PCA

December 15, 2022

Imports

```python
import numpy as np
import pandas as pd
from sklearn.decomposition import PCA
from sklearn.manifold import TSNE
from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import classification_report
import plotly as py
import plotly.graph_objs as go
from plotly.offline import download_plotlyjs, init_notebook_mode, plot, iplot
```

Reading The Data

```python
df = pd.read_csv("Forest_Original.csv")
```

Creating New Data Frame & Naming It As 'X' So We Can Modify The Same Accordingly

```python
X = df.copy()
```

Any Missing Values ?

```python
X.isnull().sum()
```

```
Elevation                            0
Aspect                               0
Slope                                0
Horizontal_Distance_To_Hydrology     0
Vertical_Distance_To_Hydrology       0
Horizontal_Distance_To_Roadways      0
Hillshade_9am                        0
Hillshade_Noon                       0
Hillshade_3pm                        0
Horizontal_Distance_To_Fire_Points   0
Wilderness_Area1                     0
Wilderness_Area2                     0
Wilderness_Area3                     0
```

```
Wilderness_Area4            0
Soil_Type1                  0
Soil_Type2                  0
Soil_Type3                  0
Soil_Type4                  0
Soil_Type5                  0
Soil_Type6                  0
Soil_Type7                  0
Soil_Type8                  0
Soil_Type9                  0
Soil_Type10                 0
Soil_Type11                 0
Soil_Type12                 0
Soil_Type13                 0
Soil_Type14                 0
Soil_Type15                 0
Soil_Type16                 0
Soil_Type17                 0
Soil_Type18                 0
Soil_Type19                 0
Soil_Type20                 0
Soil_Type21                 0
Soil_Type22                 0
Soil_Type23                 0
Soil_Type24                 0
Soil_Type25                 0
Soil_Type26                 0
Soil_Type27                 0
Soil_Type28                 0
Soil_Type29                 0
Soil_Type30                 0
Soil_Type31                 0
Soil_Type32                 0
Soil_Type33                 0
Soil_Type34                 0
Soil_Type35                 0
Soil_Type36                 0
Soil_Type37                 0
Soil_Type38                 0
Soil_Type39                 0
Soil_Type40                 0
Cover_Type                  0
dtype: int64
```

Sweet ! No Null Values

```
[ ]: X.head()
```

```
[ ]:    Elevation  Aspect  Slope  Horizontal_Distance_To_Hydrology  \
     0       2596      51      3                               258
     1       2590      56      2                               212
     2       2804     139      9                               268
     3       2785     155     18                               242
     4       2595      45      2                               153

        Vertical_Distance_To_Hydrology  Horizontal_Distance_To_Roadways  \
     0                               0                              510
     1                              -6                              390
     2                              65                             3180
     3                             118                             3090
     4                              -1                              391

        Hillshade_9am  Hillshade_Noon  Hillshade_3pm  \
     0            221             232            148
     1            220             235            151
     2            234             238            135
     3            238             238            122
     4            220             234            150

        Horizontal_Distance_To_Fire_Points  …  Soil_Type32  Soil_Type33  \
     0                                 6279  …            0            0
     1                                 6225  …            0            0
     2                                 6121  …            0            0
     3                                 6211  …            0            0
     4                                 6172  …            0            0

        Soil_Type34  Soil_Type35  Soil_Type36  Soil_Type37  Soil_Type38  \
     0            0            0            0            0            0
     1            0            0            0            0            0
     2            0            0            0            0            0
     3            0            0            0            0            0
     4            0            0            0            0            0

        Soil_Type39  Soil_Type40  Cover_Type
     0            0            0           5
     1            0            0           5
     2            0            0           2
     3            0            0           2
     4            0            0           5

     [5 rows x 55 columns]
```

Creating & Replacing Colummns For Better Perspective & Meaning

```python
X["Distance_To_Hydrology"] = ( (X["Horizontal_Distance_To_Hydrology"] ** 2) +
  (X["Vertical_Distance_To_Hydrology"] ** 2) ) ** (0.5)
```

```python
X.drop(["Horizontal_Distance_To_Hydrology","Vertical_Distance_To_Hydrology"],
  axis=1, inplace=True)
```

```python
X['Cover_Type'].replace({1:'Spruce/Fir', 2:'Lodgepole Pine', 3:'Ponderosa
  Pine', 4:'Cottonwood/Willow', 5:'Aspen', 6:'Douglas-fir', 7:'Krummholz'},
  inplace=True)
```

```python
X.head()
```

```
   Elevation  Aspect  Slope  Horizontal_Distance_To_Roadways  Hillshade_9am  \
0       2596      51      3                              510            221
1       2590      56      2                              390            220
2       2804     139      9                             3180            234
3       2785     155     18                             3090            238
4       2595      45      2                              391            220

   Hillshade_Noon  Hillshade_3pm  Horizontal_Distance_To_Fire_Points  \
0             232            148                                6279
1             235            151                                6225
2             238            135                                6121
3             238            122                                6211
4             234            150                                6172

   Wilderness_Area1  Wilderness_Area2  …  Soil_Type33  Soil_Type34  \
0                 1                 0  …            0            0
1                 1                 0  …            0            0
2                 1                 0  …            0            0
3                 1                 0  …            0            0
4                 1                 0  …            0            0

   Soil_Type35  Soil_Type36  Soil_Type37  Soil_Type38  Soil_Type39  \
0            0            0            0            0            0
1            0            0            0            0            0
2            0            0            0            0            0
3            0            0            0            0            0
4            0            0            0            0            0

   Soil_Type40       Cover_Type  Distance_To_Hydrology
0            0            Aspen             258.000000
1            0            Aspen             212.084889
2            0  Lodgepole Pine             275.769832
3            0  Lodgepole Pine             269.235956
4            0            Aspen             153.003268
```

