source

May 25, 2024

[1]:
```
!pip install pyspark findspark
```

```
Collecting pyspark
  Downloading pyspark-3.5.1.tar.gz (317.0 MB)
                           317.0/317.0

MB 2.0 MB/s eta 0:00:00
  Preparing metadata (setup.py) … done
WARNING: Retrying (Retry(total=4, connect=None, read=None, redirect=None,

status=None)) after connection broken by 'ProtocolError('Connection aborted.',

RemoteDisconnected('Remote end closed connection without response'))':

/simple/findspark/

Collecting findspark
  Downloading findspark-2.0.1-py2.py3-none-any.whl (4.4 kB)
Requirement already satisfied: py4j==0.10.9.7 in /usr/local/lib/python3.10/dist-
packages (from pyspark) (0.10.9.7)
Building wheels for collected packages: pyspark
  Building wheel for pyspark (setup.py) … done
  Created wheel for pyspark: filename=pyspark-3.5.1-py2.py3-none-any.whl
size=317488491
sha256=b7ca25f273628e79e35111358be0d9d82b370c8b7b894f2fab962a4a8270c6a5
  Stored in directory: /root/.cache/pip/wheels/80/1d/60/2c256ed38dddce2fdd93be54
5214a63e02fbd8d74fb0b7f3a6
Successfully built pyspark
Installing collected packages: findspark, pyspark
Successfully installed findspark-2.0.1 pyspark-3.5.1
```

[2]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

[3]:
```
mnist_mini = "/content/drive/MyDrive/Colab Notebooks/MMDS/final/mnist_mini.csv"
```

[4]:
```
ratings2k = "/content/drive/MyDrive/Colab Notebooks/MMDS/final/ratings2k.csv"
```

[5]:
```
stockHVN2022 = "/content/drive/MyDrive/Colab Notebooks/MMDS/final/stockHVN2022.
↪csv"
```

[6]:
```
from pyspark.sql import SparkSession
from pyspark.ml.feature import VectorAssembler
from pyspark.ml.clustering import KMeans
from pyspark.ml.linalg import Vectors as VectorsML

from pyspark.sql import Row, DataFrame
from pyspark.sql.functions import udf, col, sum, count,␣
↪monotonically_increasing_id, when, to_date, month, \
                                    lag, col, month, array

from pyspark.sql.types import IntegerType, FloatType, ArrayType, DoubleType
from pyspark.mllib.linalg.distributed import RowMatrix
from pyspark.mllib.linalg import DenseMatrix, Vectors
from pyspark.ml.regression import LinearRegression
from pyspark.ml.classification import MultilayerPerceptronClassifier,␣
↪RandomForestClassifier, LinearSVC, OneVsRest
from pyspark.ml.evaluation import MulticlassClassificationEvaluator,␣
↪RegressionEvaluator
from pyspark.sql.window import Window
from pyspark.ml.recommendation import ALS

import math
import matplotlib.pyplot as plt
import numpy as np
from mpl_toolkits.mplot3d import Axes3D
```

