day-47-pca-implementaion

May 26, 2025

0.0.1 Task How dimensionality reduction using Principal Component Analysis (PCA) on the Wine Quality dataset contributes to improving the classification accuracy and efficiency of wine type.

Note : Use KNN for Classification.

Data Link : Wine Data

[ ]:
```
import numpy as np
```

[ ]:
```
# Data Loading
import pandas as pd
wine_data_path = "https://docs.google.com/spreadsheets/d/e/
↪2PACX-1vQDVwxneOKOaJL13QMhkAhYrgWlH1tICY7RacUnj_lL8m9uUWaaUf3p7bScNyh_D2Rvt7nc1q11adSy/
↪pub?gid=647503637&single=true&output=csv"
wine = pd.read_csv(wine_data_path)
wine.sample(5)
```

[ ]:
```
        type  fixed acidity  volatile acidity  citric acid  residual sugar  \
1823   white            7.3             0.190         0.24             6.3
3517   white            6.6             0.290         0.29             1.8
6092     red            7.0             0.745         0.12             1.8
5823     red            8.6             0.220         0.36             1.9
118    white            7.2             0.310         0.50            13.3

      chlorides  free sulfur dioxide  total sulfur dioxide  density    pH  \
1823      0.054                 34.0                 231.0  0.99640  3.36
3517      0.036                 38.0                 102.0  0.98819  3.08
6092      0.114                 15.0                  64.0  0.99588  3.22
5823      0.064                 53.0                  77.0  0.99604  3.47
118       0.056                 68.0                 195.0  0.99820  3.01

      sulphates  alcohol  quality
1823       0.54     10.0        6
3517       0.42     13.7        7
6092       0.59      9.5        6
5823       0.87     11.0        7
118        0.47      9.2        5
```

[ ]:
```
# Your Code goes Here
```

[ ]:
```
wine.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6497 entries, 0 to 6496
Data columns (total 13 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   type                  6497 non-null   object
 1   fixed acidity         6487 non-null   float64
 2   volatile acidity      6489 non-null   float64
 3   citric acid           6494 non-null   float64
 4   residual sugar        6495 non-null   float64
 5   chlorides             6495 non-null   float64
 6   free sulfur dioxide   6497 non-null   float64
 7   total sulfur dioxide  6497 non-null   float64
 8   density               6497 non-null   float64
 9   pH                    6488 non-null   float64
 10  sulphates             6493 non-null   float64
 11  alcohol               6497 non-null   float64
 12  quality               6497 non-null   int64
dtypes: float64(11), int64(1), object(1)
memory usage: 660.0+ KB
```

[ ]:
```
wine.isnull().sum()
```

[ ]:
```
type                     0
fixed acidity           10
volatile acidity         8
citric acid              3
residual sugar           2
chlorides                2
free sulfur dioxide      0
total sulfur dioxide     0
density                  0
pH                       9
sulphates                4
alcohol                  0
quality                  0
dtype: int64
```

[ ]:
```
df=wine.dropna()
df.head()
```

[ ]:
```
    type  fixed acidity  volatile acidity  citric acid  residual sugar  \
0  white            7.0              0.27         0.36            20.7
```

```
1  white            6.3              0.30         0.34             1.6
2  white            8.1              0.28         0.40             6.9
3  white            7.2              0.23         0.32             8.5
4  white            7.2              0.23         0.32             8.5

   chlorides  free sulfur dioxide  total sulfur dioxide  density    pH  \
0      0.045                 45.0                 170.0   1.0010  3.00
1      0.049                 14.0                 132.0   0.9940  3.30
2      0.050                 30.0                  97.0   0.9951  3.26
3      0.058                 47.0                 186.0   0.9956  3.19
4      0.058                 47.0                 186.0   0.9956  3.19

   sulphates  alcohol  quality
0       0.45      8.8        6
1       0.49      9.5        6
2       0.44     10.1        6
3       0.40      9.9        6
4       0.40      9.9        6
```

```
[ ]: df['type'].unique(),df['quality'].unique()
```

```
[ ]: (array(['white', 'red'], dtype=object), array([6, 5, 7, 8, 4, 3, 9]))
```

```
[ ]: df.isnull().sum()
```

```
[ ]: type                    0
     fixed acidity           0
     volatile acidity        0
     citric acid             0
     residual sugar          0
     chlorides               0
     free sulfur dioxide     0
     total sulfur dioxide    0
     density                 0
     pH                      0
     sulphates               0
     alcohol                 0
     quality                 0
     dtype: int64
```