[5 rows x 54 columns]

Implementing One Hot Encoder

```
[ ]: X = pd.get_dummies(X)
```

```
[ ]: X.head()
```

```
[ ]:    Elevation  Aspect  Slope  Horizontal_Distance_To_Roadways  Hillshade_9am  \
     0       2596      51      3                              510            221
     1       2590      56      2                              390            220
     2       2804     139      9                             3180            234
     3       2785     155     18                             3090            238
     4       2595      45      2                              391            220

        Hillshade_Noon  Hillshade_3pm  Horizontal_Distance_To_Fire_Points  \
     0             232            148                                6279
     1             235            151                                6225
     2             238            135                                6121
     3             238            122                                6211
     4             234            150                                6172

        Wilderness_Area1  Wilderness_Area2  …  Soil_Type39  Soil_Type40  \
     0                 1                 0  …            0            0
     1                 1                 0  …            0            0
     2                 1                 0  …            0            0
     3                 1                 0  …            0            0
     4                 1                 0  …            0            0

        Distance_To_Hydrology  Cover_Type_Aspen  Cover_Type_Cottonwood/Willow  \
     0             258.000000                 1                             0
     1             212.084889                 1                             0
     2             275.769832                 0                             0
     3             269.235956                 0                             0
     4             153.003268                 1                             0

        Cover_Type_Douglas-fir  Cover_Type_Krummholz  Cover_Type_Lodgepole Pine  \
     0                       0                     0                          0
     1                       0                     0                          0
     2                       0                     0                          1
     3                       0                     0                          1
     4                       0                     0                          0

        Cover_Type_Ponderosa Pine  Cover_Type_Spruce/Fir
     0                          0                      0
     1                          0                      0
     2                          0                      0
```

3	0	0
4	0	0

[5 rows x 60 columns]

Feature Scale Numerical Data

```
[ ]: numer =␣
     ↪X[["Elevation","Aspect","Slope","Horizontal_Distance_To_Roadways","Hillshade_9am","Hillshad
```

```
[ ]: cater =␣
     ↪X[["Wilderness_Area1","Wilderness_Area2","Wilderness_Area3","Wilderness_Area4","Soil_Type1"
     ↪Willow","Cover_Type_Douglas-fir","Cover_Type_Krummholz","Cover_Type_Lodgepole␣
     ↪Pine","Cover_Type_Ponderosa Pine","Cover_Type_Spruce/Fir"]]
```

```
[ ]: numer.head()
```

```
[ ]:    Elevation  Aspect  Slope  Horizontal_Distance_To_Roadways  Hillshade_9am  \
     0       2596      51      3                              510            221
     1       2590      56      2                              390            220
     2       2804     139      9                             3180            234
     3       2785     155     18                             3090            238
     4       2595      45      2                              391            220

        Hillshade_Noon  Hillshade_3pm  Horizontal_Distance_To_Fire_Points  \
     0             232            148                                6279
     1             235            151                                6225
     2             238            135                                6121
     3             238            122                                6211
     4             234            150                                6172

        Distance_To_Hydrology
     0             258.000000
     1             212.084889
     2             275.769832
     3             269.235956
     4             153.003268
```

```
[ ]: cater.head()
```

```
[ ]:    Wilderness_Area1  Wilderness_Area2  Wilderness_Area3  Wilderness_Area4  \
     0                 1                 0                 0                 0
     1                 1                 0                 0                 0
     2                 1                 0                 0                 0
     3                 1                 0                 0                 0
     4                 1                 0                 0                 0
```

	Soil_Type1	Soil_Type2	Soil_Type3	Soil_Type4	Soil_Type5	Soil_Type6	\
0	0	0	0	0	0	0	
1	0	0	0	0	0	0	
2	0	0	0	0	0	0	
3	0	0	0	0	0	0	
4	0	0	0	0	0	0	

	…	Soil_Type38	Soil_Type39	Soil_Type40	Cover_Type_Aspen	\
0	…	0	0	0	1	
1	…	0	0	0	1	
2	…	0	0	0	0	
3	…	0	0	0	0	
4	…	0	0	0	1	

	Cover_Type_Cottonwood/Willow	Cover_Type_Douglas-fir	Cover_Type_Krummholz	\
0	0	0	0	
1	0	0	0	
2	0	0	0	
3	0	0	0	
4	0	0	0	

	Cover_Type_Lodgepole Pine	Cover_Type_Ponderosa Pine	Cover_Type_Spruce/Fir
0	0	0	0
1	0	0	0
2	1	0	0
3	1	0	0
4	0	0	0

[5 rows x 51 columns]

```
scaler = StandardScaler()
```

```
numer = pd.DataFrame(scaler.fit_transform(numer))
```

```
numer.columns =␣
 ↪["Elevation_Scaled","Aspect_Scaled","Slope_Scaled","Horizontal_Distance_To_Roadways_Scaled"
```

```
X = pd.concat([numer, cater], axis=1, join='inner')
```

```
X.head()
```

