Assignment 5

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```
import numpy as np
from scipy.cluster.hierarchy import dendrogram, linkage
from scipy.spatial.distance import euclidean
from scipy.spatial.distance import pdist,squareform
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.cluster import AgglomerativeClustering
from sklearn.cluster import KMeans
from collections import defaultdict
from sklearn.metrics import silhouette_score
from itertools import combinations
```

```
# read excel file into pandas dataframe
df = pd.read_excel('Cereals.xlsx', sheet_name = 'Data from DASL', index_col = 'name')
```

```
df.head()
```

	mfr	type	calories	protein	fat	sodium	fiber	carbo	sugars	potass	vitamins	shelf	weig
name													
100%_Bran	N	C	70	4	1	130	10.0	5.0	6.0	280.0	25	3	1.0
100%_Natural_Bran	Q	C	120	3	5	15	2.0	8.0	8.0	135.0	0	3	1.0
All-Bran	K	C	70	4	1	260	9.0	7.0	5.0	320.0	25	3	1.0
All-Bran_with_Extra_Fiber	K	C	50	4	0	140	14.0	8.0	0.0	330.0	25	3	1.0
Almond_Delight	R	C	110	2	2	200	1.0	14.0	8.0	NaN	25	3	1.0

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 77 entries, 100%_Bran to Wheaties_Honey_Gold
Data columns (total 15 columns):
mfr         77 non-null object
type        77 non-null object
calories    77 non-null int64
protein     77 non-null int64
fat         77 non-null int64
sodium      77 non-null int64
fiber       77 non-null float64
carbo       76 non-null float64
sugars      76 non-null float64
potass      75 non-null float64
vitamins    77 non-null int64
shelf       77 non-null int64
weight      77 non-null float64
cups        77 non-null float64
rating      77 non-null float64
dtypes: float64(7), int64(6), object(2)
memory usage: 9.6+ KB
```

```
originalrow= len(df.index)
originalrow
```

```
77
```

Data preprocessing

Keep numerical value column

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

```
df.head()
```

	calories	protein	fat	sodium	fiber	carbo	sugars	potass	vitamins	shelf	weight	cups	
name													
100%_Bran	70	4	1	130	10.0	5.0	6.0	280.0	25	3	1.0	0.33	6
100%_Natural_Bran	120	3	5	15	2.0	8.0	8.0	135.0	0	3	1.0	1.00	3
All-Bran	70	4	1	260	9.0	7.0	5.0	320.0	25	3	1.0	0.33	5
All-Bran_with_Extra_Fiber	50	4	0	140	14.0	8.0	0.0	330.0	25	3	1.0	0.50	9
Almond_Delight	110	2	2	200	1.0	14.0	8.0	NaN	25	3	1.0	0.75	3

Remove missing value

```
df.isnull().any()
# missing values exists in column 'carbo','sodium','potass'
```

```
mfr         False
type        False
calories    False
protein     False
fat         False
sodium      False
fiber       False
carbo        True
sugars       True
potass       True
vitamins    False
shelf       False
weight      False
cups        False
rating      False
dtype: bool
```

```
df1 = df.dropna()
```

```
newrow = len(df1.index)
rowsremoved = originalrow - newrow
```

```
print('Number of rows removed = ', rowsremoved)
```

```
Number of rows removed =  3
```

Normalize the data (z-transformation)

```
df1.head(5)
# check the data before normalization
```

	calories	protein	fat	sodium	fiber	carbo	sugars	potass	vitamins	shelf	weight	cups
name												
100%_Bran	70	4	1	130	10.0	5.0	6.0	280.0	25	3	1.0	0.33
100%_Natural_Bran	120	3	5	15	2.0	8.0	8.0	135.0	0	3	1.0	1.00
All-Bran	70	4	1	260	9.0	7.0	5.0	320.0	25	3	1.0	0.33
All-Bran_with_Extra_Fiber	50	4	0	140	14.0	8.0	0.0	330.0	25	3	1.0	0.50
Apple_Cinnamon_Cheerios	110	2	2	180	1.5	10.5	10.0	70.0	25	1	1.0	0.75

```
from sklearn import preprocessing
```

```
# transformer = preprocessing.Normalizer()
# transformer.transform(df1)
```

```
df2 = preprocessing.normalize(df1, norm='l2')
```

```
df2 = pd.DataFrame(df2)
```

```
df2.index = df1.index
```

```
df2.head()
# the data after normalization
```

