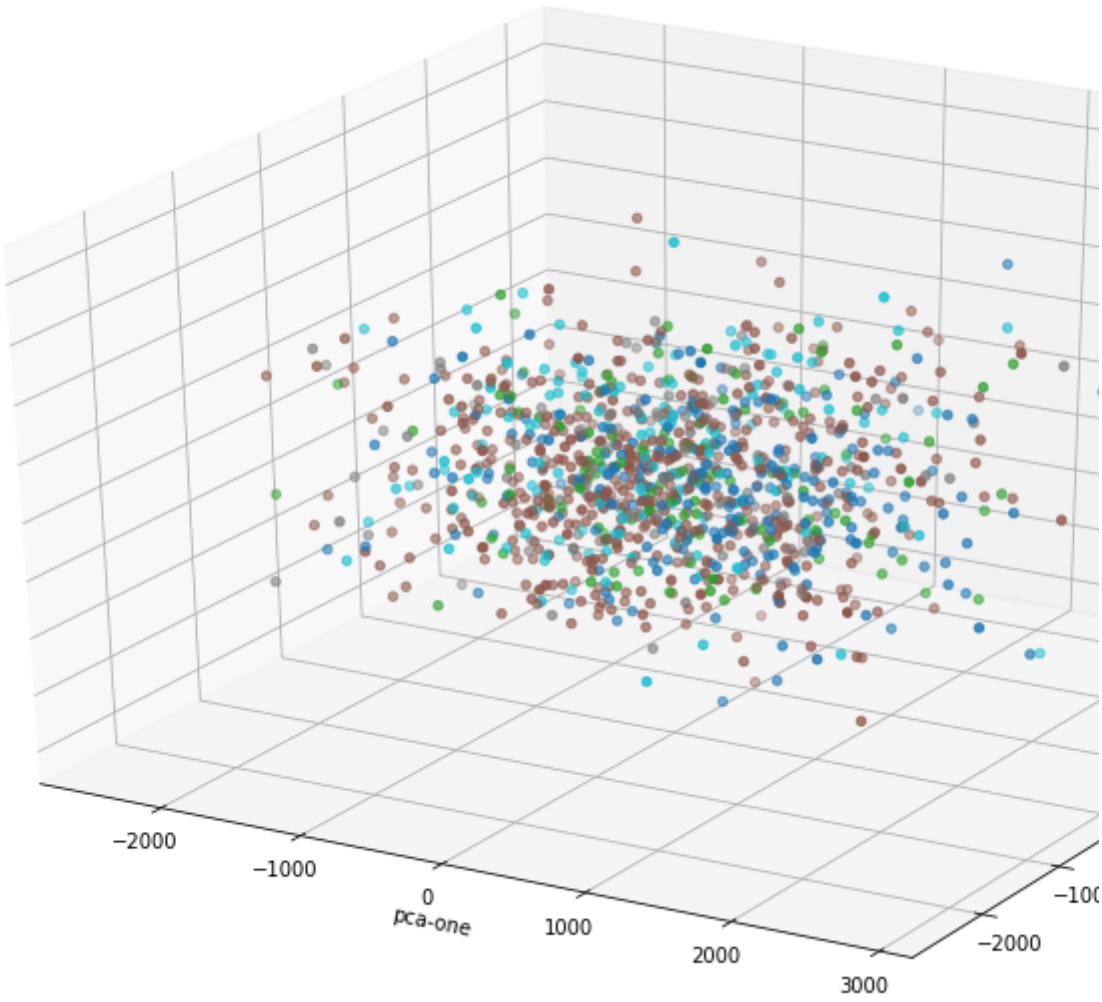
```
Total explained variance by principal components: 0.9245465397834778
```

```
X_pca_train = pca.transform(X_train)
X_pca_test = pca.transform(X_test)
```

```
pca = PCA(n_components=3)
pca_result = pca.fit_transform(df[cols].values)
df['pca-one'] = pca_result[:,0]
df['pca-two'] = pca_result[:,1]
df['pca-three'] = pca_result[:,2]
print('Explained variation per principal component: {}'.format(pca.explained_variance_rati
```

```
Explained variation per principal component: [0.18081571 0.15304321 0.07267769]
```

```
ax = plt.figure(figsize=(16,10)).gca(projection='3d')
ax.scatter(
    xs=df["pca-one"],
    ys=df["pca-two"],
    zs=df["pca-three"],
    c=df["y"],
    cmap='tab10'
)
ax.set_xlabel('pca-one')
ax.set_ylabel('pca-two')
ax.set_zlabel('pca-three')
plt.show()
```