	Elevation_Scaled	Aspect_Scaled	Slope_Scaled	\
0	-1.297805	-0.935157	-1.482820	
1	-1.319235	-0.890480	-1.616363	
2	-0.554907	-0.148836	-0.681563	
3	-0.622768	-0.005869	0.520322	
4	-1.301377	-0.988770	-1.616363	

```
     Horizontal_Distance_To_Roadways_Scaled  Hillshade_9am_Scaled  \
0                                  -1.180146              0.330743
1                                  -1.257106              0.293388
2                                   0.532212              0.816364
3                                   0.474492              0.965786
4                                  -1.256464              0.293388


   Hillshade_Noon_Scaled  Hillshade_3pm_Scaled  \
0               0.439143              0.142960
1               0.590899              0.221342
2               0.742654             -0.196691
3               0.742654             -0.536343
4               0.540313              0.195215


   Horizontal_Distance_To_Fire_Points_Scaled  Distance_To_Hydrology_Scaled  \
0                                    3.246283                     -0.083233
1                                    3.205504                     -0.294777
2                                    3.126965                     -0.001362
3                                    3.194931                     -0.031466
4                                    3.165479                     -0.566983


   Wilderness_Area1  …  Soil_Type38  Soil_Type39  Soil_Type40  \
0                 1  …            0            0            0
1                 1  …            0            0            0
2                 1  …            0            0            0
3                 1  …            0            0            0
4                 1  …            0            0            0


   Cover_Type_Aspen  Cover_Type_Cottonwood/Willow  Cover_Type_Douglas-fir  \
0                 1                             0                       0
1                 1                             0                       0
2                 0                             0                       0
3                 0                             0                       0
4                 1                             0                       0


   Cover_Type_Krummholz  Cover_Type_Lodgepole Pine  Cover_Type_Ponderosa Pine  \
0                     0                          0                          0
1                     0                          0                          0
2                     0                          1                          0
3                     0                          1                          0
4                     0                          0                          0


   Cover_Type_Spruce/Fir
0                      0
1                      0
2                      0
```

```
3                    0
4                    0
```

[5 rows x 60 columns]

Time To Build Our Clusters

```python
kmeans = KMeans(n_clusters=3)
```

```python
kmeans.fit(X)
```

```
KMeans(n_clusters=3)
```

```python
clusters = kmeans.predict(X)
```

```python
X["Cluster"] = clusters
```

Principal Component Analysis

```python
plotX = pd.DataFrame(np.array(X.sample(5000)))
plotX.columns = X.columns
```

```python
pca_1d = PCA(n_components=1)
pca_2d = PCA(n_components=2)
pca_3d = PCA(n_components=3)
```

```python
PCs_1d = pd.DataFrame(pca_1d.fit_transform(plotX.drop(["Cluster"], axis=1)))
PCs_2d = pd.DataFrame(pca_2d.fit_transform(plotX.drop(["Cluster"], axis=1)))
PCs_3d = pd.DataFrame(pca_3d.fit_transform(plotX.drop(["Cluster"], axis=1)))
```

```python
PCs_1d.columns = ["PC1_1d"]
PCs_2d.columns = ["PC1_2d", "PC2_2d"]
PCs_3d.columns = ["PC1_3d", "PC2_3d", "PC3_3d"]
```

```python
plotX = pd.concat([plotX,PCs_1d,PCs_2d,PCs_3d], axis=1, join='inner')
```

```python
plotX["dummy"] = 0
```

```python
cluster0 = plotX[plotX["Cluster"] == 0]
cluster1 = plotX[plotX["Cluster"] == 1]
cluster2 = plotX[plotX["Cluster"] == 2]
```

PCA Visualizations

1-D Visualization

```python
trace1 = go.Scatter(
                    x = cluster0["PC1_1d"],
                    y = cluster0["dummy"],
```

```
                    mode = "markers",
                    name = "Cluster 0",
                    marker = dict(color = 'rgba(255, 128, 255, 0.8)'),
                    text = None)
trace2 = go.Scatter(
                    x = cluster1["PC1_1d"],
                    y = cluster1["dummy"],
                    mode = "markers",
                    name = "Cluster 1",
                    marker = dict(color = 'rgba(255, 128, 2, 0.8)'),
                    text = None)
trace3 = go.Scatter(
                    x = cluster2["PC1_1d"],
                    y = cluster2["dummy"],
                    mode = "markers",
                    name = "Cluster 2",
                    marker = dict(color = 'rgba(0, 255, 200, 0.8)'),
                    text = None)

data = [trace1, trace2, trace3]
title = "Visualizing Clusters in One Dimension Using PCA"
layout = dict(title = title,
              xaxis= dict(title= 'PC1',ticklen= 5,zeroline= False),
              yaxis= dict(title= '',ticklen= 5,zeroline= False)
             )
fig = dict(data = data, layout = layout)
iplot(fig)
```