	0	1	2	3	4	5	6	7	8	
name										
100%_Bran	0.215316	0.012304	0.003076	0.399873	0.030759	0.015380	0.018456	0.861265	0.076899	0.00
100%_Natural_Bran	0.649058	0.016226	0.027044	0.081132	0.010818	0.043271	0.043271	0.730190	0.000000	0.01
All-Bran	0.165342	0.009448	0.002362	0.614126	0.021258	0.016534	0.011810	0.755848	0.059051	0.00
All-Bran_with_Extra_Fiber	0.133302	0.010664	0.000000	0.373245	0.037324	0.021328	0.000000	0.879791	0.066651	0.00
Apple_Cinnamon_Cheerios	0.486522	0.008846	0.008846	0.796126	0.006634	0.046441	0.044229	0.309605	0.110573	0.00

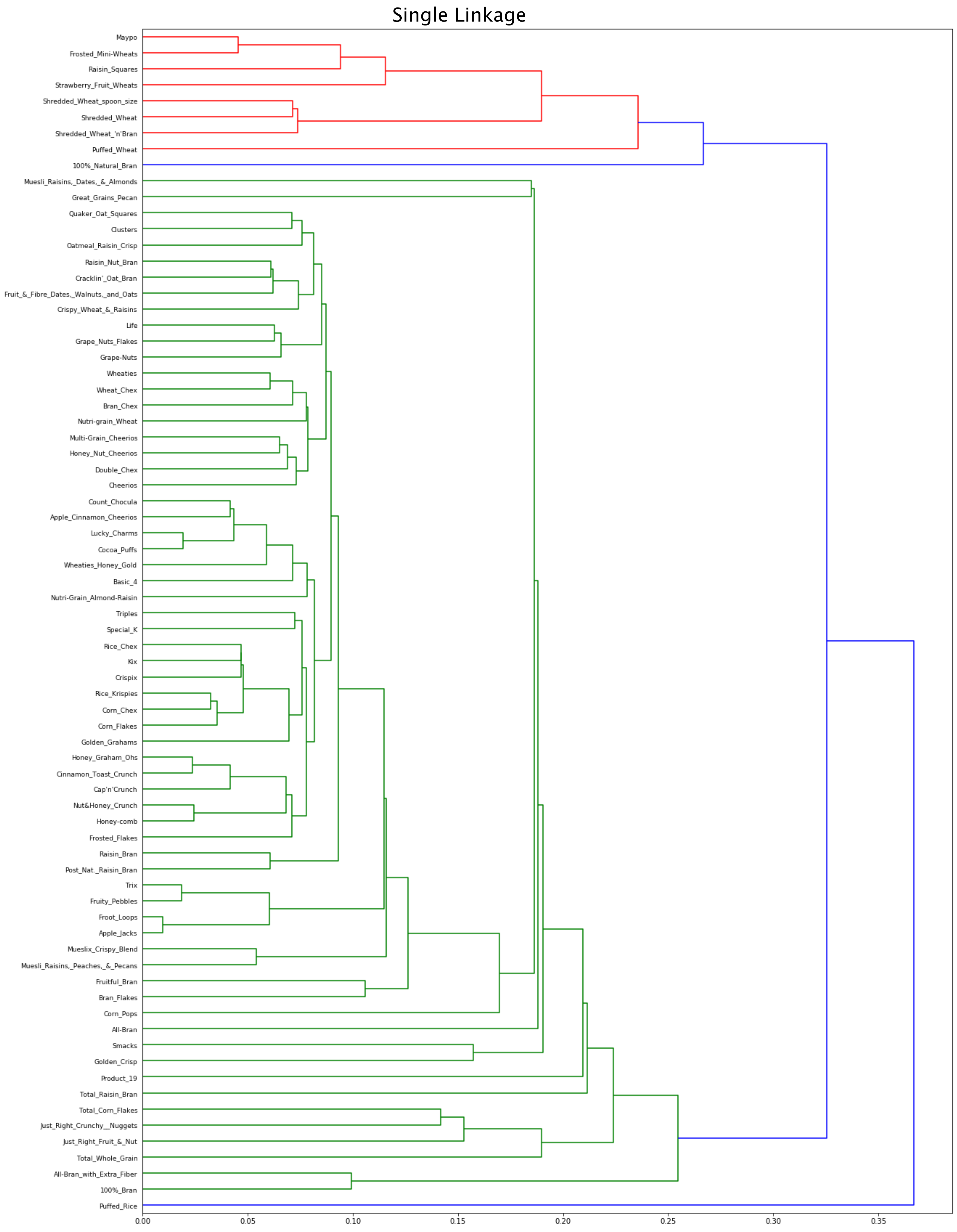
Clustering

Single Linkage

```
link = linkage(df2, method='single', metric='euclidean')
fig, ax = plt.subplots(1, figsize=(20, 30))


dendro = dendrogram(link, color_threshold=None, leaf_font_size=9,get_leaves=True,truncate_mode=None,
orientation='right', labels=df2.index, count_sort=False, distance_sort=False, show_leaf_counts=True, no_plot=False,
no_labels=False,  leaf_rotation=None, leaf_label_func=None,
 show_contracted=False, link_color_func=None, ax=None)

plt.savefig('single')
plt.show()
```

