

In [1]:

```
# This Python 3 environment comes with many helpful analytics libraries installed
# It is defined by the kaggle/python docker image: https://github.com/kaggle/docker-
python
# For example, here's several helpful packages to load in

import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)

# Input data files are available in the "../input/" directory.
# For example, running this (by clicking run or pressing Shift+Enter) will list the
files in the input directory

import os
print(os.listdir("../input"))

# Any results you write to the current directory are saved as output.

['seed-from-uci', 'seeds-width-length', 'fishdata', 'wineuci', 'wikipediavectors']
```

Clustering for dataset exploration ¶

Definition

Unsupervised learning is all about finding patterns in the data.

Ex: Clustering Customers by their purchases , Compressing the data using purchase pattern
(dimensionality reduction)

Difference between Supervised and Unsupervised Learning

Supervised learning finds the pattern for a prediction task , unsupervised learning find patterns
but without specific prediction in mind.

Datasets used Iris

K Means Clustering Finds clusters of samples

Number of clusters must be specified in advance.

New samples can be assigned to existing cluster

K means remembers the mean of each cluster (Cluster Centroids)

Finds the nearest centroid for each new sample

In [2]:

```
from sklearn.datasets import load_iris
import matplotlib.pyplot as plt
from sklearn.cluster import KMeans
```

In [3]:

```
iris=load_iris()
```

```

samples=iris.data
model=KMeans(n_clusters=3)
model.fit(samples)
labels=model.predict(samples)
print(labels)

```

```

[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 2 2 2 2 1 2 2 2
 2 2 1 1 2 2 2 2 1 2 1 2 1 2 2 1 1 2 2 2 2 1 2 2 2 2 1 2 2 2 1 2
 2 1]

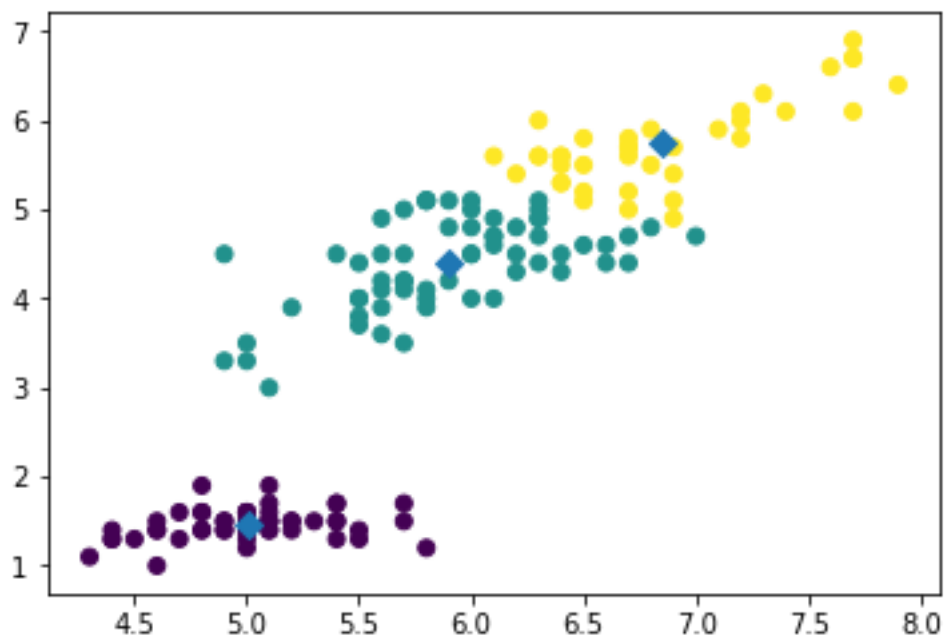
```

In [4]:

```

# plotting sepal length and petal length
xs=samples[:,0]
ys=samples[:,2]
plt.scatter(xs,ys,c=labels)
centroids=model.cluster_centers_
centroids_x=centroids[:,0]
centroids_y=centroids[:,2]
plt.scatter(centroids_x,centroids_y,marker='D',s=50)
plt.show()

```



Evaluating a Cluster Inertia measures cluster quality Measures how spread the clusters are , the lower the better Distance from each sample to centroid of its cluster After fit available as attribute inertia_ k means attempts to minimize the inertia when choosing the clusters

The number of clusters More clusters means lower inertia , A good clustering has tight clusters , so low inertia but not too many clusters Choose an elbow in the inertia plot , where inertia begins to decrease more slowly

Analysing seeds data from UCI

In [5]:

```
seeds=pd.read_csv('../input/seed-from-uci/Seed_Data.csv')
seeds.head()
```

Out[5]:

	A	P	C	LK	WKA_Coef	LKG	target
0	15.26	14.84	0.8710	5.763	3.312	2.221	5.220
1	14.88	14.57	0.8811	5.554	3.333	1.018	4.956
2	14.29	14.09	0.9050	5.291	3.337	2.699	4.825
3	13.84	13.94	0.8955	5.324	3.379	2.259	4.805
4	16.14	14.99	0.9034	5.658	3.562	1.355	5.175

In [6]:

```
seed_dict={
    0:'Kama',
    1:'Rosa',
    2:'Canadian'
}
seed_list=seeds['target'].map(seed_dict).tolist()
```

In [7]:

```
# Preparing seeds for clustering by dropping the target column

seeds=seeds.drop(['target'],axis=1)
seeds.head()
```

Out[7]:

	A	P	C	LK	WKA_Coef	LKG
0	15.26	14.84	0.8710	5.763	3.312	2.221
1	14.88	14.57	0.8811	5.554	3.333	1.018
2	14.29	14.09	0.9050	5.291	3.337	2.699
3	13.84	13.94	0.8955	5.324	3.379	2.259
4	16.14	14.99	0.9034	5.658	3.562	1.355

In [8]:

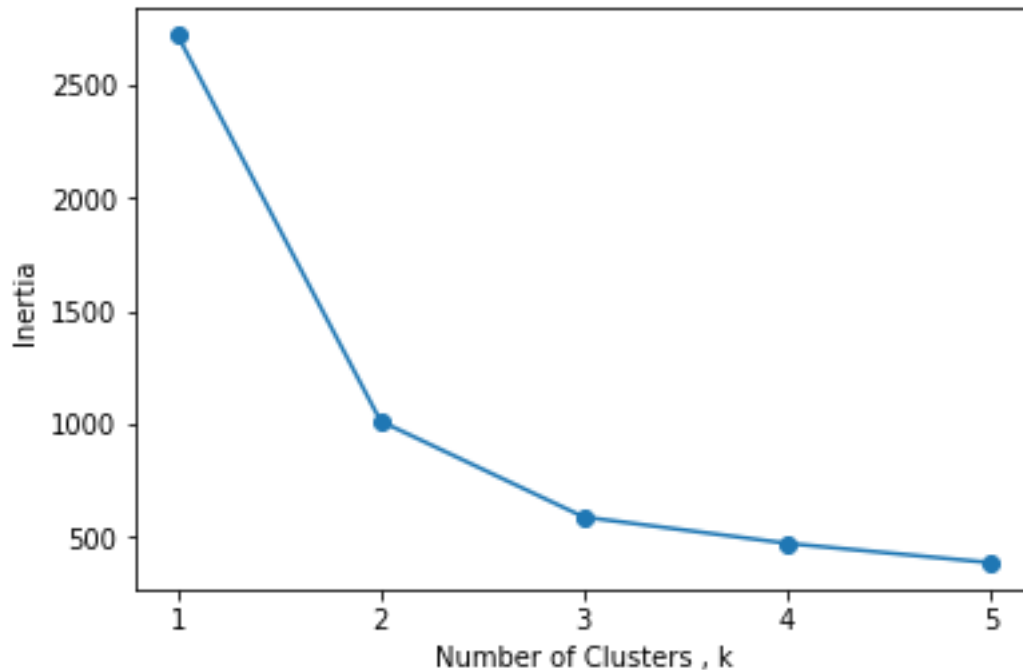
```
ks=range(1,6)
inertias=[]

for k in ks:
    model=KMeans(n_clusters=k)
    model.fit(seeds)
    inertias.append(model.inertia_)

plt.plot(ks,inertias,'-o')
```

```
plt.xlabel('Number of Clusters , k')
plt.ylabel('Inertia')
plt.xticks(ks)
plt.show()

# Inertia decreases from 3 to 4 very slowly , so 3 can be a good choice
```



In [9]:

```
seeds.head()
```

Out[9]:

	A	P	C	LK	WKA	Coef	LKG
0	15.26	14.84	0.8710	5.763	3.312	2.221	5.220
1	14.88	14.57	0.8811	5.554	3.333	1.018	4.956
2	14.29	14.09	0.9050	5.291	3.337	2.699	4.825
3	13.84	13.94	0.8955	5.324	3.379	2.259	4.805
4	16.14	14.99	0.9034	5.658	3.562	1.355	5.175

In [10]:

```
model=KMeans(n_clusters=3)
seed_labels=model.fit_predict(seeds)
centroids=model.cluster_centers_
centroids
```

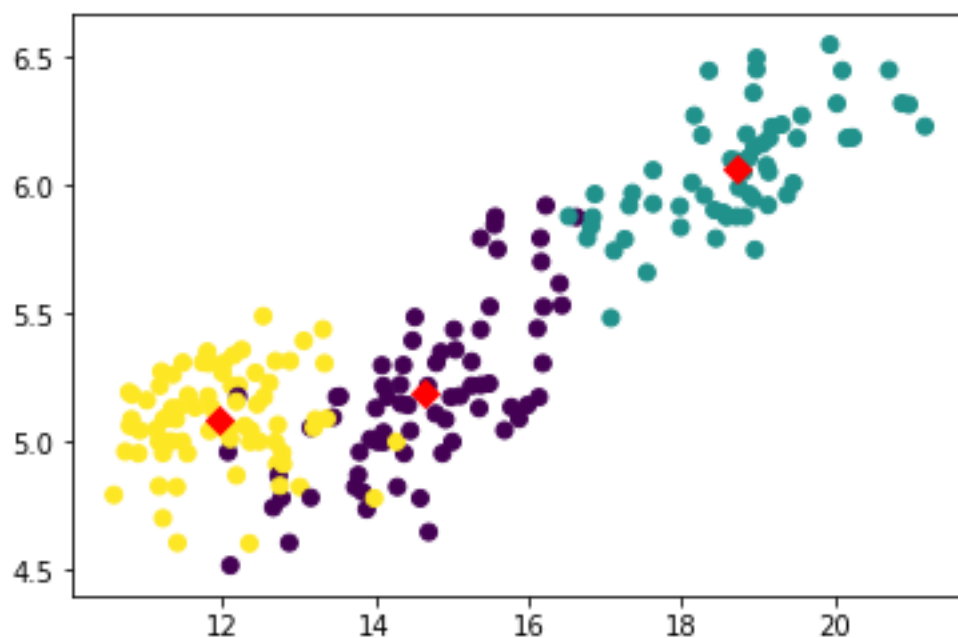
Out[10]:

```
array([[14.64847222, 14.46041667,  0.87916667,  5.56377778,  3.27790278,
        2.64893333,  5.19231944],
       [18.72180328, 16.29737705,  0.88508689,  6.20893443,  3.72267213,
        3.60359016,  6.06609836],
       [11.96441558, 13.27480519,  0.8522      ,  5.22928571,  2.87292208,
```

```
4.75974026, 5.08851948]])
```