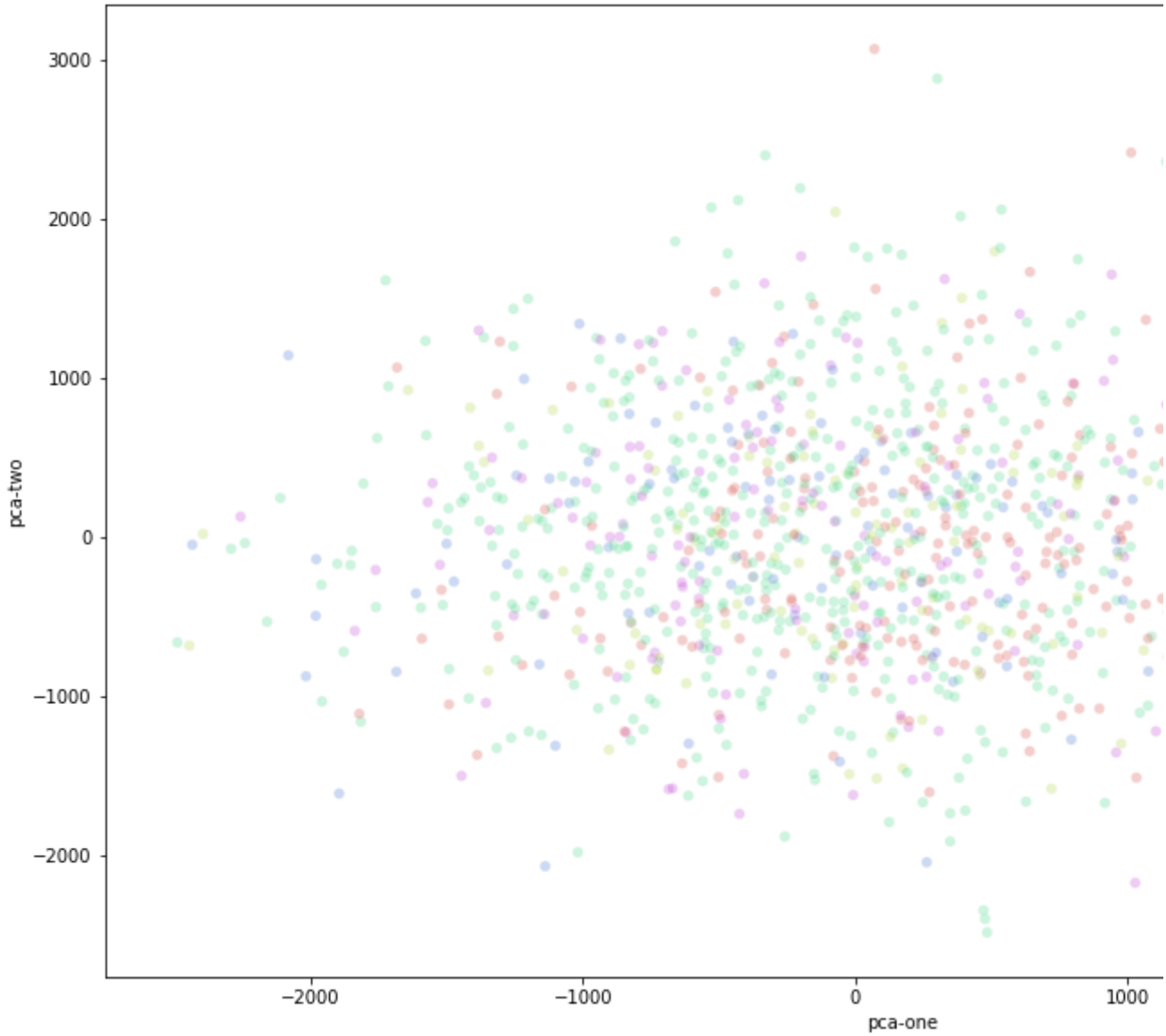

```
pca = PCA(n_components=2)
pca_result = pca.fit_transform(df[cols].values)
```

```
df['pca-one'] = pca_result[:,0]
df['pca-two'] = pca_result[:,1]
print('Explained variation per principal component: {}'.format(pca.explained_variance_rati
```

```
Explained variation per principal component: [0.18081589 0.15304321]
```

```
plt.figure(figsize=(16,10))
sns.scatterplot(
    x="pca-one", y="pca-two",
    hue="y",
    palette=sns.color_palette("hls", 5),
    data=df,
    legend="full",
    alpha=0.3
)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fbc8c68f978>
```




```
df_subset = df.copy()
data_subset = df_subset[cols].values
pca = PCA(n_components=3)
pca_result = pca.fit_transform(data_subset)
df_subset['pca-one'] = pca_result[:,0]
df_subset['pca-two'] = pca_result[:,1]
```

