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DA_Homework_06_r09546042_TerryYang

April 11, 2021

1 Q1

import package

```
[1]: import numpy as np
     import pandas as pd
```

read AutoMPG data

```
[2]: data = pd.read_csv(r"C:\Users\TerryYang\pythonwork\pythonwork\Data Analytics␣
      ↪Homework\DA_Demo.csv")
     X=data.drop(" car name",axis = 1).to_numpy()
```

define Factor Analysis function

```
[3]: def FA(dataMat, factor_number):
         meanVals = np.mean(dataMat, axis=0)
         meanRemoved = dataMat - meanVals
         covMat = np.cov(meanRemoved, rowvar=0)
         eigVal, eigVect = np.linalg.eig(np.mat(covMat))
         selected_eigenvalue = eigVal[:factor_number]
         eigenvalues_diagonal = np.zeros((eigVal.shape[0], eigVal.shape[0]), float)
         np.fill_diagonal(eigenvalues_diagonal, eigVal)
         eigenvalues_diagonal_total_sqrt = np.sqrt(eigenvalues_diagonal)
         All_T =   eigenvalues_diagonal_total_sqrt @ eigVect
         All = All_T.T
         X_variance = np.diag(np.diag(All_T @ All))
         eigenvalues_diagonal = np.zeros((factor_number, factor_number), float)
         np.fill_diagonal(eigenvalues_diagonal, eigVal[:factor_number])
         eigenvalues_diagonal_sqrt = np.sqrt(eigenvalues_diagonal)
         A_T = eigVect[:, :factor_number] @ eigenvalues_diagonal_sqrt
         A = A_T.T
         Psi = X_variance - A_T @ A
         Psi_inverse = np.linalg.inv(Psi)
         inner = np.linalg.inv(A @ (Psi_inverse) @ (A_T))
         F = dataMat @ Psi_inverse @ (A_T) @ (inner)
         communality_vector = A_T @ A
         return F, A,communality_vector, Psi,eigVal, eigVect, selected_eigenvalue
```

should be a vector, not matrix
Just get the diagonal elements

calling function

[4]:
```
F, A,communality_vector, Psi,eigVal, eigVect, selected_eigenvalue = FA(X, 2)
```

find factor contribution percentage

[5]:
```
Total_eigenvalues = eigVal.sum()
for i in range(0,len(selected_eigenvalue)):
    print("Factor",i+1,"contribute",format(selected_eigenvalue[i]*100/
 ↪Total_eigenvalues,'2.2f'),"%")
```

```
Factor 1 contribute 99.75 %
Factor 2 contribute 0.21 %
```

compare to the PCA model, the explanation is almost alike, as the first factor(or component) has 99.75% explanation on variance

print out Factor matrix, Loading matrix, Communality Vector and Uniqueness Vector

[6]:
```
print("\nFactor matrix:\n",F)
print("\nLoading matrix:\n",A)
print("\nCommunality Vector:\n",communality_vector)
print("\nUniqueness Vector:\n",Psi)
```

```
Factor matrix:
 [[ 4.11130246  2.56228537]
 [ 4.33721447  1.9724159 ]
 [ 4.03424091  2.04065671]
 [ 4.02873985  2.40165545]
 [ 4.046891    2.51429333]
 [ 5.10082817  1.84986084]
 [ 5.11978803  1.20602863]
 [ 5.06897722  1.45175908]
 [ 5.20236803  1.39365311]
 [ 4.5254432   1.37339716]
 [ 4.19121337  0.69306769]
 [ 4.23825085  1.98262172]
 [ 4.42314157  0.87559924]
 [ 3.64886693 -2.74096123]
 [ 2.76949913  4.2357598 ]
 [ 3.31663549  3.410327  ]
 [ 3.24835279  3.19962533]
 [ 3.03139445  2.6082012 ]
 [ 2.48633615  3.9188881 ]
 [ 2.14356974  3.05161488]
 [ 3.11702854  5.24978455]
 [ 2.83586279  4.57870528]
 [ 2.77168215  4.48308066]
 [ 2.61076533  3.57936837]
```

```
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Loading matrix:
 [[-6.49968979e+00 -4.71932579e-01 -1.14396203e+00 -1.15757873e+00
   8.49389535e+02  3.33426322e+01  9.78372906e+01  1.53387616e+00]
 [ 6.84080607e-01  1.26349839e-01  9.32021530e-01  1.35543475e+00
   4.70363212e+00 -1.16096732e+01 -3.67976506e+01 -5.18450498e-01]]

Communality Vector:
```