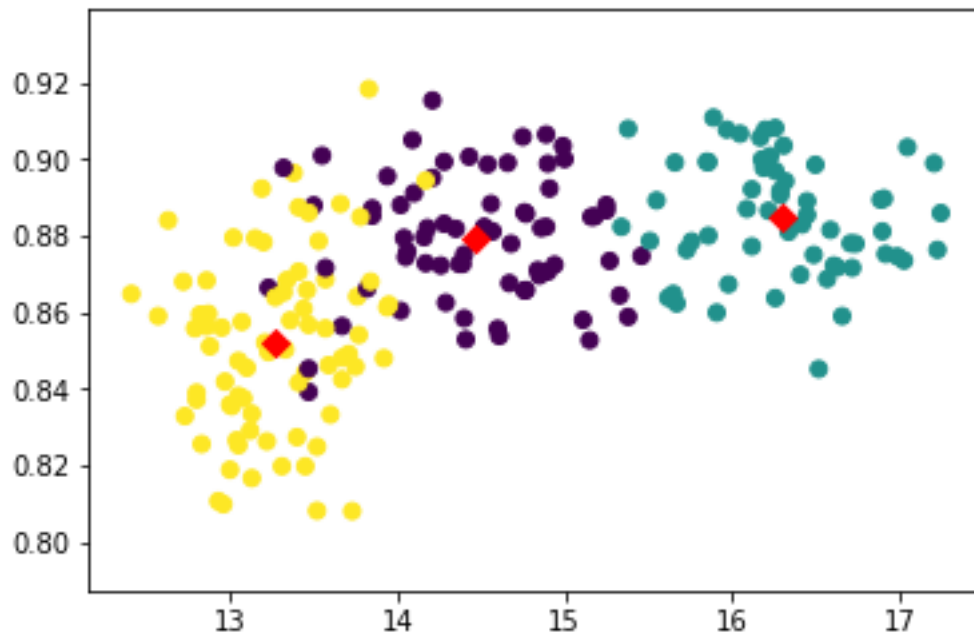
In [11]:

```
# A vs LKG
xs_A=seeds.iloc[:,0]
ys_LKG=seeds.iloc[:,-1]
centroids_xs_A=centroids[:,0]
centroids_ys_LKG=centroids[:,-1]
plt.scatter(xs_A,ys_LKG,c=seed_labels)
plt.scatter(centroids_xs_A,centroids_ys_LKG,marker='D',s=50,c='red')
plt.show()
```



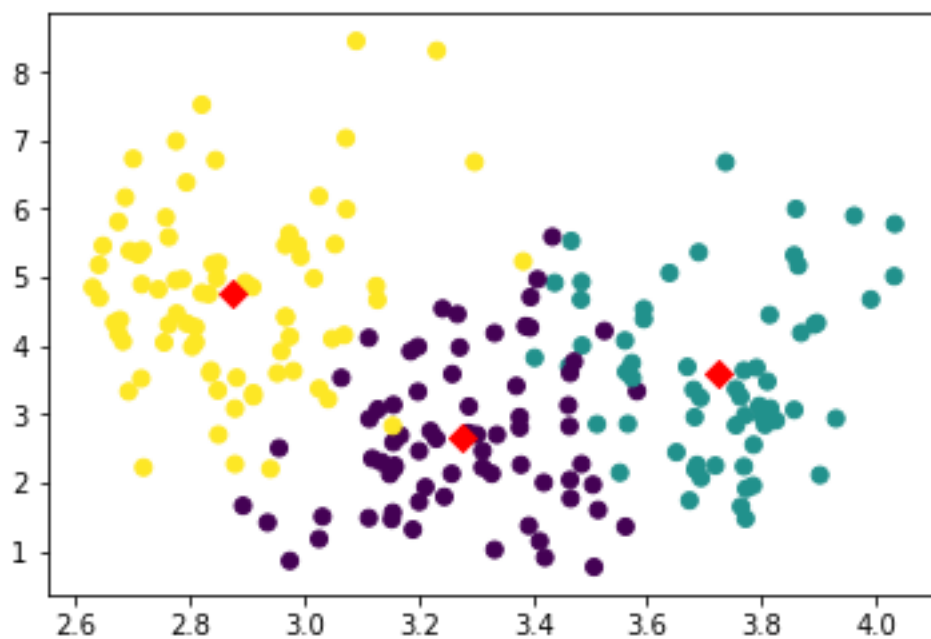
In [12]:

```
# P vs C
xs_A=seeds.iloc[:,1]
ys_LKG=seeds.iloc[:,2]
centroids_xs_A=centroids[:,1]
centroids_ys_LKG=centroids[:,2]
plt.scatter(xs_A,ys_LKG,c=seed_labels)
plt.scatter(centroids_xs_A,centroids_ys_LKG,marker='D',s=50,c='red')
plt.show()
```



In [13]:

```
# WK vs A_Coeff
xs_A=seeds.iloc[:,4]
ys_LKG=seeds.iloc[:,5]
centroids_xs_A=centroids[:,4]
centroids_ys_LKG=centroids[:,5]
plt.scatter(xs_A,ys_LKG,c=seed_labels)
plt.scatter(centroids_xs_A,centroids_ys_LKG,marker='D',s=50,c='red')
plt.show()
```



Tranforming Features for Better Clustering

Piedmont wine Dataset

In [14]:

```
wine=pd.read_csv('../input/wineuci/Wine.csv',header=None)
wine.head()
```

Out[14]:

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	1	14.23	1.71	2.43	15.6	127	2.80	3.06	0.28	2.29	5.64	1.04	3.92	1065
1	1	13.20	1.78	2.14	11.2	100	2.65	2.76	0.26	1.28	4.38	1.05	3.40	1050
2	1	13.16	2.36	2.67	18.6	101	2.80	3.24	0.30	2.81	5.68	1.03	3.17	1185
3	1	14.37	1.95	2.50	16.8	113	3.85	3.49	0.24	2.18	7.80	0.86	3.45	1480
4	1	13.24	2.59	2.87	21.0	118	2.80	2.69	0.39	1.82	4.32	1.04	2.93	735

In [15]:

```
wine.columns=['Class','Alcohol','Malic_acid','Ash','Alcalinity_of_ash','Magnesium',
'Total_phenols','Flavanoids','Nonflavanoid_phenols','Proanthocyanins','Color_intens
ity','Hue','OD280','Proline']
```

In [16]:

```
wine.head()
```

Out[16]:

	Class	Alcohol	Malic_acid	Ash	Alcalinity_of_ash	Magnesium	Total_phenols	Flavanoids	Nonflavanoid_phenols	Proanthocyanins	Color_intensity	Hue	OD280	Proline
0	1	14.23	1.71	2.43	15.6	127	2.80	3.06	0.28					2.2
1	1	13.20	1.78	2.14	11.2	100	2.65	2.76	0.26					1.2
2	1	13.16	2.36	2.67	18.6	101	2.80	3.24	0.30					2.8
3	1	14.37	1.95	2.50	16.8	113	3.85	3.49	0.24					2.1
4	1	13.24	2.59	2.87	21.0	118	2.80	2.69	0.39					1.8

In [17]:

```
wine_class=wine['Class']
wine.drop('Class',axis=1,inplace=True)
```

In [18]:

```
model=KMeans(n_clusters=3)
labels=model.fit_predict(wine)

df=pd.DataFrame({'labels':labels , 'class':wine_class})
ct=pd.crosstab(df['labels'],df['class'])
ct
```

Out[18]:

class	1	2	3
labels			
0	13	20	29

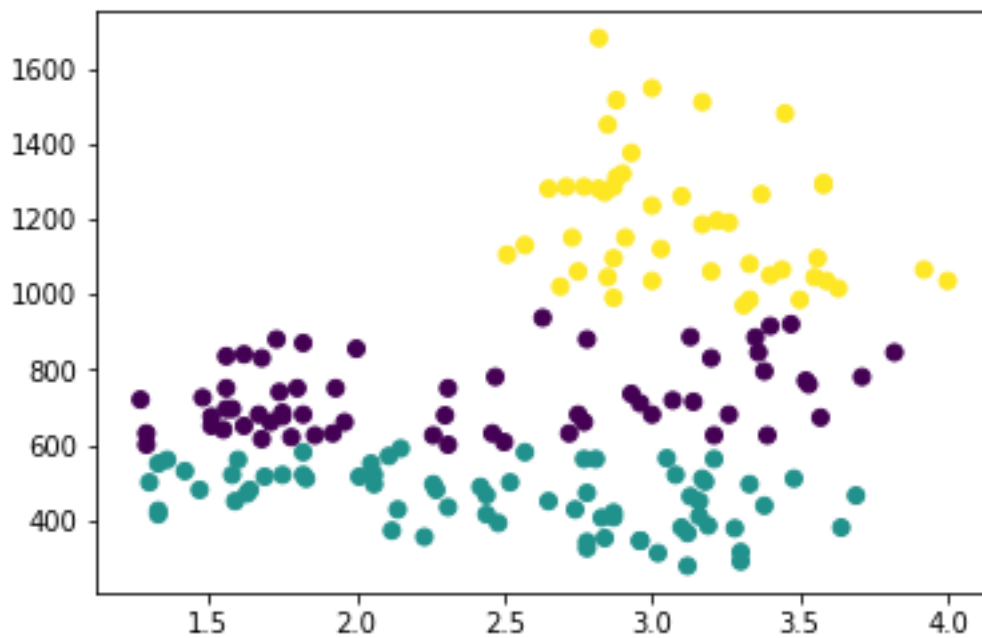
class	1	2	3
labels			
1	0	50	19
2	46	1	0

In [19]:

```
xs=wine.loc[:, 'OD280']
ys=wine.loc[:, 'Proline']
plt.scatter(xs,ys,c=labels)
```

Out[19]:

<matplotlib.collections.PathCollection at 0x7f053b953828>



Feature Variances The wine features have very different variances (spread of its values) Hence the cross tabulation results has loose clusters (too many values overlapping). Example Cluster labeled 2 , has all the three class of Wines in it.

