# Assignment Title: Unsupervised Learning with Dimensionality Reduction and Clustering

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We shall work with the MNIST handwritten digits' image dataset. The details about the dataset is available here.

We need the scikit-learn library to import the various machine leanring models for our study.

```
from sklearn.datasets import load_digits
digits = load_digits()
digits.data.shape
```

```
(1797, 64)
```

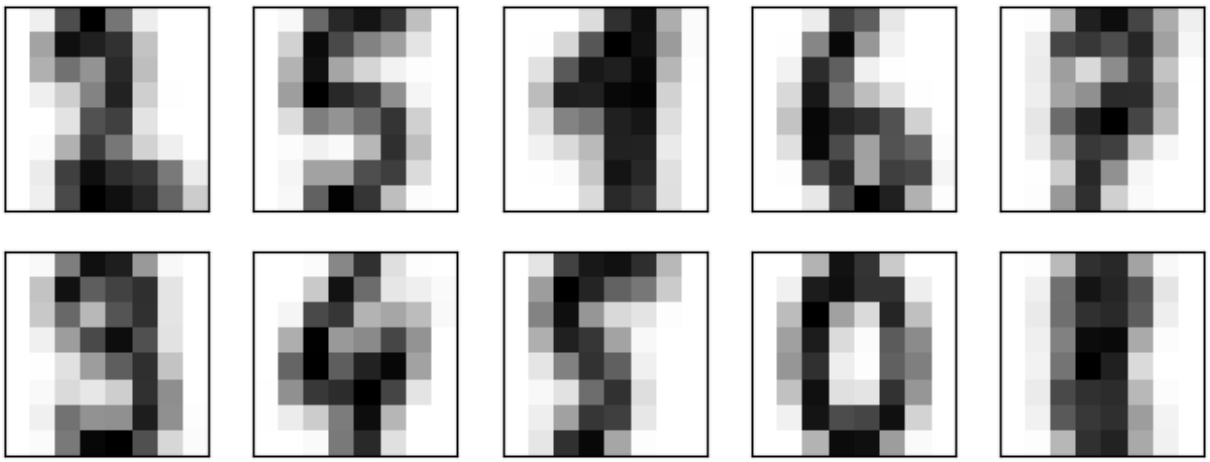
## Question 1. Complete the following lines of code for K-Means clustering

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

# kmeans = ...
# clusters = ...
kmeans = KMeans(n_clusters=10, random_state=0)
clusters = kmeans.fit_predict(digits.data)
print(kmeans.cluster_centers_.shape)
```

```
(10, 64)
```

```
fig, ax = plt.subplots(2, 5, figsize=(8, 3))
centers = kmeans.cluster_centers_.reshape(10, 8, 8)
for axi, center in zip(ax.flat, centers):
    axi.set(xticks=[], yticks=[])
    axi.imshow(center, interpolation='nearest', cmap=plt.cm.binary)
```



We see that even without the labels, KMeans is able to find clusters whose centers are recognizable digits.

Next, we shall apply dimensioanlity reduction of MNIST handwritten datasets with PCA

```
from sklearn.decomposition import PCA
import matplotlib.pyplot as plt
import numpy as np
```

# Question 2. Complete the following lines of code for

Step 1. Dimensionality reduction with PCA. The 8x8=64 dimensional data need to be reduced to 2-dimensional.

Step 2. K-means clustering should be done on the reduced diemnsional data. Initial K value should be set to 10 like before.

Step 3. Visualization code is supplied below.

```
# data loading
data = digits.data

# PCA dimensionality reduction
model = PCA(n_components=2)
reduced_data = model.fit_transform(data)

# K-Means clustering with 10 clusters
kmeans = KMeans(n_clusters=10, random_state=0)
clusters = kmeans.fit_predict(reduced_data)
```

**Data Visualization**

We shall visualize the reduced diemnsion and cluster data (overlapped) with the help of the following code snippet.

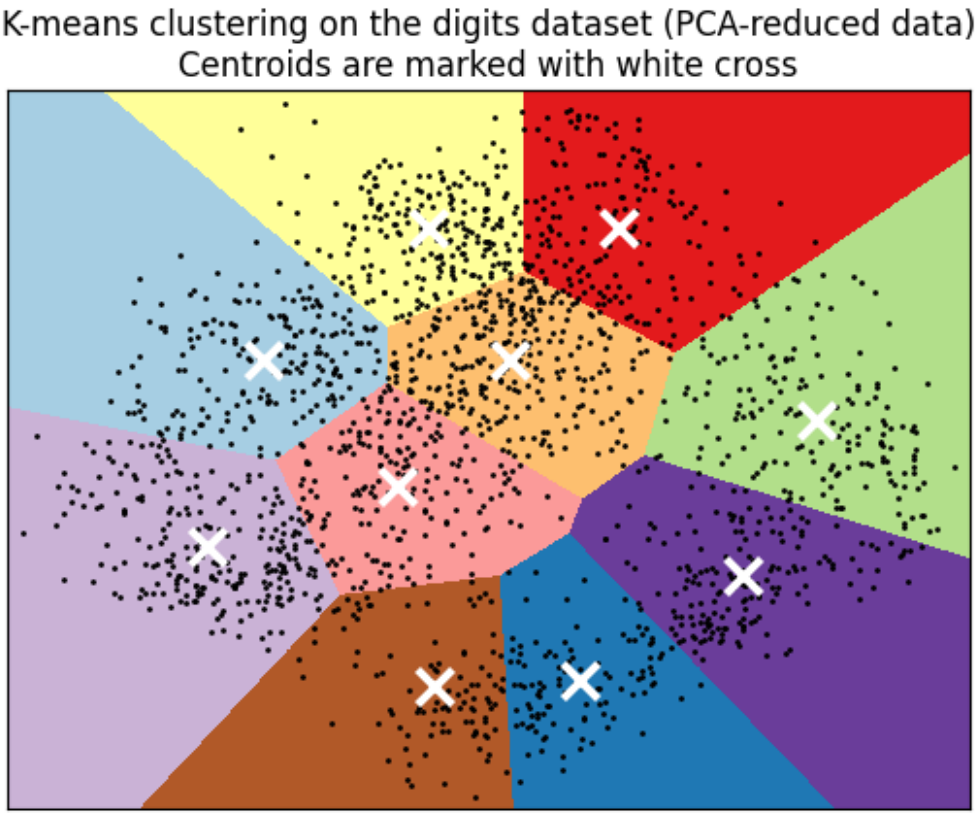
```
# Step size of the mesh. Decrease to increase the quality of the VQ.
h = 0.02  # point in the mesh [x_min, x_max]x[y_min, y_max].

