Assignment 2: Data Mining Via Dimensionality Reduction

PCA:- It is a technique through which the dimensions are reduced and it used in the exploratory data analysis.

UMAP:- This algorithm reduces the dimensionality by manifold learning techniques.

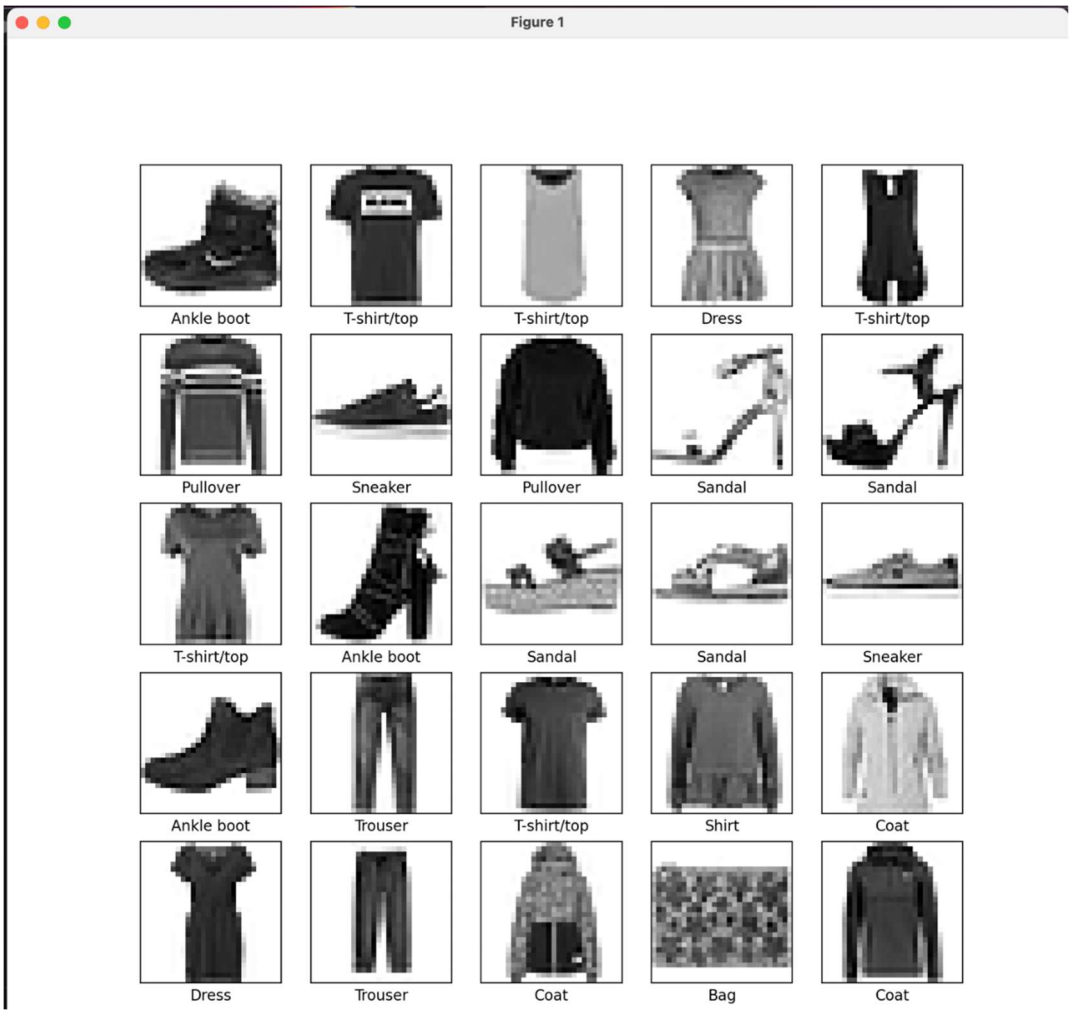
TSNE:- This method is used for the visualization of the high dimensional dataset while doing the reduction.

