Machine Learning - Clustering and Dimensionality Reduction

Assignment 3

Rhichard Koh

Flatten the data in 4070 columns (each corresponding to a stock-code), and 4373 rows (each corresponding to a customer id). Your numbers may differ depending on the way you do flattening.

In [38]:
```
import pandas as pd
from sklearn.cluster import KMeans, DBSCAN
from sklearn.preprocessing import StandardScaler, MinMaxScaler
import matplotlib.pyplot as plt
from scipy.cluster.hierarchy import dendrogram, linkage, fcluster
from sklearn.decomposition import PCA
```

In [2]:
```
df = pd.read_excel('Online Retail.xlsx')
```

In [3]:
```
df
```

Out[3]:

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Country
0	536365	85123A	WHITE HANGING HEART T-LIGHT HOLDER	6	2010-12-01 08:26:00	2.55	17850.0	United Kingdom
1	536365	71053	WHITE METAL LANTERN	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
2	536365	84406B	CREAM CUPID HEARTS COAT HANGER	8	2010-12-01 08:26:00	2.75	17850.0	United Kingdom
3	536365	84029G	KNITTED UNION FLAG HOT WATER BOTTLE	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
4	536365	84029E	RED WOOLLY HOTTIE WHITE HEART.	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
...	...	...	...	...	...	...	...	...
541904	581587	22613	PACK OF 20 SPACEBOY NAPKINS	12	2011-12-09 12:50:00	0.85	12680.0	France
541905	581587	22899	CHILDREN'S APRON DOLLY GIRL	6	2011-12-09 12:50:00	2.10	12680.0	France
541906	581587	23254	CHILDRENS CUTLERY DOLLY GIRL	4	2011-12-09 12:50:00	4.15	12680.0	France
541907	581587	23255	CHILDRENS CUTLERY CIRCUS PARADE	4	2011-12-09 12:50:00	4.15	12680.0	France
541908	581587	22138	BAKING SET 9 PIECE RETROSPOT	3	2011-12-09 12:50:00	4.95	12680.0	France

541909 rows × 8 columns

In [4]:
```
# Checking Unique Items
len(df["StockCode"].unique())
```

Out[4]:
```
4070
```

In [5]:
```
# Pivoting the CustomerID and StockCode with the calues as the Quantity
pivot_df = df.pivot_table(index='CustomerID', columns='StockCode', values='Quantity', aggfunc='sum', fill_value=0)
pivot_df
```

Out[5]:

StockCode	10002	10080	10120	10125	10133	10135	11001	15030	15034	15036	...	90214Y	90214Z	BANK CHARGES	C2	CRUK	D	DOT
CustomerID																		
12346.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
12347.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
12348.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
12349.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
12350.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
18280.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
18281.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
18282.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
18283.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0
18287.0	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0

4372 rows × 3684 columns

In [6]:

```
# Checking which item is bought the most.
pivot_df.max().sort_values()
```

Out[6]:

```
StockCode
21412          0
79320          0
85023C         0
35832          0
85098B         0
           ...
21915       8120
17003      10077
84077      10080
22197      11692
84826      12540
Length: 3684, dtype: int64
```

In [7]:
```
# Converting the columns to be all string.
pivot_df.columns = pivot_df.columns.astype(str)
```

In [8]:
```
# Checking if the conversion happened.
pivot_df.columns[1]
```

Out[8]:
```
'10080'
```

In [9]:
```
# Scaling the Quantity Values.
scaler = StandardScaler()
scaled = scaler.fit_transform(pivot_df)
```

In [10]:
```
scaled
```

Out[10]:
```
array([[-0.04089274, -0.04348365, -0.04752299, ..., -0.00995053,
        -0.03026138, -0.15831688],
       [-0.04089274, -0.04348365, -0.04752299, ..., -0.00995053,
        -0.03026138, -0.15831688],
       [-0.04089274, -0.04348365, -0.04752299, ..., -0.00995053,
        -0.03026138,  1.91678387],
       ...,
       [-0.04089274, -0.04348365, -0.04752299, ..., -0.00995053,
        -0.03026138, -0.15831688],
       [-0.04089274, -0.04348365, -0.04752299, ...,  0.01737593,
        -0.03026138, -0.15831688],
       [-0.04089274, -0.04348365, -0.04752299, ..., -0.00995053,
        -0.03026138, -0.15831688]])
```

Apply PCA and pick top 3 PCs to transform your 4070x4373 matrix into 3x4373 one.