[7]:
```
spark = SparkSession.builder.appName("Final_Project").getOrCreate()
```

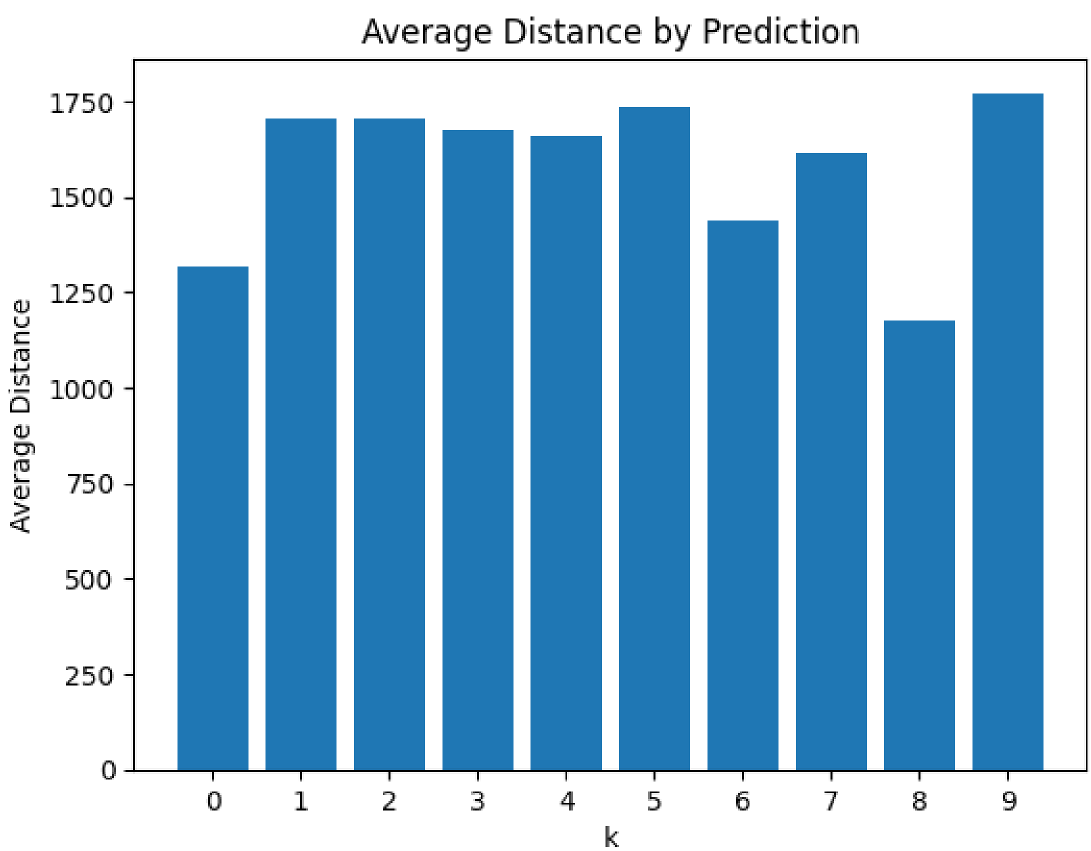
1 Task 1: Clustering

[8]:
```
class Clustering:
    def __init__(self, data_path:str ,k:int, weighted_rows:list):
        self.data = None
        self.sum_count_df = None
        self.data_path = data_path
        self.k = k
        self.weighted_rows = weighted_rows
        self.transformed_data = None

    def load_data(self):
        self.data = spark.read.csv(self.data_path, header=False,␣
↪inferSchema=True)
```

```
    def preprocess_data(self):
        assembler = VectorAssembler(inputCols=self.data.columns[1:], outputCol="features")
        self.data = assembler.transform(self.data).select("_c0", "features")

        self.data = self.data.withColumn("row_index", monotonically_increasing_id())
        self.data = self.data.withColumn("weight", when(self.data["row_index"].isin(self.weighted_rows), 100).otherwise(1)) \
                            .drop("row_index")

    def clustering(self):
        kmeans = KMeans(featuresCol="features", k=self.k, weightCol="weight", seed=42)
        model = kmeans.fit(self.data)
        transformed_data = model.transform(self.data)
        self.transformed_data = transformed_data

        l_clusters = model.clusterCenters()
        df_centers = spark.createDataFrame([(int(i), VectorsML.dense(l_clusters[i]))
                    for i in range(len(l_clusters))], ["prediction", "center"])

        transformed_data = transformed_data.join(df_centers, on='prediction', how='left')

        get_dist = udf(lambda features, center: float(math.sqrt(VectorsML.squared_distance(features, center))), FloatType())
        transformed_data = transformed_data.withColumn('dist', get_dist(col('features'), col('center')))

        self.sum_count_df = transformed_data.groupBy("prediction") \
            .agg(sum("dist").alias("sum_distance"),
                 count("*").alias("count")) \
            .withColumn('average_dist', col('sum_distance') / col('count')) \

    def plot_average_distance(self):
        result_list = self.sum_count_df.select("prediction", "average_dist").collect()

        prediction = [row.prediction for row in result_list]
        average_dist = [row.average_dist for row in result_list]

        fig, ax = plt.subplots()
        ax.bar(prediction, average_dist)
        ax.set_xlabel('k')
```

```python
        ax.set_ylabel('Average Distance')
        ax.set_title('Average Distance by Prediction')
        plt.xticks(prediction)
        plt.show()

    def run(self):
        self.load_data()
        self.preprocess_data()
        self.clustering()
        self.plot_average_distance()
```

[9]:
```python
if __name__ == "__main__":
    weighted_rows = [0, 1, 2, 3, 4, 7, 8, 11, 18, 61]
    clustering = Clustering(data_path = mnist_mini, k = 10, weighted_rows = weighted_rows)
    clustering.run()
```