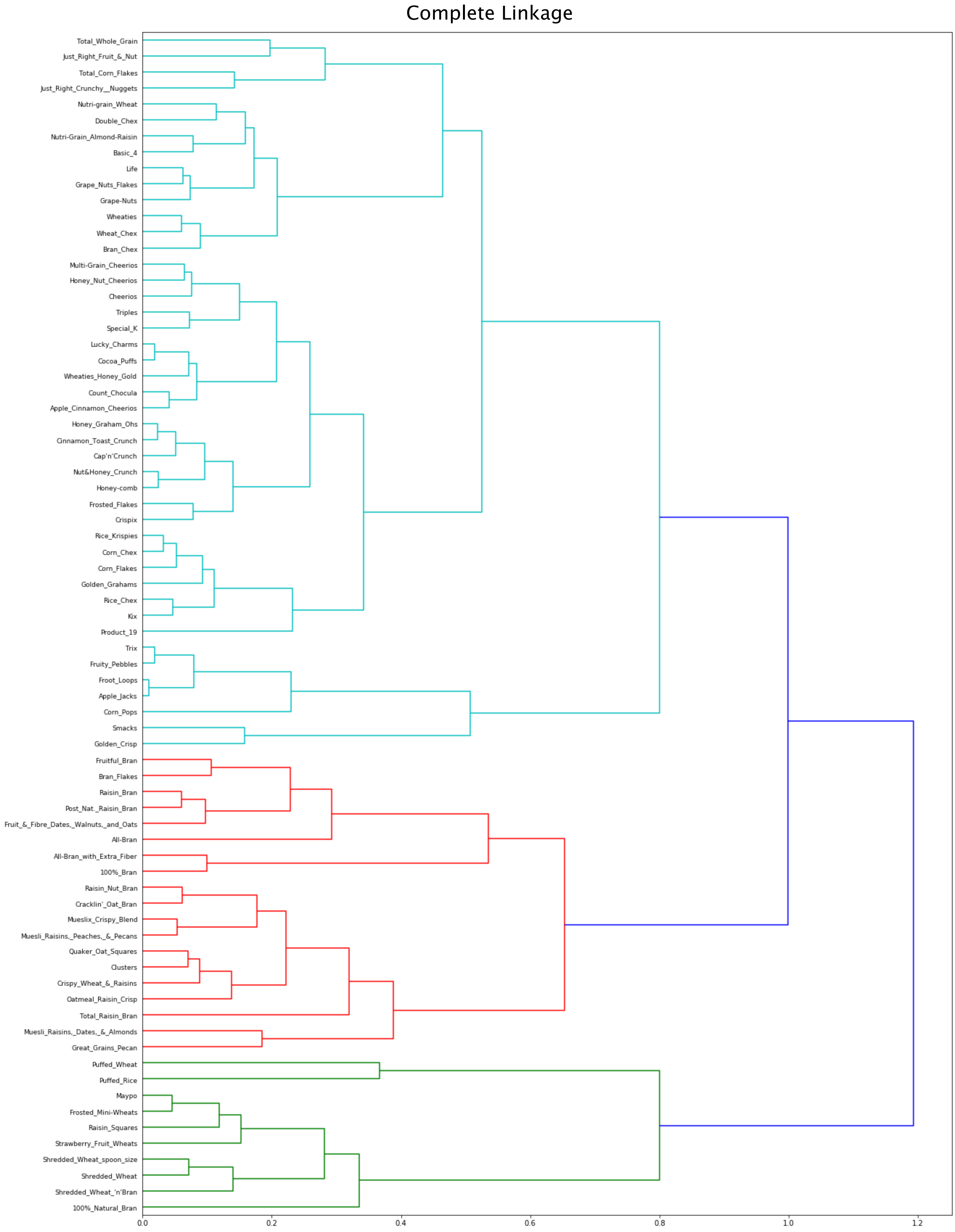

Single Linkage

Complete linkge

```
link = linkage(df2, method='complete', metric='euclidean')
fig, ax = plt.subplots(1, figsize=(20, 30))


dendro = dendrogram(link, color_threshold=None, leaf_font_size=9,get_leaves=True,truncate_mode=None,
orientation='right', labels=df2.index, count_sort=False, distance_sort=False, show_leaf_counts=True, no_plot=False,
no_labels=False,  leaf_rotation=None, leaf_label_func=None,
 show_contracted=False, link_color_func=None, ax=None)

plt.savefig('com')
plt.show()
```



Which method produces more meaningful clusters? Why?

In single-link clustering or single-linkage clustering , the similarity of two clusters is the similarity of their most similar members, more distant parts of the cluster and the clusters' overall structure are not taken into account.In complete-link clustering or complete-linkage clustering , the similarity of two clusters is the similarity of their most dissimilar members, and the entir structure is considered.

https://nlp.stanford.edu/IR-book/html/htmledition/single-link-and-complete-link-clustering-1.html

According to the result of these two different method, complete linkage is recommended in this case, cause it can create more clusters and generate more meaningful results.

How many clusters do you recommend? How many cereals are there in each cluster?

I would recommend 5 clusters and 38 cereals in cluster 1, 7 ceareals in cluster 2, 19 in cluster 3, 2 cereals in cluster 4 and 8 cereals in cluster 5.

K-means

```
df2.shape
```

```
(74, 13)
```

```
kmeans = KMeans(algorithm='auto', copy_x=True, init='k-means++', max_iter=300000,
    n_clusters=5, n_jobs=None, precompute_distances='auto',
    random_state=None, tol=0.0001, verbose=0)
kmeans.fit(df2)
```

```
KMeans(algorithm='auto', copy_x=True, init='k-means++', max_iter=300000,
    n_clusters=5, n_init=10, n_jobs=None, precompute_distances='auto',
    random_state=None, tol=0.0001, verbose=0)
```

```
print("cluster centers:")
print(kmeans.cluster_centers_)
```

```
cluster centers:
[[0.4447801  0.01155223 0.00455526 0.73451843 0.00984157 0.06349207
  0.02585704 0.42179279 0.14657933 0.01014497 0.00438534 0.00301565
  0.17954306]
 [0.58805142 0.01701275 0.00336455 0.01850309 0.01348976 0.10388814