Code:-

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.decomposition import PCA
from sklearn.manifold import TSNE
import pandas as pd
import keras
from keras import layers
from keras.utils import to_categorical
from random import randint


(x_train, y_train), (x_test, y_test) =
tf.keras.datasets.fashion_mnist.load_data()

print("x_train shape:", x_train.shape, "y_train shape:", y_train.shape)

x_train_flat = x_train.reshape(x_train.shape[0], -1)
x_test_flat = x_test.reshape(x_test.shape[0], -1)
y_train_flat = y_train.reshape(y_train.shape[0], -1)
y_test_flat = y_test.reshape(y_test.shape[0], -1)

x_train_flat = x_train_flat / 255.0
x_test_flat = x_test_flat / 255.0

class_names = ['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat',
               'Sandal', 'Shirt', 'Sneaker', 'Bag', 'Ankle boot']

plt.figure(figsize=(10, 10))
```

```
for i in range(25):
    plt.subplot(5, 5, i + 1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.imshow(x_train[i], cmap=plt.cm.binary)
    plt.xlabel(class_names[y_train[i]])
plt.show()
```

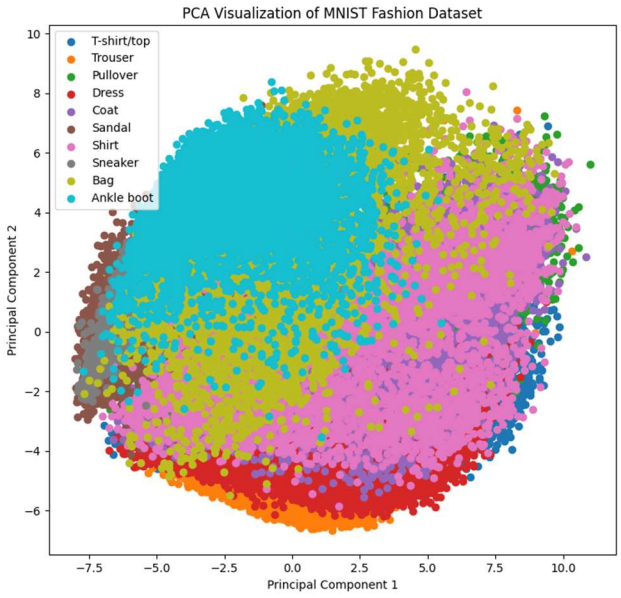
Output:-



1) We have imported the libraries which will be required and later on converted the MNIST fashion dataset into the required format.
2) This dataset is later on visualized.

Code for PCA:-

```
class PCA_and_CNN:
  def __init__(self):
    pca_model = PCA(n_components=min(x_train_flat.shape[0],
x_train_flat.shape[1]))

    x_train_pca_data = pca_model.fit_transform(x_train_flat)
    x_test_pca = pca_model.transform(x_test_flat)

    plt.figure(figsize=(10, 10))
    for i in range(10):
        plt.scatter(x_train_pca_data[y_train == i, 0],
x_train_pca_data[y_train == i, 1], label=class_names[i])
    plt.title('PCA MNIST ')
    plt.xlabel('Component 1')
    plt.ylabel('Component 2')
    plt.legend()
    plt.show()
    self.x_train_cnn = x_train_pca.reshape((-1, 28, 28, 1))
    self.x_test_cnn = x_test_pca.reshape((-1, 28, 28, 1))
```

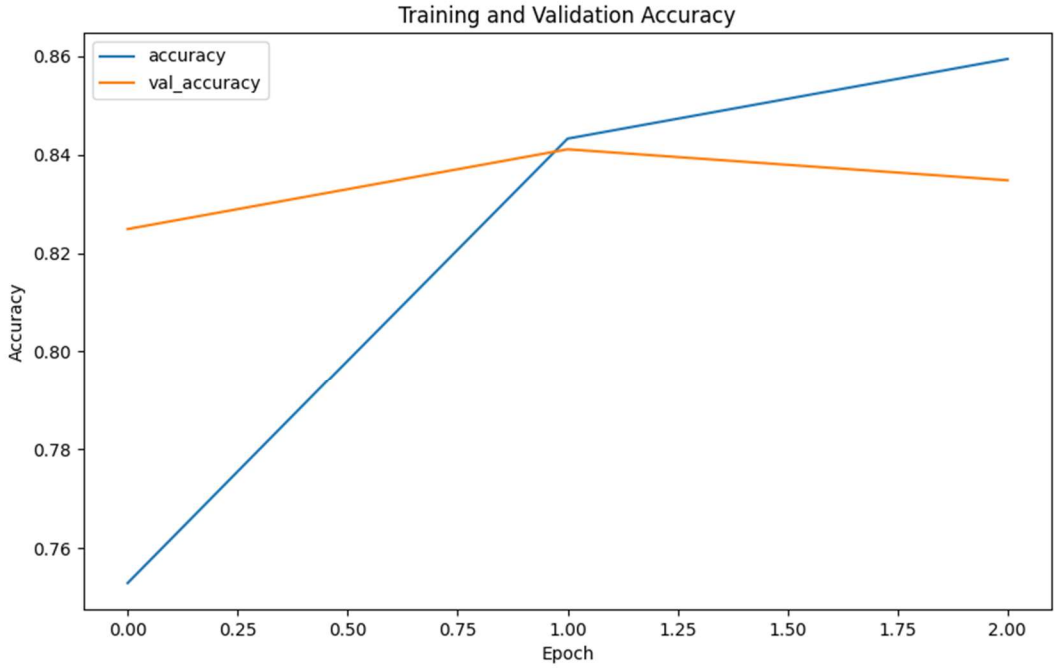


1) After the basic processing, the data was send to the PCA component reduction.
2) I have taken 50 components for now.

Applying CNN Model After tuning:-