In [20]:

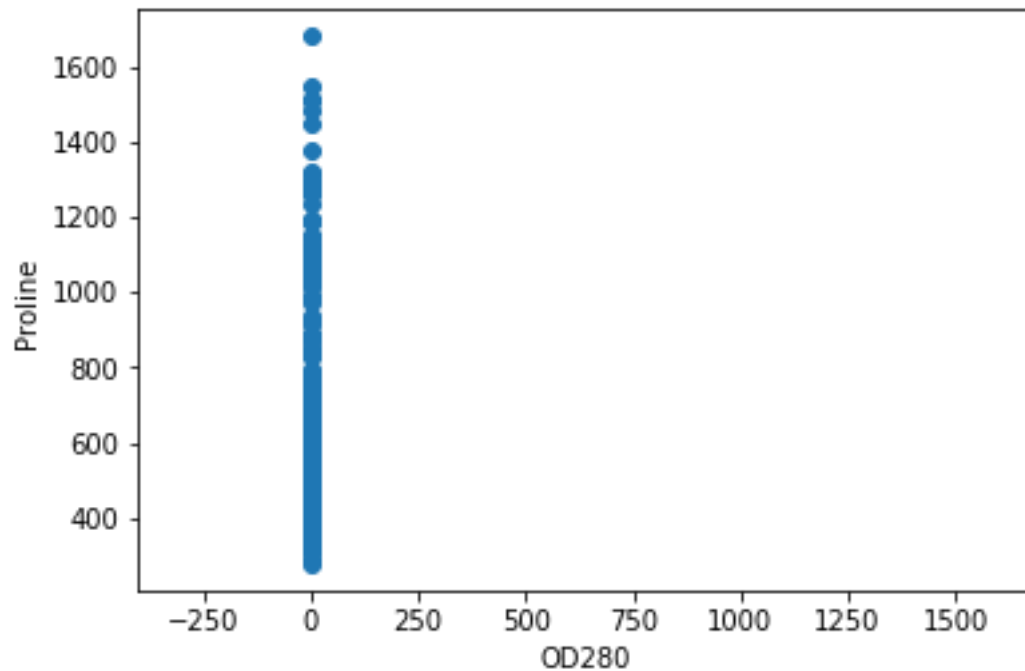
```
wine.var(axis=0)
```

Out[20]:

```
Alcohol          0.659062
Malic_acid       1.248015
Ash              0.075265
Alcalinity_of_ash 11.152686
Magnesium        203.989335
Total_phenols    0.391690
Flavanoids       0.997719
Nonflavanoid_phenols 0.015489
Proanthocyanins  0.327595
Color_intensity  5.374449
Hue              0.052245
OD280            0.504086
Proline          99166.717355
dtype: float64
```


In [21]:

```
# Variance comparison between Proline and OD280
plt.scatter(wine['OD280'],wine['Proline'])
plt.xlim(-400,max(wine['Proline']))
plt.xlabel('OD280')
plt.ylabel('Proline')
plt.show()
```



Applying Standard Scaler (then KMeans in sklearn Pipeline)

In [22]:

```
from sklearn.preprocessing import StandardScaler
from sklearn.pipeline import make_pipeline
scaler=StandardScaler()
kmeans=KMeans(n_clusters=3)
pipeline=make_pipeline(scaler,kmeans)
pipeline.fit(wine)
labels=pipeline.predict(wine)
```

In [23]:

```
df=pd.DataFrame({'labels':labels,'class':wine_class  })
ct=pd.crosstab(df['labels'],df['class'])
ct
# After scaling we get tight clusters
```

class	1	2	3
labels			
0	0	650	
1	593	0	
2	0	3	48

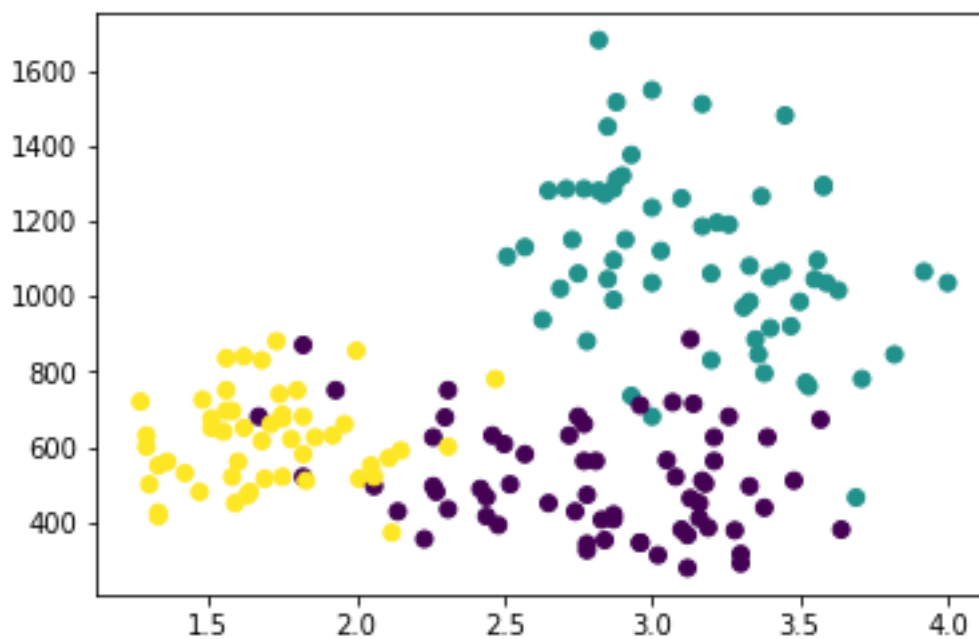
Out[23]:

In [24]:

```
xs=wine.loc[:, 'OD280']
ys=wine.loc[:, 'Proline']
plt.scatter(xs,ys,c=labels)
```

Out[24]:

<matplotlib.collections.PathCollection at 0x7f0537f9fcc0>



Scaling without pipeline

In [25]:

```
scaled_wine=scaler.fit_transform(wine)
scaled_wine.var(axis=0)
```

Out[25]:

```
array([1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1.])
```

In [26]:

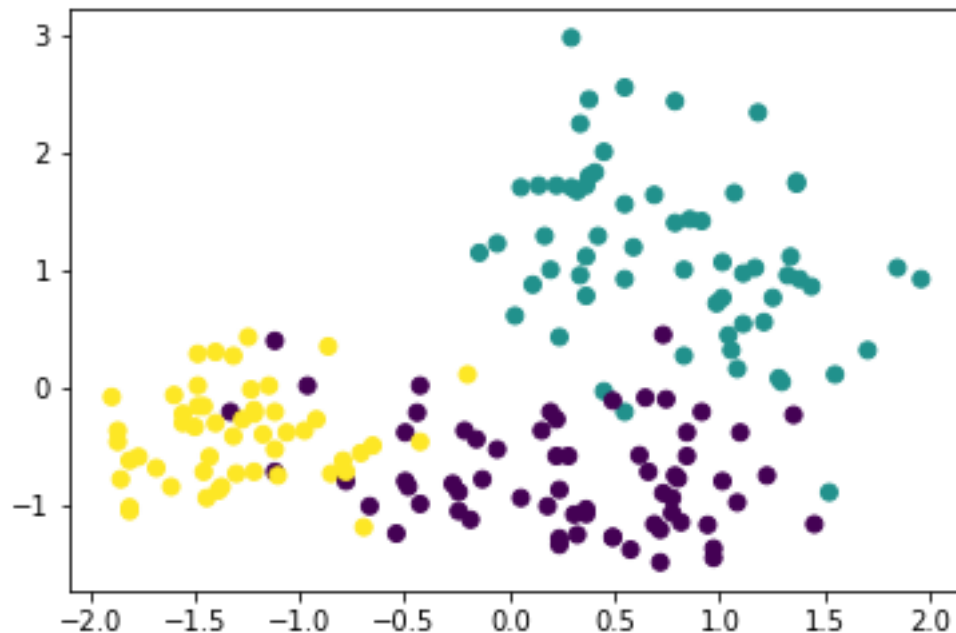
```
scaled_wine=pd.DataFrame(scaled_wine)
scaled_wine.columns=['Alcohol', 'Malic_acid', 'Ash', 'Alcalinity_of_ash', 'Magnesium', 'Total_phenols', 'Flavanoids', 'Nonflavanoid_phenols', 'Proanthocyanins', 'Color_intensity', 'Hue', 'OD280', 'Proline']
```

In [27]:

```
labels=KMeans(n_clusters=3).fit_predict(scaled_wine)
xs=scaled_wine.loc[:, 'OD280']
ys=scaled_wine.loc[:, 'Proline']
plt.scatter(xs,ys,c=labels)
```

Out[27]:

<matplotlib.collections.PathCollection at 0x7f0537f072b0>



Visualization with hierarchical clustering and t-SNE

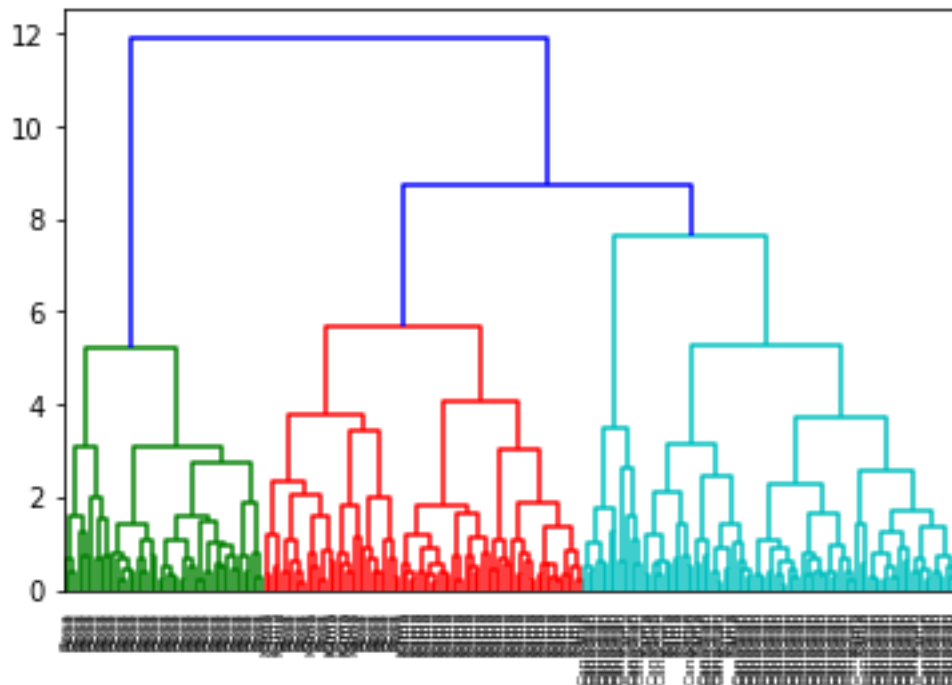
Hierarchical Clustering

In [28]:

```
from scipy.cluster.hierarchy import linkage, dendrogram, fcluster
```

In [29]:

```
mergings=linkage(seeds,method='complete')
#plt.figure(figsize=(50,50))
dendrogram(mergings,labels=seed_list,leaf_rotation=90,leaf_font_size=6)
plt.show()
```