#KNN On Dataset Without PCA

```
[ ]: X=df.iloc[:,:-1]
     y=df.iloc[:,-1]
     y.head(2)
```

```
[ ]: 0    6
     1    6
     Name: quality, dtype: int64
```

```
[ ]: from sklearn.model_selection import train_test_split
     X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.
      ↪2,random_state=40)
     X_train.head(3)
```

```
[ ]:        type  fixed acidity  volatile acidity  citric acid  residual sugar  \
     1335  white            5.7              0.21         0.24             2.3
     687   white            6.8              0.67         0.30            13.0
     6432    red            6.6              0.56         0.14             2.4

           chlorides  free sulfur dioxide  total sulfur dioxide  density    pH  \
     1335      0.047                 60.0                 189.0  0.99500  3.65
     687       0.290                 22.0                 193.0  0.99840  3.08
     6432      0.064                 13.0                  29.0  0.99397  3.42

           sulphates  alcohol
     1335       0.72     10.1
     687        0.67      9.0
     6432       0.62     11.7
```

```
[ ]: import plotly.express as ex
     ex.scatter_3d(X_train,x='fixed acidity',y='pH',z='alcohol',color=y_train.
      ↪astype('str'))
```

```
[ ]: from sklearn.preprocessing import StandardScaler,OneHotEncoder
     from sklearn.pipeline import Pipeline,make_pipeline
     from sklearn.compose import ColumnTransformer,make_column_transformer
     from sklearn.neighbors import KNeighborsClassifier
```

```
[ ]: cat_pipe=Pipeline([
         ('ohe',OneHotEncoder(sparse_output=False,dtype=np.
      ↪int32,handle_unknown='ignore'))
     ])

     CT1=ColumnTransformer([
         ('cat_pipe',cat_pipe,['type'])
     ],remainder='passthrough')

     pipe1=make_pipeline(CT1,StandardScaler(),KNeighborsClassifier())
     pipe1.fit(X_train,y_train)
```

```
/usr/local/lib/python3.11/dist-
packages/sklearn/compose/_column_transformer.py:1667: FutureWarning:
```

```
The format of the columns of the 'remainder' transformer in
ColumnTransformer.transformers_ will change in version 1.7 to match the format
of the other transformers.
At the moment the remainder columns are stored as indices (of type int). With
the same ColumnTransformer configuration, in the future they will be stored as
column names (of type str).
To use the new behavior now and suppress this warning, use
ColumnTransformer(force_int_remainder_cols=False).
```

[ ]:

```
Pipeline(steps=[('columntransformer',
                 ColumnTransformer(remainder='passthrough',
                                   transformers=[('cat_pipe',
                                                  Pipeline(steps=[('ohe',
OneHotEncoder(dtype=<class 'numpy.int32'>,
 handle_unknown='ignore',
 sparse_output=False))]),
                                                  ['type'])])),
                ('standardscaler', StandardScaler()),
                ('kneighborsclassifier', KNeighborsClassifier())])
```

[ ]:

```
y_pred1=pipe1.predict(X_test)
```

[ ]:

```
from sklearn.metrics import accuracy_score
accuracy_score(y_pred1,y_test)
```

[ ]:

```
0.5668986852281516
```

[ ]:

```
from sklearn.model_selection import cross_val_score
cross_val_score(pipe1,X_train,y_train,cv=5,scoring='accuracy').mean()
```

[ ]:

```
np.float64(0.551063829787234)
```

[ ]:

```

```

#KNN wiht PCA

[ ]:

```
from sklearn.decomposition import PCA
cat_pipe=Pipeline([
    ('ohe',OneHotEncoder(sparse_output=False,dtype=np.
 ↪int32,handle_unknown='ignore'))
])

CT1=ColumnTransformer([
    ('cat_pipe',cat_pipe,['type'])
],remainder='passthrough')

pipe2=make_pipeline(CT1,StandardScaler(),PCA(n_components=9),KNeighborsClassifier())
pipe2.fit(X_train,y_train)
```

```
/usr/local/lib/python3.11/dist-
packages/sklearn/compose/_column_transformer.py:1667: FutureWarning:


The format of the columns of the 'remainder' transformer in
ColumnTransformer.transformers_ will change in version 1.7 to match the format
of the other transformers.
At the moment the remainder columns are stored as indices (of type int). With
the same ColumnTransformer configuration, in the future they will be stored as
column names (of type str).
To use the new behavior now and suppress this warning, use
ColumnTransformer(force_int_remainder_cols=False).
```

[ ]:

```
Pipeline(steps=[('columntransformer',
                 ColumnTransformer(remainder='passthrough',
                                   transformers=[('cat_pipe',
                                                  Pipeline(steps=[('ohe',
OneHotEncoder(dtype=<class 'numpy.int32'>,
 handle_unknown='ignore',
 sparse_output=False))]),
                                                  ['type'])])),
                ('standardscaler', StandardScaler()),
                ('pca', PCA(n_components=9)),
                ('kneighborsclassifier', KNeighborsClassifier())])
```

[ ]:

```
y_pred2=pipe2.predict(X_test)
accuracy_score(y_test,y_pred2)
```

[ ]:

```
0.5707656612529002
```

[ ]:

```
pca=pipe2[2]
pca.components_
#Return Top Eigen Vectors(10 for this )
```

[ ]:

```
array([[ 0.4395198 , -0.4395198 ,  0.23971741,  0.32453196, -0.0996497 ,
        -0.2036053 ,  0.26490294, -0.29228448, -0.36278861,  0.15137623,
         0.15806978,  0.25367552,  0.00162089],
       [ 0.04899132, -0.04899132,  0.25047352,  0.01034206,  0.21352717,
         0.41288943,  0.21848224,  0.19424748,  0.21994233,  0.55094106,
        -0.20203139,  0.10595861, -0.47630145],
       [-0.04106064,  0.04106064,  0.45361504, -0.2799352 ,  0.58703746,
        -0.18278796,  0.0326532 , -0.1597158 , -0.12831291, -0.15797109,
        -0.43671411,  0.11882519,  0.24827451],
       [ 0.0080495 , -0.0080495 , -0.20072558, -0.2215061 ,  0.25856502,
        -0.17171487,  0.27002324,  0.35421302,  0.2075525 , -0.08128428,
         0.42578695,  0.61453825,  0.08459587],
       [-0.07976105,  0.07976105, -0.16609737,  0.18252533, -0.19241669,
        -0.31996517,  0.64763694,  0.11017918,  0.11002541, -0.28110632,
        -0.46218804, -0.06744486, -0.21471985],
       [ 0.13188796, -0.13188796,  0.20922978,  0.43489746, -0.14221057,
         0.14708209, -0.16119993,  0.52297355,  0.21191978, -0.06358393,
        -0.25846161,  0.12078673,  0.51049951],
       [-0.15272161,  0.15272161, -0.24756521, -0.05401744, -0.26978109,
         0.44817788,  0.06279632, -0.37707765, -0.13588327,  0.02580233,
        -0.30317938,  0.56386342,  0.2009475 ],
       [-0.02168047,  0.02168047, -0.26009807,  0.2656361 ,  0.44055113,
         0.3790096 ,  0.43995368, -0.11641715, -0.0604664 ,  0.02133994,
         0.19890542, -0.36078033,  0.37704537],
       [-0.24717678,  0.24717678,  0.0771081 ,  0.61117651,  0.22882421,
        -0.20175443, -0.20039909, -0.36859334,  0.38955611, -0.01114355,
         0.11092724,  0.20986654, -0.14495422]])
```

[ ]:
```
pca.explained_variance_
#Return Top(10) eigenValues
```

[ ]:
```
array([4.67721981, 2.53078584, 1.54277377, 0.99024238, 0.7454917 ,
       0.62471764, 0.55726978, 0.49772782, 0.37293702])
```

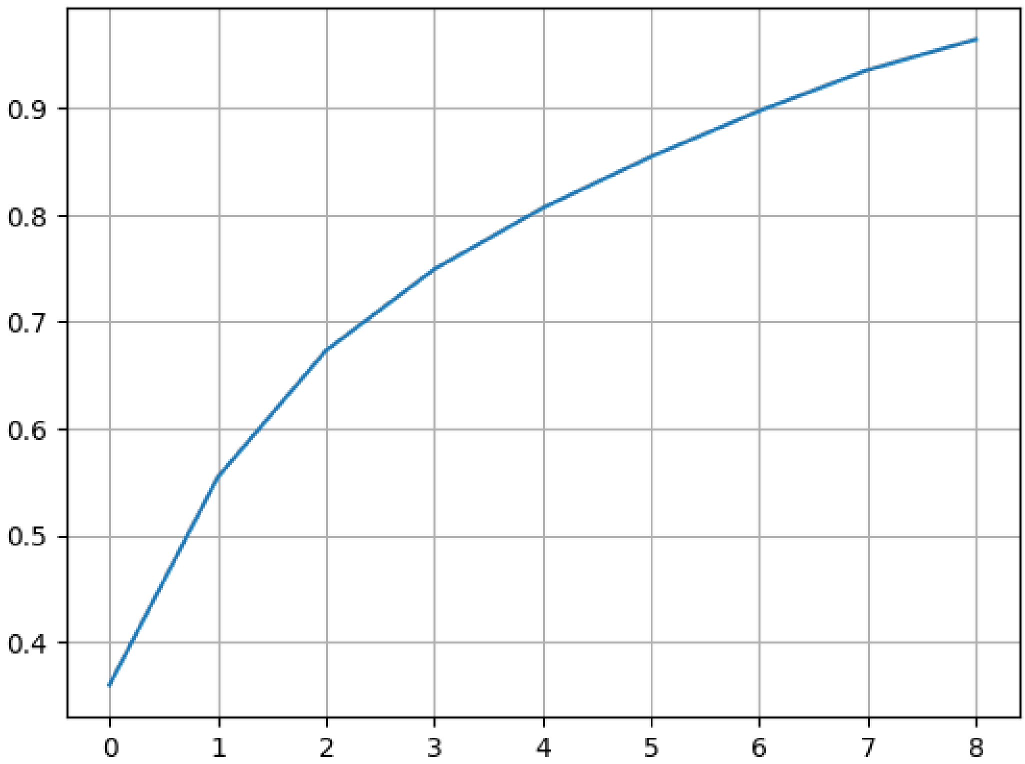
[ ]:
```
pca.explained_variance_ratio_
#Return           %
```

[ ]:
```
array([0.35971655, 0.19463818, 0.11865195, 0.07615776, 0.05733442,
       0.04804591, 0.04285861, 0.03827935, 0.02868191])
```

[ ]:
```
np.cumsum(pca.explained_variance_ratio_)
```

[ ]:
```
array([0.35971655, 0.55435473, 0.67300668, 0.74916444, 0.80649886,
       0.85454477, 0.89740338, 0.93568273, 0.96436465])
```

[ ]:
```
import matplotlib.pyplot as plt
plt.plot(np.cumsum(pca.explained_variance_ratio_))
plt.grid('True')
```



