Wikipedia Document Clustering

Q 10)

a) The implementation of the k-means algorithm along with the results is attached below, it contains full code along with the output, to cross verify everything that is written here.

b) The documents are clustered as given below:

```
----------------------------------
NUMBER OF CLUSTERS = 4
TOTAL ITERATIONS = 3
Cluster no. 1: ['Data Science']
Cluster no. 2: ['Basketball', 'Swimming', 'Cricket']
Cluster no. 3: ['European Central Bank', 'Financial technology', 'International
Monetary Fund']
Cluster no. 4: ['Linear algebra', 'Artificial intelligence']
----------------------------------
NUMBER OF CLUSTERS = 8
TOTAL ITERATIONS = 7
Cluster no. 1: ['Financial technology']
Cluster no. 2: ['Artificial intelligence']
Cluster no. 3: ['Data Science']
Cluster no. 4: ['International Monetary Fund']
Cluster no. 5: ['Swimming']
Cluster no. 6: ['Linear algebra']
Cluster no. 7: ['European Central Bank']
Cluster no. 8: ['Basketball', 'Cricket']
----------------------------------
NUMBER OF CLUSTERS = 12
TOTAL ITERATIONS = 11
Cluster no. 1: ['Financial technology']
Cluster no. 2: ['Basketball', 'Cricket']
Cluster no. 3: ['Data Science']
Cluster no. 4: ['European Central Bank']
Cluster no. 5: [ ]
Cluster no. 6: ['Swimming']
Cluster no. 7: ['Linear algebra']
Cluster no. 8: [ ]
Cluster no. 9: ['Artificial intelligence']
Cluster no. 10: [ ]
Cluster no. 11: ['International Monetary Fund']
Cluster no. 12: [ ]
```

c) K=4, ie. when number of clusters is 4 gives the best results because of the following reasons:
    i) We can observe that documents which were given to us were from 3 different categories, sports, AI/ML subjects, and financial institutions. We can see a very similar classification being done in K=4, where only data science is present in a separate cluster, otherwise all the other clusters are exactly as we expect and have unique characteristics.
    ii) For K=8, only one cluster contains two elements, otherwise all the other clusters contain only one element, so in case when the amount of training data is very less and we cannot logically make sense of 8 separate clusters, it is definitely a worse option when compared to K=4.
    iii) K=12 is impractical because having K more than the number of data points we have will leave some clusters empty which is not desirable and along with that, similar to the previous case it is hard to make sense of what kind of documents each cluster represents.

Note: To calculate these clusters we have initialised the clusters from the given data points and not randomly (can be verified through the code below), this has been done because random initialisation gives worse results and we observe that many of the clusters remain empty in that case (reason explained in Q9). We can observe this in the cluster allocation at the end of the code attached below.

[1]:
```python
from sklearn.feature_extraction.text import TfidfVectorizer
import numpy as np
import wikipedia
import random

CONVERGENCE_DELTA = 1e-5
MAXIMUM_ITERATIONS = 200
```

[2]:
```python
given_articles = [
    'Linear algebra',
    'Data Science',
    'Artificial intelligence',
    'European Central Bank',
    'Financial technology',
    'International Monetary Fund',
    'Basketball',
    'Swimming',
    'Cricket'
]
```