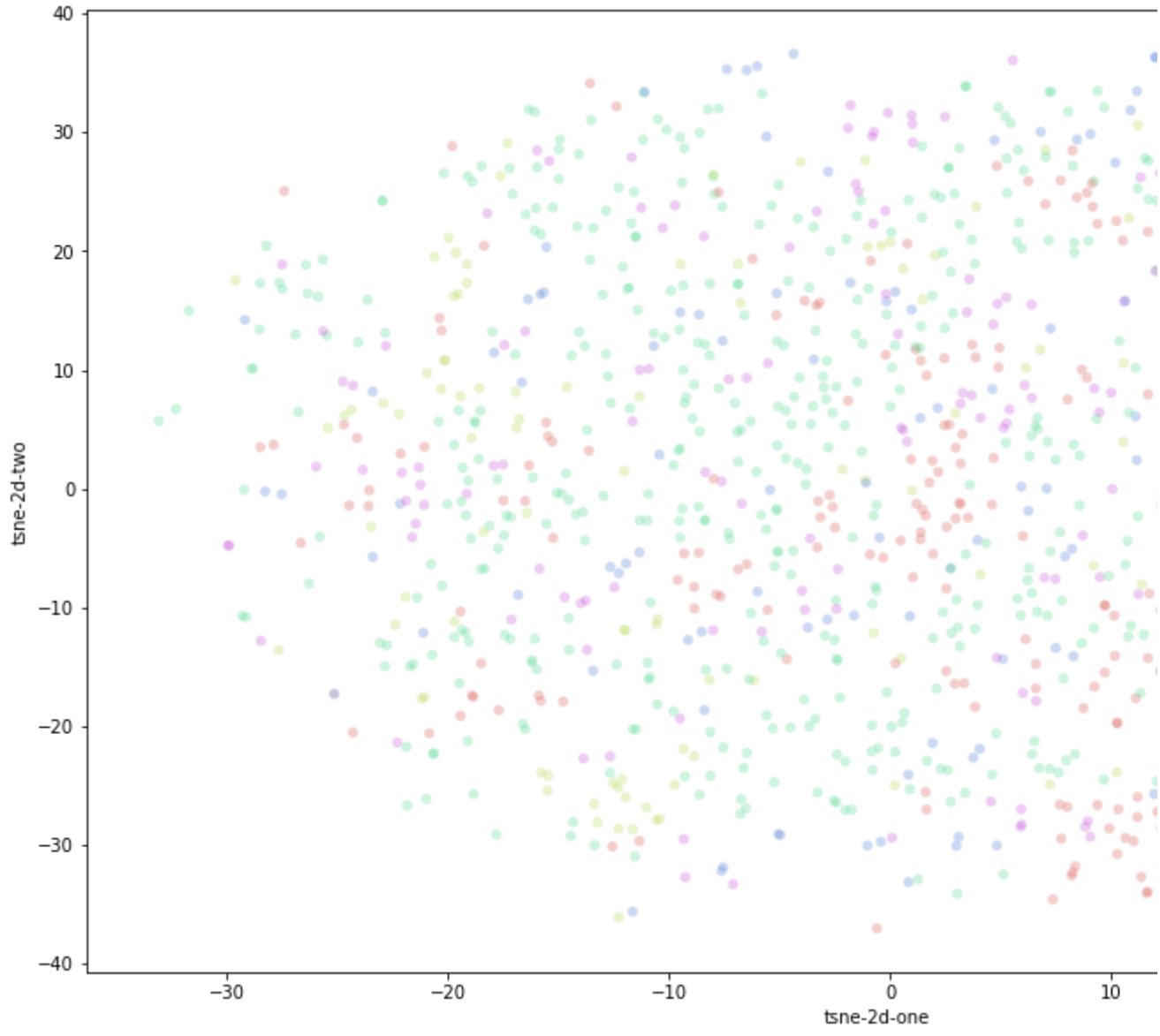
```
df_subset['pca-two'] = pca_result[:,1]
df_subset['pca-three'] = pca_result[:,2]
print('Explained variation per principal component: {}'.format(pca.explained_variance_rati
```

```
Explained variation per principal component: [0.18081571 0.15304317 0.07267761]
```

```
tsne=TSNE(n_components=2,perplexity=40,n_iter=1000).fit_transform(data_subset)
```

```
df_subset['tsne-2d-one'] = tsne[:,0]
df_subset['tsne-2d-two'] = tsne[:,1]
plt.figure(figsize=(16,10))
sns.scatterplot(
    x="tsne-2d-one", y="tsne-2d-two",
    hue="y",
    palette=sns.color_palette("hls", 5),
    data=df_subset,
    legend="full",
    alpha=0.3
)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fbc8c5e7400>
```



```
df_s2= df.loc[df['y']<=2]
```

```
df_s2
```

```
pca_result[0]
```

```
(100,)
```