Cluster Labels in Hierarchical Clustering Cluster labels at any intermediate stage can be recovered Then they can be used in cross tabulation Height can be used to extract intermediate clusters Height on the dendrogram is the distance between merging clusters

Distance Between Clusters Defined by linkage method Specified via method parameter

'complete' means distance between clusters is maximum distance between their samples

Extracting Cluster Labels Use the `fcluster` method Returns numpy array of cluster labels

In [30]:

```
labels=fcluster(mergings,6,criterion='distance')
print(labels)
```

[illegible]

In [31]:

```
df=pd.DataFrame({'labels':labels,
                  'seed_variety':seed_list})

ct=pd.crosstab(df['labels'],df['seed_variety'])
ct
```

Out[31]:

seed_variety	Canadian	Kama	Rosa
labels			
1	0	0	47
2	0	52	23

seed_variety	Canadian	Kama	Rosa
labels			
3	13	1	0
4	57	17	0

t-SNE for 2- dimensional maps t distributed stochastic neighbor embedding Maps samples to 2D or 3D space Map approximately preserves nearness of samples Great for inspecting datasets

t-SNE on iris data Iris samples are 4D t-SNE maps samples to 2D space

Interpreting t-SNE scatter plots 'versicolor' and 'virginica' harder to distinguish Consistent with inertia plot from KMeans (both 2 and 3 clusters can be viewed)

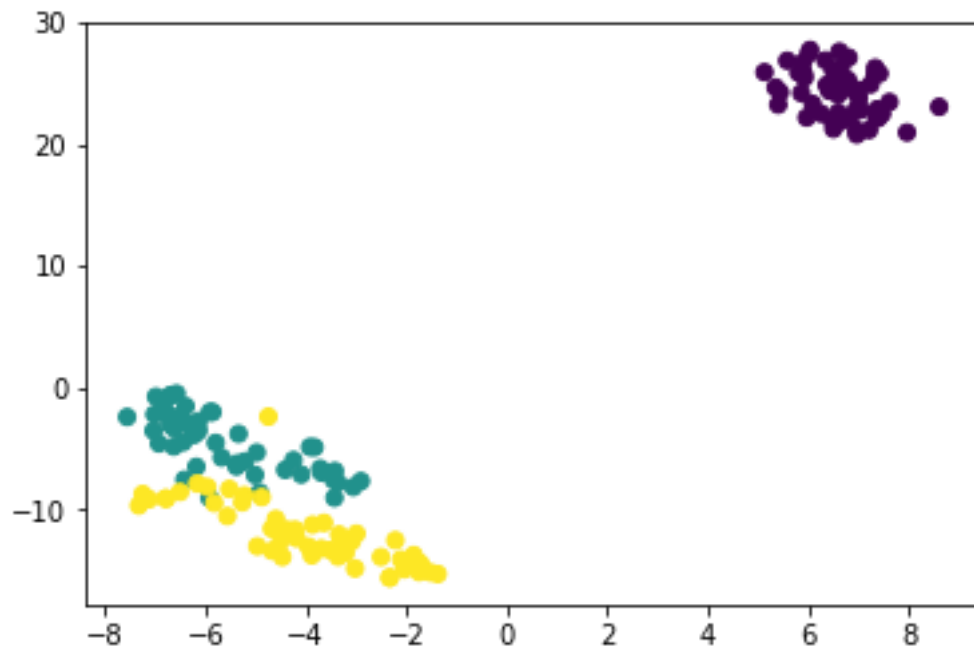
t SNE in sklearn It has a fit_transform method , no separate fit and transform methods exist.Cant extend the map to new data. Learning rate should be carefully chosen , wrong choice can bunch points together , values between 50 and 200 can be chosen. t sne features are different every time , running again gives a different scatter plot , although the relative position of clusters remain the same.

In [32]:

```
from sklearn.datasets import load_iris
from sklearn.manifold import TSNE
iris=load_iris()
data=iris.data
species=iris.target
```

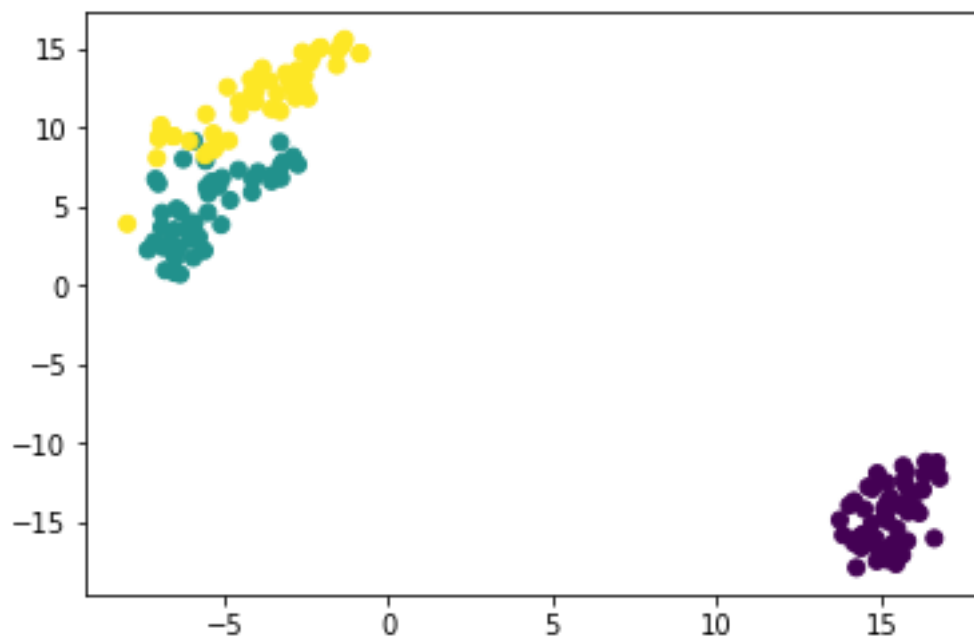
In [33]:

```
import seaborn as sns
model=TSNE(learning_rate=100)
transformed=model.fit_transform(data)
xs=transformed[:,0]
ys=transformed[:,1]
plt.scatter(xs,ys,c=species)
#plt.legend(species)
#sns.scatterplot(xs,ys,hue=species)
plt.show()
```



In [34]:

```
model=TSNE(learning_rate=100)
transformed=model.fit_transform(data)
xs=transformed[:,0]
ys=transformed[:,1]
plt.scatter(xs,ys,c=species)
#plt.legend(species)
#sns.scatterplot(xs,ys,hue=species)
plt.show()
```



In [35]:

```
# TSNE on Seed Data

# Create a TSNE instance: model
model = TSNE(learning_rate=200)

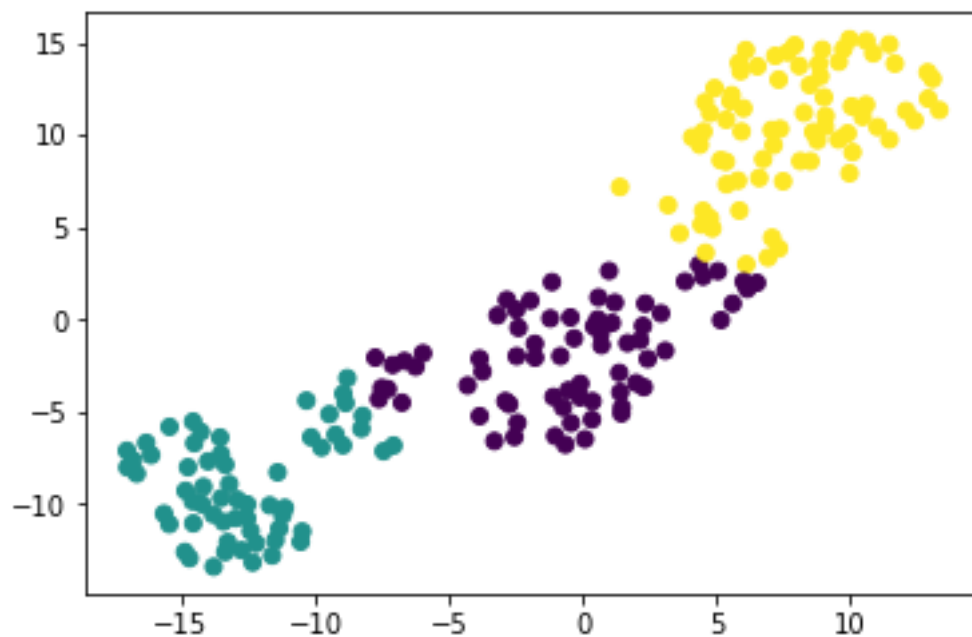
# Apply fit_transform to samples: tsne_features
tsne_features = model.fit_transform(seeds)

# Select the 0th feature: xs
xs = tsne_features[:,0]

# Select the 1st feature: ys
ys = tsne_features[:,1]

# Scatter plot, coloring by variety_numbers
plt.scatter(xs,ys,c=seed_labels)
plt.show()

# the t-SNE visualization manages to separate the 3 varieties of grain samples.
# Annotate the points
# for x, y, seedlabel in zip(xs, ys, seed_labels):
#     plt.annotate(seedlabel, (x, y), fontsize=5, alpha=0.75)
```



Decorrelating your data and dimension reduction ¶

Dimension reduction summarizes a dataset using its common occurring patterns. In this section, you'll learn about the most fundamental of dimension reduction techniques, "Principal Component Analysis" ("PCA"). PCA is often used before supervised learning to improve model performance and generalization. It can also be useful for unsupervised learning. For example, you'll employ a variant of PCA will allow you to cluster Wikipedia articles by their content!

Visualizing the PCA Transformation Dimension Reduction Removes less informative noise features **Principal Component Analysis** Fundamental Dimension Reduction Technique First step is 'decorrealtion' second is 'reducing dimension' **PCA aligns data with axes** Rotates data samples to be aligned with axes Shifts data samples so they have mean 0 No information is lost PCA follows the fit/transform pattern

PCA Features Rows of tranformed corresponds to samples columns are PCA features Features of the data are correlated but but PCA Features are not linearly correlated.

