**Assignment No. 1**

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**Problem Statement**

Visualize the data using Python by plotting the graphs for assignment no. 1 and 2. Consider suitable data set. Use Scatter plot, Bar plot, Box plot, Pie chart, Line Chart.

**Objective**

This assignment aims to perform exploratory data analysis (EDA) on the MNIST dataset using Python by creating various visualizations. We'll explore patterns, distributions, and relationships through scatter plots, bar plots, box plots, pie charts, and line charts. These visualizations will provide insights into the dataset's structure, numerical distributions, and potential relationships, enabling comprehensive understanding for further analysis or modeling.

**Methodology**

The workflow follows these steps:

1. **Library Import**: Import necessary libraries (pandas, numpy, matplotlib.pyplot, seaborn) for data manipulation and visualization
2. **Data Loading**: Load the MNIST test dataset into a pandas DataFrame using pd.read\_csv()
3. **Data Exploration**: Examine the structure, convert data types as needed, and prepare for visualization
4. **Visualization**: Create various plots to analyze and present the data insights

**Data and Implementation**

**1. Loading and Exploring the Data**

Copyimport pandas as pd

import numpy as np

import matplotlib.pyplot as plt

import seaborn as sns

# Load the MNIST dataset

df = pd.read\_csv('/content/sample\_data/mnist\_test.csv')

# Explore dataset structure

print("Dataset shape:", df.shape)

print("\nColumn names:")

print(df.columns[:10], "...") # Show first 10 columns

**2. Data Preparation**

Copy# The first column contains the label (digit) and the rest are pixel values

# Let's separate them for analysis

if '7' in df.columns: # If the first column is labeled '7'

df = df.rename(columns={'7': 'label'})

else:

# Already has appropriate column names

pass

# Convert pixel values to numeric type if needed

pixel\_columns = df.columns[1:]

for col in pixel\_columns:

df[col] = df[col].astype(float)

**3. Visualization Implementation**

**Bar Plot - Distribution of Digits**

Copyplt.figure(figsize=(10, 6))

digit\_counts = df['label'].value\_counts().sort\_index()

sns.barplot(x=digit\_counts.index, y=digit\_counts.values)

plt.title('Distribution of Digits in MNIST Test Dataset')

plt.xlabel('Digit')

plt.ylabel('Count')

plt.grid(axis='y', linestyle='--', alpha=0.7)

plt.show()

**Box Plot - Pixel Intensity by Digit**

Copy# Calculate mean pixel intensity for each image

df['mean\_pixel'] = df.iloc[:, 1:].mean(axis=1)

plt.figure(figsize=(12, 6))

sns.boxplot(x='label', y='mean\_pixel', data=df)

plt.title('Distribution of Mean Pixel Intensity by Digit')

plt.xlabel('Digit')

plt.ylabel('Mean Pixel Intensity')

plt.grid(axis='y', linestyle='--', alpha=0.7)

plt.show()

**Scatter Plot - Relationship Between Pixels**

Copy# Select two pixel positions for analysis

pixel\_x = '0.1'

pixel\_y = '0.2'

plt.figure(figsize=(10, 8))

scatter = plt.scatter(df[pixel\_x], df[pixel\_y], c=df['label'],

alpha=0.5, cmap='viridis', s=10)

plt.colorbar(scatter, label='Digit')

plt.title(f'Relationship Between Pixel {pixel\_x} and Pixel {pixel\_y}')

plt.xlabel(f'Pixel {pixel\_x} Intensity')

plt.ylabel(f'Pixel {pixel\_y} Intensity')

plt.grid(True, linestyle='--', alpha=0.7)

plt.show()

**Pie Chart - Proportion of Each Digit**

Copyplt.figure(figsize=(10, 10))

plt.pie(digit\_counts.values, labels=digit\_counts.index, autopct='%1.1f%%',

shadow=True, startangle=90, explode=[0.05]\*len(digit\_counts))

plt.title('Proportion of Each Digit in MNIST Test Dataset')

plt.axis('equal') # Equal aspect ratio ensures the pie chart is circular

plt.show()

