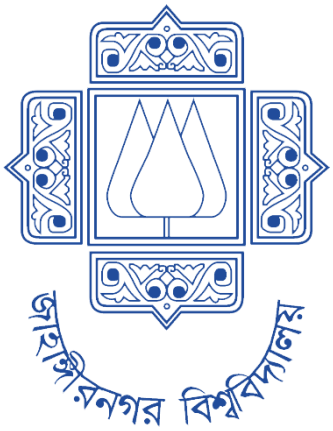
Institute of Information Technology (IIT)

Jahangirnagar University



Lab Report: 08

Submitted by:

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Roll No: 2023

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K-Means Clustering

K-Means Clustering is an Unsupervised Learning algorithm, which groups the unlabeled dataset into different clusters. Here K defines the number of pre-defined clusters that need to be created in the process, as if K=2, there will be two clusters, and for K=3, there will be three clusters, and so on.

“It is an iterative algorithm that divides the unlabeled dataset into k different clusters in such a way that each dataset belongs only one group that has similar properties.”

It allows us to cluster the data into different groups and a convenient way to discover the categories of groups in the unlabeled dataset on its own without the need for any training.

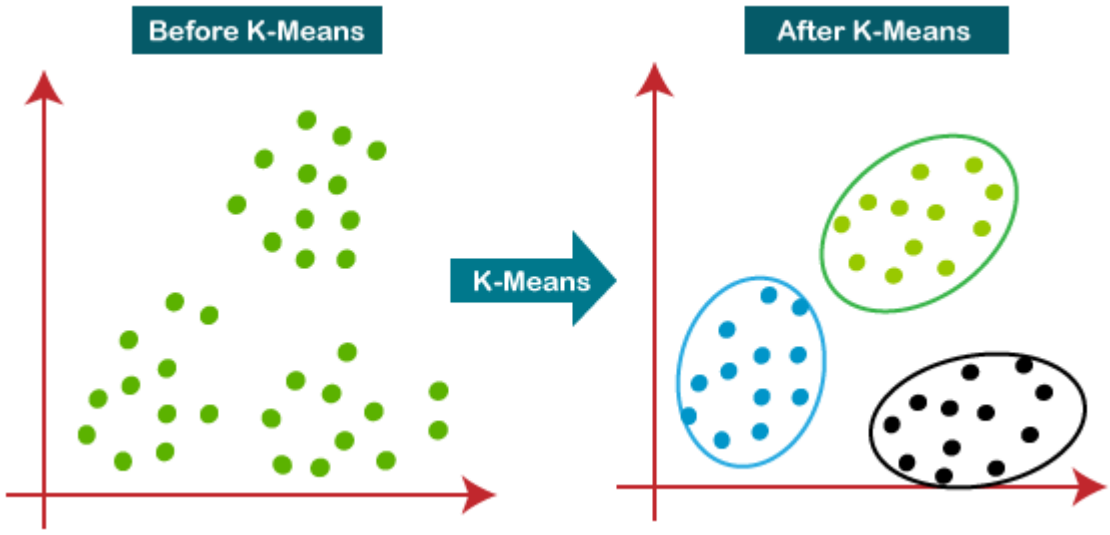
It is a centroid-based algorithm, where each cluster is associated with a centroid. The main aim of this algorithm is to minimize the sum of distances between the data point and their corresponding clusters.

The k-means clustering algorithm mainly performs two tasks:

- Determines the best value for K center points or centroids by an iterative process.
- Assigns each data point to its closest k-center. Those data points which are near to the particular k-center, create a cluster.

Hence each cluster has datapoints with some commonalities, and it is away from other clusters.

The below diagram explains the working of the K-means Clustering Algorithm:



How does the K-Means Algorithm Work?

The working of the K-Means algorithm is explained in the below steps:

Step-1: Select the number K to decide the number of clusters.

Step-2: Select random K points or centroids. (It can be other from the input dataset).

Step-3: Assign each data point to their closest centroid, which will form the predefined K clusters.

Step-4: Calculate the variance and place a new centroid of each cluster.

Step-5: Repeat the third steps, which means reassign each datapoint to the new closest centroid of each cluster.

Step-6: If any reassignment occurs, then go to step-4 else go to FINISH.

Step-7: The model is ready.

When using the Kmeans algorithm under normal circumstances, it is because you don't have labels. In this case we will use the labels to try to get an idea of how well the algorithm performed, but you won't usually do this for Kmeans, so the classification report and confusion matrix at the end of this project, don't truly make sense in a real world setting!.

Connectivity-based clustering

- Distance based
- E.g., Hierarchical clustering

Centroid-based clustering

- Represents each cluster by a single mean vector
- E.g., k-means algorithm

Distribution-based clustering

- Modeled using statistical distributions
- E.g., Multivariate normal distributions used by the expectation-maximization algorithm.