  0.01812115 0.61827183 0.06594027 0.0162238  0.00604101 0.00647405
  0.44141646]
 [0.39968795 0.01156998 0.00633785 0.53081871 0.01742387 0.04252292
  0.02952683 0.68675555 0.10253351 0.01023993 0.00391275 0.00219605
  0.15693801]
 [0.42048626 0.00741637 0.00318315 0.86021968 0.00161508 0.06185044
  0.02739787 0.17784679 0.11649019 0.00659476 0.00378256 0.00362618
  0.12738624]
 [0.6788657  0.01003929 0.00337864 0.6251141  0.00357529 0.07204692
  0.08414075 0.19228427 0.15686693 0.01141448 0.00627468 0.0056916
  0.20198817]]
```

```
labels = pd.DataFrame(kmeans.labels_)
labels.index= df2.index
labels.info()
print(labels.head())
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 74 entries, 100%_Bran to Wheaties_Honey_Gold
Data columns (total 1 columns):
0    74 non-null int32
dtypes: int32(1)
memory usage: 3.4+ KB
                           0
name
100%_Bran                  2
100%_Natural_Bran          1
All-Bran                   2
All-Bran_with_Extra_Fiber  2
Apple_Cinnamon_Cheerios    0
```

```
top_centroids = kmeans.cluster_centers_.argsort()[:,-1:-14:-1]
print("features for each cluster:")
for num, centroid in enumerate(top_centroids):
    print("%d: %s" % (num, ", ".join(df2.index[i] for i in centroid)))
```

```
features for each cluster:
0: All-Bran_with_Extra_Fiber, 100%_Bran, Bran_Chex, Clusters, Bran_Flakes, Apple_Jacks, Basic_4, 100%_Natural_Bran, Cap'n'Crunch, Apple_Cin
namon_Cheerios, All-Bran, Cheerios, Cinnamon_Toast_Crunch
1: Bran_Chex, 100%_Bran, Clusters, Apple_Jacks, Bran_Flakes, All-Bran_with_Extra_Fiber, Basic_4, 100%_Natural_Bran, Cap'n'Crunch, Apple_Cin
namon_Cheerios, Cinnamon_Toast_Crunch, Cheerios, All-Bran
2: Bran_Chex, All-Bran_with_Extra_Fiber, 100%_Bran, Clusters, Bran_Flakes, Apple_Jacks, Basic_4, Apple_Cinnamon_Cheerios, 100%_Natural_Bran
, Cap'n'Crunch, All-Bran, Cheerios, Cinnamon_Toast_Crunch
3: All-Bran_with_Extra_Fiber, 100%_Bran, Bran_Chex, Clusters, Bran_Flakes, Apple_Jacks, Basic_4, 100%_Natural_Bran, Cap'n'Crunch, Cheerios,
 Cinnamon_Toast_Crunch, All-Bran, Apple_Cinnamon_Cheerios
4: 100%_Bran, All-Bran_with_Extra_Fiber, Clusters, Bran_Chex, Bran_Flakes, Basic_4, Apple_Jacks, Cap'n'Crunch, 100%_Natural_Bran, Cheerios,
 Cinnamon_Toast_Crunch, Apple_Cinnamon_Cheerios, All-Bran
```