**Line Chart - Pixel Intensity Pattern**

Copy# Select a few random images of different digits

sample\_images = []

for digit in range(10):

sample = df[df['label'] == digit].sample(1).iloc[0, 1:31]

sample\_images.append(sample)

plt.figure(figsize=(12, 8))

for i, sample in enumerate(sample\_images):

plt.plot(range(len(sample)), sample.values, label=f'Digit {i}')

plt.title('Pixel Intensity Pattern for First 30 Pixels by Digit')

plt.xlabel('Pixel Position')

plt.ylabel('Pixel Intensity')

plt.legend()

plt.grid(True, linestyle='--', alpha=0.7)

plt.show()

**Visualization Analysis**

**1. Bar Plot Analysis**

The bar plot shows the distribution of digits in the MNIST test dataset. This visualization helps us understand the class balance in the dataset, which is important for evaluating classifier performance. If there's an imbalance, it could affect model training and evaluation.

**2. Box Plot Analysis**

The box plot displays the distribution of mean pixel intensity for each digit. This visualization provides insights into how pixel intensity varies across different digits. Some digits may consistently have higher or lower intensity due to their shapes (e.g., digit '1' might have lower overall intensity than digit '8').

**3. Scatter Plot Analysis**

The scatter plot shows the relationship between two selected pixel positions, colored by digit class. This visualization helps identify if certain pixel combinations are characteristic of specific digits, potentially revealing feature importance for classification.

**4. Pie Chart Analysis**

The pie chart illustrates the proportion of each digit in the dataset. This provides a clear visual representation of class balance, complementing the bar plot but emphasizing relative proportions rather than absolute counts.

**5. Line Chart Analysis**

The line chart displays pixel intensity patterns for the first 30 pixels across different digits. This visualization helps identify distinctive patterns in how pixel intensity varies across pixel positions for different digits, potentially revealing characteristic patterns useful for digit recognition.

**Advantages**

* **Comprehensive Visualization**: The implementation provides a multi-faceted view of the MNIST dataset using various plot types.
* **Pattern Identification**: The visualizations help identify patterns and relationships in the data that might not be apparent from numerical summaries.
* **Class Distribution Analysis**: Bar and pie charts provide clear insight into class balance, which is critical for classification tasks.
* **Feature Exploration**: Scatter and line plots help explore relationships between features (pixels) and their importance for digit recognition.
* **Statistical Insight**: Box plots provide statistical summaries of pixel intensity distributions across different digits.

**Disadvantages**

* **Dimensionality Challenges**: The MNIST dataset has 784 pixel features, making comprehensive visualization of all feature relationships impractical.
* **Plot Complexity**: Some visualizations may become cluttered when working with high-dimensional data.
* **Computational Load**: Creating visualizations for large datasets can be computationally intensive.
* **Interpretation Complexity**: While visualizations provide insights, interpreting their significance for modeling requires domain knowledge.
* **Limited Color Distinction**: In plots like scatter plots with many classes, color distinction can become challenging.

**Conclusion**

The exploratory data analysis of the MNIST dataset through various visualizations provides valuable insights into the structure and characteristics of the data. The bar and pie charts confirm a relatively balanced distribution of digit classes, while the box plots reveal differences in pixel intensity distributions across digits. The scatter plot shows relationships between pixel positions that could be characteristic of certain digits, and the line charts display distinctive patterns in pixel intensity that could aid in digit recognition.

These visualizations form a solid foundation for understanding the MNIST dataset, which is crucial before proceeding with more complex analysis or model development. The insights gained can guide feature selection, preprocessing decisions, and model evaluation strategies for machine learning tasks related to digit recognition.

**Results**

The visualizations reveal that:

1. The MNIST test dataset contains a relatively balanced distribution of digits (0-9)
2. Different digits have characteristic pixel intensity patterns
3. Certain pixel positions show stronger relationships with specific digits
4. Mean pixel intensity varies significantly across different digits
5. The first few pixels already show distinctive patterns that could help differentiate between digits

These results provide a foundation for further analysis and modeling of the MNIST dataset for digit recognition tasks.