Principal Components Principal components is the 'direction of variance' PCA Aligns principal componenets with the axes Available as components_ attribute of PCA object Each row defines displacement from mean

In [36]:

```
# WINE DATA

# Samples contain two wine features
samples=wine[['Total_phenols','OD280']]

from sklearn.decomposition import PCA

model=PCA()

model.fit(samples)

transformed=model.transform(samples)

print(model.components_)

transformed[:10]
```

```
[[[-0.64116665 -0.76740167]
  [-0.76740167  0.64116665]]
```

Out[36]:

```
array([[ -1.32771994,  0.45139607],
       [-0.83249607,  0.23309966],
       [-0.75216868, -0.02947892],
       [-1.64026613, -0.65572401],
       [-0.56799228, -0.18335891],
       [-0.80794847, -0.59533103],
       [-0.87445337,  0.46361991],
       [-0.93857004,  0.38687974],
       [-0.50660014, -0.23465224],
       [-1.15919131,  0.07603211]])
```

In [37]:

```
# Seeds width length Data
```



```

grains=pd.read_csv('../input/seeds-width-length/seeds-width-vs-length.csv',header=None)

from scipy.stats import pearsonr

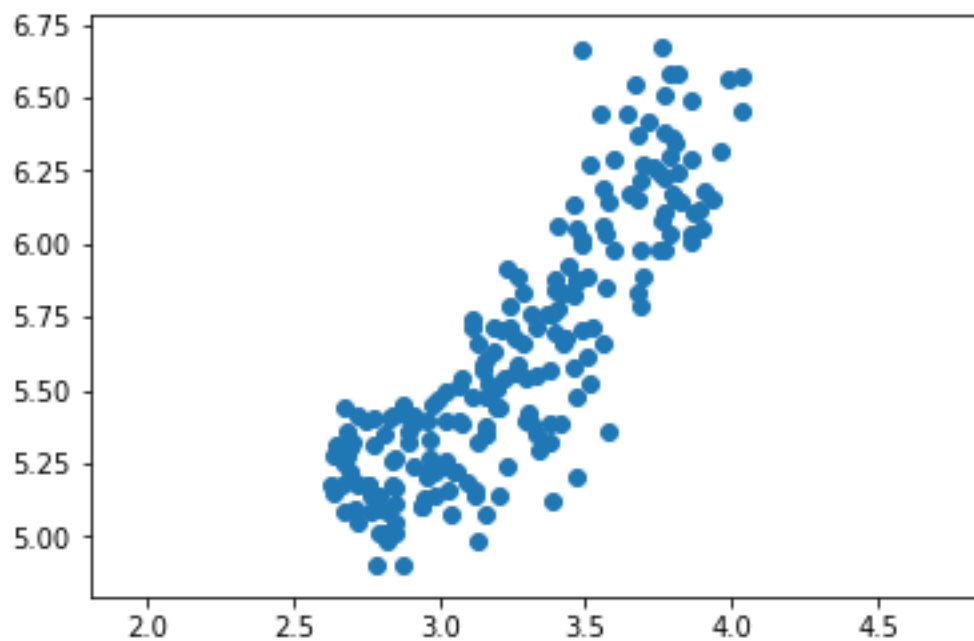
width = grains.iloc[:,0]
length = grains.iloc[:,1]

# Scatter plot width vs length
plt.scatter(width, length)
plt.axis('equal')
plt.show()

# Calculate the Pearson correlation
correlation, pvalue = pearsonr(width,length)

# Display the correlation
print(correlation)
'''
As you would expect, the width and length of the grain samples are highly correlated.
Pearson Correlation is 0.86
'''

```



0.8604149377143466

Out[37]:
'\nAs you would expect, the width and length of the grain samples are highly correlated.\nPearson Correlation is 0.86\n\n'

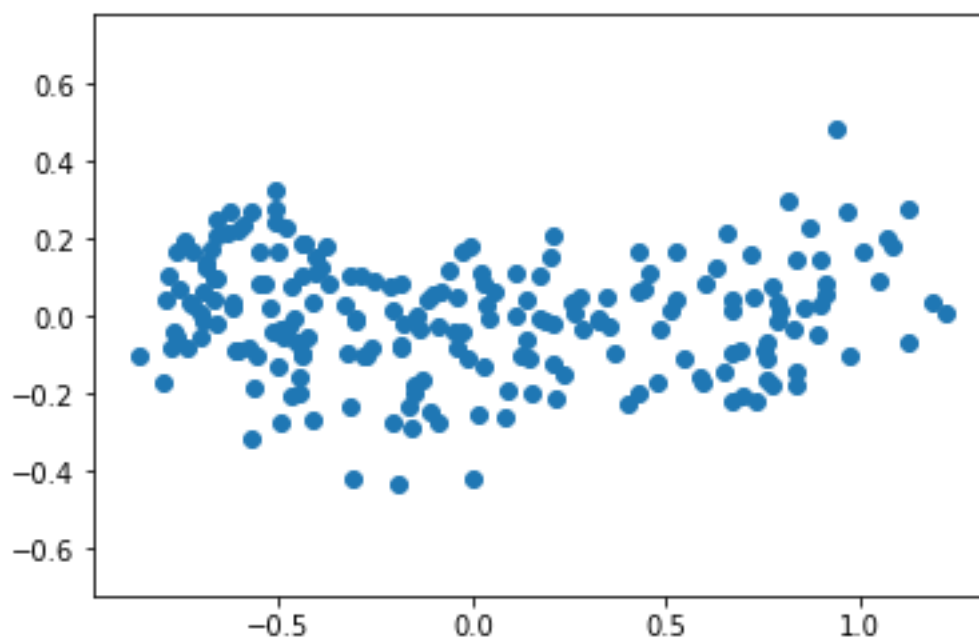
Decorrelating the grain measurements with PCA You observed in the previous exercise that the width and length measurements of the grain are correlated. Now, you'll use PCA to decorrelate these measurements, then plot the decorrelated points and measure their Pearson correlation.

In [38]:

```
model = PCA()
# Apply the fit_transform method of model to grains: pca_features
pca_features = model.fit_transform(grains)
# Assign 0th column of pca_features: xs
xs = pca_features[:,0]
# Assign 1st column of pca_features: ys
ys = pca_features[:,1]
# Scatter plot xs vs ys
plt.scatter(xs, ys)
plt.axis('equal')
plt.show()

# Calculate the Pearson correlation of xs and ys
correlation, pvalue = pearsonr(xs, ys)
# Display the correlation
print(correlation)

'''
We've successfully decorrelated the grain measurements with PCA!
'''
```



2.5478751053409354e-17

Out[38]:

"\nWe've successfully decorrelated the grain measurements with PCA!\n"

Intrinsic dimensions Intrinsic dimension is the number of features needed to approximate the dataset It is the essential idea behind dimension reduction Intrinsic dimension = number of PCA Features with significant variance

In []:

In [39]:

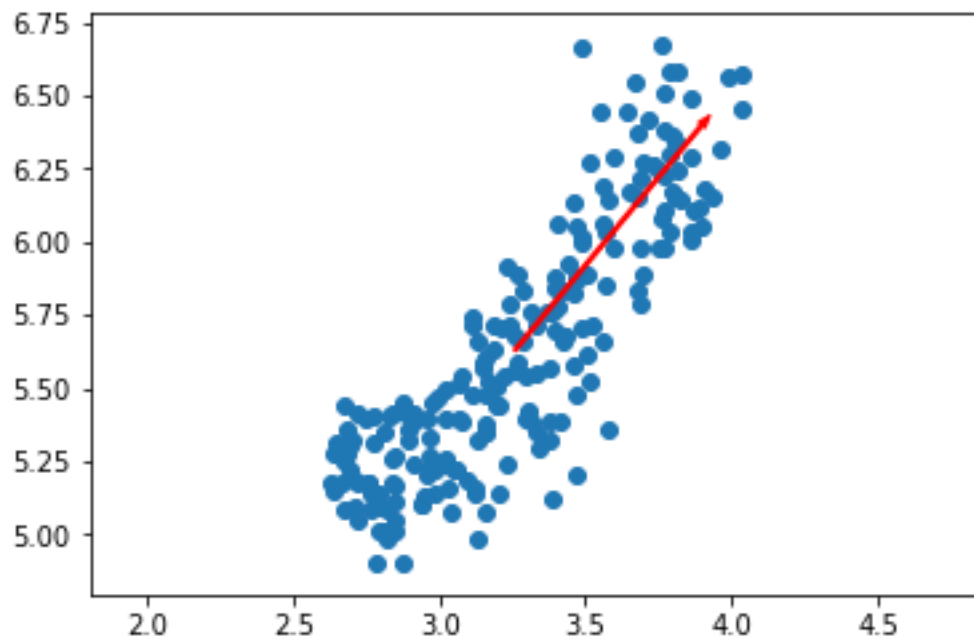
```
# Make a scatter plot of the untransformed points
plt.scatter(grains.iloc[:,0],grains.iloc[:,1])

model=PCA()
model.fit(grains)
# the coordinates of the mean of the data
mean=model.mean_
# Get the first principal component: first_pc Data varies the most along this direction
first_pc = model.components_[0]
# Plot first_pc as an arrow, starting at mean
plt.arrow(mean[0], mean[1], first_pc[0], first_pc[1], color='red', width=0.01)

# Keep axes on same scale
plt.axis('equal')
```

Out[39]:

(2.549993369175627, 4.113006630824374, 4.795023399558499, 6.778976600441501)



In [40]:

```
# FISH DATA
fish=pd.read_csv("../input/fishdata/fish.csv", header=None).drop([0],axis=1)
fish.head()
```

Out[40]:

	1	2	3	4	5	6
0	242.0	23.2	25.4	30.0	38.4	13.4
1	290.0	24.0	26.3	31.2	40.0	13.8
2	340.0	23.9	26.5	31.1	39.8	15.1
3	363.0	26.3	29.0	33.5	38.0	13.3
4	430.0	26.5	29.0	34.0	36.6	15.1

In [41]:

```
fish.var()
```

Out[41]:

```
1    145110.683403
2     127.451689
3     148.475328
4     174.168524
5     107.154440
6       4.483703
dtype: float64
```

In [42]:

```
scaler=StandardScaler()
pca=PCA()
pipeline=make_pipeline(scaler,pca)
pipeline.fit(fish)
# Plot the explained variances
```

```

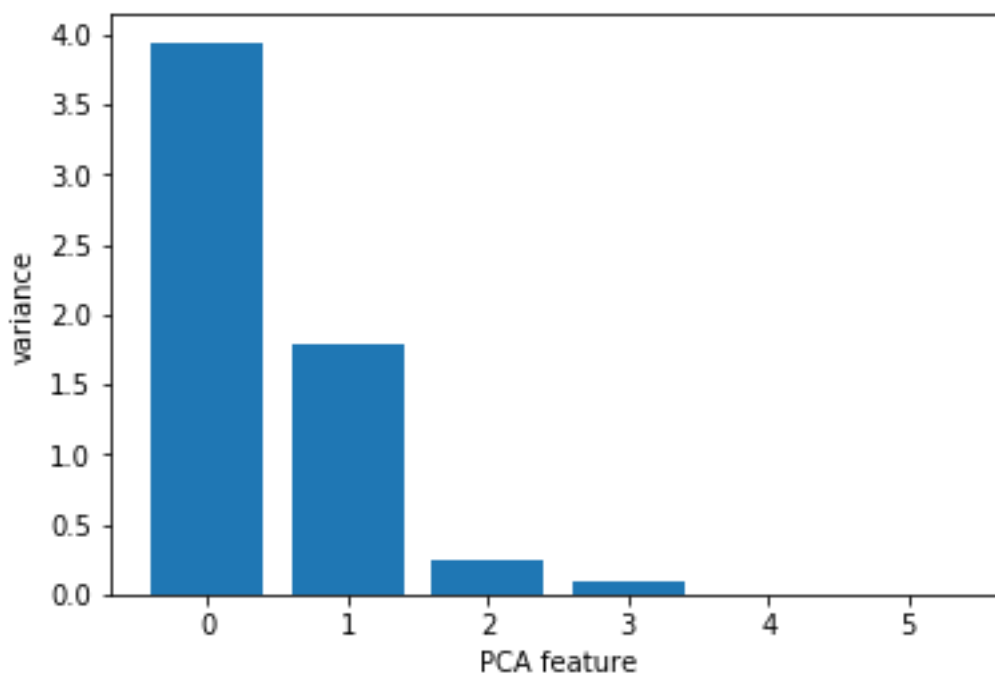
features = range(pca.n_components_)
plt.bar(features, pca.explained_variance_)
plt.xlabel('PCA feature')
plt.ylabel('variance')
plt.xticks(features)
plt.show()
'''

It looks like PCA features 0 and 1 have significant variance.

Since PCA features 0 and 1 have significant variance, the intrinsic dimension of th
is dataset appears to be 2.

'''

```



Out[42]:

```

'\nIt looks like PCA features 0 and 1 have significant variance.\nSince PCA feature
s 0 and 1 have significant variance, the intrinsic dimension of this dataset appear
s to be 2.\n'

```

Dimension Reduction with PCA Dimension reduction of the fish measurements In a previous exercise, you saw that 2 was a reasonable choice for the "intrinsic dimension" of the fish measurements. Now use PCA for dimensionality reduction of the fish measurements, retaining only the 2 most important components.