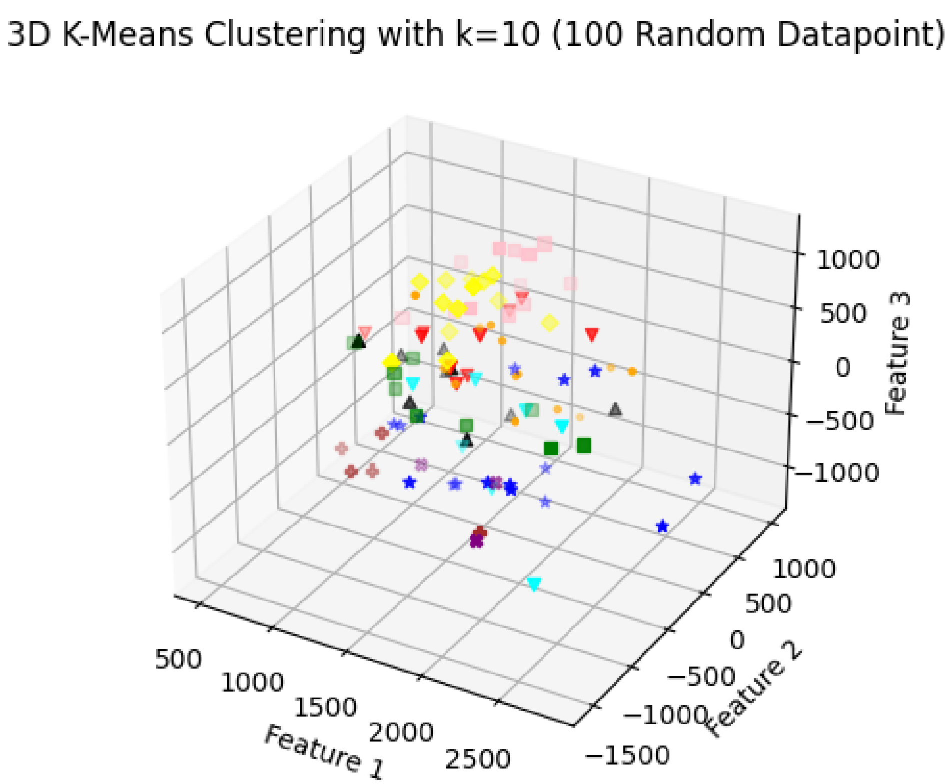


2 Task 2: Dimensionality Deduction with SVD

[10]:
```python
class SVD:
    def __init__(self, data_path:str, clustering_result:DataFrame):
        self.data = None
        self.data_path = data_path
        self.processed_data = None
        self.clustering_result = clustering_result

    def load_data(self):
        self.data = spark.read.csv(self.data_path, header=False, inferSchema=True)

    def preprocess_data(self):
        assembler = VectorAssembler(inputCols=self.data.columns[1:], outputCol="features")
        self.data = assembler.transform(self.data) \
                        .select("_c0", "features")

    def svd(self):
        ml_vectors = self.data.select("features").rdd.map(lambda row: Vectors.dense(row.features.toArray()))
        row=RowMatrix(ml_vectors)
        svd = row.computeSVD(3, True)
        u = svd.U
        s = DenseMatrix(len(svd.s), len(svd.s), np.diag(svd.s).ravel("F"))

        def row_to_dict(row):
            return Row(features=Vectors.dense(row.toArray()))

        row_matrix_rows = u.multiply(s).rows.map(row_to_dict)
        df = spark.createDataFrame(row_matrix_rows)

        vector_to_array = udf(lambda v: v.toArray().tolist(), ArrayType(DoubleType()))
        df = df.withColumn("features_array", vector_to_array(df["features"]))
        df = df.select([df["features_array"][i].alias(f"_c{i+1}") for i in range(3)])

        data = self.clustering_result.withColumn("unique_id", monotonically_increasing_id())
        df = df.withColumn("unique_id", monotonically_increasing_id())
        merged_df = data[['_c0','unique_id', "prediction"]].join(df, "unique_id").drop("unique_id")

        self.processed_data = merged_df.sample(fraction=0.01).limit(100)
```

```
    def plot_3d(self):
        color = ["red", "blue", "orange", "green", "purple", "brown", "pink",␣
↪"yellow", "black", "cyan"]
        marker = ["v", "*", ".", ",", "X", "P", "s", "D", "^", "v"]

        fig = plt.figure()
        ax = fig.add_subplot(111, projection='3d')

        for i in range(0, 10):
            data = self.processed_data.filter(self.processed_data.prediction ==␣
↪i)
            x = data.select('_c1').rdd.map(lambda row: row['_c1']).collect()
            y = data.select('_c2').rdd.map(lambda row: row['_c2']).collect()
            z = data.select('_c3').rdd.map(lambda row: row['_c3']).collect()
            ax.scatter(x, y, z, c=color[i], marker=marker[i])

        ax.set_title('3D K-Means Clustering with k=10 (100 Random Datapoint)')
        ax.set_xlabel('Feature 1')
        ax.set_ylabel('Feature 2')
        ax.set_zlabel('Feature 3')
        plt.show()

    def run(self):
        self.load_data()
        self.preprocess_data()
        self.svd()
        self.plot_3d()
```