Q1 Task 2

```
data_subset = df_s2[cols].values
pca = PCA(n_components=100)
pca_result = pca.fit_transform(data_subset)
print('Explained variation per principal component: {}'.format(pca.explained_variance_rati
```

```
Explained variation per principal component: [0.1802307  0.15899023 0.0730623  0.0582
 0.0252844  0.02196893 0.02067236 0.01825465 0.01606864 0.01435229
 0.0123146  0.01154876 0.00972918 0.00921667 0.00913657 0.00826943
 0.00799337 0.00719698 0.00683502 0.00619819 0.00602588 0.00583099
 0.00550758 0.00500583 0.00479189 0.00451381 0.00421237 0.0040203
 0.00390887 0.0037882  0.00374038 0.00361721 0.00343553 0.00337381
 0.00325839 0.00312423 0.00293974 0.00291392 0.00273787 0.00270423
 0.00266427 0.00254143 0.00250753 0.00246773 0.00236898 0.00232305
 0.00223546 0.00218963 0.00209896 0.00206012 0.00204049 0.00195427
 0.00192761 0.00188466 0.00182959 0.00175414 0.00174163 0.00172374
 0.00167123 0.00166012 0.00160388 0.00159984 0.00156399 0.00152419
 0.00148273 0.00145497 0.00143347 0.00138956 0.00136624 0.00135505
 0.0013269  0.00128713 0.00125919 0.00124328 0.00121654 0.00120192
 0.00119441 0.00118707 0.0011459  0.00110689 0.00109492 0.00107999
 0.00106521 0.00104437 0.00099526 0.00097864 0.00097133 0.00096446
 0.00094762 0.00093516 0.00091613 0.00089885 0.00087908 0.00086349
 0.00084948 0.00083003 0.00081845 0.00081335]
```