In [43]:

```

scaler=StandardScaler()
scaled_fish=scaler.fit_transform(fish)

pca=PCA(n_components=2)
pca_features=pca.fit_transform(scaled_fish)
pca_features.shape

```

```
'''  
Successfully reduced the dimensionality from 6 to 2.  
'''
```

Out[43]:

```
'\nSuccessfully reduced the dimensionality from 6 to 2.\n\n'
```

In [44]:

```
# # Perform the necessary imports  
# from sklearn.decomposition import TruncatedSVD  
  
# # Create a TruncatedSVD instance: svd  
# svd = TruncatedSVD(n_components=50)  
  
# # Create a KMeans instance: kmeans  
# kmeans = KMeans(n_clusters=6)  
  
# # Create a pipeline: pipeline  
# pipeline = make_pipeline(svd, kmeans)  
  
# # Import pandas  
# import pandas as pd  
  
# # Fit the pipeline to articles  
# pipeline.fit(articles)  
  
# # Calculate the cluster labels: labels  
# labels = pipeline.predict(articles)  
  
# # Create a DataFrame aligning labels and titles: df  
# df = pd.DataFrame({'label': labels, 'article': titles})  
  
# # Display df sorted by cluster label  
# print(df.sort_values('label'))
```

Discovering interpretable features ¶

In this chapter, you'll learn about a dimension reduction technique called "Non-negative matrix factorization" ("NMF") that expresses samples as combinations of interpretable parts. For example, it expresses documents as combinations of topics, and images in terms of commonly

occurring visual patterns. You'll also learn to use NMF to build recommender systems that can find you similar articles to read, or musical artists that match your listening history!

Non-negative matrix factorization ¶

NMF is non negative matrix factorization

Dimension reduction technique

NMF models are interpretable unlike PCA

All features must be non negative

Using scikit-learn NMF ¶

Follows fit transform pattern

must specify number of components

works with numpy array and with csr_matrix

NMF components ¶

NMF has components just like PCA has principal components Dimension of components = dimension of samples

Entries are non negative

NMF features ¶

NMF Feature values are non negative

Can be used to reconstruct the samples , combine feature values with components

Sample reconstruction ¶

Multiply feature values with components and add up Sample can be expressed as the product of matrices hence the term Matrix Factorization

In [45]:

```
from scipy.sparse import csr_matrix

df=pd.read_csv('../input/wikipediavectors/wikipedia-vectors.csv',index_col=0)
print('Shape of Wiki vector :{}'.format(df.shape))

'''
The wikipedia vector file has tf-idf entries for 13125 words covering 60 topics
'''

df.head(3)
```

Shape of Wiki vector :(13125, 60)

Out[45]:

	HT TP 40 4	Alex a Inter net	Inter net Expl orer	HT TP coo kie	Go gle Sea rch	Tu mbl r	Hype rtext Trans fer Proto col	Soc ial sea rch	Fire fox	Link edIn	Glob al war ming	Nation ally Appro priate Mitigat ion Action	Nige l Law son	Conni e Hedeg aard	Clim ate cha nge	Kyot o Prot ocol	350. org	Greenh ouse gas emissi ons by the United States	2010 United Nation s Climat e Chang e Confer ence	2007 United Nation s Climat e Chang e Confer ence
0	0.0	0.000 000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.000 000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.029 607	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

In [46]:

```
words=['aaron','abandon','abandoned','abandoning','abandonment','abbas','abbey','ab
breviated','abbreviation','abc','abdomen','abdominal','abdul','abel','abilities','a
bility','able','abnormal','abnormalities','abnormally','aboard','abolish','abolishe
d','abolishing','abolition','aboriginal','abortion','abraham','abroad','abrupt','ab
ruptly','absence','absent','absolute','absolutely','absorb','absorbed','absorbing','
absorbs','absorption','abstract','abstraction','absurd','abu','abundance','abundan
t','abuse','abused','abuses','abusive','academia','academic','academics','academies
','academy','accelerate','accelerated','accelerating','acceleration','accent','acce
nts','accept','acceptable','acceptance','accepted','accepting','accepts','access','
accessed','accessible','accessing','accession','accessories','accessory','accident'
,'accidental','accidentally','accidents','acclaim','acclaimed','accolades','accommo
date','accompanied','accompaniment','accompany','accompanying','accomplish','accomp
lished','accomplishment','accomplishments','accord','accordance','according','accor
dingly','account','accountability','accountable','accounted','accounting','accounts
','accredited','accumulate','accumulated','accumulation','accuracy','accurate','acc
urately','accusation','accusations','accused','accusing','ace','achieve','achieved'
,'achievement','achievements','achieves','achieving','acid','acidic','acids','ackno
wledge','acknowledged','acknowledges','acknowledging','acoustic','acquaintance','ac
quainted','acquire','acquired','acquiring','acquisition','acquisitions','acquitted'
,'acre','acres','acronym','act','acted','acting','action','actions','activate','act
ivated','activates','activation','active','actively','activism','activist','activis
ts','activities','activity','actor','actors','actress','actresses','acts','actual'
,'actually','acute','adam','adams','adapt','adaptation','adaptations','adapted','ada
pting','adaption','adaptive','add','added','addicted','addiction','adding','additio
n','additional','additionally','additions','additive','address','addressed','adres
ses','addressing','adds','adept','adequate','adequately','adhere','adhered','adhere
nce','adherents','adjacent','adjective','adjoining','adjust','adjusted','adjusting'
,'adjustment','adjustments','administer','administered','administering','administra
tion','administrations','administrative','administrator','administrators','admiral'
,'admiration','admired','admission','admissions','admit','admits','admitted','admit
ting','adolescence','adolescent','adolescents','adolf','adopt','adopted','adopting'
,'adoption','adrian','ads','adult','adultery','adulthood','adults','advance','advan
ced','advancement','advances','advancing','advantage','advantageous','advantages','
advent','adventure','adventures','adversary','adverse','adversely','advertise','adv
ertised','advertisement','advertisements','advertising','advice','advise','advised'
,'adviser','advisers','advises','advising','advisor','advisors','advisory','advocac
y','advocate','advocated','advocates','advocating','aerial','aerospace','aesthetic'
,'aesthetics','affair','affairs','affect','affected','affecting','affection','affec
ts','affiliate','affiliated','affiliates','affiliation','affinity','affirmative','a
ffirmed','afflicted','affluent','afford','affordable','afforded','afghan','afghanis
tan','aforementioned','afraid','africa','african','africans','afro','afterlife','af
termath','afternoon','afterward','age','aged','agencies','agency','agenda','agent'
,'agents','ages','aggravated','aggregate','aggregator','aggression','aggressive','ag
gressively','aging','agitation','agnostic','ago','agrarian','agree','agreed','agree
ing','agreement','agreements','agrees','agricultural','agriculture','ahead','ahmad'
,'ahmed','aid','aide','aided','aides','aiding','aids','ailments','aim','aimed','aim
```