Healthiness table for cereals in cluster 0

```
# generate the dataframe which contains the column calories, fat, sodium, sugar and protein
# for cereals in different clusters, it will be helpful to compare their healthiness


list = labels[labels[0] == 0]
df4 = df1[['calories','protein','fat','sodium','sugars','rating']]
df5 = df4.loc[list.index]
df5.describe()
```

	calories	protein	fat	sodium	sugars	rating
count	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000
mean	109.000000	2.800000	1.100000	182.250000	6.350000	43.490230
std	15.183093	0.615587	0.718185	32.137656	2.814904	7.990124
min	90.000000	2.000000	0.000000	135.000000	2.000000	29.509541
25%	100.000000	2.000000	1.000000	165.000000	4.500000	36.909842
50%	100.000000	3.000000	1.000000	175.000000	6.000000	42.673174
75%	112.500000	3.000000	2.000000	202.500000	8.250000	49.580767
max	140.000000	4.000000	2.000000	240.000000	12.000000	59.642837

Healthiness table for cereals in cluster 1

```
list = labels[labels[0] == 1]
df4 = df1[['calories','protein','fat','sodium','sugars','rating']]
df6 = df4.loc[list.index]
df6.describe()
```

	calories	protein	fat	sodium	sugars	rating
count	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000
mean	86.000000	2.500000	0.600000	3.000000	2.900000	60.114925
std	21.705094	0.849837	1.577621	6.324555	3.314949	11.445232
min	50.000000	1.000000	0.000000	0.000000	0.000000	33.983679
25%	82.500000	2.000000	0.000000	0.000000	0.000000	56.086142
50%	90.000000	2.500000	0.000000	0.000000	1.500000	60.060052
75%	97.500000	3.000000	0.000000	0.000000	5.750000	66.928325
max	120.000000	4.000000	5.000000	15.000000	8.000000	74.472949

Healthiness table for cereals in cluster 2

```
list = labels[labels[0] == 2]
df4 = df1[['calories','protein','fat','sodium','sugars','rating']]
df7 = df4.loc[list.index]
df7.describe()
```

	calories	protein	fat	sodium	sugars	rating
count	14.000000	14.000000	14.000000	14.000000	14.000000	14.000000
mean	112.142857	3.357143	1.642857	160.714286	8.571429	46.357907
std	33.091614	0.497245	1.081818	49.023430	4.237457	17.510978
min	50.000000	3.000000	0.000000	75.000000	0.000000	28.592785
25%	92.500000	3.000000	1.000000	140.000000	5.250000	37.312796
50%	120.000000	3.000000	1.500000	150.000000	9.000000	40.076086
75%	135.000000	4.000000	2.750000	197.500000	11.750000	51.438289
max	160.000000	4.000000	3.000000	260.000000	14.000000	93.704912