```
def CNN(self):
    model = models.Sequential([
        layers.Conv2D(32, (3, 3), activation='relu', input_shape=(28, 28,
1)),
        layers.MaxPooling2D((2, 2)),
        layers.Conv2D(64, (3, 3), activation='relu'),
        layers.MaxPooling2D((2, 2)),
        layers.Conv2D(64, (3, 3), activation='relu'),
        layers.Flatten(),
        layers.Dense(64, activation='relu'),
        layers.Dense(10, activation='softmax')
    ])

    model.compile(optimizer='adam',
                  loss='sparse_categorical_crossentropy',
                  metrics=['accuracy'])

    history = model.fit(self.x_train_cnn, y_train, epochs=3,
validation_data=(self.x_test_cnn, y_test))

    plt.figure(figsize=(10, 6))
    plt.plot(history.history['accuracy'], label='accuracy')
    plt.plot(history.history['val_accuracy'], label='val_accuracy')
    plt.xlabel('Epoch')
    plt.ylabel('Accuracy')
    plt.title('Training and Validation Accuracy')
    plt.legend()
    plt.show()

    test_loss, test_accuracy = model.evaluate(self.x_test_cnn, y_test)

    print(f"Test Loss: {test_loss}")
    print(f"Test Accuracy: {test_accuracy}")

pca_and_cnn = PCA_and_CNN()
pca_and_cnn.CNN()
```

```
x_train shape: (60000, 28, 28) y_train shape: (60000,)
Epoch 1/3
1875/1875 [==============================] - 14s 7ms/step - loss: 0.6762 - accuracy: 0.7530 - val_loss: 0.4775 - val_accuracy: 0.8249
Epoch 2/3
1875/1875 [==============================] - 15s 8ms/step - loss: 0.4305 - accuracy: 0.8433 - val_loss: 0.4297 - val_accuracy: 0.8411
Epoch 3/3
1875/1875 [==============================] - 16s 9ms/step - loss: 0.3799 - accuracy: 0.8594 - val_loss: 0.4458 - val_accuracy: 0.8348
313/313 [==============================] - 1s 4ms/step - loss: 0.4458 - accuracy: 0.8348
Test Loss: 0.4457664489746094
Test Accuracy: 0.8348000049591064
```

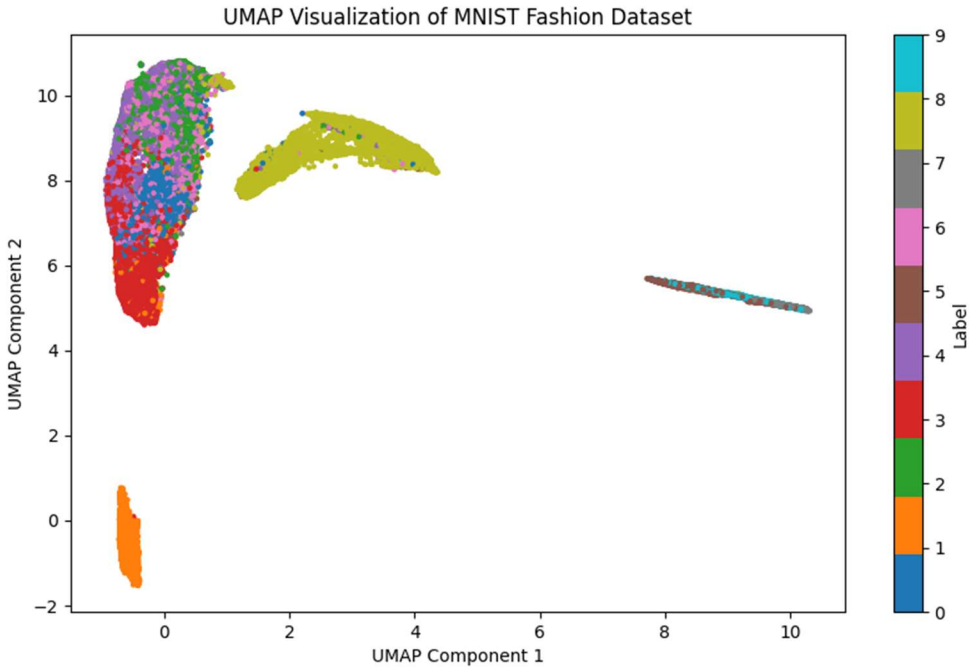


1) After the applying the PCA, the data is then send to the CNN model for the training of the data.
2) After the training of the data we get the accuracy of 84%.

Implementing the UMAP:-