ing', 'aims', 'ain', 'air', 'airborne', 'aircraft', 'aired', 'airing', 'airline', 'airlines', 'airplane', 'airplanes', 'airplay', 'airport', 'airports', 'airs', 'airways', 'ajax', 'aka', 'akin', 'alabama', 'alan', 'alarm', 'alaska', 'albania', 'albeit', 'albert', 'alberto', 'album', 'albums', 'alcohol', 'alcoholic', 'alcoholism', 'alec', 'alert', 'alex', 'alexander', 'alexandra', 'alexandre', 'alexandria', 'alexis', 'alfred', 'algae', 'algeria', 'algorithm', 'algorithms', 'ali', 'alias', 'alice', 'alicia', 'alien', 'alienated', 'alienation', 'aliens', 'align', 'aligned', 'alignment', 'alike', 'alive', 'allan', 'allegation', 'allegations', 'alleged', 'allegedly', 'allegiance', 'alleging', 'allegory', 'allen', 'allergic', 'alleviate', 'alley', 'alliance', 'alliances', 'allied', 'allies', 'allmusic', 'allocated', 'allocation', 'allow', 'allowance', 'allowed', 'allowing', 'allows', 'alloy', 'allusions', 'ally', 'alma', 'alongside', 'alpha', 'alphabet', 'alpine', 'alps', 'alt', 'altar', 'alter', 'alteration', 'alterations', 'altercation', 'altered', 'altering', 'alternate', 'alternately', 'alternating', 'alternative', 'alternatively', 'alternatives', 'altitude', 'altitudes', 'alto', 'altogether', 'aluminium', 'aluminum', 'alumni', 'amanda', 'amassed', 'amateur', 'amazing', 'amazon', 'ambassador', 'ambassadors', 'amber', 'ambient', 'ambiguity', 'ambiguous', 'ambition', 'ambitions', 'ambitious', 'ambulance', 'ambush', 'ambushed', 'amended', 'amendment', 'amendments', 'america', 'american', 'americans', 'americas', 'amid', 'amidst', 'amino', 'ammonia', 'ammunition', 'amnesty', 'amounted', 'amounting', 'amounts', 'amphibians', 'ample', 'amplification', 'amsterdam', 'amusement', 'amy', 'ana', 'anal', 'analog', 'analogous', 'analogue', 'analogy', 'analyses', 'analysis', 'analyst', 'analysts', 'analytic', 'analyze', 'analyzed', 'analyzing', 'anarchy', 'anatolia', 'anatomical', 'anatomy', 'ancestor', 'ancestors', 'ancestral', 'ancestry', 'anchor', 'anchored', 'ancient', 'anderson', 'andr', 'andrea', 'andrew', 'andrews', 'android', 'andy', 'anemia', 'angel', 'angela', 'angeles', 'angelo', 'angels', 'anger', 'angered', 'angle', 'angles', 'anglican', 'anglo', 'angola', 'angrily', 'angry', 'angular', 'animal', 'animals', 'animated', 'animation', 'anime', 'animosity', 'ankle', 'ann', 'anna', 'anne', 'annex', 'annexation', 'annexed', 'annie', 'anniversary', 'announce', 'announced', 'announcement', 'announcements', 'announcing', 'annual', 'annually', 'anonymous', 'anonymously', 'answer', 'answered', 'answering', 'answers', 'ant', 'antagonist', 'antagonists', 'antarctic', 'antarctica', 'anterior', 'anthem', 'anthology', 'anthony', 'anthropogenic', 'anthropologist', 'anthropology', 'anti', 'antibiotics', 'antibodies', 'anticipated', 'anticipation', 'antics', 'antiquity', 'antoinette', 'anton', 'antonio', 'anus', 'anxiety', 'anxious', 'anybody', 'anymore', 'apache', 'apart', 'apartheid', 'apartment', 'apartments', 'apex', 'api', 'apocalypse', 'apocalyptic', 'apollo', 'apologize', 'apologized', 'apology', 'app', 'appalled', 'apparatus', 'apparel', 'apparent', 'apparently', 'appeal', 'appealed', 'appealing', 'appeals', 'appear', 'appearance', 'appearances', 'appeared', 'appearing', 'appears', 'appetite', 'applauded', 'applause', 'apple', 'apples', 'applicable', 'applicants', 'application', 'applications', 'applied', 'applies', 'apply', 'applying', 'appoint', 'appointed', 'appointing', 'appointment', 'appointments', 'apoints', 'appreciate', 'appreciated', 'appreciation', 'apprentice', 'approach', 'approached', 'approaches', 'approaching', 'appropriate', 'appropriately', 'approval', 'approve', 'approved', 'approving', 'approximate', 'approximately', 'approximation', 'apps', 'april', 'aquatic', 'arab', 'arabia', 'arabian', 'arabic', 'arable', 'arabs', 'arbitrarily', 'arbitrary', 'arbitration', 'arc', 'arcade', 'arch', 'archaeological', 'archaeologists', 'archaeology', 'archaic', 'archbishop', 'archer', 'archipelago', 'architect', 'architects', 'architectural', 'architecture', 'archive', 'archives', 'arctic', 'area', 'areas', 'aren', 'arena', 'arenas', 'argentina', 'argentine', 'arguably', 'argue', 'argued', 'argues', 'arguing', 'argument', 'arguments', 'arid', 'arise', 'arisen', 'arises', 'arising', 'aristocracy', 'aristocratic', 'aristocrats', 'aristotle', 'arithmetic', 'arizona', 'arkansas', 'arm', 'armed', 'armenia', 'armenian', 'armies', 'armistice', 'armor', 'armored', 'arms', 'armstrong', 'army', 'arnold', 'arose', 'arousal', 'aroused', 'arrange', 'arranged', 'arrangement', 'arrangements', 'arranging', 'array', 'arrest', 'arrested', 'arresting', 'arrests', 'arrival', 'arrivals', 'arrive', 'arrived', 'arrives', 'arriving', 'arrow', 'arrows', 'arsenal', 'art', 'arteries', 'artery', 'arthur', 'article', 'articles', 'articulated', 'artifacts', 'artificial', 'artificially', 'artillery', 'artisans', 'artist', 'artistic', 'artistry', 'artists', 'arts', 'artwork', 'aryan', 'ascended', 'ascertain', 'ascribed', 'ash', 'ashes', 'ashley', 'ashton', 'asia', 'asian', 'asians', 'asiatic', 'aside', 'ask', 'asked', 'asking', 'asks', 'asleep', 'aspect', 'aspects', 'aspirations', 'aspiring', 'ass', 'assassin', 'assassinate', 'assassinated', 'assassination', 'assassinations', 'assassins', 'assault', 'assaulted', 'assaults', 'assemble', 'assembled', 'assemblies', 'assembly', 'assert', 'asserted', 'asserting', 'assertion', 'assertions', 'asserts', 'assess', 'assessed', 'assessing', 'assessment', 'assessments', 'asset', 'assets', 'assign', 'assigned', 'assignment', 'assigns', 'assimilated', 'assimilation', 'assist', 'assistance', 'assistant', 'assistants', 'assisted', 'assisting', 'assists', 'associate', 'associated', 'associates', 'association', 'associations', 'assortment', 'assume', 'assumed', 'assumes', 'assuming', 'assumption', 'assumptions', 'assurance', 'assure', 'assured', 'asteroid', 'asthma', 'astonishing', 'astronaut', 'astronauts', 'astronomer', 'astronomers', 'astronomical', 'astronomy', 'asylum', 'ate', 'atheist', 'atheists', 'athens', 'athlete', 'athletes', 'athletic', 'athletics', 'atlanta', 'atlantic', 'atlas', 'atm', 'atmosphere', 'atmospheric', 'atom', 'atomic', 'atoms', 'atop', 'atp',

'atrocities', 'attach', 'attached', 'attachment', 'attack', 'attacked', 'attackers', 'attacking', 'attacks', 'attain', 'attained', 'attaining', 'attempt', 'attempted', 'attempting', 'attempts', 'attend', 'attendance', 'attendant', 'attended', 'attending', 'attends', 'attention', 'attested', 'attire', 'attitude', 'attitudes', 'attorney', 'attorneys', 'attract', 'attracted', 'attracting', 'attraction', 'attractions', 'attractive', 'attracts', 'attributable', 'attribute', 'attributed', 'attributes', 'attributing', 'atypical', 'auction', 'auctioned', 'audience', 'audiences', 'audio'

, 'audition', 'auditioned', 'auditioning', 'auditions', 'auditorium', 'augmented', 'august', 'augustine', 'augustus', 'aunt', 'auspices', 'austin', 'australia', 'australian', 'australians',

'austria', 'austrian', 'authentic', 'authentication', 'authenticity', 'author', 'authored', 'authorised', 'authoritarian', 'authorities', 'authority', 'authorization', 'authorized', 'authors',

'authorship', 'autism', 'auto', 'autobiographical', 'autobiography', 'automated', 'automatic', 'automatically', 'automobile', 'automobiles', 'automotive', 'autonomous', 'autonomy', 'autopsy',

'autumn', 'auxiliary', 'availability', 'available', 'avant', 'avatar', 'avenue', 'avenues', 'average', 'averaged', 'averages', 'averaging', 'aviation', 'avid', 'avoid', 'avoidance', 'avoided',

'avoiding', 'avoids', 'awaiting', 'awakening', 'award', 'awarded', 'awards', 'aware', 'awareness', 'away', 'awful', 'awkward', 'axe', 'axis', 'azerbaijan', 'babies', 'baby', 'babylonian', 'bachelor',

'backbone', 'backdrop', 'backed', 'background', 'backgrounds', 'backing', 'backlash', 'backs', 'backstage', 'backup', 'backward', 'backwards', 'bacon', 'bacteria', 'bacterial', 'bacterium', 'bad',

'badge', 'badly', 'bafta', 'bag', 'baghdad', 'bags', 'bah', 'bahamas', 'bail', 'baked', 'baker', 'baking', 'balance', 'balanced', 'balances', 'balancing', 'bald', 'baldwin', 'bali', 'balkans', 'ball',

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ing','smith','smithsonian','smoke','smoked','smoking','smooth','smoothly','smugglin
g','snake','snakes','snap','snl','snoop','snow','snowfall','soap','soared','sober',
'soccer','social','socialism','socialist','socialists','socially','societal','socie
ties','society','socio','socioeconomic','sociological','sociology','soda','sodium',

'sofia','soft','softer','software','soil','soils','solar','sold','soldier','soldier s','sole','solely','solid','solidarity','solidified','solids','solitary','solo','solomon','soluble','solution','solutions','solve','solved','solvent','solving','somalia','somebody','somewhat','son','song','songs','songwriter','songwriters','songwriting','sonic','sonny','sons','sony','soon','sooner','sophia','sophisticated','sophistication','sophomore','soprano','sorrow','sorry','sort','sorts','sought','soul','souls','sound','sounded','sounding','sounds','soundtrack','soundtracks','soup','sour','source','sourced','sources','south','southeast','southeastern','southern','southernmost','southward','southwest','southwestern','sovereign','sovereignty','soviet','soviets','soy','space','spacecraft','spaced','spaces','spain','span','spaniards','spanish','spanned','spanning','spans','spare','spared','spark','sparked','sparking','sparks','sparse','sparsely','spatial','spawned','speak','speaker','speakers','speaking','speaks','spearheaded','spears','special','specialised','specialist','specialists','specialization','specialized','specializing','specially','specials','specialty','species','specific','specifically','specification','specifications','specified','specifies','specify','specifying','specimen','specimens','spectacle','spectacular','spectator','spectators','spectrum','speculate','speculated','speculation','speculative','speech','speeches','speed','speeds','spell','spelled','spelling','spencer','spend','spending','spends','spent','sperm','sphere','spheres','spherical','spice','spices','spider','spielberg','spies','spike','spin','spinal','spine','spinning','spiral','spirit','spirited','spirits','spiritual','spirituality','spite','split','splitting','spoke','spoken','spokesman','spokesperson','spokeswoman','sponsor','sponsored','sponsors','sponsorship','spontaneous','spontaneously','spoof','sporadic','sport','sporting','sports','spot','spotlight','spots','spotted','sprang','spray','spread','spreading','spreads','spring','springs','spun','spurred','spurs','spy','squad','squadron','squads','square','squares','squash','sri','stability','stabilization','stabilize','stabilized','stabilizing','stable','stack','stadium','stadiums','staff','stage','staged','stages','staging','stagnation','stake','stalemate','stalin','stalled','stamp','stamps','stan','stance','stand','standard','standardization','standardized','standards','standing','standpoint','stands','stanford','stanley','staple','staples','star','starch','stardom','stark','starred','starring','stars','start','started','starter','starting','starts','starvation','state','stated','statement','statements','states','statesman','statewide','static','stating','station','stationary','stationed','stations','statistical','statistically','statistics','statue','statues','stature','status','statute','statutes','statutory','stay','stayed','staying','stays','steadily','steady','steal','stealing','steals','steam','steel','steep','steering','stefan','stella','stellar','stem','stemmed','stemming','stems','step','stepfather','stephanie','stephen','stepped','stepping','steps','stereo','stereotypes','stereotypical','sterile','sterling','stern','steve','steven','stevens','stevens on','stevie','stewart','stick','sticks','stiff','stigma','stimulate','stimulated','stimulates','stimulating','stimulation','stimuli','stimulus','stint','stipulated','stir','stock','stockholm','stocks','stole','stolen','stomach','stone','stones','stood','stop','stopped','stopping','stops','storage','store','stored','stores','stories','storing','storm','storms','story','storyline','storylines','storytelling','straight','straightforward','strain','strained','strains','strait','straits','stranded','strands','strange','stranger','strangers','strategic','strategically','strategies','strategy','straw','streak','stream','streamed','streaming','streams','street','streets','strength','strengthen','strengthened','strengthening','strengths','stress','stressed','stresses','stretch','stretched','stretches','stretching','stricken','strict','stricter','strictly','strife','strike','strikes','striking','string','strings','stringent','strings','strip','stripes','stripped','strips','strive','stroke','strokes','strong','stronger','strongest','stronghold','strongly','struck','structural','structurally','structure','structured','structures','struggle','struggled','struggles','struggling','stuart','stuck','student','students','studied','studies','studio','studios','study','studying','stuff','stuffed','stunned','stunning','stunt','stunts','stupid','style','styled','styles','stylistic','stylized','sub','subcontinent','subdivided','subdivisions','subdued','subgroup','subject','subjected','subjective','subjects','submarine','submarines','submerged','submission','submit','submitted','subordinate','subscribers','subscription','subsequent','subsequently','subset','subsidiary','subsides','subsistence','subspecies','substance','substances','substantial','substantially','substitute','substituted','substitutes','substitution','substrate','subtle','subtropical','suburb','suburban','suburbs','subway','succeed','succeeded','succeeding','succeeds','success','successes','successful','successfully','succession','successive','successor','successors','sudan','sudden','suddenly','sue','sued','suez','suffer','suffered','suffering','suffers','sufficient','sufficiently','suffix','suffrage','sugar','sugars','suggest','suggested','suggesting','suggestion','suggestions','suggestive','suggests','suicidal','suicide','suit','suitable','suite','suited','suits','sulfate','sulfur','sullivan','sultan','sum','summarized','summary'