Density-based clustering

- Defines clusters as connected dense regions in the data space.
- E.g., DBSCAN

Source of the data
https://www.kaggle.com/datasets/karthikthallam/college-data/code

Import libraries

In [1]:

```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import matplotlib.pyplot as plt # for data visualization
import seaborn as sns # for statistical data visualization
%matplotlib inline
```

In [3]:

```
df = pd.read_csv('../Resource/College.csv')
```

Exploratory data analysis

In [4]:

```
df.shape
```

Out[4]:

```
(777, 19)
```

In [5]:

```
df.head()
```

Out[5]:

	Unnamed: 0	Private	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undergr
0	Abilene Christian University	Yes	1660	1232	721	23	52	2885	5
1	Adelphi University	Yes	2186	1924	512	16	29	2683	12
2	Adrian College	Yes	1428	1097	336	22	50	1036	
3	Agnes Scott College	Yes	417	349	137	60	89	510	
4	Alaska Pacific University	Yes	193	146	55	16	44	249	8

In [6]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 777 entries, 0 to 776
Data columns (total 19 columns):
 #   Column       Non-Null Count  Dtype  
---  ------       --------------  -----  
 0   Unnamed: 0   777 non-null    object 
 1   Private      777 non-null    object 
 2   Apps         777 non-null    int64  
 3   Accept       777 non-null    int64  
 4   Enroll       777 non-null    int64  
 5   Top10perc    777 non-null    int64  
 6   Top25perc    777 non-null    int64  
 7   F.Undergrad  777 non-null    int64  
 8   P.Undergrad  777 non-null    int64  
 9   Outstate     777 non-null    int64  
 10  Room.Board   777 non-null    int64  
 11  Books        777 non-null    int64  
 12  Personal     777 non-null    int64  
 13  PhD          777 non-null    int64  
 14  Terminal     777 non-null    int64  
 15  S.F.Ratio    777 non-null    float64
 16  perc.alumni  777 non-null    int64  
 17  Expend       777 non-null    int64  
 18  Grad.Rate    777 non-null    int64  
dtypes: float64(1), int64(16), object(2)
memory usage: 115.5+ KB
```

In [7]:

```
df.isnull().sum()
```

Out[7]:

```
Unnamed: 0     0
Private        0
Apps           0
Accept         0
Enroll         0
Top10perc      0
Top25perc      0
F.Undergrad    0
P.Undergrad    0
Outstate       0
Room.Board     0
Books          0
Personal       0
PhD            0
Terminal       0
S.F.Ratio      0
perc.alumni    0
Expend         0
Grad.Rate      0
dtype: int64
```

In [8]:

```
df.drop(['S.F.Ratio', 'perc.alumni', 'Expend', 'Grad.Rate'], axis=1, inplace=True)
```

In [9]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 777 entries, 0 to 776
Data columns (total 15 columns):
 #   Column        Non-Null Count  Dtype  
---  ------------  --------------  -----  
 0   Unnamed: 0    777 non-null    object 
 1   Private       777 non-null    object 
 2   Apps          777 non-null    int64  
 3   Accept        777 non-null    int64  
 4   Enroll        777 non-null    int64  
 5   Top10perc     777 non-null    int64  
 6   Top25perc     777 non-null    int64  
 7   F.Undergrad   777 non-null    int64  
 8   P.Undergrad   777 non-null    int64  
 9   Outstate      777 non-null    int64  
 10  Room.Board    777 non-null    int64  
 11  Books         777 non-null    int64  
 12  Personal      777 non-null    int64  
 13  PhD           777 non-null    int64  
 14  Terminal      777 non-null    int64  
dtypes: int64(13), object(2)
memory usage: 91.2+ KB
```

In [10]:

```
df.describe()
```

Out[10]:

	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.U
count	777.000000	777.000000	777.000000	777.000000	777.000000	777.000000	7
mean	3001.638353	2018.804376	779.972973	27.558559	55.796654	3699.907336	8
std	3870.201484	2451.113971	929.176190	17.640364	19.804778	4850.420531	15
min	81.000000	72.000000	35.000000	1.000000	9.000000	139.000000	
25%	776.000000	604.000000	242.000000	15.000000	41.000000	992.000000	
50%	1558.000000	1110.000000	434.000000	23.000000	54.000000	1707.000000	3
75%	3624.000000	2424.000000	902.000000	35.000000	69.000000	4005.000000	9
max	48094.000000	26330.000000	6392.000000	96.000000	100.000000	31643.000000	218