[11]:
```
if __name__ == "__main__":
    svd = SVD(data_path = mnist_mini, clustering_result = clustering.
↪transformed_data)
    svd.run()
```

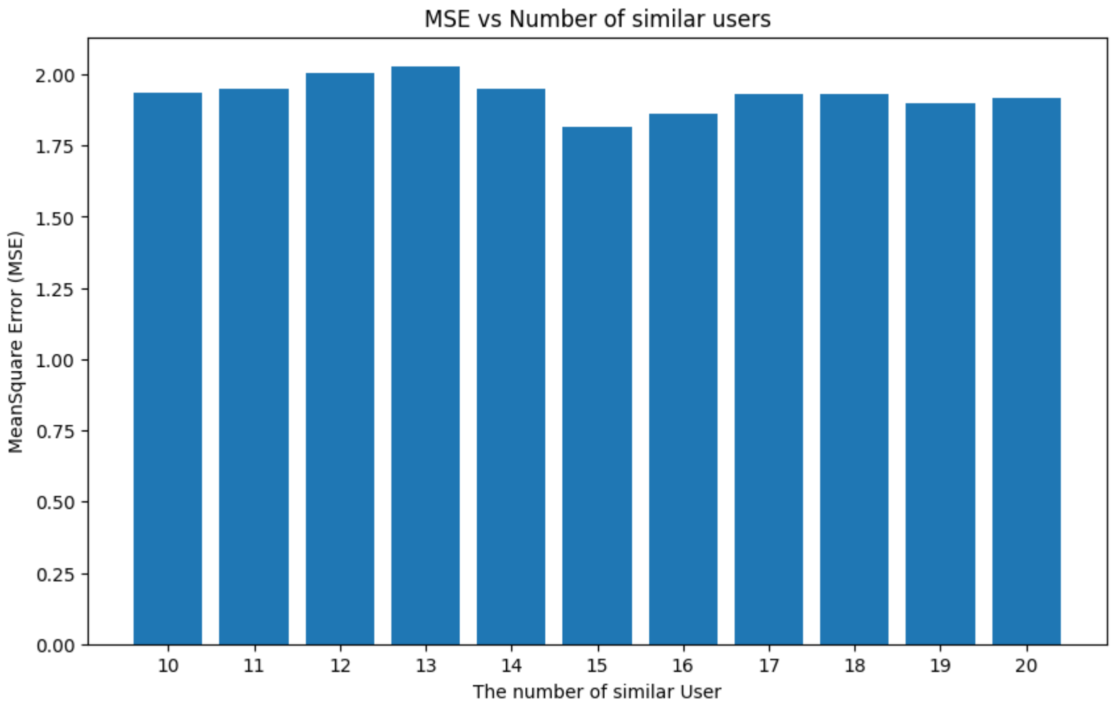


3 Task 3: Recommendation with Collaborative Filtering

[12]:
```
class CollaborativeFiltering:
    def __init__(self, data_path: str = "ratings2k.csv", num_user_blocks_range: array = np.arange(10, 21)):
        self.data = None
        self.train_data = None
        self.test_data = None
        self.als_model = None
        self.data_path = data_path
        self.num_user_blocks_range =  num_user_blocks_range

    def load_data(self):
        self.data = spark.read.csv(self.data_path, header=True, inferSchema=True)

    def split_data(self):
        self.train_data, self.test_data = self.data.randomSplit([0.7, 0.3], seed=42)

    def train_model(self, rank=10, max_iter=20, reg_param=0.01):
```

```
        als = ALS(rank=rank, maxIter=max_iter, regParam=reg_param,␣
↪userCol="user", itemCol="item", ratingCol="rating",
                  coldStartStrategy="drop", nonnegative=True)

        self.als_model = als.fit(self.train_data)

    def evaluate_model(self):
        predictions = self.als_model.transform(self.test_data)
        evaluator = RegressionEvaluator(metricName="mse", labelCol="rating",␣
↪predictionCol="prediction")
        mse = evaluator.evaluate(predictions)
        return mse

    def visualize_results(self):
        mse_values = []
        ranks = np.arange(10, 21)
        for rank in ranks:
            self.train_model(rank = rank)
            mse = self.evaluate_model()
            mse_values.append(mse)

        plt.figure(figsize=(10, 6))
        plt.bar(np.arange(10, 21), mse_values)
        plt.xlabel("The number of similar User")
        plt.ylabel("MeanSquare Error (MSE)")
        plt.title("MSE vs Number of similar users")
        plt.xticks(np.arange(10, 21))
        plt.show()

    def run(self):
        self.load_data()
        self.split_data()
        self.visualize_results()
```

[13]:
```
if __name__ == "__main__":
    collaborativeFiltering = CollaborativeFiltering(data_path = ratings2k)
    collaborativeFiltering.run()
```