2-D Visualization

```
[ ]: trace1 = go.Scatter(
                    x = cluster0["PC1_2d"],
                    y = cluster0["PC2_2d"],
                    mode = "markers",
                    name = "Cluster 0",
                    marker = dict(color = 'rgba(255, 128, 255, 0.8)'),
                    text = None)
trace2 = go.Scatter(
                    x = cluster1["PC1_2d"],
                    y = cluster1["PC2_2d"],
                    mode = "markers",
                    name = "Cluster 1",
                    marker = dict(color = 'rgba(255, 128, 2, 0.8)'),
                    text = None)
trace3 = go.Scatter(
                    x = cluster2["PC1_2d"],
                    y = cluster2["PC2_2d"],
```

```
                 mode = "markers",
                 name = "Cluster 2",
                 marker = dict(color = 'rgba(0, 255, 200, 0.8)'),
                 text = None)
data = [trace1, trace2, trace3]
title = "Visualizing Clusters in Two Dimensions Using PCA"
layout = dict(title = title,
              xaxis= dict(title= 'PC1',ticklen= 5,zeroline= False),
              yaxis= dict(title= 'PC2',ticklen= 5,zeroline= False)
             )
fig = dict(data = data, layout = layout)
iplot(fig)
```

3-D Visualization

```
[ ]: trace1 = go.Scatter3d(
                    x = cluster0["PC1_3d"],
                    y = cluster0["PC2_3d"],
                    z = cluster0["PC3_3d"],
                    mode = "markers",
                    name = "Cluster 0",
                    marker = dict(color = 'rgba(255, 128, 255, 0.8)'),
                    text = None)
     trace2 = go.Scatter3d(
                    x = cluster1["PC1_3d"],
                    y = cluster1["PC2_3d"],
                    z = cluster1["PC3_3d"],
                    mode = "markers",
                    name = "Cluster 1",
                    marker = dict(color = 'rgba(255, 128, 2, 0.8)'),
                    text = None)
     trace3 = go.Scatter3d(
                    x = cluster2["PC1_3d"],
                    y = cluster2["PC2_3d"],
                    z = cluster2["PC3_3d"],
                    mode = "markers",
                    name = "Cluster 2",
                    marker = dict(color = 'rgba(0, 255, 200, 0.8)'),
                    text = None)
     data = [trace1, trace2, trace3]
     title = "Visualizing Clusters in Three Dimensions Using PCA"
     layout = dict(title = title,
                   xaxis= dict(title= 'PC1',ticklen= 5,zeroline= False),
                   yaxis= dict(title= 'PC2',ticklen= 5,zeroline= False)
                  )
     fig = dict(data = data, layout = layout)
     iplot(fig)
```

Converting To PDF File

```
[ ]: !sudo apt-get install texlive-xetex texlive-fonts-recommended␣
     ↪texlive-plain-generic
```

Reading package lists… Done
Building dependency tree
Reading state information… Done
The following package was automatically installed and is no longer required:
  libnvidia-common-460
Use 'sudo apt autoremove' to remove it.
The following additional packages will be installed:
  fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono fonts-texgyre
  javascript-common libcupsfilters1 libcupsimage2 libgs9 libgs9-common
  libijs-0.35 libjbig2dec0 libjs-jquery libkpathsea6 libpotrace0 libptexenc1
  libruby2.5 libsynctex1 libtexlua52 libtexluajit2 libzzip-0-13 lmodern
  poppler-data preview-latex-style rake ruby ruby-did-you-mean ruby-minitest
  ruby-net-telnet ruby-power-assert ruby-test-unit ruby2.5
  rubygems-integration t1utils tex-common tex-gyre texlive-base
  texlive-binaries texlive-latex-base texlive-latex-extra
  texlive-latex-recommended texlive-pictures tipa
Suggested packages:
  fonts-noto apache2 | lighttpd | httpd poppler-utils ghostscript
  fonts-japanese-mincho | fonts-ipafont-mincho fonts-japanese-gothic
  | fonts-ipafont-gothic fonts-arphic-ukai fonts-arphic-uming fonts-nanum ri
  ruby-dev bundler debhelper gv | postscript-viewer perl-tk xpdf-reader
  | pdf-viewer texlive-fonts-recommended-doc texlive-latex-base-doc
  python-pygments icc-profiles libfile-which-perl
  libspreadsheet-parseexcel-perl texlive-latex-extra-doc
  texlive-latex-recommended-doc texlive-pstricks dot2tex prerex ruby-tcltk
  | libtcltk-ruby texlive-pictures-doc vprerex
The following NEW packages will be installed:
  fonts-droid-fallback fonts-lato fonts-lmodern fonts-noto-mono fonts-texgyre
  javascript-common libcupsfilters1 libcupsimage2 libgs9 libgs9-common
  libijs-0.35 libjbig2dec0 libjs-jquery libkpathsea6 libpotrace0 libptexenc1
  libruby2.5 libsynctex1 libtexlua52 libtexluajit2 libzzip-0-13 lmodern
  poppler-data preview-latex-style rake ruby ruby-did-you-mean ruby-minitest
  ruby-net-telnet ruby-power-assert ruby-test-unit ruby2.5
  rubygems-integration t1utils tex-common tex-gyre texlive-base
  texlive-binaries texlive-fonts-recommended texlive-latex-base
  texlive-latex-extra texlive-latex-recommended texlive-pictures
  texlive-plain-generic texlive-xetex tipa
0 upgraded, 46 newly installed, 0 to remove and 20 not upgraded.
Need to get 146 MB of archives.
After this operation, 460 MB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-droid-fallback
all 1:6.0.1r16-1.1 [1,805 kB]
Get:2 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-lato all 2.0-2