```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import fetch_openml
from sklearn.preprocessing import StandardScaler
from umap import UMAP

class UMAP_and_CNN:
  def __init__(self):
    umap = UMAP(n_components=50,n_neighbors=20,min_dist=0.2)
    umap_results = umap.fit_transform(x_train_flat)
    umap_test = umap.fit_transform(x_test_flat)
```

```
    plt.figure(figsize=(10, 6))
    plt.scatter(umap_results[:, 0], umap_results[:, 1], c=y_train_flat,
cmap='tab10', s=5)
    plt.title('UMAP Visualization of MNIST Fashion Dataset')
    plt.xlabel('UMAP Component 1')
    plt.ylabel('UMAP Component 2')
    plt.colorbar(label='Label')
    plt.show()
    self.x_train_cnn = umap_results.reshape((-1, 20, 5, 1))
    self.x_test_cnn = umap_test.reshape((-1, 20, 5, 1))
```



Applying the CNN model on the following :-

```
def CNN(self):
    model = models.Sequential([
        layers.Conv2D(32, (3, 3), activation='relu', input_shape=(20, 5,
1)),
        layers.Conv2D(32, (3, 3), activation='relu', padding='same'),
        layers.MaxPooling2D((1, 1), padding='valid', strides=(1, 1)),
        layers.Conv2D(64, (3, 3), activation='relu', padding='same'),
        layers.Conv2D(64, (3, 3), activation='relu', padding='same'),
        layers.MaxPooling2D((1, 1), padding='valid', strides=(1, 1)),
```

```
        layers.Conv2D(128, (3, 3), activation='relu', padding='same'),
        layers.Conv2D(128, (3, 3), activation='relu', padding='same'),
        layers.MaxPooling2D((1, 1), padding='valid', strides=(1, 1)),
        layers.Flatten(),
        layers.Dense(64, activation='relu'),
        layers.Dense(10, activation='softmax')
    ])
    model.compile(optimizer='adam',
                  loss='sparse_categorical_crossentropy',
                  metrics=['accuracy'])

    history = model.fit(self.x_train_cnn, y_train, epochs=1,
validation_data=(self.x_test_cnn, y_test))

    plt.figure(figsize=(10, 6))
    plt.plot(history.history['accuracy'], label='accuracy')
    plt.plot(history.history['val_accuracy'], label='val_accuracy')
    plt.xlabel('Epoch')
    plt.ylabel('Accuracy')
    plt.title('Training and Validation Accuracy')
    plt.legend()
    plt.show()

    test_loss, test_accuracy = model.evaluate(self.x_test_cnn, y_test)