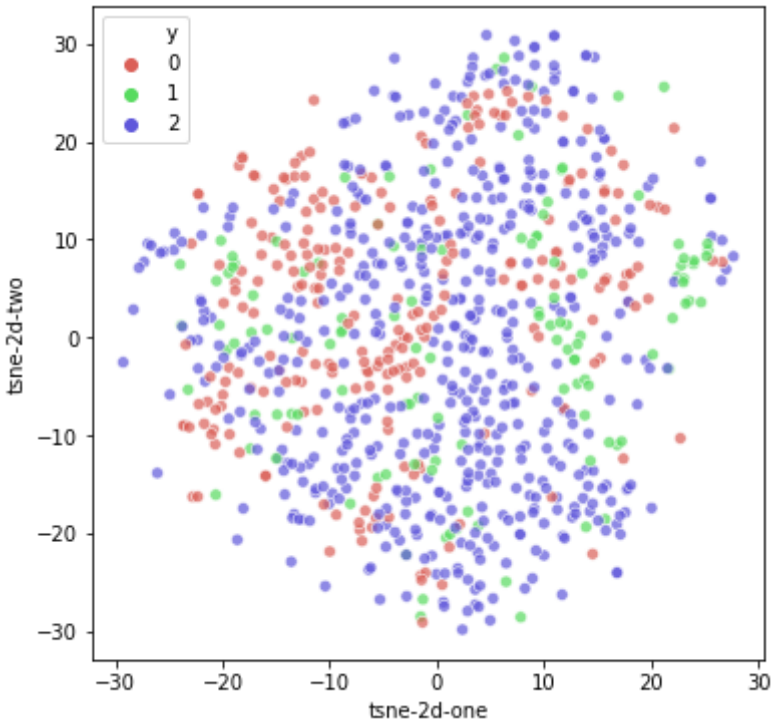
```
tsne=TSNE(n_components=2,perplexity=40,n_iter=1000).fit_transform(pca_result)
df_s2['tsne-2d-one'] = tsne[:,0]
df_s2['tsne-2d-two'] = tsne[:,1]
plt.figure(figsize=(6,6))
sns.scatterplot(
    x="tsne-2d-one", y="tsne-2d-two",
    hue="y",
    palette=sns.color_palette("hls", 3),
    data=df_s2,
    legend="full",
    alpha=0.7
)
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:2: SettingWithCopyWarnin
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us

/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:3: SettingWithCopyWarnin
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
  This is separate from the ipykernel package so we can avoid doing imports until
<matplotlib.axes._subplots.AxesSubplot at 0x7fbc87732ac8>
```




```
tsne=TSNE(n_components=3,perplexity=40,n_iter=1000).fit_transform(pca_result)
df_s2['tsne-2d-one'] = tsne[:,0]
df_s2['tsne-2d-two'] = tsne[:,1]
df_s2['tsne-2d-three'] = tsne[:,2]
ax = plt.figure(figsize=(7,7)).gca(projection='3d')
ax.scatter(
    xs=df_s2["tsne-2d-one"],
    ys=df_s2["tsne-2d-two"],
    zs=df_s2["tsne-2d-three"],
    c=df_s2["y"],
    cmap='tab10'
)
ax.set_xlabel('tsne-one')
ax.set_ylabel('tsne-two')
ax.set_zlabel('tsne-three')
plt.show()
```

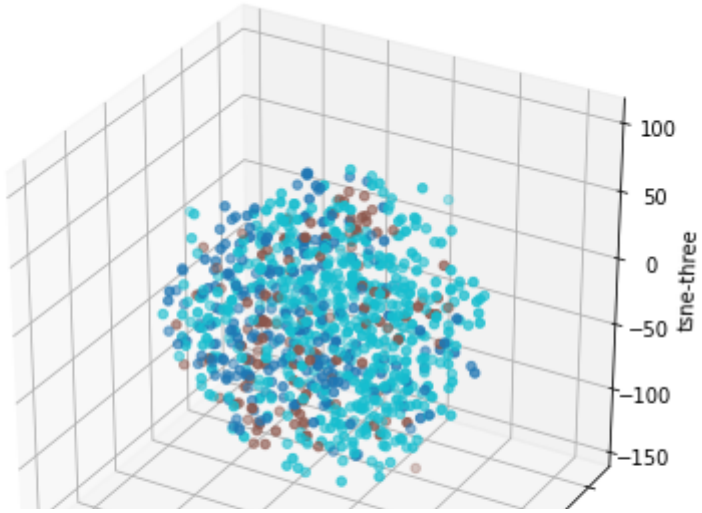
```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:2: SettingWithCopyWarnin
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us

/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:3: SettingWithCopyWarnin
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
  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: SettingWithCopyWarnin
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
  after removing the cwd from sys.path.
```




```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
from sklearn.neighbors import KNeighborsClassifier
from sklearn.model_selection import train_test_split
import seaborn as sns
```

q 1 task 3

```
knn = KNeighborsClassifier(n_neighbors=1, )
knn.fit(X_pca_train, y_train)
```

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=1, p=2,
                     weights='uniform')
```

```
y_pred = knn.predict(X_pca_test)
```

```
print(classification_report(y_test,y_pred))
```

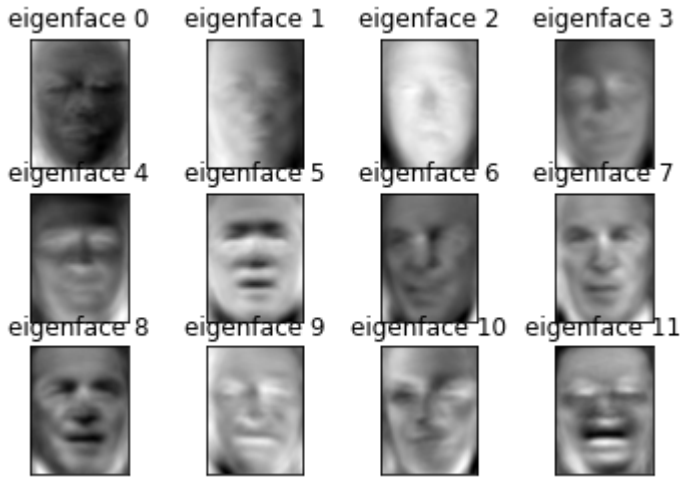
```
                  precision    recall  f1-score   support

               0       0.78      0.64      0.70        78
               1       0.58      0.55      0.57        38
               2       0.75      0.81      0.78       159
               3       0.54      0.47      0.50        30
               4       0.40      0.49      0.44        37