[2,698 kB]
Get:3 http://archive.ubuntu.com/ubuntu bionic/main amd64 poppler-data all
0.4.8-2 [1,479 kB]
Get:4 http://archive.ubuntu.com/ubuntu bionic/main amd64 tex-common all 6.09
[33.0 kB]
Get:5 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-lmodern all
2.004.5-3 [4,551 kB]
Get:6 http://archive.ubuntu.com/ubuntu bionic/main amd64 fonts-noto-mono all
20171026-2 [75.5 kB]
Get:7 http://archive.ubuntu.com/ubuntu bionic/universe amd64 fonts-texgyre all
20160520-1 [8,761 kB]
Get:8 http://archive.ubuntu.com/ubuntu bionic/main amd64 javascript-common all
11 [6,066 B]
Get:9 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libcupsfilters1
amd64 1.20.2-0ubuntu3.1 [108 kB]
Get:10 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libcupsimage2
amd64 2.2.7-1ubuntu2.9 [18.6 kB]
Get:11 http://archive.ubuntu.com/ubuntu bionic/main amd64 libijs-0.35 amd64
0.35-13 [15.5 kB]
Get:12 http://archive.ubuntu.com/ubuntu bionic/main amd64 libjbig2dec0 amd64
0.13-6 [55.9 kB]
Get:13 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libgs9-common
all 9.26~dfsg+0-0ubuntu0.18.04.17 [5,092 kB]
Get:14 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libgs9 amd64
9.26~dfsg+0-0ubuntu0.18.04.17 [2,267 kB]
Get:15 http://archive.ubuntu.com/ubuntu bionic/main amd64 libjs-jquery all
3.2.1-1 [152 kB]
Get:16 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libkpathsea6
amd64 2017.20170613.44572-8ubuntu0.1 [54.9 kB]
Get:17 http://archive.ubuntu.com/ubuntu bionic/main amd64 libpotrace0 amd64
1.14-2 [17.4 kB]
Get:18 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libptexenc1
amd64 2017.20170613.44572-8ubuntu0.1 [34.5 kB]
Get:19 http://archive.ubuntu.com/ubuntu bionic/main amd64 rubygems-integration
all 1.11 [4,994 B]
Get:20 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 ruby2.5 amd64
2.5.1-1ubuntu1.12 [48.6 kB]
Get:21 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby amd64 1:2.5.1
[5,712 B]
Get:22 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 rake all
12.3.1-1ubuntu0.1 [44.9 kB]
Get:23 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-did-you-mean all
1.2.0-2 [9,700 B]
Get:24 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-minitest all
5.10.3-1 [38.6 kB]
Get:25 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-net-telnet all
0.1.1-2 [12.6 kB]
Get:26 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-power-assert all

```
0.3.0-1 [7,952 B]
Get:27 http://archive.ubuntu.com/ubuntu bionic/main amd64 ruby-test-unit all
3.2.5-1 [61.1 kB]
Get:28 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libruby2.5
amd64 2.5.1-1ubuntu1.12 [3,073 kB]
Get:29 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libsynctex1
amd64 2017.20170613.44572-8ubuntu0.1 [41.4 kB]
Get:30 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libtexlua52
amd64 2017.20170613.44572-8ubuntu0.1 [91.2 kB]
Get:31 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libtexluajit2
amd64 2017.20170613.44572-8ubuntu0.1 [230 kB]
Get:32 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libzzip-0-13
amd64 0.13.62-3.1ubuntu0.18.04.1 [26.0 kB]
Get:33 http://archive.ubuntu.com/ubuntu bionic/main amd64 lmodern all 2.004.5-3
[9,631 kB]
Get:34 http://archive.ubuntu.com/ubuntu bionic/main amd64 preview-latex-style
all 11.91-1ubuntu1 [185 kB]
Get:35 http://archive.ubuntu.com/ubuntu bionic/main amd64 t1utils amd64 1.41-2
[56.0 kB]
Get:36 http://archive.ubuntu.com/ubuntu bionic/universe amd64 tex-gyre all
20160520-1 [4,998 kB]
Get:37 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 texlive-
binaries amd64 2017.20170613.44572-8ubuntu0.1 [8,179 kB]
Get:38 http://archive.ubuntu.com/ubuntu bionic/main amd64 texlive-base all
2017.20180305-1 [18.7 MB]
Get:39 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-fonts-
recommended all 2017.20180305-1 [5,262 kB]
Get:40 http://archive.ubuntu.com/ubuntu bionic/main amd64 texlive-latex-base all
2017.20180305-1 [951 kB]
Get:41 http://archive.ubuntu.com/ubuntu bionic/main amd64 texlive-latex-
recommended all 2017.20180305-1 [14.9 MB]
Get:42 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-pictures
all 2017.20180305-1 [4,026 kB]
Get:43 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-latex-
extra all 2017.20180305-2 [10.6 MB]
Get:44 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-plain-
generic all 2017.20180305-2 [23.6 MB]
Get:45 http://archive.ubuntu.com/ubuntu bionic/universe amd64 tipa all 2:1.3-20
[2,978 kB]
Get:46 http://archive.ubuntu.com/ubuntu bionic/universe amd64 texlive-xetex all
2017.20180305-1 [10.7 MB]
Fetched 146 MB in 7s (21.7 MB/s)
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line 76,
<> line 46.)
debconf: falling back to frontend: Readline
debconf: unable to initialize frontend: Readline
```

```
debconf: (This frontend requires a controlling tty.)
debconf: falling back to frontend: Teletype
dpkg-preconfigure: unable to re-open stdin:
Selecting previously unselected package fonts-droid-fallback.
(Reading database … 124013 files and directories currently installed.)
Preparing to unpack …/00-fonts-droid-fallback_1%3a6.0.1r16-1.1_all.deb …
Unpacking fonts-droid-fallback (1:6.0.1r16-1.1) …
Selecting previously unselected package fonts-lato.
Preparing to unpack …/01-fonts-lato_2.0-2_all.deb …
Unpacking fonts-lato (2.0-2) …
Selecting previously unselected package poppler-data.
Preparing to unpack …/02-poppler-data_0.4.8-2_all.deb …
Unpacking poppler-data (0.4.8-2) …
Selecting previously unselected package tex-common.
Preparing to unpack …/03-tex-common_6.09_all.deb …
Unpacking tex-common (6.09) …
Selecting previously unselected package fonts-lmodern.
Preparing to unpack …/04-fonts-lmodern_2.004.5-3_all.deb …
Unpacking fonts-lmodern (2.004.5-3) …
Selecting previously unselected package fonts-noto-mono.
Preparing to unpack …/05-fonts-noto-mono_20171026-2_all.deb …
Unpacking fonts-noto-mono (20171026-2) …
Selecting previously unselected package fonts-texgyre.
Preparing to unpack …/06-fonts-texgyre_20160520-1_all.deb …
Unpacking fonts-texgyre (20160520-1) …
Selecting previously unselected package javascript-common.
Preparing to unpack …/07-javascript-common_11_all.deb …
Unpacking javascript-common (11) …
Selecting previously unselected package libcupsfilters1:amd64.
Preparing to unpack …/08-libcupsfilters1_1.20.2-0ubuntu3.1_amd64.deb …
Unpacking libcupsfilters1:amd64 (1.20.2-0ubuntu3.1) …
Selecting previously unselected package libcupsimage2:amd64.
Preparing to unpack …/09-libcupsimage2_2.2.7-1ubuntu2.9_amd64.deb …
Unpacking libcupsimage2:amd64 (2.2.7-1ubuntu2.9) …
Selecting previously unselected package libijs-0.35:amd64.
Preparing to unpack …/10-libijs-0.35_0.35-13_amd64.deb …
Unpacking libijs-0.35:amd64 (0.35-13) …
Selecting previously unselected package libjbig2dec0:amd64.
Preparing to unpack …/11-libjbig2dec0_0.13-6_amd64.deb …
Unpacking libjbig2dec0:amd64 (0.13-6) …
Selecting previously unselected package libgs9-common.
Preparing to unpack …/12-libgs9-common_9.26~dfsg+0-0ubuntu0.18.04.17_all.deb
…
Unpacking libgs9-common (9.26~dfsg+0-0ubuntu0.18.04.17) …
Selecting previously unselected package libgs9:amd64.
Preparing to unpack …/13-libgs9_9.26~dfsg+0-0ubuntu0.18.04.17_amd64.deb …
Unpacking libgs9:amd64 (9.26~dfsg+0-0ubuntu0.18.04.17) …
Selecting previously unselected package libjs-jquery.
```