    print(f"Test Loss: {test_loss}")
    print(f"Test Accuracy: {test_accuracy}")
umap_and_cnn = UMAP_and_CNN()
umap_and_cnn.CNN()
```

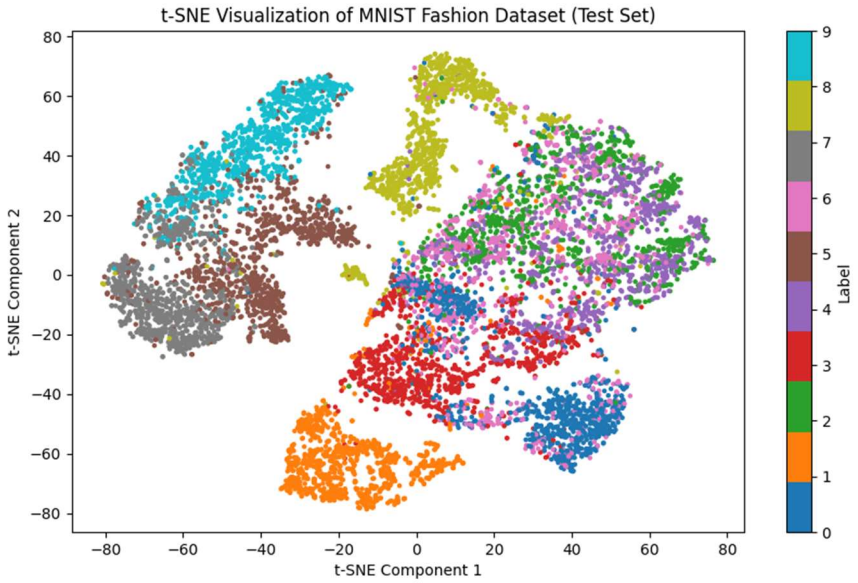
```
313/313 [==============================] - 5s 16ms/step - loss: 2.8094 - accuracy: 0.2992
Test Loss: 2.8094255924224854
Test Accuracy: 0.29919999837875366
```

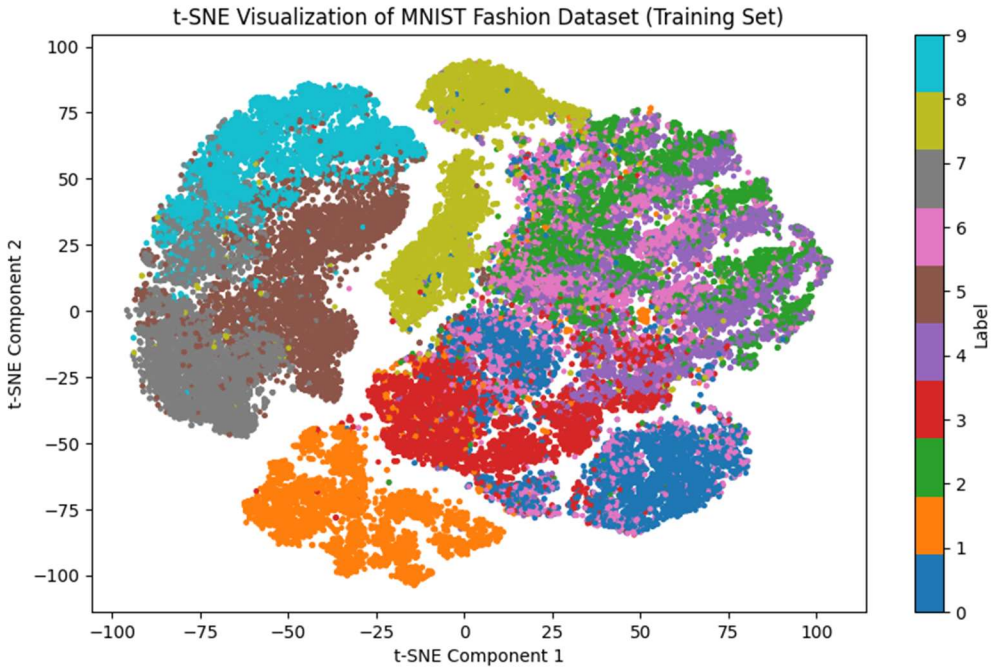
Implementing the CNN model on the UMAP Dataset.
Note that this model is tuned and shape of the data has been changed according to required format.

TSNE:-