# Plot the decision boundary. For that, we will assign a color to each
x_min, x_max = reduced_data[:, 0].min() - 1, reduced_data[:, 0].max()
+ 1
y_min, y_max = reduced_data[:, 1].min() - 1, reduced_data[:, 1].max()
+ 1
xx, yy = np.meshgrid(np.arange(x_min, x_max, h), np.arange(y_min,
y_max, h))

# Obtain labels for each point in mesh. Use last trained model.
clusters = kmeans.predict(np.c_[xx.ravel(), yy.ravel()])

# Put the result into a color plot
clusters = clusters.reshape(xx.shape)
plt.figure(1)
plt.clf()
plt.imshow(
    clusters,
    interpolation="nearest",
    extent=(xx.min(), xx.max(), yy.min(), yy.max()),
    cmap=plt.cm.Paired,
    aspect="auto",
    origin="lower",
)

plt.plot(reduced_data[:, 0], reduced_data[:, 1], "k.", markersize=2)
# Plot the centroids as a white X
centroids = kmeans.cluster_centers_
plt.scatter(
    centroids[:, 0],
    centroids[:, 1],
    marker="x",
    s=169,
    linewidths=3,
    color="w",
    zorder=10,
)
plt.title(
    "K-means clustering on the digits dataset (PCA-reduced data)\n"
    "Centroids are marked with white cross"
)
plt.xlim(x_min, x_max)
plt.ylim(y_min, y_max)
plt.xticks(())
plt.yticks(())
plt.show()
```




## Question 3.

Find a high dimensional dataset of you choice. Show how you load the dataset. Do the basic exploratory data analysis to become familiar with the dataset.

## Question 4.

Next, the objective would be to reduce the dimension of your dataset and do the clustering on it. Complete the following code for clustering in an object-oriented manner. Do the exact process as above: PCA dimension reduction followed by clustering.

A template code is provided below for your guidance.

```
class YourDataClustering:
    def __init__(self, n_clusters=3):
        self.n_clusters = n_clusters
        self.data = ______
        self.labels = ______
        self.kmeans = ______
        self.scaled_data = ______

    def load_data(self):
        """Load the Iris dataset"""
```

```
        iris = ________.________()
        self.data = iris.________
        return ________

    def preprocess_data(self):
        """Standardize the dataset"""
        scaler = _________.__________()
        self.scaled_data = scaler.________(________)
        return ________

    def apply_kmeans(self):
        """Apply KMeans clustering"""
        self.kmeans = ________.________(n_clusters=self.n_clusters,
random_state=42)
        self.labels = self.kmeans.________(________)
        return ________

    def evaluate_clusters(self):
        """Compute silhouette score"""
        score = ________.________(________, ________)
        print(f"Silhouette Score: {score:.3f}")
        return ________

    def visualize_clusters_matplotlib(self):
        """Visualize clustering result using Matplotlib"""
        plt.scatter(________[:, 0], ________[:, 1], c=________,
cmap='viridis')
        plt.title("KMeans Clustering on Iris Dataset (Matplotlib)")
        plt.xlabel("________")
        plt.ylabel("________")
        plt.show()

    def visualize_clusters_opencv(self):
        """Visualize clustering result using OpenCV"""
        canvas = np.ones((______, ______, 3), dtype=np.uint8) * 255
        colors = [(255, 0, 0), (0, 255, 0), (0, 0, 255)]
        scaled = (________[:, :2] * 100 + 250).astype(int)

        for i, point in enumerate(________):
            cv2.circle(canvas, tuple(point), 5, colors[________ % 3],
-1)

        cv2.imshow("KMeans Clustering (OpenCV)", ________)
        cv2.waitKey(0)
        cv2.destroyAllWindows()
```

The following code executes all teh parts of teh complete system.

```
  # Step 1: Create clustering object
```

```
    clustering = __________(n_clusters=3)

    # Step 2: Load dataset
    data = clustering._________()

    # Step 3: Preprocess dataset
    scaled_data = clustering._________()

    # Step 4: Apply KMeans clustering
    labels = clustering._________()

    # Step 5: Evaluate clusters
    score = clustering._________()

    # Step 6: Visualize with Matplotlib
    clustering._________()

    # Step 7: Visualize with OpenCV
    clustering._________()
```