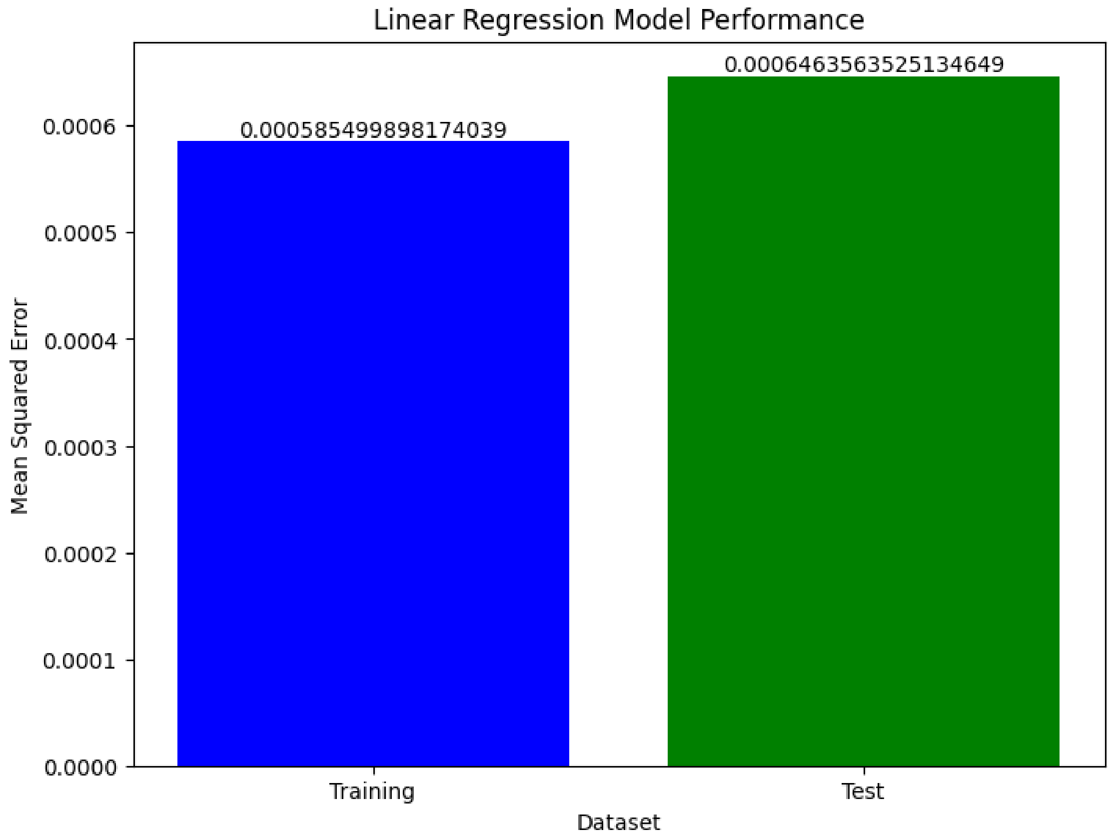


4 Task 4: Stock price regression

[14]:
```
class StockPriceRegression:
    def __init__(self, k_prev_dates:int = 5, data_path:str = "stockHVN2022.
↪csv"):
        self.k_prev_dates = k_prev_dates
        self.data = None
        self.data_path = data_path
        self.train_data, self.test_data  = None, None
        self.model = None
        self.train_mse, self.test_mse  = None, None

    def load_data(self):
        self.data = spark.read.csv(self.data_path, header=True,␣
↪inferSchema=True)

    def preprocess_data(self):
        self.data = self.data.withColumn("Ngay", to_date(self.data.Ngay, "dd/MM/
↪yyyy")) \
                        .orderBy('Ngay')\
                        .withColumn('fluctuation', (col('HVN') - lag('HVN', 1).
↪over(Window.orderBy('Ngay'))) / lag('HVN', 1).over(Window.orderBy('Ngay')))\
                        .na.fill(0.0, subset=['fluctuation'])
```

```
        for i in range(1, self.k_prev_dates + 1):
            self.data = self.data.withColumn(f'prev_range_{i}',␣
↪lag('fluctuation', i).over(Window.partitionBy().orderBy('Ngay')))
        self.data = self.data.dropna()

        train_data = self.data.filter(month('Ngay') <= 6) \
                        .drop("Ngay", "HVN")
        test_data = self.data.filter(month('Ngay') > 6) \
                        .drop("Ngay", "HVN")