[3]:
```python
class KMeans():
    def __init__(
        self,
        x_train,
        y_train,
        num_clusters=3,
        seed: str = "random",
    ):
        self.dataset = x_train
        self.targets = y_train
        self.k = num_clusters
        self.num_features = x_train.shape[1]
        self.num_samples = x_train.shape[0]
        if seed == "random":
            self.centroids = self.random_initialise_centroids()
        elif seed == "custom":
            self.centroids = self.initialise_from_data()
        else:
            raise ValueError("Cohoose a seed between ['random', 'custom']")
        self.old_centroids = np.copy(self.centroids)
        self.cluster_labels = np.zeros(self.num_samples, dtype=int)
        for i in range(self.num_samples):
            self.cluster_labels[i] = np.argmin(
                np.linalg.norm(self.dataset[i]-self.centroids, ord=2, axis=1))


    def random_initialise_centroids(self):
        mean = np.mean(self.dataset, axis = 0)
        std = np.std(self.dataset, axis = 0)
        return np.random.randn(self.k, self.num_features)*std + mean

    def initialise_from_data(self):
        centroids = np.copy(self.dataset[np.random.choice(
                self.num_samples, self.k, replace=(False if self.k <= self.
↪num_samples else True))])
        return centroids

    def get_centroid_labels(self):
        centroid_labels = np.zeros(self.k)
        for i in range(self.k):
            count = np.bincount(self.targets[self.cluster_labels == i])
            if len(count) > 0:
                centroid_labels[i] = np.argmax(count)
        return centroid_labels

    def calculate_loss(self):
        loss = np.mean(np.linalg.norm(
            self.dataset - self.centroids[self.cluster_labels], ord=2, axis=1),␣
↪axis=0)
        return loss

    def fit(self):
        for i in range(MAXIMUM_ITERATIONS):
            # assigning clusters to all data points
            for i in range(self.num_samples):
                self.cluster_labels[i] = np.argmin(
                    np.linalg.norm(self.dataset[i]-self.centroids, ord=2,␣
↪axis=1))
            prev_centers = np.copy(self.centroids)
            converged = True
            for i in range(self.k):
                alloted = self.dataset[self.cluster_labels == i]
                if len(alloted) > 0:
                    self.centroids[i] = np.mean(alloted, axis=0)
                else:
                    self.centroids[i] = np.zeros(self.num_features)
                if np.linalg.norm(prev_centers[i] - self.centroids[i]) >␣
↪CONVERGENCE_DELTA:
                    converged = False
            loss = self.calculate_loss()
            if converged is True:
                print(f"TOTAL ITERATIONS = {i}")
                break
            self.old_centroids = np.copy(self.centroids)
```

```
[4]: articles = []
     for article_name in given_articles:
         text = wikipedia.page(article_name, preload=True).content
         articles.append(text)
     vectorizer = TfidfVectorizer(stop_words={'english'})
     x_train = vectorizer.fit_transform(articles).toarray()
     y_train = np.arange(len(given_articles))
     k = [4, 8, 12]
     losses = []
```

```
[5]: random.seed(60)
     np.random.seed(60)
```

```
[45]: for num_clusters in k:
          kmeans = KMeans(x_train, y_train, num_clusters=num_clusters, seed='custom')
          print(f"\n----------------------------------\nNUMBER OF CLUSTERS =␣
       ↪{num_clusters}")
          kmeans.fit()
          losses.append(kmeans.calculate_loss())
          clusters = [[] for i in range(num_clusters)]
          for i, article in enumerate(given_articles):
              index = kmeans.cluster_labels[i]
              clusters[index].append(article)
          for i, cluster in enumerate(clusters):
              print("Cluster no. {}: {}".format(i+1, cluster))
```

```
----------------------------------
NUMBER OF CLUSTERS = 4
TOTAL ITERATIONS = 3
Cluster no. 1: ['Data Science']
Cluster no. 2: ['Basketball', 'Swimming', 'Cricket']
Cluster no. 3: ['European Central Bank', 'Financial technology', 'International
Monetary Fund']
Cluster no. 4: ['Linear algebra', 'Artificial intelligence']

----------------------------------
NUMBER OF CLUSTERS = 8
TOTAL ITERATIONS = 7
Cluster no. 1: ['Financial technology']
Cluster no. 2: ['Artificial intelligence']
Cluster no. 3: ['Data Science']
Cluster no. 4: ['International Monetary Fund']
Cluster no. 5: ['Swimming']
Cluster no. 6: ['Linear algebra']
Cluster no. 7: ['European Central Bank']
Cluster no. 8: ['Basketball', 'Cricket']
```

```
----------------------------------
NUMBER OF CLUSTERS = 12
TOTAL ITERATIONS = 11
Cluster no. 1: ['Financial technology']
Cluster no. 2: ['Basketball', 'Cricket']
Cluster no. 3: ['Data Science']
Cluster no. 4: ['European Central Bank']
Cluster no. 5: []
Cluster no. 6: ['Swimming']
Cluster no. 7: ['Linear algebra']
Cluster no. 8: []
Cluster no. 9: ['Artificial intelligence']
Cluster no. 10: []
Cluster no. 11: ['International Monetary Fund']
Cluster no. 12: []
```

0.0.1 This is the part where clusters are initialised randomly, as we can observe many clusters remain empty and classification is not as good as when clusters are initialised from data

[6]:
```
for num_clusters in k:
    kmeans = KMeans(x_train, y_train, num_clusters=num_clusters, seed='random')
    print(f"\n----------------------------------\nNUMBER OF CLUSTERS =␣
 ↪{num_clusters}")
    kmeans.fit()
    losses.append(kmeans.calculate_loss())
    clusters = [[] for i in range(num_clusters)]
    for i, article in enumerate(given_articles):
        index = kmeans.cluster_labels[i]
        clusters[index].append(article)
    for i, cluster in enumerate(clusters):
        print("Cluster no. {}: {}".format(i+1, cluster))
```

```
----------------------------------
NUMBER OF CLUSTERS = 4
TOTAL ITERATIONS = 3
Cluster no. 1: []
Cluster no. 2: ['Linear algebra', 'Cricket']
Cluster no. 3: ['Data Science']
Cluster no. 4: ['Artificial intelligence', 'European Central Bank', 'Financial
technology', 'International Monetary Fund', 'Basketball', 'Swimming']

----------------------------------
NUMBER OF CLUSTERS = 8
TOTAL ITERATIONS = 7
Cluster no. 1: ['European Central Bank']
Cluster no. 2: []
Cluster no. 3: ['International Monetary Fund']
Cluster no. 4: ['Artificial intelligence', 'Cricket']
Cluster no. 5: []
Cluster no. 6: ['Financial technology', 'Basketball']
Cluster no. 7: ['Swimming']
Cluster no. 8: ['Linear algebra', 'Data Science']

----------------------------------
NUMBER OF CLUSTERS = 12
TOTAL ITERATIONS = 11
Cluster no. 1: ['Linear algebra', 'Data Science']
Cluster no. 2: []
Cluster no. 3: []
Cluster no. 4: ['European Central Bank']
Cluster no. 5: ['Artificial intelligence', 'Financial technology']
Cluster no. 6: ['Basketball']
Cluster no. 7: []
Cluster no. 8: []
Cluster no. 9: []
Cluster no. 10: ['International Monetary Fund']
Cluster no. 11: ['Swimming', 'Cricket']
Cluster no. 12: []
```