```
class TSNE_and_CNN:
  def __init__(self):
    tsne = TSNE(n_components=2)

    tsne_results_train = tsne.fit_transform(x_train_flat)
```

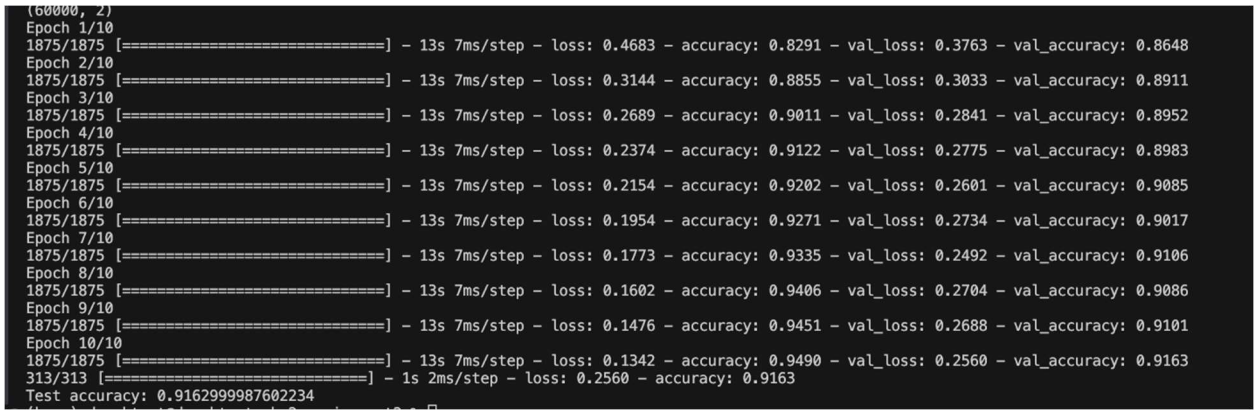
```
    tsne_results_test = tsne.fit_transform(x_test_flat)
    print(tsne_results_train.shape)
    plt.figure(figsize=(10, 6))
    plt.scatter(tsne_results_train[:, 0], tsne_results_train[:, 1],
c=y_train, cmap='tab10', s=5)
    plt.title('t-SNE  (Training Set)')
    plt.xlabel('t-SNE Component 1')
    plt.ylabel('t-SNE Component 2')
    plt.colorbar(label='Label')
    plt.show()

    plt.figure(figsize=(10, 6))
    plt.scatter(tsne_results_test[:, 0], tsne_results_test[:, 1],
c=y_test, cmap='tab10', s=5)
    plt.title('t-SNE  (Test Set)')
    plt.xlabel('t-SNE Component 1')
    plt.ylabel('t-SNE Component 2')
    plt.colorbar(label='Label')
    plt.show()

    self.x_train = x_train_flat.reshape((-1, 28, 28, 1))
    self.x_test = x_test_flat.reshape((-1, 28, 28, 1))
```






```
  def CNN(self):


    assert len(self.x_train) == len(y_train), "Number of samples and
labels should match"

    num_classes = 10
    y_train = to_categorical(y_train, num_classes=num_classes)
    y_test = to_categorical(y_test, num_classes=num_classes)

    model = keras.Sequential()
    model.add(layers.Conv2D(32, (3, 3), activation='relu',
input_shape=(28, 28, 1)))
    model.add(layers.MaxPooling2D((2, 2)))
    model.add(layers.Conv2D(64, (3, 3), activation='relu'))
    model.add(layers.MaxPooling2D((2, 2)))
    model.add(layers.Flatten())
    model.add(layers.Dense(64, activation='relu'))
    model.add(layers.Dense(num_classes, activation='softmax'))

    model.compile(optimizer='adam',
                  loss='categorical_crossentropy',
                  metrics=['accuracy'])
```

```
    model.fit(x_train, y_train, epochs=10, validation_data=(x_test,
y_test))

    test_loss, test_accuracy = model.evaluate(x_test, y_test)
    print('Test accuracy:', test_accuracy)
tsne_and_cnn = TSNE_and_CNN()
tsne_and_cnn.CNN()
```



The TSNE provided highest accuracy after the applying CNN on the following dataset.

How To run:-

1) Install all the import libraries
Pip install tensorflow umap-learn numpy scikit-learn

2) Run the code by following on the terminal.
Python VaibhavParikh_Assignment2.py