        assembler = VectorAssembler(inputCols=list(train_data.columns[::-1][:
↪-1]), outputCol='features')
        self.train_data = assembler.transform(train_data)
        self.test_data = assembler.transform(test_data)

    def train_model(self):
        lr = LinearRegression(featuresCol='features', labelCol='fluctuation')
        self.model = lr.fit(self.train_data)

    def evaluate_model(self):
        evaluator = RegressionEvaluator(predictionCol='prediction',␣
↪labelCol='fluctuation', metricName='mse')

        self.train_mse = evaluator.evaluate(self.model.transform(self.
↪train_data))
        self.test_mse = evaluator.evaluate(self.model.transform(self.test_data))

    def plot_results(self):
        plt.figure(figsize=(8, 6))
        plt.bar(['Training', 'Test'], [self.train_mse, self.test_mse],␣
↪color=['blue', 'green'])
        plt.xlabel('Dataset')
        plt.ylabel('Mean Squared Error')
        plt.title('Linear Regression Model Performance')
        for i, v in enumerate([self.train_mse, self.test_mse]):
            plt.text(i, v, str(v), ha='center', va='bottom')
        plt.show()

    def run(self):
        self.load_data()
        self.preprocess_data()
        self.train_model()
        self.evaluate_model()
        self.plot_results()
```

[15]:
```
if __name__ == "__main__":
    stockPriceRegression = StockPriceRegression(data_path = stockHVN2022)
    stockPriceRegression.run()
```



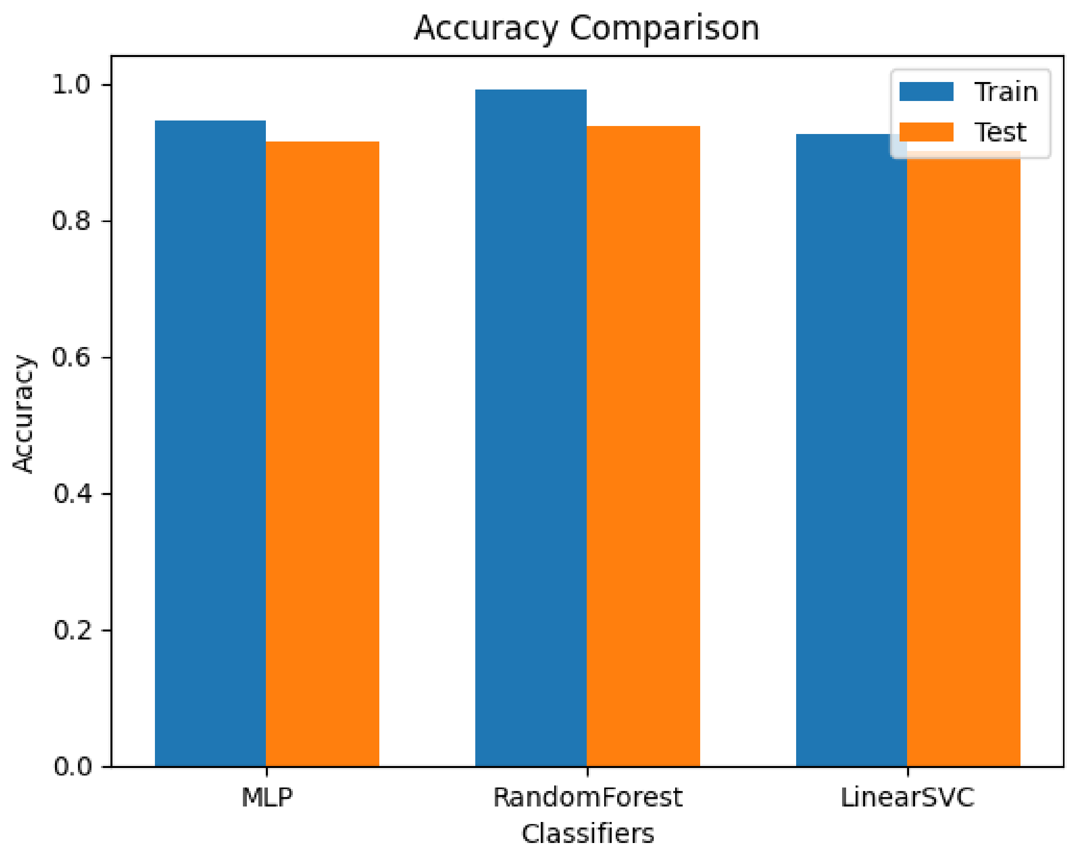
5 Task 5: Multi-class classification

[16]:
```
class MultiClassClassification:
    def __init__(self, data_path:str):
        self.data = None
        self.classification = ["MLP", "RandomForest", "LinearSVC"]
        self.train_accuracies = []
        self.test_accuracies = []
        self.data_path = data_path

    def load_data(self):
        self.data = spark.read.csv(self.data_path, header=False,␣
 ↪inferSchema=True)

    def preprocess_data(self):
```

```
        assembler = VectorAssembler(inputCols=self.data.columns[1:],␣
↪outputCol="features")
        self.data = assembler.transform(self.data) \
                        .select("_c0", "features") \
                        .withColumnRenamed("_c0", "label")

    def run_classification(self):
        (train_data, test_data) = self.data.randomSplit([0.7, 0.3], seed=42)

        for classifier_name in self.classification:
            if classifier_name == "MLP":
                classifier = MultilayerPerceptronClassifier(maxIter=100,␣
↪layers=[784, 128, 64, 10], blockSize=128, seed=42)
            elif classifier_name == "RandomForest":
                classifier = RandomForestClassifier(numTrees=100, maxDepth=10,␣
↪seed=42)
            else:
                classifier = OneVsRest(classifier=LinearSVC(maxIter=100,␣
↪regParam=0.1))

            model = classifier.fit(train_data)

            evaluator = MulticlassClassificationEvaluator(metricName="accuracy")
            train_accuracy = evaluator.evaluate(model.transform(train_data))
            test_accuracy = evaluator.evaluate(model.transform(test_data))

            self.train_accuracies.append(train_accuracy)
            self.test_accuracies.append(test_accuracy)

    def plot_accuracies(self):
        x = np.arange(len(self.classification))
        fig, ax = plt.subplots()
        bar_width = 0.35

        rects1 = ax.bar(x - bar_width / 2, self.train_accuracies, bar_width,␣
↪label='Train')
        rects2 = ax.bar(x + bar_width / 2, self.test_accuracies, bar_width,␣
↪label='Test')

        ax.set_xlabel('Classifiers')
        ax.set_ylabel('Accuracy')
        ax.set_title('Accuracy Comparison')
        ax.set_xticks(x)
        ax.set_xticklabels(self.classification)
        ax.legend()
        plt.show()
```

```
    def run(self):
        self.load_data()
        self.preprocess_data()
        self.run_classification()
        self.plot_accuracies()
```

[17]:
```
if __name__ == "__main__":
    multiClassClassification = MultiClassClassification(data_path = mnist_mini)
    multiClassClassification.run()
```



[18]:
```
spark.stop()
```