Healthiness table for cereals in cluster 3

```
list = labels[labels[0] == 3]
df4 = df1[['calories','protein','fat','sodium','sugars','rating']]
df8 = df4.loc[list.index]
df8.describe()
```

	calories	protein	fat	sodium	sugars	rating
count	23.000000	23.000000	23.000000	23.000000	23.000000	23.000000
mean	110.869565	2.043478	0.826087	233.043478	6.826087	34.440072
std	5.146087	1.397344	0.834058	42.898907	4.292193	10.292353
min	100.000000	1.000000	0.000000	180.000000	1.000000	18.042851
25%	110.000000	1.000000	0.000000	200.000000	3.000000	25.269279
50%	110.000000	2.000000	1.000000	220.000000	8.000000	36.187559
75%	110.000000	2.000000	1.000000	270.000000	11.000000	41.474280
max	120.000000	6.000000	3.000000	320.000000	13.000000	53.131324

Healthiness table for cereals in cluster 4

```
list = labels[labels[0] == 4]
df4 = df1[['calories','protein','fat','sodium','sugars','rating']]
df9 = df4.loc[list.index]
df9.describe()
```

	calories	protein	fat	sodium	sugars	rating
count	7.000000	7.000000	7.000000	7.000000	7.000000	7.000000
mean	108.571429	1.571429	0.571429	104.285714	13.285714	31.918004
std	3.779645	0.534522	0.534522	36.449574	1.380131	3.180258
min	100.000000	1.000000	0.000000	45.000000	12.000000	27.753301
25%	110.000000	1.000000	0.000000	80.000000	12.000000	29.627910
50%	110.000000	2.000000	1.000000	125.000000	13.000000	32.207582
75%	110.000000	2.000000	1.000000	130.000000	14.500000	34.213269
max	110.000000	2.000000	1.000000	140.000000	15.000000	35.782791

According to the description tables of these 5 clusters, I made a table for easily compare their healthiness.

Cluster	Calories	Protein	Fat	Sodium	Sugers	Rating
Cluster 0	109	2.8	1.1	182.25	6.35	43.49
Cluster 1	86	2.5	0.6	3	2.9	60.11
Cluster 2	112.14	3.35	1.65	160.71	8.57	46.36
Cluster 3	110.87	2.04	0.82	233.04	6.83	34.44
Cluster 4	108.57	1.57	0.57	104.29	13.29	31.92

According to the descriptions of the data on different cereals in these 5 clusters. We can see that cluster 1 is most healthy amount the 5 clusters, it cobtains high protein and low cal low sugers and low fat and sodium. Therefore I would like to recommend the primary school choose the cereals in cluster 1 and the rating for cluster 1 is highest, so the student will like the cereals in the cluster 1.

```
df6
```

	calories	protein	fat	sodium	sugars	rating
name						
100%_Natural_Bran	120	3	5	15	8.0	33.983679
Frosted_Mini-Wheats	100	3	0	0	7.0	58.345141
Maypo	100	4	1	0	3.0	54.850917
Puffed_Rice	50	1	0	0	0.0	60.756112
Puffed_Wheat	50	2	0	0	0.0	63.005645
Raisin_Squares	90	2	0	0	6.0	55.333142
Shredded_Wheat	80	2	0	0	0.0	68.235885
Shredded_Wheat_'n'Bran	90	3	0	0	0.0	74.472949
Shredded_Wheat_spoon_size	90	3	0	0	0.0	72.801787
Strawberry_Fruit_Wheats	90	2	0	15	5.0	59.363993

```
print('The name of the cereals in cluster 1:')
print(df6.index)
```

```
The name of the cereals in cluster 1:
Index(['100%_Natural_Bran', 'Frosted_Mini-Wheats', 'Maypo', 'Puffed_Rice',
       'Puffed_Wheat', 'Raisin_Squares', 'Shredded_Wheat',
       'Shredded_Wheat_'n'Bran', 'Shredded_Wheat_spoon_size',
       'Strawberry_Fruit_Wheats'],
      dtype='object', name='name')
```

I will recommend the cereals above to the prime school.