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Preparing to unpack …/14-libjs-jquery_3.2.1-1_all.deb …
Unpacking libjs-jquery (3.2.1-1) …
Selecting previously unselected package libkpathsea6:amd64.
Preparing to unpack …/15-libkpathsea6_2017.20170613.44572-8ubuntu0.1_amd64.deb
…
Unpacking libkpathsea6:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package libpotrace0.
Preparing to unpack …/16-libpotrace0_1.14-2_amd64.deb …
Unpacking libpotrace0 (1.14-2) …
Selecting previously unselected package libptexenc1:amd64.
Preparing to unpack …/17-libptexenc1_2017.20170613.44572-8ubuntu0.1_amd64.deb
…
Unpacking libptexenc1:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package rubygems-integration.
Preparing to unpack …/18-rubygems-integration_1.11_all.deb …
Unpacking rubygems-integration (1.11) …
Selecting previously unselected package ruby2.5.
Preparing to unpack …/19-ruby2.5_2.5.1-1ubuntu1.12_amd64.deb …
Unpacking ruby2.5 (2.5.1-1ubuntu1.12) …
Selecting previously unselected package ruby.
Preparing to unpack …/20-ruby_1%3a2.5.1_amd64.deb …
Unpacking ruby (1:2.5.1) …
Selecting previously unselected package rake.
Preparing to unpack …/21-rake_12.3.1-1ubuntu0.1_all.deb …
Unpacking rake (12.3.1-1ubuntu0.1) …
Selecting previously unselected package ruby-did-you-mean.
Preparing to unpack …/22-ruby-did-you-mean_1.2.0-2_all.deb …
Unpacking ruby-did-you-mean (1.2.0-2) …
Selecting previously unselected package ruby-minitest.
Preparing to unpack …/23-ruby-minitest_5.10.3-1_all.deb …
Unpacking ruby-minitest (5.10.3-1) …
Selecting previously unselected package ruby-net-telnet.
Preparing to unpack …/24-ruby-net-telnet_0.1.1-2_all.deb …
Unpacking ruby-net-telnet (0.1.1-2) …
Selecting previously unselected package ruby-power-assert.
Preparing to unpack …/25-ruby-power-assert_0.3.0-1_all.deb …
Unpacking ruby-power-assert (0.3.0-1) …
Selecting previously unselected package ruby-test-unit.
Preparing to unpack …/26-ruby-test-unit_3.2.5-1_all.deb …
Unpacking ruby-test-unit (3.2.5-1) …
Selecting previously unselected package libruby2.5:amd64.
Preparing to unpack …/27-libruby2.5_2.5.1-1ubuntu1.12_amd64.deb …
Unpacking libruby2.5:amd64 (2.5.1-1ubuntu1.12) …
Selecting previously unselected package libsynctex1:amd64.
Preparing to unpack …/28-libsynctex1_2017.20170613.44572-8ubuntu0.1_amd64.deb
…
Unpacking libsynctex1:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package libtexlua52:amd64.
```

```
Preparing to unpack …/29-libtexlua52_2017.20170613.44572-8ubuntu0.1_amd64.deb
…
Unpacking libtexlua52:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package libtexluajit2:amd64.
Preparing to unpack
…/30-libtexluajit2_2017.20170613.44572-8ubuntu0.1_amd64.deb …
Unpacking libtexluajit2:amd64 (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package libzzip-0-13:amd64.
Preparing to unpack …/31-libzzip-0-13_0.13.62-3.1ubuntu0.18.04.1_amd64.deb …
Unpacking libzzip-0-13:amd64 (0.13.62-3.1ubuntu0.18.04.1) …
Selecting previously unselected package lmodern.
Preparing to unpack …/32-lmodern_2.004.5-3_all.deb …
Unpacking lmodern (2.004.5-3) …
Selecting previously unselected package preview-latex-style.
Preparing to unpack …/33-preview-latex-style_11.91-1ubuntu1_all.deb …
Unpacking preview-latex-style (11.91-1ubuntu1) …
Selecting previously unselected package t1utils.
Preparing to unpack …/34-t1utils_1.41-2_amd64.deb …
Unpacking t1utils (1.41-2) …
Selecting previously unselected package tex-gyre.
Preparing to unpack …/35-tex-gyre_20160520-1_all.deb …
Unpacking tex-gyre (20160520-1) …
Selecting previously unselected package texlive-binaries.
Preparing to unpack …/36-texlive-
binaries_2017.20170613.44572-8ubuntu0.1_amd64.deb …
Unpacking texlive-binaries (2017.20170613.44572-8ubuntu0.1) …
Selecting previously unselected package texlive-base.
Preparing to unpack …/37-texlive-base_2017.20180305-1_all.deb …
Unpacking texlive-base (2017.20180305-1) …
Selecting previously unselected package texlive-fonts-recommended.
Preparing to unpack …/38-texlive-fonts-recommended_2017.20180305-1_all.deb …
Unpacking texlive-fonts-recommended (2017.20180305-1) …
Selecting previously unselected package texlive-latex-base.
Preparing to unpack …/39-texlive-latex-base_2017.20180305-1_all.deb …
Unpacking texlive-latex-base (2017.20180305-1) …
Selecting previously unselected package texlive-latex-recommended.
Preparing to unpack …/40-texlive-latex-recommended_2017.20180305-1_all.deb …
Unpacking texlive-latex-recommended (2017.20180305-1) …
Selecting previously unselected package texlive-pictures.
Preparing to unpack …/41-texlive-pictures_2017.20180305-1_all.deb …
Unpacking texlive-pictures (2017.20180305-1) …
Selecting previously unselected package texlive-latex-extra.
Preparing to unpack …/42-texlive-latex-extra_2017.20180305-2_all.deb …
Unpacking texlive-latex-extra (2017.20180305-2) …
Selecting previously unselected package texlive-plain-generic.
Preparing to unpack …/43-texlive-plain-generic_2017.20180305-2_all.deb …
Unpacking texlive-plain-generic (2017.20180305-2) …
Selecting previously unselected package tipa.
```

```
Preparing to unpack …/44-tipa_2%3a1.3-20_all.deb …
Unpacking tipa (2:1.3-20) …
Selecting previously unselected package texlive-xetex.
Preparing to unpack …/45-texlive-xetex_2017.20180305-1_all.deb …
Unpacking texlive-xetex (2017.20180305-1) …
Setting up libgs9-common (9.26~dfsg+0-0ubuntu0.18.04.17) …
Setting up libkpathsea6:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up libjs-jquery (3.2.1-1) …
Setting up libtexlua52:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up fonts-droid-fallback (1:6.0.1r16-1.1) …
Setting up libsynctex1:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up libptexenc1:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up tex-common (6.09) …
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line
76.)
debconf: falling back to frontend: Readline
update-language: texlive-base not installed and configured, doing nothing!
Setting up poppler-data (0.4.8-2) …
Setting up tex-gyre (20160520-1) …
Setting up preview-latex-style (11.91-1ubuntu1) …
Setting up fonts-texgyre (20160520-1) …
Setting up fonts-noto-mono (20171026-2) …
Setting up fonts-lato (2.0-2) …
Setting up libcupsfilters1:amd64 (1.20.2-0ubuntu3.1) …
Setting up libcupsimage2:amd64 (2.2.7-1ubuntu2.9) …
Setting up libjbig2dec0:amd64 (0.13-6) …
Setting up ruby-did-you-mean (1.2.0-2) …
Setting up t1utils (1.41-2) …
Setting up ruby-net-telnet (0.1.1-2) …
Setting up libijs-0.35:amd64 (0.35-13) …
Setting up rubygems-integration (1.11) …
Setting up libpotrace0 (1.14-2) …
Setting up javascript-common (11) …
Setting up ruby-minitest (5.10.3-1) …
Setting up libzzip-0-13:amd64 (0.13.62-3.1ubuntu0.18.04.1) …
Setting up libgs9:amd64 (9.26~dfsg+0-0ubuntu0.18.04.17) …
Setting up libtexluajit2:amd64 (2017.20170613.44572-8ubuntu0.1) …
Setting up fonts-lmodern (2.004.5-3) …
Setting up ruby-power-assert (0.3.0-1) …
Setting up texlive-binaries (2017.20170613.44572-8ubuntu0.1) …
update-alternatives: using /usr/bin/xdvi-xaw to provide /usr/bin/xdvi.bin
(xdvi.bin) in auto mode
update-alternatives: using /usr/bin/bibtex.original to provide /usr/bin/bibtex
(bibtex) in auto mode
Setting up texlive-base (2017.20180305-1) …
mktexlsr: Updating /var/lib/texmf/ls-R-TEXLIVEDIST…
```

```
mktexlsr: Updating /var/lib/texmf/ls-R-TEXMFMAIN...
mktexlsr: Updating /var/lib/texmf/ls-R...
mktexlsr: Done.
tl-paper: setting paper size for dvips to a4:
/var/lib/texmf/dvips/config/config-paper.ps
tl-paper: setting paper size for dvipdfmx to a4:
/var/lib/texmf/dvipdfmx/dvipdfmx-paper.cfg
tl-paper: setting paper size for xdvi to a4: /var/lib/texmf/xdvi/XDvi-paper
tl-paper: setting paper size for pdftex to a4:
/var/lib/texmf/tex/generic/config/pdftexconfig.tex
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line
76.)
debconf: falling back to frontend: Readline
Setting up texlive-fonts-recommended (2017.20180305-1) ...
Setting up texlive-plain-generic (2017.20180305-2) ...
Setting up texlive-latex-base (2017.20180305-1) ...
Setting up lmodern (2.004.5-3) ...
Setting up texlive-latex-recommended (2017.20180305-1) ...
Setting up texlive-pictures (2017.20180305-1) ...
Setting up tipa (2:1.3-20) ...
Regenerating '/var/lib/texmf/fmtutil.cnf-DEBIAN'... done.
Regenerating '/var/lib/texmf/fmtutil.cnf-TEXLIVEDIST'... done.
update-fmtutil has updated the following file(s):
        /var/lib/texmf/fmtutil.cnf-DEBIAN
        /var/lib/texmf/fmtutil.cnf-TEXLIVEDIST
If you want to activate the changes in the above file(s),
you should run fmtutil-sys or fmtutil.
Setting up texlive-latex-extra (2017.20180305-2) ...
Setting up texlive-xetex (2017.20180305-1) ...
Setting up ruby2.5 (2.5.1-1ubuntu1.12) ...
Setting up ruby (1:2.5.1) ...
Setting up ruby-test-unit (3.2.5-1) ...
Setting up rake (12.3.1-1ubuntu0.1) ...
Setting up libruby2.5:amd64 (2.5.1-1ubuntu1.12) ...
Processing triggers for mime-support (3.60ubuntu1) ...
Processing triggers for libc-bin (2.27-3ubuntu1.6) ...
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
Processing triggers for fontconfig (2.12.6-0ubuntu2) ...
Processing triggers for tex-common (6.09) ...
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based
frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line
76.)
debconf: falling back to frontend: Readline
Running updmap-sys. This may take some time... done.
Running mktexlsr /var/lib/texmf ... done.
```

```
Building format(s) --all.
        This may take some time… done.
```

```
[ ]: !jupyter nbconvert --to pdf /content/PCA.ipynb
```

```
[NbConvertApp] Converting notebook /content/PCA.ipynb to pdf
/usr/local/lib/python3.8/dist-packages/nbconvert/filters/datatypefilter.py:39:
UserWarning: Your element with mimetype(s) dict_keys(['text/html']) is not able
to be represented.
  warn("Your element with mimetype(s) {mimetypes}"
/usr/local/lib/python3.8/dist-packages/nbconvert/filters/datatypefilter.py:39:
UserWarning: Your element with mimetype(s) dict_keys(['text/html']) is not able
to be represented.
  warn("Your element with mimetype(s) {mimetypes}"
/usr/local/lib/python3.8/dist-packages/nbconvert/filters/datatypefilter.py:39:
UserWarning: Your element with mimetype(s) dict_keys(['text/html']) is not able
to be represented.
  warn("Your element with mimetype(s) {mimetypes}"
[NbConvertApp] Writing 72501 bytes to ./notebook.tex
[NbConvertApp] Building PDF
[NbConvertApp] Running xelatex 3 times: ['xelatex', './notebook.tex', '-quiet']
[NbConvertApp] Running bibtex 1 time: ['bibtex', './notebook']
[NbConvertApp] WARNING | bibtex had problems, most likely because there were no
citations
[NbConvertApp] PDF successfully created
[NbConvertApp] Writing 52642 bytes to /content/PCA.pdf
```