, 'summed', 'summer', 'summers', 'summit', 'summoned', 'sums', 'sun', 'sundance', 'sunday', 'sung', 'sunlight', 'sunni', 'sunny', 'sunrise', 'sunset', 'sunshine', 'super', 'superficial', 'superhero', 'superior', 'superiority', 'superiors', 'superman', 'supermarket', 'supernatural', 'superseded', 'superstar', 'supervised', 'supervising', 'supervision', 'supervisor', 'supplanted', 'supplement', 'supplemented', 'supplements', 'supplied', 'supplier', 'suppliers', 'supplies', 'supply', 'supplying', 'support', 'supported', 'supporter', 'supporters', 'supporting', 'supportive', 'supports', 'suppose', 'supposed', 'supposedly', 'suppress', 'suppressed', 'suppressing', 'suppression', 'supremacy', 'supreme', 'sur', 'sure', 'surely', 'surface', 'surfaced', 'surfaces', 'surge', 'surgeon', 'surgeons', 'surgery', 'surgical', 'surname', 'surpass', 'surpassed', 'surpassing', 'surplus', 'surprise', 'surprised', 'surprising', 'surprisingly', 'surrender', 'surrendered', 'surrogate', 'surround', 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on', 'transfer', 'transferred', 'transferring', 'transfers', 'transform', 'transformation'
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idad', 'trinity', 'trio', 'trip', 'triple', 'trips', 'triumph', 'trivial', 'troop', 'troops'
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g', 'turnout', 'turnover', 'turns', 'tutor', 'tutors', 'tweeted', 'twelfth', 'twenties', 'tw
entieth', 'twice', 'twilight', 'twin', 'twins', 'twist', 'twisted', 'twitter', 'tying', 'tyl
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da', 'ugly', 'ukraine', 'ukrainian', 'ultimate', 'ultimately', 'ultimatum', 'ultra', 'ultra
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nimous', 'unanimously', 'unauthorized', 'unavailable', 'unaware', 'uncertain', 'uncertain
ty', 'unchanged', 'uncle', 'unclear', 'uncomfortable', 'uncommon', 'unconscious', 'unconst
itutional', 'unconventional', 'uncovered', 'uncredited', 'und', 'undefeated', 'undercover'
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rstand', 'understanding', 'understood', 'undertake', 'undertaken', 'undertaking', 'undert
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ted', 'unpredictable', 'unpublished', 'unrealistic', 'unrelated', 'unreleased', 'unreliab
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wards', 'uranium', 'urban', 'urbanization', 'urdu', 'urge', 'urged', 'urgent', 'urging', 'ur
inary', 'urine', 'uruguay', 'usa', 'usable', 'usage', 'usb', 'usd', 'use', 'used', 'useful', '
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In [47]:

```
len(words)
```

Out[47]:

13125

In [48]:

```
articles=csr_matrix(df.transpose())
```



```
titles=list(df.columns)
```

In [49]:

```
# nmf_features is a numpy array with shape (Topics * Components)
from sklearn.decomposition import NMF
model=NMF(n_components=6)
model.fit(articles)
nmf_features=model.transform(articles)
print(nmf_features.shape)
print(nmf_features)

'''

these NMF features don't make much sense at this point, but you will explore them i
n the next exercise!

'''
```

```
(60, 6)
[[0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 4.40551395e-01]
 [0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 5.66715310e-01]
 [3.82074066e-03 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 3.98724250e-01]
 [0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
 0.00000000e+00 3.81814350e-01]
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 [0.00000000e+00 0.00000000e+00 2.06739639e-02 0.00000000e+00
 6.04307903e-03 3.59131253e-01]
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 2.62542804e-02 4.80868179e-01]
 [1.11742928e-02 3.13694246e-02 3.09482283e-02 6.56906085e-02
 1.96619649e-02 3.38354666e-01]
 [0.00000000e+00 0.00000000e+00 5.30713199e-01 0.00000000e+00
 2.83596173e-02 0.00000000e+00]
 [0.00000000e+00 0.00000000e+00 3.56505120e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00]
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 1.13827915e-02 1.92639823e-02]
 [3.93501795e-03 6.24466823e-03 3.42369232e-01 1.10753066e-02
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 [0.00000000e+00 0.00000000e+00 4.83283424e-01 0.00000000e+00
 0.00000000e+00 0.00000000e+00]
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 [0.00000000e+00 0.00000000e+00 4.80908121e-01 0.00000000e+00
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 0.00000000e+00 0.00000000e+00]
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 5.81237878e-02 1.37880768e-02]
 [0.00000000e+00 0.00000000e+00 0.00000000e+00 5.10402098e-01
```

0.00000000e+00 0.00000000e+00]
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[9.88434657e-02 8.60077021e-02 3.91031088e-03 3.80962924e-01
4.39110619e-04 5.22253581e-03]
[0.00000000e+00 0.00000000e+00 0.00000000e+00 5.72087869e-01
0.00000000e+00 7.13681755e-03]
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0.00000000e+00 1.16332689e-02]
[3.84563817e-03 0.00000000e+00 0.00000000e+00 5.75628033e-01
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[0.00000000e+00 0.00000000e+00 0.00000000e+00 0.00000000e+00
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3.72775177e-01 0.00000000e+00]
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2.30441739e-01 0.00000000e+00]
[1.12522343e-02 2.12335599e-03 1.60970805e-02 1.02470210e-02
3.25364130e-01 3.75954065e-02]
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0.00000000e+00 0.00000000e+00]
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0.00000000e+00 0.00000000e+00]
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1.95909240e-03 2.11685803e-02]
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```

0.00000000e+00 0.00000000e+00]
[2.75494357e-01 4.46973702e-03 0.00000000e+00 5.29579647e-02
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1.87640327e-01 9.24145639e-03]
[3.78290014e-01 1.43975731e-02 0.00000000e+00 9.85098334e-02
1.35859808e-02 0.00000000e+00]]

```

Out[49]:

"\nthese NMF features don't make much sense at this point, but you will explore the m in the next exercise! \n"

In [50]:

```

# Lets consider the Topic 'Anne Hathaway' and 'Denzel Washington' and see what thei
r NMF Features has to say.

# note that , This will be a row corresponding to these topics from the NMF Feature
s matrix which is of (topic*component) dimension

df=pd.DataFrame(nmf_features,index=titles)

# Print the row for 'Anne Hathaway'
print(df.loc['Anne Hathaway',:])

# Print the row for 'Denzel Washington'
print(df.loc['Denzel Washington',:])

'''

Notice that for both actors, the NMF feature 3 has by far the highest value.
This means that both articles are reconstructed using mainly the 3rd NMF component.

So out of the 6 components , both these topics have inclination towards components
3 , which shows they are related in some sense.

'''

```

```

0      0.003846
1      0.000000
2      0.000000
3      0.575628
4      0.000000
5      0.000000
Name: Anne Hathaway, dtype: float64
0      0.000000
1      0.005601
2      0.000000
3      0.422319
4      0.000000
5      0.000000
Name: Denzel Washington, dtype: float64

```

Out[50]:

'\nNotice that for both actors, the NMF feature 3 has by far the highest value. \nT his means that both articles are reconstructed using mainly the 3rd NMF component.\n\nSo out of the 6 components , both these topics have inclination towards componen ts 3 , which shows they are related in some sense.\n\n'

NMF learns interpretable parts ¶

NMF learns topics of documents ¶

When NMF is applied to documents, the components correspond to topics of documents, and the NMF features reconstruct the documents from the topics. Verify this for yourself for the NMF model that you built earlier using the Wikipedia articles. Previously, you saw that the 3rd NMF feature value was high for the articles about actors Anne Hathaway and Denzel Washington. In this exercise, identify the topic of the corresponding NMF component.

After you are done, take a moment to recognise the topic that the articles about Anne Hathaway and Denzel Washington have in common!

In [51]:

```
components_df=pd.DataFrame(model.components_,columns=words)
print(components_df.shape)
component=components_df.iloc[3]
print(component.nlargest())
```

```
(6, 13125)
film      0.627967
award     0.253168
starred   0.245319
role      0.211481
actress   0.186424
Name: 3, dtype: float64
```

Which articles are similar to 'Cristiano Ronaldo'? ¶

You learned how to use NMF features and the cosine similarity to find similar articles.

Apply this to your NMF model for popular Wikipedia articles, by finding the articles most similar to the article about the footballer Cristiano Ronaldo.

In [52]:

```
from sklearn.preprocessing import normalize
norm_features=normalize(nmf_features)
df=pd.DataFrame(norm_features,index=titles)
article=df.loc['Cristiano Ronaldo']

# Compute the dot products: similarities , dot product is cosine , hence cosine sim
ialrity

similarities = df.dot(article)
print(similarities.nlargest())
```

```
Cristiano Ronaldo      1.000000
Franck Ribéry         0.999972
Radamel Falcao         0.999942
Zlatan Ibrahimović     0.999942
France national football team  0.999923
dtype: float64
```

In []:

In []: