solution

October 15, 2024

1 PCA with Scratch

1. Import required libraries

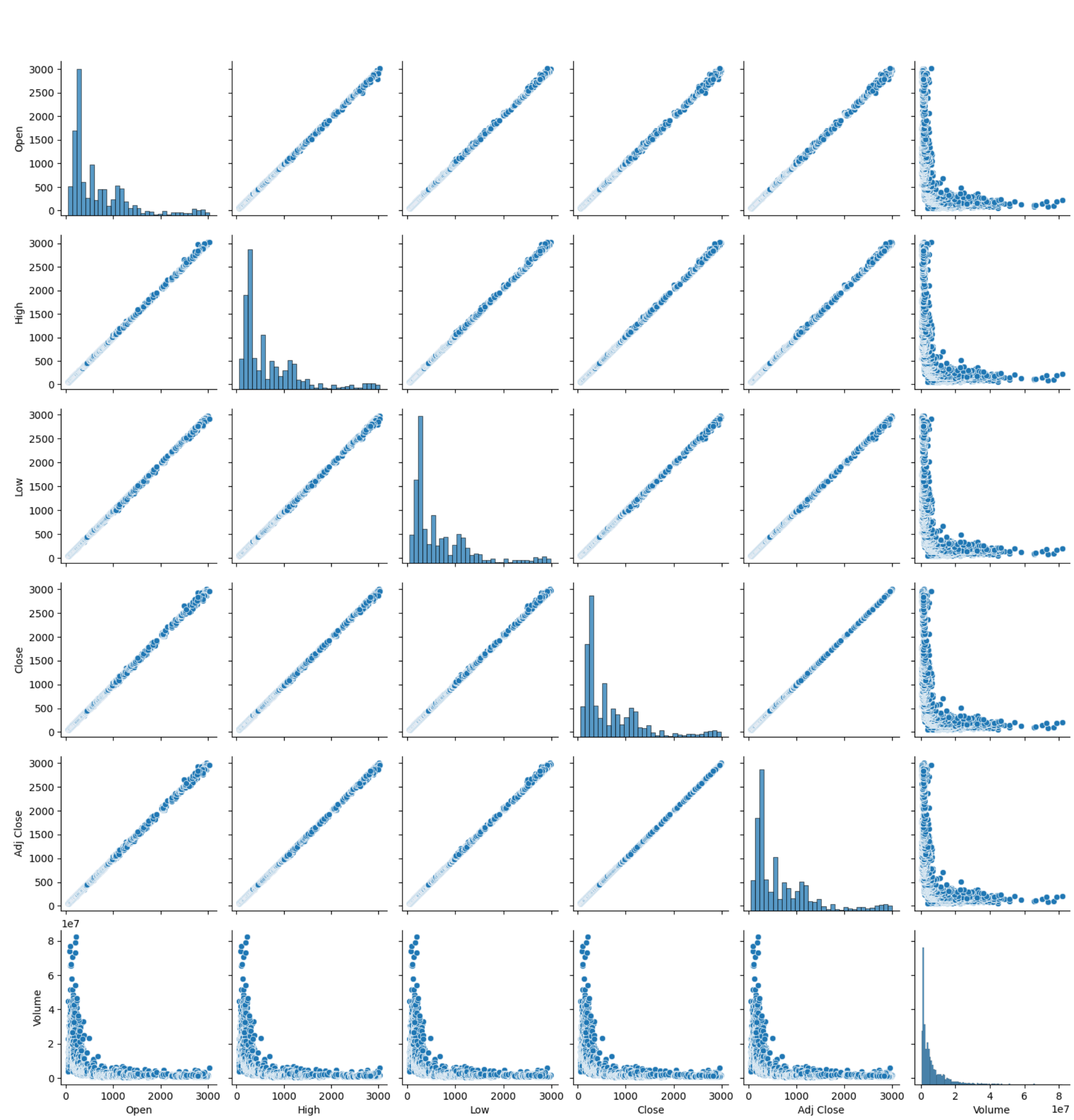
[4]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

from numpy.linalg import eig
from sklearn.decomposition import PCA
```

2. Load the dataset and remove the `Date` column, and plot it

[5]:
```
data = pd.read_csv('../Datasets/Week-8 (PCA with Scratch)/GOOGL.csv').
  ↪drop(columns=['Date'])
sns.pairplot(data)
```

[5]:
```
<seaborn.axisgrid.PairGrid at 0x1a545376c00>
```



3. Data Normalization

```
[6]: def normalize_data(data):
         return (data - data.mean()) / data.std()

     normalized_data = normalize_data(data)
     normalized_data.head()
```

```
[6]:        Open      High       Low     Close  Adj Close    Volume
     0 -0.996773 -0.994354 -0.999172 -0.996419  -0.996419  4.969098
     1 -0.995990 -0.990496 -0.995614 -0.990236  -0.990236  2.131158
     2 -0.988433 -0.987115 -0.988912 -0.989390  -0.989390  1.535838
     3 -0.988053 -0.988560 -0.993207 -0.992905  -0.992905  1.144596
```

```
4 -0.992925 -0.991326 -0.992964 -0.992028  -0.992028  0.356760
```

4. Covariance calculation

[7]:
```
def covar(data):
    return np.dot(data.T, data) / (data.shape[0] - 1)

covar_matrix = covar(normalized_data)
covar_matrix
```

[7]:
```
array([[ 1.        ,  0.99991523,  0.99990248,  0.99980806,  0.99980806,
        -0.45388433],
       [ 0.99991523,  1.        ,  0.99987656,  0.99990272,  0.99990272,
        -0.45285544],
       [ 0.99990248,  0.99987656,  1.        ,  0.99991415,  0.99991415,
        -0.45544721],
       [ 0.99980806,  0.99990272,  0.99991415,  1.        ,  1.        ,
        -0.45425163],
       [ 0.99980806,  0.99990272,  0.99991415,  1.        ,  1.        ,
        -0.45425163],
       [-0.45388433, -0.45285544, -0.45544721, -0.45425163, -0.45425163,
         1.        ]])
```

5. Eigen Vector Calculation

[15]:
```
w,v=eig(covar_matrix)
print(f'EigenValues={w}\n\nEigenvectors={v}')
```

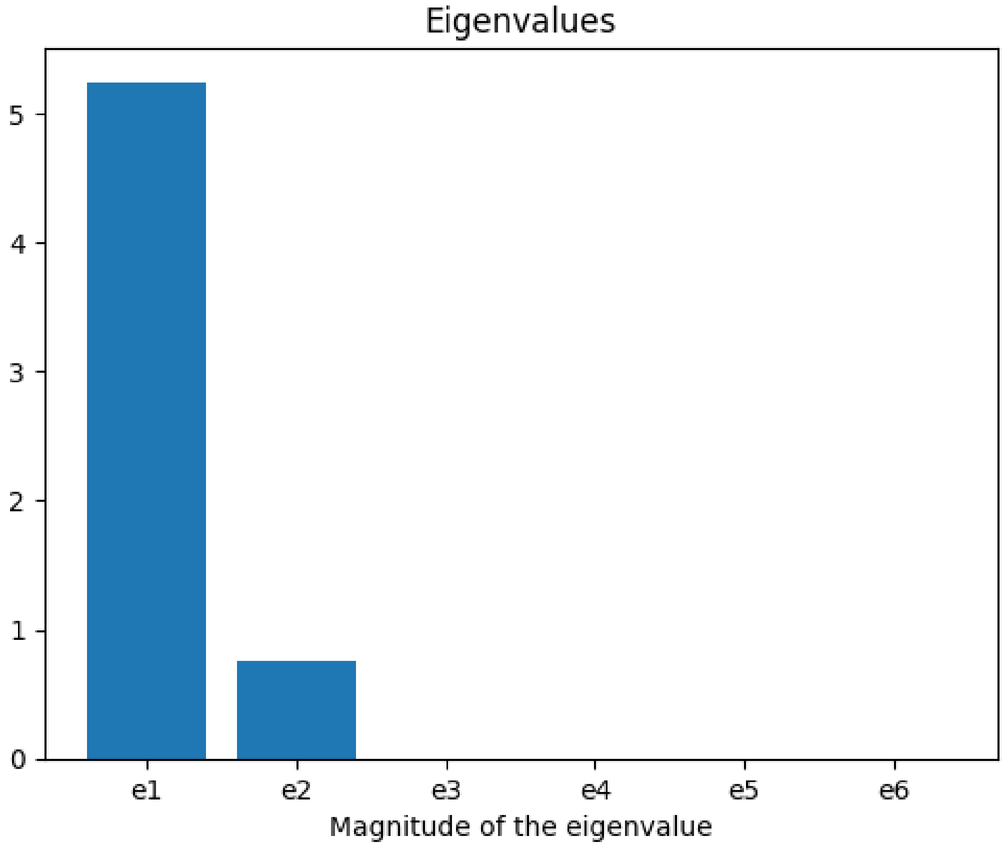
```
EigenValues=[ 5.24263577e+00  7.56946230e-01  2.71606923e-04  1.18006602e-04
  2.83882262e-05 -6.90639791e-22]

Eigenvectors=[[ 4.34905489e-01 -1.04407202e-01  6.99170760e-01  5.81060908e-02
  -5.54743439e-01 -1.01681966e-17]
 [ 4.34873360e-01 -1.05751771e-01  1.96410562e-01 -6.88115636e-01
   5.36303540e-01  1.77344587e-16]
 [ 4.34989279e-01 -1.02422693e-01  7.11708797e-02  7.20495903e-01
   5.25465773e-01  7.94350833e-17]
 [ 4.34937652e-01 -1.03961367e-01 -4.83486064e-01 -4.47272573e-02
  -2.53499450e-01 -7.07106781e-01]
 [ 4.34937652e-01 -1.03961367e-01 -4.83486064e-01 -4.47272573e-02
  -2.53499450e-01  7.07106781e-01]
 [-2.32777107e-01 -9.72527305e-01 -5.45996092e-04  2.26979323e-03
   9.54631766e-05 -5.90726888e-18]]
```

6. Plot with PyPlot

[9]:
```
plt.bar(["e" + str(i+1) for i in range(len(w))], w)
plt.title("Eigenvalues")
plt.xlabel("Magnitude of the eigenvalue")
```

```
[9]: Text(0.5, 0, 'Magnitude of the eigenvalue')
```

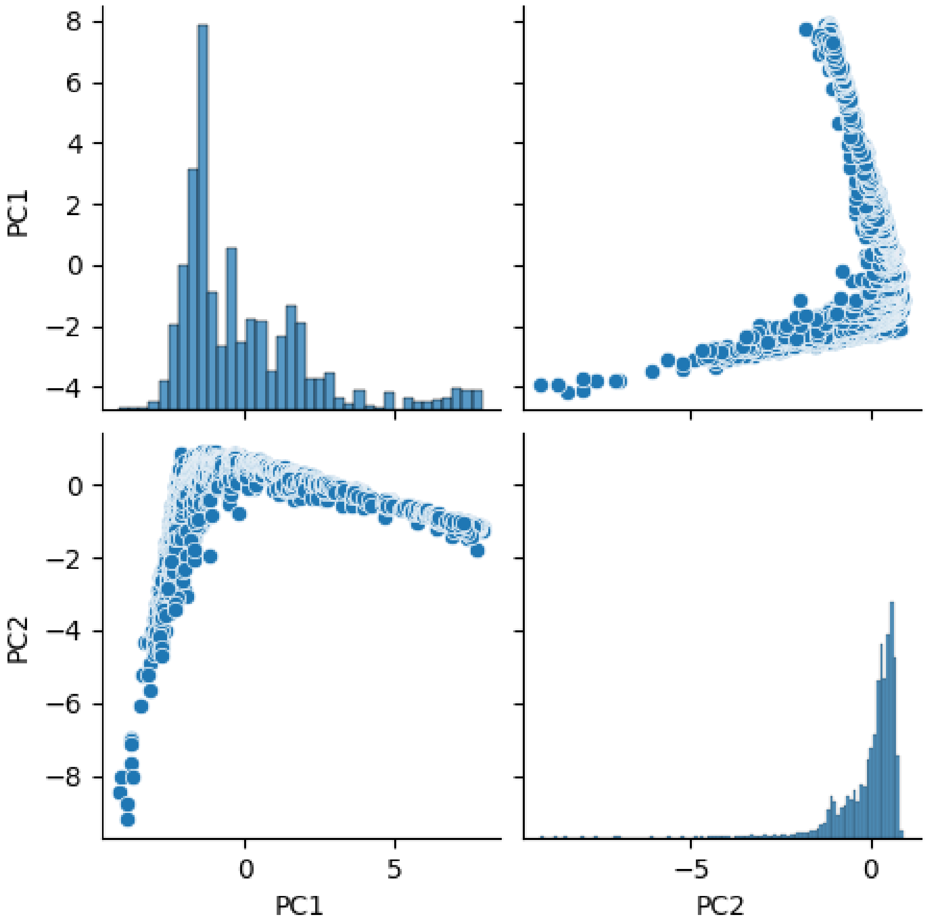


7. Reduce the Dimensions and plot the graphs with 2 principle components

```
[10]: useful_data = np.dot(normalized_data, v[:, :2])
      useful_data = pd.DataFrame(useful_data, columns=["PC1", "PC2"])
      useful_data.head()

      sns.pairplot(useful_data)
```

```
[10]: <seaborn.axisgrid.PairGrid at 0x1a54ba06930>
```

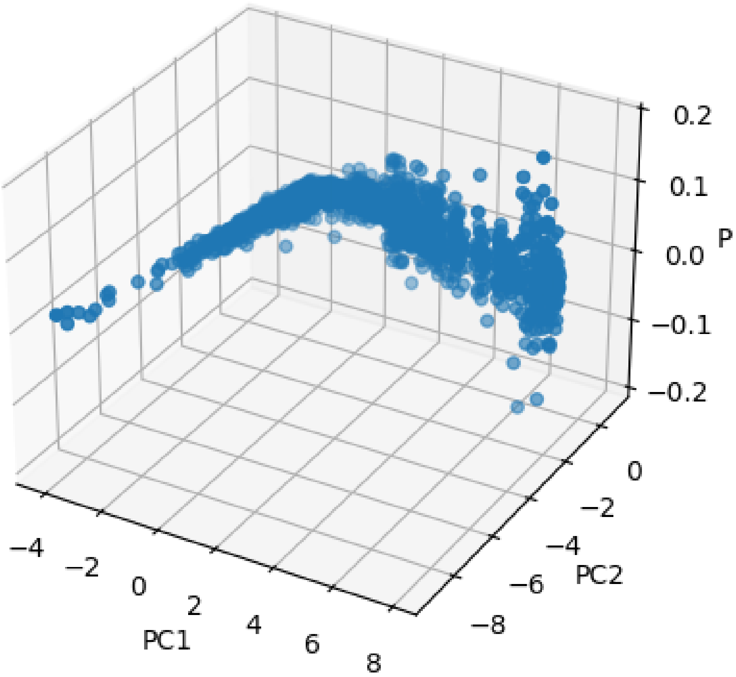


8. Repeat with 3 components with 3d plots

[11]:

```
# using 3 components and 3D plot
useful_data = np.dot(normalized_data, v[:, :3])
useful_data = pd.DataFrame(useful_data, columns=["PC1", "PC2", "PC3"])
useful_data.head()

fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.scatter(useful_data['PC1'], useful_data['PC2'], useful_data['PC3'])
ax.set_xlabel('PC1')
ax.set_ylabel('PC2')
ax.set_zlabel('PC3')
plt.show()
```

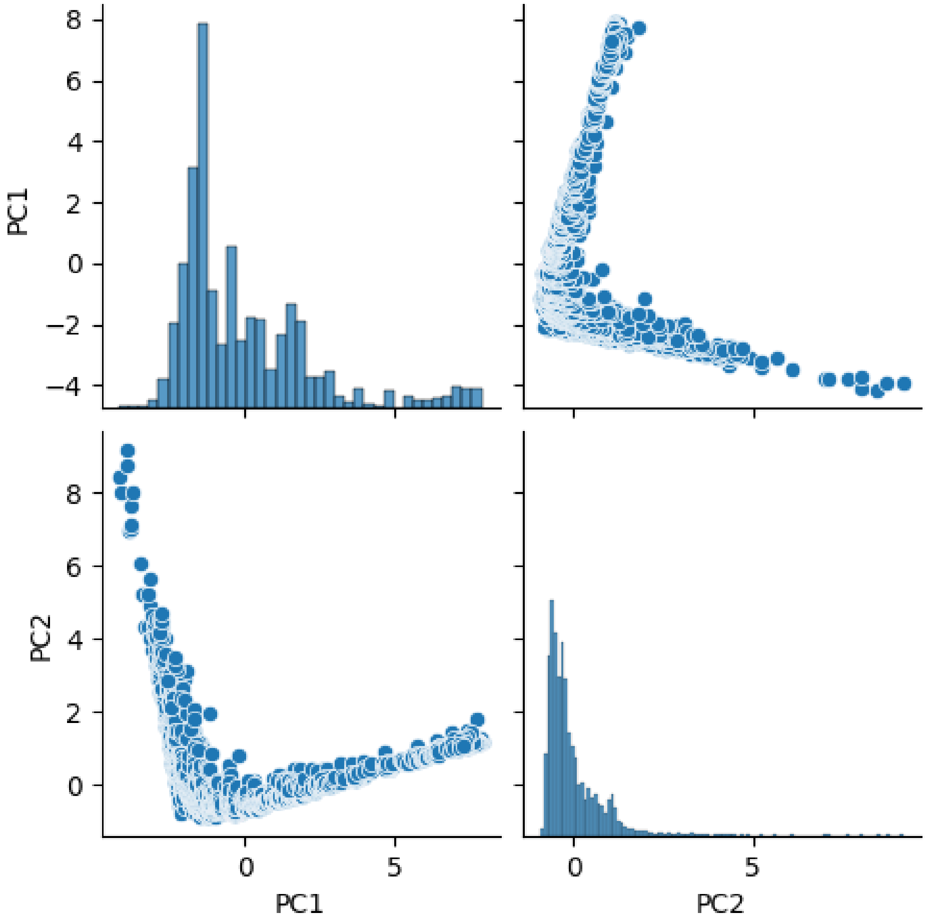


9. Now we cross-check by thing the inbuilt PCA library for 2 Components

[12]:
```
# using inbuilt PCA
pca = PCA(n_components=2)
pca_data = pca.fit_transform(normalized_data)
pca_data = pd.DataFrame(pca_data, columns=["PC1", "PC2"])
pca_data.head()

sns.pairplot(pca_data)
```

[12]:
```
<seaborn.axisgrid.PairGrid at 0x1a5471cfb00>
```

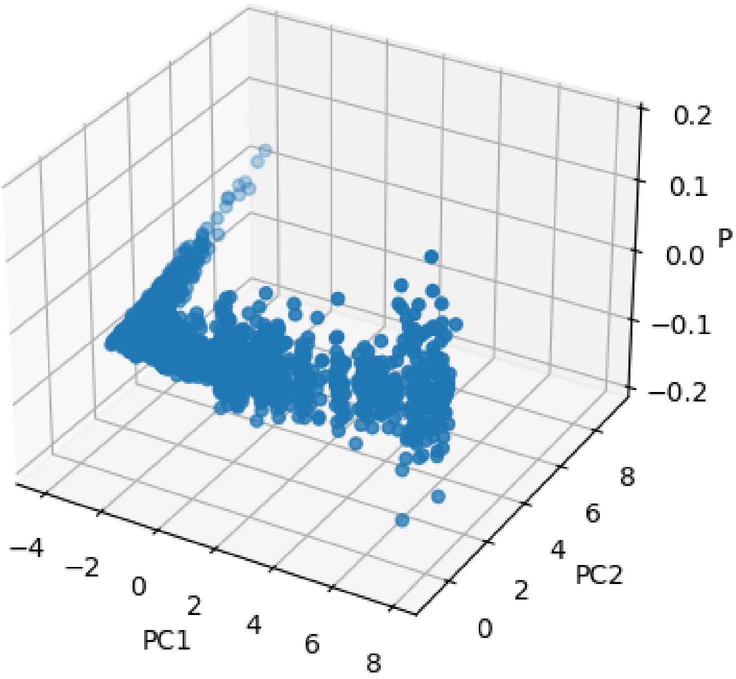


10. Inbuilt PCA with 3 components with 3D Graph

[14]:

```
pca = PCA(n_components=3)
pca_data = pca.fit_transform(normalized_data)
pca_data = pd.DataFrame(pca_data, columns=["PC1", "PC2", "PC3"])
pca_data.head()

fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.scatter(pca_data['PC1'], pca_data['PC2'], pca_data['PC3'])
ax.set_xlabel('PC1')
ax.set_ylabel('PC2')
ax.set_zlabel('PC3')
plt.show()
```


0.2
0.1
0.0
−0.1
−0.2
P
8
6
4
2
0
PC2
−4
−2
0
2
4
6
8
PC1