Should be vector

```
 [[ 4.27139337e+01  3.15384884e+00  8.07297620e+00  8.45112931e+00
  -5.51755083e+03 -2.24658718e+02 -6.61084598e+02 -1.03243811e+01]
 [ 3.15384884e+00  2.38684641e-01  6.57633723e-01  7.17558081e-01
  -4.00260291e+02 -1.72023548e+01 -5.08219821e+01 -7.89392267e-01]
 [ 8.07297620e+00  6.57633723e-01  2.17731327e+00  2.58752049e+00
  -9.67285493e+02 -4.89631707e+01 -1.46218348e+02 -2.23790311e+00]
 [ 8.45112931e+00  7.17558081e-01  2.58752049e+00  3.17719189e+00
  -9.76859796e+02 -5.43328765e+01 -1.63131181e+02 -2.47830824e+00]
```

```
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[-2.24658718e+02 -1.72023548e+01 -4.89631707e+01 -5.43328765e+01
  2.82662752e+04  1.24651563e+03  3.68936149e+03  5.71625094e+01]
[-6.61084598e+02 -5.08219821e+01 -1.46218348e+02 -1.63131181e+02
  8.29288882e+04  3.68936149e+03  1.09262025e+04  1.69148047e+02]
[-1.03243811e+01 -7.89392267e-01 -2.23790311e+00 -2.47830824e+00
  1.30041975e+03  5.71625094e+01  1.69148047e+02  2.62156698e+00]]

Uniqueness Vector:
```

should be vector

```
[[ 7.32151205e+05 -3.15384884e+00 -8.07297620e+00 -8.45112931e+00
  5.51755083e+03  2.24658718e+02  6.61084598e+02  1.03243811e+01]
[-3.15384884e+00  1.51419566e+03 -6.57633723e-01 -7.17558081e-01
  4.00260291e+02  1.72023548e+01  5.08219821e+01  7.89392267e-01]
[-8.07297620e+00 -6.57633723e-01  2.59495868e+02 -2.58752049e+00
  9.67285493e+02  4.89631707e+01  1.46218348e+02  2.23790311e+00]
[-8.45112931e+00 -7.17558081e-01 -2.58752049e+00  2.00797674e+01
  9.76859796e+02  5.43328765e+01  1.63131181e+02  2.47830824e+00]
[ 5.51755083e+03  4.00260291e+02  9.67285493e+02  9.76859796e+02
 -7.21479163e+05 -2.82662752e+04 -8.29288882e+04 -1.30041975e+03]
[ 2.24658718e+02  1.72023548e+01  4.89631707e+01  5.43328765e+01
 -2.82662752e+04 -1.24365843e+03 -3.68936149e+03 -5.71625094e+01]
[ 6.61084598e+02  5.08219821e+01  1.46218348e+02  1.63131181e+02
 -8.29288882e+04 -3.68936149e+03 -1.09258421e+04 -1.69148047e+02]
[ 1.03243811e+01  7.89392267e-01  2.23790311e+00  2.47830824e+00
 -1.30041975e+03 -5.71625094e+01 -1.69148047e+02 -2.36309207e+00]]
```

2 Q2

import package

[1]:
```
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image
from numpy import array
from tkinter import _flatten
```

read data

[2]:
```
X = np.zeros((400, 2576))
for j in range(0, 40):
    for i in range(0, 10):
        image = Image.open(r"C:\Users\TerryYang\pythonwork\pythonwork\Data␣
↪Analytics Homework\ORL Faces\%s_%s.png" %(j+1, i+1))
        image_array = array(image)
        X[i+j*10] = image_array.flatten()
```

define Factor Analysis function

[3]:
```python
def FA(dataMat, factor_number):
    meanVals = np.mean(dataMat, axis=0)
    meanRemoved = dataMat - meanVals
    covMat = np.cov(meanRemoved, rowvar=0)
    eigVal, eigVect = np.linalg.eig(np.mat(covMat))
    selected_eigenvalue = eigVal[:factor_number]
    eigenvalues_diagonal = np.zeros((eigVal.shape[0], eigVal.shape[0]), float)
    np.fill_diagonal(eigenvalues_diagonal, eigVal)
    eigenvalues_diagonal_total_sqrt = np.sqrt(eigenvalues_diagonal)
    All_T =   eigenvalues_diagonal_total_sqrt @ eigVect
    All = All_T.T
    X_variance = np.diag(np.diag(All_T @ All))
    eigenvalues_diagonal = np.zeros((factor_number, factor_number), float)
    np.fill_diagonal(eigenvalues_diagonal, eigVal[:factor_number])
    eigenvalues_diagonal_sqrt = np.sqrt(eigenvalues_diagonal)
    A_T = eigVect[:, :factor_number] @ eigenvalues_diagonal_sqrt
    A = A_T.T
    Psi = X_variance - A_T @ A
    Psi_inverse = np.linalg.inv(Psi)
    inner = np.linalg.inv(A @ (Psi_inverse) @ (A_T))
    F = dataMat @ Psi_inverse @ (A_T) @ (inner)
    communality_vector = A_T @ A
    return F, A,communality_vector, Psi,eigVal, eigVect, selected_eigenvalue
```