In [11]:

```
df['Unnamed: 0'].unique()
```

Out[11]:

```
array(['Abilene Christian University', 'Adelphi University',
       'Adrian College', 'Agnes Scott College',
       'Alaska Pacific University', 'Albertson College',
       'Albertus Magnus College', 'Albion College', 'Albright Colleg
e',
       'Alderson-Broaddus College', 'Alfred University',
       'Allegheny College', 'Allentown Coll. of St. Francis de Sales',
       'Alma College', 'Alverno College',
       'American International College', 'Amherst College',
       'Anderson University', 'Andrews University',
       'Angelo State University', 'Antioch University',
       'Appalachian State University', 'Aquinas College',
       'Arizona State University Main campus',
       'Arkansas College (Lyon College)', 'Arkansas Tech University',
       'Assumption College', 'Auburn University-Main Campus',
       'Augsburg College', 'Augustana College IL', 'Augustana Colleg
e',
       'Austin College', 'Averett College', 'Baker University',
```

In [12]:

```
len(df['Unnamed: 0'].unique())
```

Out[12]:

```
777
```

In [13]:

```
df['Private'].unique()
```

Out[13]:

```
array(['Yes', 'No'], dtype=object)
```

In [14]:

```
len(df['Private'].unique())
```

Out[14]:

```
2
```

In [15]:

```
df.drop(['Private'], axis=1, inplace=True)
```

In [16]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 777 entries, 0 to 776
Data columns (total 14 columns):
 #   Column       Non-Null Count  Dtype
---  ------------     --------------------  ---------
 0   Unnamed: 0   777 non-null    object
 1   Apps         777 non-null    int64
 2   Accept       777 non-null    int64
 3   Enroll       777 non-null    int64
 4   Top10perc    777 non-null    int64
 5   Top25perc    777 non-null    int64
 6   F.Undergrad  777 non-null    int64
 7   P.Undergrad  777 non-null    int64
 8   Outstate     777 non-null    int64
 9   Room.Board   777 non-null    int64
 10  Books        777 non-null    int64
 11  Personal     777 non-null    int64
 12  PhD          777 non-null    int64
 13  Terminal     777 non-null    int64
dtypes: int64(13), object(1)
memory usage: 85.1+ KB
```

In [17]:

```
df.head()
```

Out[17]:

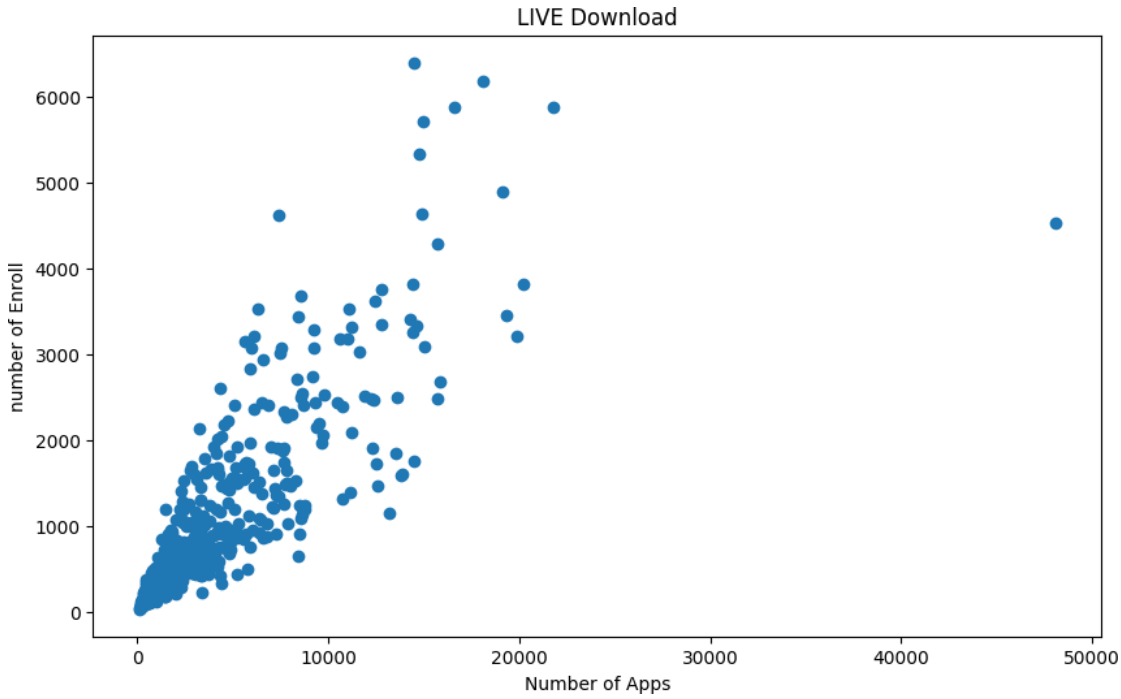
	Unnamed: 0	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undergrad	Outs
0	Abilene Christian University	1660	1232	721	23	52	2885	537	7
1	Adelphi University	2186	1924	512	16	29	2683	1227	12
2	Adrian College	1428	1097	336	22	50	1036	99	11
3	Agnes Scott College	417	349	137	60	89	510	63	12
4	Alaska Pacific University	193	146	55	16	44	249	869	7

In [18]:

```
plt.figure(figsize=(10,6))
plt.scatter(df['Apps'],df['Enroll'])
plt.xlabel('Number of Apps')
plt.ylabel('number of Enroll')
plt.title('LIVE Download')
```

Out[18]:

```
Text(0.5, 1.0, 'LIVE Download')
```



Declare feature vector and target variable

In [19]:

```
df.head(2)
```

Out[19]:

	Unnamed: 0	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undergrad	Outs
0	Abilene Christian University	1660	1232	721	23	52	2885	537	7
1	Adelphi University	2186	1924	512	16	29	2683	1227	12

Convert categorical variable into integers

In [20]:

```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
df['Unnamed: 0'] = le.fit_transform(df['Unnamed: 0'])
```

In [22]:

```
y=df
cols = y.columns
from sklearn.preprocessing import MinMaxScaler
ms = MinMaxScaler()
y = ms.fit_transform(y)
y = pd.DataFrame(y, columns=[cols])
```

In [23]:

```
X = y.values
X[:5] # Show first 5 records only
```

Out[23]:

```
array([[0.        , 0.03288693, 0.04417701, 0.10791254, 0.23157895,
        0.47252747, 0.08716353, 0.02454774, 0.26342975, 0.23959647,
        0.15775401, 0.29770992, 0.65263158, 0.71052632],
       [0.00128866, 0.04384229, 0.07053089, 0.07503539, 0.15789474,
        0.21978022, 0.08075165, 0.05614839, 0.51342975, 0.73612863,
        0.29144385, 0.19083969, 0.22105263, 0.07894737],
       [0.00257732, 0.0280549 , 0.03903572, 0.04734938, 0.22105263,
        0.45054945, 0.02847257, 0.00448821, 0.46022727, 0.31052963,
        0.13547237, 0.13969466, 0.47368421, 0.55263158],
       [0.00386598, 0.0069981 , 0.01054917, 0.0160453 , 0.62105263,
        0.87912088, 0.01177628, 0.00283948, 0.54855372, 0.57849937,
        0.15775401, 0.09541985, 0.88421053, 0.96052632],
       [0.00515464, 0.0023327 , 0.00281819, 0.00314614, 0.15789474,
        0.38461538, 0.00349162, 0.03975269, 0.2696281 , 0.36885246,
        0.31372549, 0.19083969, 0.71578947, 0.63157895]])
```

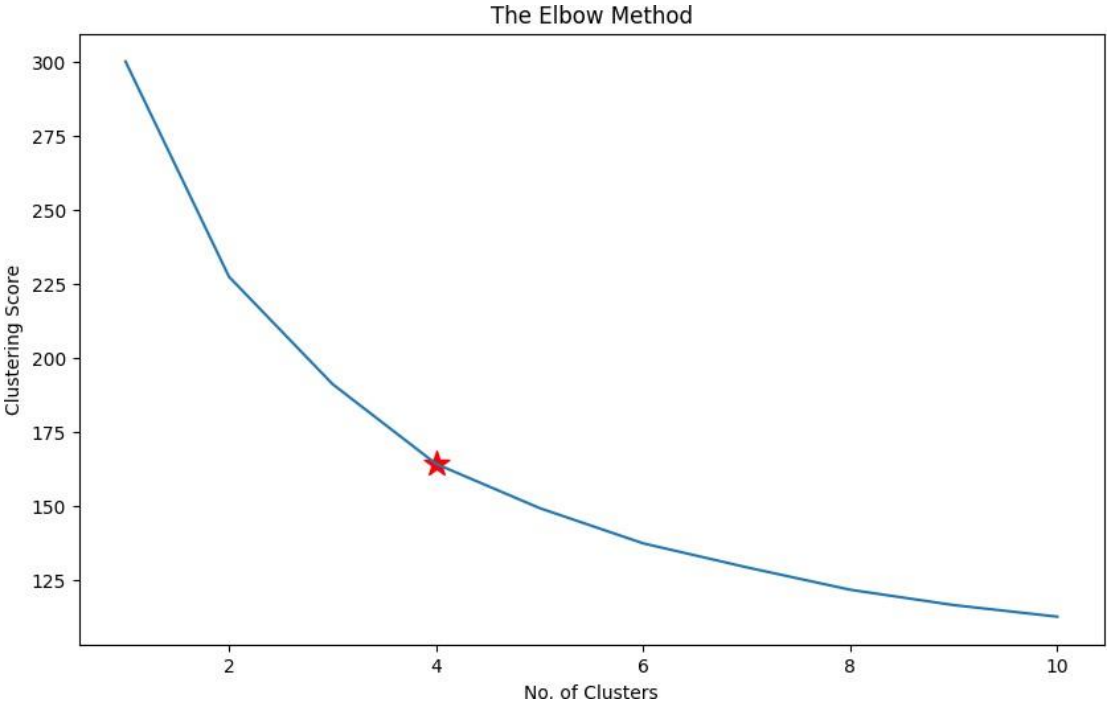
Feature Scaling

In [25]:

```
from sklearn.cluster import KMeans
clustering_score = []
for i in range(1, 11):
    kmeans = KMeans(n_clusters = i, init = 'random', random_state = 42)
    kmeans.fit(X)
    clustering_score.append(kmeans.inertia_)

plt.figure(figsize=(10,6))
plt.plot(range(1, 11), clustering_score)
plt.scatter(4,clustering_score[3], s = 200, c = 'red', marker='*')
plt.title('The Elbow Method')
plt.xlabel('No. of Clusters')
plt.ylabel('Clustering Score')
plt.show()
```

```
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
```


The Elbow Method
Clustering Score
No. of Clusters
300
275
250
225
200
175
150
125
2
4
6
8
10

K-Means model with five clusters

In [26]:

```
kmeans= KMeans(n_clusters = 5, random_state = 42)
# Compute k-means clustering
kmeans.fit(X)
# Compute cluster centers and predict cluster index for each sample.
pred = kmeans.predict(X)
pred
```

```
c:\Users\USER\AppData\Local\Programs\Python\Python39\lib\site-packages\sk
learn\cluster\_kmeans.py:1412: FutureWarning: The default value of `n_ini
t` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explic
itly to suppress the warning
  super()._check_params_vs_input(X, default_n_init=10)
```

Out[26]:

```
array([0, 0, 0, 2, 0, 0, 2, 2, 2, 0, 2, 2, 2, 2, 0, 0, 2, 0, 0, 0, 0, 0,
       0, 4, 2, 0, 2, 4, 0, 2, 0, 2, 0, 0, 0, 0, 2, 2, 0, 0, 2, 0, 0, 0,
       2, 0, 0, 0, 2, 0, 0, 0, 0, 0, 2, 0, 0, 0, 0, 2, 2, 4, 0, 2, 2, 0,
       0, 0, 0, 4, 2, 2, 2, 0, 2, 0, 0, 0, 2, 0, 0, 0, 0, 0, 0, 0, 2, 2,
       0, 0, 0, 2, 0, 0, 2, 0, 2, 0, 0, 2, 0, 2, 0, 0, 0, 0, 2, 2, 2, 0,
       2, 0, 0, 0, 2, 2, 0, 2, 4, 0, 2, 0, 2, 2, 0, 0, 0, 0, 0, 0, 2, 0,
       0, 0, 0, 0, 0, 2, 2, 2, 2, 4, 0, 0, 2, 0, 0, 0, 0, 2, 0, 2, 2, 0,
       0, 0, 0, 0, 2, 2, 0, 0, 2, 2, 2, 0, 0, 0, 0, 0, 0, 2, 2, 2, 2, 2,
       4, 0, 0, 0, 0, 0, 0, 0, 2, 2, 2, 0, 0, 0, 2, 2, 0, 2, 0, 0, 2, 0,
       0, 0, 2, 4, 0, 4, 0, 2, 0, 0, 0, 0, 0, 0, 0, 2, 0, 0, 0, 0, 2, 2,
       0, 2, 2, 0, 0, 2, 0, 2, 0, 0, 2, 0, 0, 0, 0, 0, 0, 2, 0, 2, 2, 0,
       2, 2, 2, 0, 2, 0, 0, 2, 2, 2, 0, 2, 2, 2, 2, 2, 2, 2, 2, 2, 0, 0,
       0, 0, 0, 0, 2, 4, 2, 0, 0, 0, 4, 0, 0, 4, 2, 4, 0, 0, 0, 2, 2, 0,
       0, 2, 4, 0, 0, 0, 2, 0, 0, 0, 2, 0, 2, 2, 0, 2, 0, 0, 0, 0, 2, 2,
       2, 2, 2, 0, 0, 2, 0, 0, 0, 0, 2, 0, 0, 0, 0, 0, 4, 0, 2, 2, 2, 2,
       2, 0, 0, 0, 2, 0, 0, 0, 2, 2, 0, 0, 2, 3, 2, 4, 2, 2, 3, 0, 3, 2,
       0, 0, 1, 0, 0, 0, 0, 2, 0, 3, 3, 0, 3, 4, 4, 2, 0, 3, 0, 3, 2, 0,
       3, 3, 0, 0, 0, 2, 3, 3, 3, 3, 0, 3, 2, 3, 0, 0, 1, 0, 0, 0, 0, 3,
       3, 2, 2, 0, 2, 3, 3, 3, 2, 2, 2, 1, 0, 1, 3, 3, 4, 3, 1, 3, 3, 3,
       4, 4, 4, 3, 3, 3, 1, 3, 0, 3, 1, 1, 1, 2, 4, 1, 3, 3, 4, 3, 3, 3,
       1, 1, 3, 1, 3, 4, 1, 3, 3, 3, 3, 3, 3, 1, 3, 3, 1, 3, 3, 1, 3, 4,
       3, 3, 3, 3, 3, 3, 1, 1, 3, 1, 1, 3, 1, 3, 1, 3, 3, 3, 1, 3, 3, 4,
       1, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 1, 3, 1, 1, 3, 3, 1, 1, 3, 3, 1,
       3, 3, 3, 3, 4, 1, 1, 3, 3, 1, 1, 1, 3, 3, 3, 3, 3, 3, 1, 3, 3, 1,
       1, 3, 3, 3, 3, 3, 1, 3, 4, 3, 3, 3, 1, 3, 1, 3, 3, 3, 3, 1, 3, 1,
       1, 3, 3, 3, 3, 3, 1, 1, 3, 1, 4, 4, 4, 4, 3, 3, 3, 3, 3, 1, 3, 3,
       3, 3, 1, 1, 1, 3, 3, 3, 3, 4, 3, 3, 3, 4, 3, 3, 3, 3, 1, 1, 3, 1,
       1, 3, 1, 1, 3, 3, 3, 1, 3, 3, 4, 4, 1, 4, 3, 1, 4, 4, 1, 3, 4, 1,
       3, 3, 3, 4, 4, 3, 4, 4, 4, 3, 4, 3, 4, 3, 3, 3, 3, 4, 4, 3, 1, 4,
       3, 1, 4, 3, 4, 1, 3, 3, 3, 4, 3, 4, 3, 4, 4, 3, 3, 4, 1, 4, 3, 4,
       1, 4, 4, 1, 4, 1, 1, 4, 1, 1, 1, 1, 3, 1, 3, 4, 4, 1, 3, 3, 3, 3,
       1, 4, 3, 4, 4, 3, 1, 1, 1, 4, 1, 1, 4, 3, 3, 3, 3, 3, 4, 4, 3, 3,
       1, 3, 3, 1, 1, 1, 1, 4, 3, 4, 3, 3, 3, 3, 1, 3, 1, 3, 3, 3, 1, 1,
       1, 4, 1, 3, 3, 3, 3, 1, 1, 3, 3, 1, 3, 3, 3, 3, 1, 4, 3, 3, 4, 3,
       3, 3, 3, 1, 1, 1, 3, 1, 1, 1, 1, 3, 1, 3, 3, 1, 3, 3, 3, 3, 3, 1,
       1, 1, 3, 3, 3, 1, 3])
```

In [27]:

```
df['Cluster'] = pd.DataFrame(pred, columns=['cluster'] )
print('Number of data points in each cluster= \n', df['Cluster'].value_counts())
df
```

```
Number of data points in each cluster=
 0    226
3     219
2     143
1     111
4      78
Name: Cluster, dtype: int64
```

Out[27]:

	Unnamed: 0	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undergrad	O
0	0	1660	1232	721	23	52	2885	537	
1	1	2186	1924	512	16	29	2683	1227	
2	2	1428	1097	336	22	50	1036	99	
3	3	417	349	137	60	89	510	63	
4	4	193	146	55	16	44	249	869	
...	...	...	...	...	...	...	...	...	
772	772	2197	1515	543	4	26	3089	2029	
773	773	1959	1805	695	24	47	2849	1107	
774	774	2097	1915	695	34	61	2793	166	
775	775	10705	2453	1317	95	99	5217	83	
776	776	2989	1855	691	28	63	2988	1726	

777 rows × 15 columns

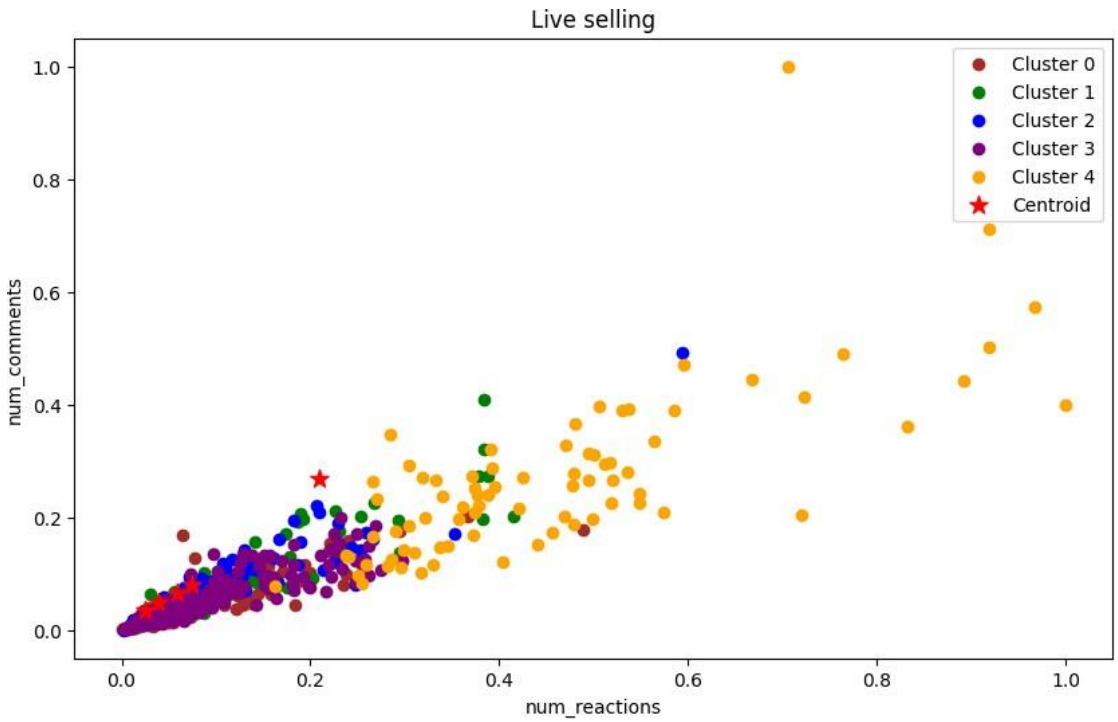
Vizualization

In [28]:

```
plt.figure(figsize=(10,6))
plt.scatter(X[pred == 0, 3], X[pred == 0, 2], c = 'brown', label = 'Cluster 0')
plt.scatter(X[pred == 1, 3], X[pred == 1, 2], c = 'green', label = 'Cluster 1')
plt.scatter(X[pred == 2, 3], X[pred == 2, 2], c = 'blue', label = 'Cluster 2')
plt.scatter(X[pred == 3, 3], X[pred == 3, 2], c = 'purple', label = 'Cluster 3')
plt.scatter(X[pred == 4, 3], X[pred == 4, 2], c = 'orange', label = 'Cluster 4')
plt.scatter(kmeans.cluster_centers_[:,1], kmeans.cluster_centers_[:, 2],s =100, c = 'red
plt.xlabel('num_reactions')
plt.ylabel('num_comments')
plt.legend()
plt.title('Live selling')
```

Out[28]:

```
Text(0.5, 1.0, 'Live selling')
```



K-Means model parameters study

In [29]:

```
labels1 = kmeans.labels_
centroids1 = kmeans.cluster_centers_
labels1
```

Out[29]:

```
array([0, 0, 0, 2, 0, 0, 2, 2, 2, 0, 2, 2, 2, 2, 0, 0, 2, 0, 0, 0, 0, 0,
       0, 4, 2, 0, 2, 4, 0, 2, 0, 2, 0, 0, 0, 0, 2, 2, 0, 0, 2, 0, 0, 0,
       2, 0, 0, 0, 2, 0, 0, 0, 0, 0, 2, 0, 0, 0, 0, 2, 2, 4, 0, 2, 2, 0,
       0, 0, 0, 4, 2, 2, 2, 0, 2, 0, 0, 0, 2, 0, 0, 0, 0, 0, 0, 0, 2, 2,
       0, 0, 0, 2, 0, 0, 2, 0, 2, 0, 0, 2, 0, 2, 0, 0, 0, 0, 2, 2, 2, 0,
       2, 0, 0, 0, 2, 2, 0, 2, 4, 0, 2, 0, 2, 2, 0, 0, 0, 0, 0, 0, 2, 0,
       0, 0, 0, 0, 0, 2, 2, 2, 2, 4, 0, 0, 2, 0, 0, 0, 0, 2, 0, 2, 2, 0,
       0, 0, 0, 0, 2, 2, 0, 0, 2, 2, 2, 0, 0, 0, 0, 0, 0, 2, 2, 2, 2, 2,
       4, 0, 0, 0, 0, 0, 0, 0, 2, 2, 2, 0, 0, 0, 2, 2, 0, 2, 0, 0, 2, 0,
       0, 0, 2, 4, 0, 4, 0, 2, 0, 0, 0, 0, 0, 0, 0, 0, 2, 0, 0, 0, 0, 2, 2,
       0, 2, 2, 0, 0, 2, 0, 2, 0, 0, 2, 0, 0, 0, 0, 0, 0, 0, 2, 0, 2, 2, 0,
       2, 2, 2, 0, 2, 0, 0, 2, 2, 2, 0, 2, 2, 2, 2, 2, 2, 2, 2, 2, 0, 0,
       0, 0, 0, 0, 2, 4, 2, 0, 0, 0, 4, 0, 0, 4, 2, 4, 0, 0, 0, 2, 2, 0,
       0, 2, 4, 0, 0, 0, 2, 0, 0, 0, 2, 0, 2, 2, 0, 2, 0, 0, 0, 0, 2, 2,
       2, 2, 2, 0, 0, 2, 0, 0, 0, 0, 2, 0, 0, 0, 0, 0, 4, 0, 2, 2, 2, 2,
       2, 0, 0, 0, 2, 0, 0, 0, 2, 2, 0, 0, 2, 3, 2, 4, 2, 2, 3, 0, 3, 2,
       0, 0, 1, 0, 0, 0, 0, 2, 0, 3, 3, 0, 3, 4, 4, 2, 0, 3, 0, 3, 2, 0,
       3, 3, 0, 0, 0, 2, 3, 3, 3, 3, 0, 3, 2, 3, 0, 0, 1, 0, 0, 0, 0, 3,
       3, 2, 2, 0, 2, 3, 3, 3, 2, 2, 2, 1, 0, 1, 3, 3, 4, 3, 1, 3, 3, 3,
       4, 4, 4, 3, 3, 3, 1, 3, 0, 3, 1, 1, 1, 2, 4, 1, 3, 3, 4, 3, 3, 3,
       1, 1, 3, 1, 3, 4, 1, 3, 3, 3, 3, 3, 3, 1, 3, 3, 1, 3, 3, 1, 3, 4,
       3, 3, 3, 3, 3, 3, 1, 1, 3, 1, 1, 3, 1, 3, 1, 3, 3, 3, 1, 3, 3, 4,
       1, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 1, 3, 1, 1, 3, 3, 1, 1, 3, 3, 1,
       3, 3, 3, 3, 4, 1, 1, 3, 3, 1, 1, 1, 3, 3, 3, 3, 3, 3, 1, 3, 3, 1,
       1, 3, 3, 3, 3, 3, 1, 3, 4, 3, 3, 3, 1, 3, 1, 3, 3, 3, 3, 1, 3, 1,
       1, 3, 3, 3, 3, 3, 1, 1, 3, 1, 4, 4, 4, 4, 3, 3, 3, 3, 3, 1, 3, 3,
       3, 3, 1, 1, 1, 3, 3, 3, 3, 4, 3, 3, 3, 4, 3, 3, 3, 3, 1, 1, 3, 1,
       1, 3, 1, 1, 3, 3, 3, 1, 3, 3, 4, 4, 1, 4, 3, 1, 4, 4, 1, 3, 4, 1,
       3, 3, 3, 4, 4, 3, 4, 4, 4, 3, 4, 3, 4, 3, 3, 3, 3, 4, 4, 3, 1, 4,
       3, 1, 4, 3, 4, 1, 3, 3, 3, 4, 3, 4, 3, 4, 4, 3, 3, 4, 1, 4, 3, 4,
       1, 4, 4, 1, 4, 1, 1, 4, 1, 1, 1, 1, 3, 1, 3, 4, 4, 1, 3, 3, 3, 3,
       1, 4, 3, 4, 4, 3, 1, 1, 1, 4, 1, 1, 4, 3, 3, 3, 3, 3, 4, 4, 3, 3,
       1, 3, 3, 1, 1, 1, 1, 4, 3, 4, 3, 3, 3, 3, 1, 3, 1, 3, 3, 3, 1, 1,
       1, 4, 1, 3, 3, 3, 3, 1, 1, 3, 3, 1, 3, 3, 3, 3, 1, 4, 3, 3, 4, 3,
       3, 3, 3, 1, 1, 1, 3, 1, 1, 1, 1, 3, 1, 3, 3, 1, 3, 3, 3, 3, 3, 1,
       1, 1, 3, 3, 3, 1, 3])
```

In [30]:

```
kmeans.inertia_
```

Out[30]:

```
149.2353098465791
```