In [11]:
```
# Applying PCA so we are only left with 3 columns.
pca = PCA(n_components=3)
scaled_pca = pca.fit_transform(scaled)
```

In [12]:
```
scaled_pca
```

Out[12]:
```
array([[-2.40439108, -1.35824465, -1.12467836],
       [ 4.53401998,  4.77331158,  5.52102463],
       [ 0.43233602, -0.89957571, -0.58101546],
       ...,
       [-2.09091299, -0.80098264, -0.41156032],
       [ 0.59991994, -1.23800721, -0.47412906],
       [ 1.99955835,  7.31157919, -1.31877326]])
```

In [13]:
```
# Converting the scaled data into a dataframe for easier use.
scaled_df = pd.DataFrame(data=scaled, columns=pivot_df.columns, index=pivot_df.index)
scaled_df
```

Out[13]:

StockCode	10002	10080	10120	10125	10133	10135	11001	15030	15034	15036	...	90214Y	9021
CustomerID													
12346.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
12347.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
12348.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
12349.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
12350.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
...	...	...	...	...	...	...	...	...	...	...	...	...	
18280.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
18281.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
18282.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
18283.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151
18287.0	-0.040893	-0.043484	-0.047523	-0.038833	-0.102894	-0.076524	-0.051014	-0.032103	-0.047351	-0.077025	...	-0.018645	-0.0151

4372 rows × 3684 columns

In [14]:
```
# Converting the scaled and PCA transformed data into a dataframe for easier use.
scaled_pca_df = pd.DataFrame(data=scaled_pca, columns=['Principal Component 1', 'Principal Component 2', 'Principal Com
scaled_pca_df
```

Out[14]:

CustomerID	Principal Component 1	Principal Component 2	Principal Component 3
12346.0	-2.404391	-1.358245	-1.124678
12347.0	4.534020	4.773312	5.521025
12348.0	0.432336	-0.899576	-0.581015
12349.0	-0.266184	-0.597366	0.383031
12350.0	-1.918710	-0.589165	-0.547577
...	...	...	...
18280.0	-2.315659	-1.261694	-0.943462
18281.0	-2.089671	-1.432836	-1.041452
18282.0	-2.090913	-0.800983	-0.411560
18283.0	0.599920	-1.238007	-0.474129
18287.0	1.999558	7.311579	-1.318773

4372 rows × 3 columns

In [46]:

```
# Viewing a 3D visual of the scaled and PCA transformed data.
import plotly.express as px
fig = px.scatter_3d(scaled_pca_df, x='Principal Component 1', y='Principal Component 2', z='Principal Component 3', tit
fig.show()
```

Get cluster labels from each algorithm.