#Extract Principle Components Step by Setp

```
[ ]: pipe2.named_steps
```

```
[ ]: {'columntransformer': ColumnTransformer(remainder='passthrough',
                        transformers=[('cat_pipe',
                                       Pipeline(steps=[('ohe',
                                                        OneHotEncoder(dtype=<class
     'numpy.int32'>,
     handle_unknown='ignore',
     sparse_output=False))]),
                                       ['type'])]),
      'standardscaler': StandardScaler(),
      'pca': PCA(n_components=9),
      'kneighborsclassifier': KNeighborsClassifier()}
```

```
[ ]: X_ct_tf=pipe2.named_steps['columntransformer'].transform(X_train)
     X_ct_tf
     #return Transformed Value After ColumnTransformation
```

```
[ ]: array([[ 0.  ,  1.  ,  5.7 , …,  3.65,  0.72, 10.1 ],
            [ 0.  ,  1.  ,  6.8 , …,  3.08,  0.67,  9.  ],
            [ 1.  ,  0.  ,  6.6 , …,  3.42,  0.62, 11.7 ],
            …,
            [ 1.  ,  0.  ,  7.1 , …,  3.37,  0.64, 10.4 ],
            [ 1.  ,  0.  ,  7.  , …,  3.35,  0.81, 10.6 ],
            [ 0.  ,  1.  ,  6.4 , …,  3.36,  0.71, 12.5 ]])
```

[ ]:
```
# X_scal_tf=pipe2.named_steps['standardscaler'].transform(X_train) #can't␣
 ↪transform cause X_train has Object Feature.(It do not come throuthout the␣
 ↪Pipeline)
X_scal_tf=pipe2.named_steps['standardscaler'].transform(X_ct_tf)
X_scal_tf
#return Transformed Value After ColumnTransformation and Scaling(Standardscaler)
```

[ ]:
```
array([[-0.56945833,  0.56945833, -1.17771746, …,  2.72328632,
         1.26520297, -0.33159867],
       [-0.56945833,  0.56945833, -0.31966768, …, -0.86292183,
         0.9308388 , -1.2591166 ],
       [ 1.75605475, -1.75605475, -0.47567673, …,  1.27621988,
         0.59647463,  1.01751832],
       …,
       [ 1.75605475, -1.75605475, -0.0856541 , …,  0.96164021,
         0.7302203 , -0.07863923],
       [ 1.75605475, -1.75605475, -0.16365863, …,  0.83580835,
         1.86705847,  0.09000039],
       [-0.56945833,  0.56945833, -0.63168578, …,  0.89872428,
         1.19833013,  1.69207682]])
```

[ ]:
```
pc_arr=pipe2.named_steps['pca'].transform(X_scal_tf)
pc_arr
#return Principle Components  Value After␣
 ↪ColumnTransformation,Scaling(Standardscaler) and PCA
```

[ ]:
```
array([[-1.10909323, -0.39168954, -2.04089563, …, -0.64479607,
        -0.78692477,  0.27399249],
       [ 1.41733436,  3.70585203, -0.92957337, …,  1.86433063,
         3.07620001,  0.79888528],
       [ 3.33932332, -1.75159753, -1.16604761, …,  0.29496307,
         0.34368436, -0.39552174],
       …,
       [ 2.96839472, -0.37446528, -0.94476846, …, -0.32082645,
        -0.2563766 , -0.68802611],
       [ 3.65276052, -0.94496631, -1.20588557, …,  1.094111  ,
        -1.05356732, -0.80871388],
       [-0.33749006, -2.00822909,  0.03226068, …,  1.30439898,
         0.13622127,  0.65121656]])
```

[ ]:
```
pc_arr.shape
```

[ ]:
```
(5170, 9)
```

[ ]:
```

```

[ ]:
```
import pandas as pd
pc_df=pd.DataFrame(pc_arr,columns=[f'pc{i}' for i in range(1,pc_arr.
 ↪shape[1]+1)])
pc_df
```

[ ]:
```
           pc1       pc2       pc3       pc4       pc5       pc6       pc7  \
0    -1.109093 -0.391690 -2.040896  3.070201 -0.682777 -0.294053 -0.644796
1     1.417334  3.705852 -0.929573  1.176738  4.599229 -0.493413  1.864331
2     3.339323 -1.751598 -1.166048  0.027140 -0.436086  0.420919  0.294963
3    -1.543580 -1.186004  1.509760 -1.191898  0.851457  0.807433 -0.706016
4    -1.467607  0.554879 -0.050763 -0.628583 -0.265288  0.677590  0.326453
…          …         …         …         …         …         …         …
5165 -0.677255 -1.451142  0.876912  1.118235 -0.335408 -0.200552  0.827484
5166  3.184019  0.951241 -1.333397 -1.158235  1.058241  0.840810 -0.217774
5167  2.968395 -0.374465 -0.944768  0.509827 -0.060742  0.148953 -0.320826
5168  3.652761 -0.944966 -1.205886  0.590422  0.087716  0.002629  1.094111
5169 -0.337490 -2.008229  0.032261  1.029364 -0.762488  0.290952  1.304399

           pc8       pc9
0    -0.786925  0.273992
1     3.076200  0.798885
2     0.343684 -0.395522
3    -1.152065 -0.956210
4    -0.192881 -0.310100
…          …         …
5165 -0.771040 -0.199638
5166  0.432851  0.554165
5167 -0.256377 -0.688026
5168 -1.053567 -0.808714
5169  0.136221  0.651217

[5170 rows x 9 columns]
```

[ ]:
```
ex.scatter_3d(pc_df,x='pc1',y='pc2',z='pc3',color=y_train.astype('str'))
```

[ ]:
```
pca2=pipe2.named_steps['pca']
pca2.components_
```

[ ]:
```
array([[ 0.4395198 , -0.4395198 ,  0.23971741,  0.32453196, -0.0996497 ,
        -0.2036053 ,  0.26490294, -0.29228448, -0.36278861,  0.15137623,
         0.15806978,  0.25367552,  0.00162089],
       [ 0.04899132, -0.04899132,  0.25047352,  0.01034206,  0.21352717,
         0.41288943,  0.21848224,  0.19424748,  0.21994233,  0.55094106,
        -0.20203139,  0.10595861, -0.47630145],
       [-0.04106064,  0.04106064,  0.45361504, -0.2799352 ,  0.58703746,
        -0.18278796,  0.0326532 , -0.1597158 , -0.12831291, -0.15797109,
        -0.43671411,  0.11882519,  0.24827451],
       [ 0.0080495 , -0.0080495 , -0.20072558, -0.2215061 ,  0.25856502,
        -0.17171487,  0.27002324,  0.35421302,  0.2075525 , -0.08128428,
         0.42578695,  0.61453825,  0.08459587],
       [-0.07976105,  0.07976105, -0.16609737,  0.18252533, -0.19241669,
        -0.31996517,  0.64763694,  0.11017918,  0.11002541, -0.28110632,
        -0.46218804, -0.06744486, -0.21471985],
       [ 0.13188796, -0.13188796,  0.20922978,  0.43489746, -0.14221057,
         0.14708209, -0.16119993,  0.52297355,  0.21191978, -0.06358393,
        -0.25846161,  0.12078673,  0.51049951],
       [-0.15272161,  0.15272161, -0.24756521, -0.05401744, -0.26978109,
         0.44817788,  0.06279632, -0.37707765, -0.13588327,  0.02580233,
        -0.30317938,  0.56386342,  0.2009475 ],
       [-0.02168047,  0.02168047, -0.26009807,  0.2656361 ,  0.44055113,
         0.3790096 ,  0.43995368, -0.11641715, -0.0604664 ,  0.02133994,
         0.19890542, -0.36078033,  0.37704537],
       [-0.24717678,  0.24717678,  0.0771081 ,  0.61117651,  0.22882421,
        -0.20175443, -0.20039909, -0.36859334,  0.38955611, -0.01114355,
         0.11092724,  0.20986654, -0.14495422]])
```

```
[ ]:
```