        accuracy                           0.68       342
       macro avg       0.61      0.59      0.60       342
```

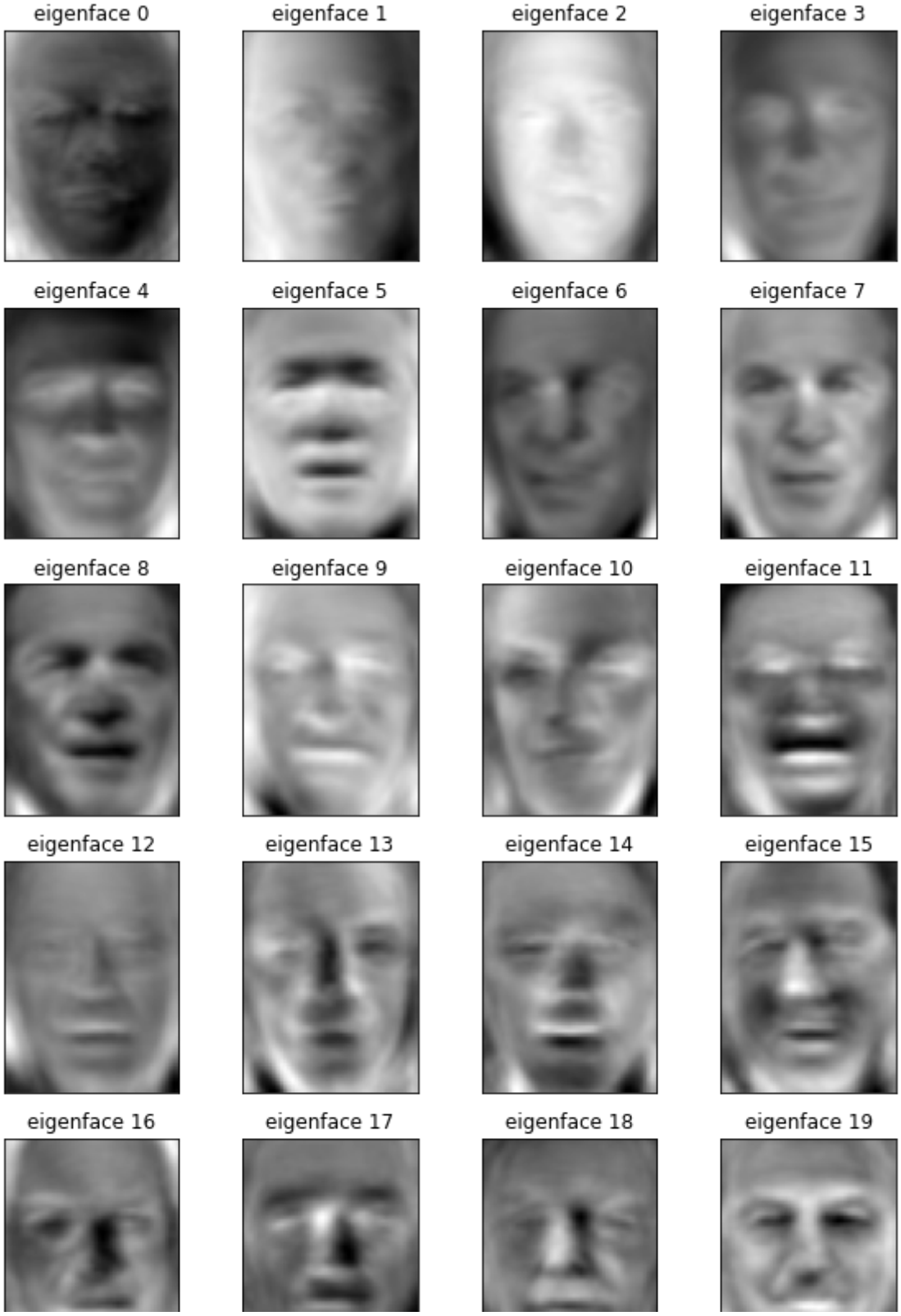
```
def plot_gallery(images, titles, h, w, rows=3, cols=4):
    plt.figure()
    for i in range(rows * cols):
        plt.subplot(rows, cols, i + 1)
        plt.imshow(images[i].reshape((h, w)), cmap=plt.cm.gray)
        plt.title(titles[i])
        plt.xticks(())
        plt.yticks(())
eigenfaces = pca.components_.reshape((n_components, h, w))
eigenface_titles = ["eigenface {0}".format(i) for i in range(eigenfaces.shape[0])]
plot_gallery(eigenfaces, eigenface_titles, h, w)

plt.show()
```




```
def plot_gallery(images, titles, h, w, rows=5, cols=4):
    plt.figure(figsize=(10,15))
    for i in range(rows * cols):
        plt.subplot(rows, cols, i + 1)
        plt.imshow(images[i].reshape((h, w)), cmap=plt.cm.gray)
        plt.title(titles[i])
        plt.xticks(())
        plt.yticks(())
eigenfaces = pca.components_.reshape((n_components, h, w))
eigenface_titles = ["eigenface {0}".format(i) for i in range(eigenfaces.shape[0])]
plot_gallery(eigenfaces, eigenface_titles, h, w)

plt.show()
```




```
n_components = 32
X_full=np.concatenate((X_train,X_test))
pca = PCA(n_components=n_components, whiten=True,random_state=42).fit(X_train)
print('Total explained variance by principal components: {}'.format(pca.explained_variance
pca_result = pca.transform( X_train )
pca_test= pca.transform(X_test)
knn = KNeighborsClassifier(n_neighbors=1 )
knn.fit(pca_result, y_train)
y_pred = knn.predict(pca_test)
```

```
print(classification_report(y_test,y_pred))
```

```
Total explained variance by principal components: 0.8079198598861694
              precision    recall  f1-score   support

           0       0.66      0.73      0.70        78
           1       0.56      0.66      0.60        38
           2       0.75      0.73      0.74       159
           3       0.57      0.27      0.36        30
           4       0.50      0.57      0.53        37

    accuracy                           0.66       342
   macro avg       0.61      0.59      0.59       342
weighted avg       0.67      0.66      0.66       342
```

```
X_train.shape
```

```
(798, 2914)
```

```
pca_result.shape
```

```
(798, 32)
```