K-Means

In [16]:
```
# Finding the optimal number of clusters for K-Means.
wcss = []

for each in range(1, 100):
    kmeans = KMeans(n_clusters=each)
```

```
    kmeans.fit(scaled_df)
    wcss.append(kmeans.inertia_)

plt.plot(range(1, 100), wcss)
plt.title('Elbow plot')
plt.xlabel("Number of k value (each)")
plt.ylabel("WCSS")
plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress th
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e warning

/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress th
e warning

/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress th
e warning

/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress th
e warning

/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

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/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

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```
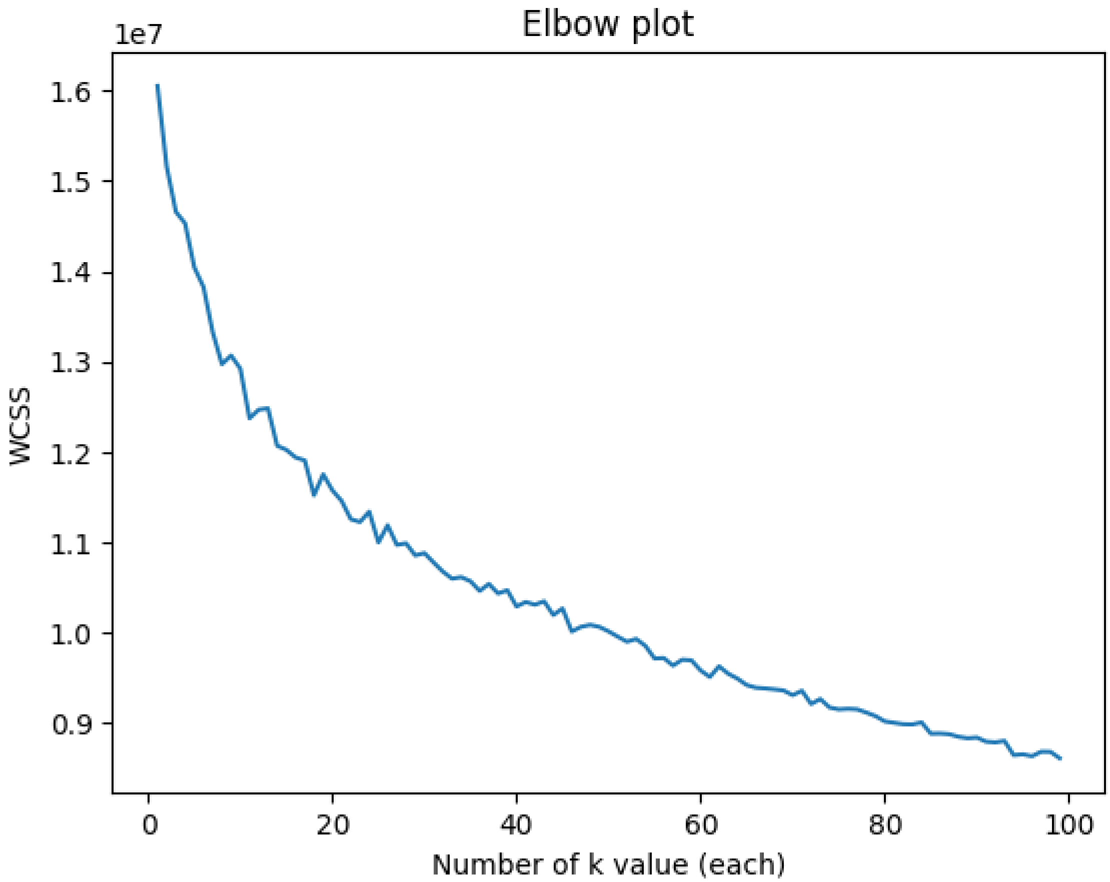



In [17]:
```
# Initializing the cluster size to be 4 for K-Means.
kmeans1 = KMeans(n_clusters=4)
cluster_k = kmeans1.fit_predict(scaled_pca_df)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress th
e warning
```

In [18]:
```
# Creating a DataFrame for the prediction of K-Means.
with_km_df = pd.DataFrame(scaled_pca_df, columns=scaled_pca_df.columns, index=scaled_pca_df.index)
with_km_df['cluster'] = cluster_k
with_km_df.head()
```

Out[18]:

	Principal Component 1	Principal Component 2	Principal Component 3	cluster
CustomerID				
12346.0	-2.404391	-1.358245	-1.124678	0
12347.0	4.534020	4.773312	5.521025	0
12348.0	0.432336	-0.899576	-0.581015	0
12349.0	-0.266184	-0.597366	0.383031	0
12350.0	-1.918710	-0.589165	-0.547577	0

In [19]:

```
# Checking how many values each cluster has.
with_km_df['cluster'].value_counts(ascending=True)
```

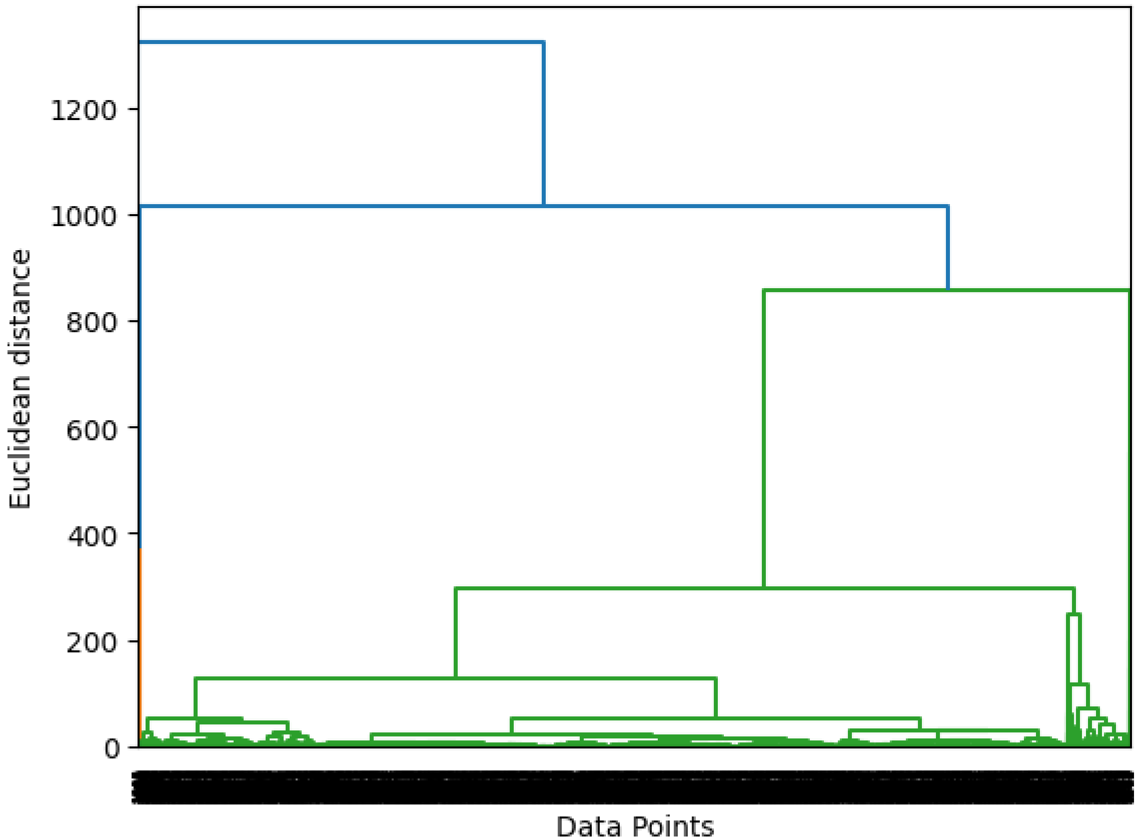
Out[19]:

```
1       1
2       2
3       4
0    4365
Name: cluster, dtype: int64
```

Hierarchical Clustering

In [28]:

```
# Initializing hierarchical clustering and plotting a dendrogram.
merging = linkage(scaled_pca_df.drop(columns=['cluster']), method='ward')
dendrogram(merging, leaf_rotation=90)
plt.xlabel('Data Points')
plt.ylabel('Euclidean distance')
plt.show()
```



In [40]:
```python
# Perform hierarchical clustering
Z = linkage(scaled_pca_df.drop(columns=['cluster']), method='ward')

# Cut the dendrogram to have exactly 4 clusters
clusters_hierarchical = fcluster(Z, 4, criterion='maxclust')

# clusters will contain the cluster labels (from 1 to 4) for each point in the dataset
print(clusters_hierarchical)
```

```
[2 2 2 ... 2 2 2]
```

In [41]:
```python
# Creating a DataFrame for the prediction of hierarchical clustering.
with_hierarchical_df = pd.DataFrame(scaled_pca_df, columns=scaled_pca_df.columns, index=scaled_pca_df.index)
with_hierarchical_df['cluster'] = clusters_hierarchical
with_hierarchical_df.head()
```

Out[41]:

CustomerID	Principal Component 1	Principal Component 2	Principal Component 3	cluster
12346.0	-2.404391	-1.358245	-1.124678	2
12347.0	4.534020	4.773312	5.521025	2
12348.0	0.432336	-0.899576	-0.581015	2
12349.0	-0.266184	-0.597366	0.383031	2
12350.0	-1.918710	-0.589165	-0.547577	2

DB Scan

In [83]:
```
# Initializing DB Scan.
dbscan = DBSCAN(eps=100, min_samples=10)
```

In [84]:
```
# Predicting the clusters with DB Scan.
cluster_dbscan = dbscan.fit_predict(scaled_pca)
```

In [85]:
```
# Viewing the predicted clusters.
cluster_dbscan
```

Out[85]:
```
array([0, 0, 0, ..., 0, 0, 0])
```

In [86]:
```
# Creating a DataFrame for the prediction of DB Scan.
with_dbscan_df = pd.DataFrame(scaled_pca_df, columns=scaled_pca_df.columns, index=scaled_pca_df.index)
with_dbscan_df['cluster'] = cluster_dbscan
with_dbscan_df.head()
```

Out[86]:

	Principal Component 1	Principal Component 2	Principal Component 3	cluster
CustomerID				
12346.0	-2.404391	-1.358245	-1.124678	0
12347.0	4.534020	4.773312	5.521025	0
12348.0	0.432336	-0.899576	-0.581015	0
12349.0	-0.266184	-0.597366	0.383031	0
12350.0	-1.918710	-0.589165	-0.547577	0

In [87]:

```
# Checking how many values each cluster has.
with_dbscan_df['cluster'].value_counts(ascending=True)
```

Out[87]:

```
-1       7
 0    4365
Name: cluster, dtype: int64
```

Visualize the transformed data-points in 3D.

- Use cluster-labels to color the data-points.
- There will be 3 plots each for a given algorithm.

In [45]:

```
fig = px.scatter_3d(with_km_df, x='Principal Component 1', y='Principal Component 2', z='Principal Component 3', color=
fig.show()
```

In [44]:
```
fig = px.scatter_3d(with_hierarchical_df, x='Principal Component 1', y='Principal Component 2', z='Principal Component 
fig.show()
```

In [88]:
```
fig = px.scatter_3d(with_dbscan_df, x='Principal Component 1', y='Principal Component 2', z='Principal Component 3', co
fig.show()
```

For this experiment I believe K-Means performed the best as it has identified the most accurate clusters. Hierarchical comes second as it also performed pretty well, However, it got confused with the clusters close to each other in the middle of the plot. Whereas DB Scan performed the worst because it was only able to identify the clusters which were close in proximity.