define Factor Analysis function

[8]:
```python
def analyse_data(eigenvalues_selected, Total_eigenvalues):
    Printed = 0
    cumulated_values = 0
    for i in range(0, len(eigenvalues_selected)):
        cumulated_values += eigenvalues_selected[i]
        if  60 > (cumulated_values/Total_eigenvalues*100).real > 50 and Printed␣
↪== 0:
            print('Principal components %s, Variance percentage %s%%, Cumulated␣
↪percentage %s%%' % (format(i+1, '2.0f'), format(eigenvalues_selected[i]/
↪Total_eigenvalues*100, '4.2f'), format(cumulated_values/
↪Total_eigenvalues*100, '4.1f')))
            Printed = 1
        elif 70 > (cumulated_values/Total_eigenvalues*100).real > 60 and␣
↪Printed == 1:
            print('Principal components %s, Variance percentage %s%%, Cumulated␣
↪percentage %s%%' % (format(i+1, '2.0f'), format(eigenvalues_selected[i]/
↪Total_eigenvalues*100, '4.2f'), format(cumulated_values/
↪Total_eigenvalues*100, '4.1f')))
            Printed = 2
        elif 80 > (cumulated_values/Total_eigenvalues*100).real > 70 and␣
↪Printed == 2:
```

```
            print('Principal components %s, Variance percentage %s%%, Cumulated␣
↪percentage %s%%' % (format(i+1, '2.0f'), format(eigenvalues_selected[i]/
↪Total_eigenvalues*100, '4.2f'), format(cumulated_values/
↪Total_eigenvalues*100, '4.1f')))
            Printed = 3
        elif 90 > (cumulated_values/Total_eigenvalues*100).real > 80 and␣
↪Printed == 3:
            print('Principal components %s, Variance percentage %s%%, Cumulated␣
↪percentage %s%%' % (format(i+1, '2.0f'), format(eigenvalues_selected[i]/
↪Total_eigenvalues*100, '4.2f'), format(cumulated_values/
↪Total_eigenvalues*100, '4.1f')))
            Printed = 4
        elif (cumulated_values/Total_eigenvalues*100).real > 90 and Printed ==␣
↪4:
            print('Principal components %s, Variance percentage %s%%, Cumulated␣
↪percentage %s%%' % (format(i+1, '2.0f'), format(eigenvalues_selected[i]/
↪Total_eigenvalues*100, '4.2f'), format(cumulated_values/
↪Total_eigenvalues*100, '4.1f')))
            Printed = 5
```

call function

[9]:
```
F, A,communality_vector, Psi,eigVal, eigVect, selected_eigenvalue = FA(X.T, 100)
analyse_data(selected_eigenvalue.real,eigVal.real.sum())
```

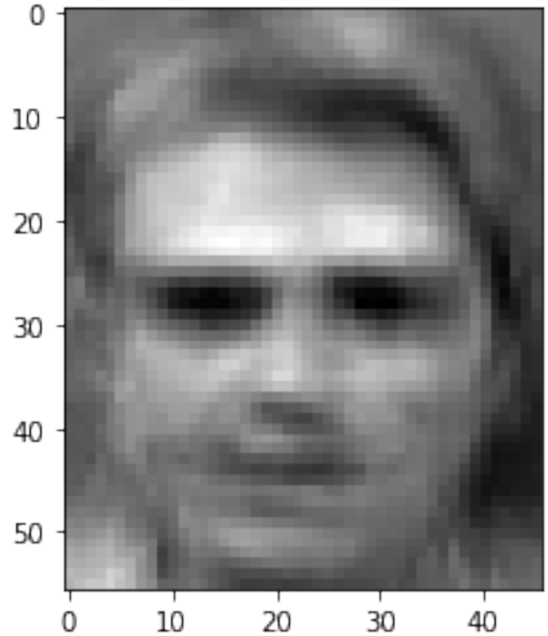
```
Principal components  2, Variance percentage 10.55%, Cumulated percentage 57.0%
Principal components  3, Variance percentage 4.57%, Cumulated percentage 61.5%
Principal components  6, Variance percentage 2.07%, Cumulated percentage 70.5%
Principal components 15, Variance percentage 0.66%, Cumulated percentage 80.2%
Principal components 47, Variance percentage 0.17%, Cumulated percentage 90.1%
```

plot image when selecting 15 factors

[12]:
```
F, A,communality_vector, Psi,eigVal, eigVect, eigenvalues_selected = FA(X.T, 15)

first_PC = F@A
first_PC=first_PC.T[0]
first_PC_array=first_PC.reshape(56,46).real
min_first_PC_array = np.min(first_PC_array)
range_first_PC_array = np.max(first_PC_array) - np.min(first_PC_array)
for i, j in enumerate(first_PC_array):
    first_PC_array[i] = 255 * ((j - min_first_PC_array) / range_first_PC_array)

imgplot = plt.imshow(first_PC_array, cmap='gray', vmin=0, vmax=255)
plt.show()
```



```
[ ]:
```