mnist-data

September 3, 2024

[105]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from scipy.stats import multivariate_normal as mvn
```

[106]:
```
mnist_data = pd.read_csv("/content/MNIST_train.csv")
mnist_test_data = pd.read_csv("/content/MNIST_test.csv")
mnist_data
```

[106]:

	Unnamed: 0	index	labels	0	1	2	3	4	5	6	…	774	775	776	\
0	0	0	5	0	0	0	0	0	0	0	…	0	0	0	
1	1	1	0	0	0	0	0	0	0	0	…	0	0	0	
2	2	2	4	0	0	0	0	0	0	0	…	0	0	0	
3	3	3	1	0	0	0	0	0	0	0	…	0	0	0	
4	4	4	9	0	0	0	0	0	0	0	…	0	0	0	
…	…	…	…	..	..	..	..	..	..	..	…	…	…	…	
59995	59995	59995	8	0	0	0	0	0	0	0	…	0	0	0	
59996	59996	59996	3	0	0	0	0	0	0	0	…	0	0	0	
59997	59997	59997	5	0	0	0	0	0	0	0	…	0	0	0	
59998	59998	59998	6	0	0	0	0	0	0	0	…	0	0	0	
59999	59999	59999	8	0	0	0	0	0	0	0	…	0	0	0	

	777	778	779	780	781	782	783
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
…	…	…	…	…	…	…	…
59995	0	0	0	0	0	0	0
59996	0	0	0	0	0	0	0
59997	0	0	0	0	0	0	0
59998	0	0	0	0	0	0	0
59999	0	0	0	0	0	0	0

[60000 rows x 787 columns]

[107]:
```
unique_labels = mnist_data['labels'].unique()
print(unique_labels)
```

```
[5 0 4 1 9 2 3 6 7 8]
```

[108]:
```
for column in mnist_data.columns:
  print(column)
```

```
Unnamed: 0
index
labels
0
1
2
3
4
5
6
7
8
9
10
11
12
13
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771
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773
774
775
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777
778
779
780
781
782
783
```

[109]:
```
mnist_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 60000 entries, 0 to 59999
Columns: 787 entries, Unnamed: 0 to 783
dtypes: int64(787)
memory usage: 360.3 MB
```

[110]:
```
mnist_data.describe()
```

[110]:

	Unnamed: 0	index	labels	0	1	2	\
count	60000.000000	60000.000000	60000.000000	60000.0	60000.0	60000.0	
mean	29999.500000	29999.500000	4.453933	0.0	0.0	0.0	
std	17320.652413	17320.652413	2.889270	0.0	0.0	0.0	
min	0.000000	0.000000	0.000000	0.0	0.0	0.0	
25%	14999.750000	14999.750000	2.000000	0.0	0.0	0.0	
50%	29999.500000	29999.500000	4.000000	0.0	0.0	0.0	
75%	44999.250000	44999.250000	7.000000	0.0	0.0	0.0	
max	59999.000000	59999.000000	9.000000	0.0	0.0	0.0	

```
              3        4        5        6  …           774           775  \
count  60000.0  60000.0  60000.0  60000.0  …  60000.000000  60000.000000
mean       0.0      0.0      0.0      0.0  …      0.200433      0.088867
std        0.0      0.0      0.0      0.0  …      6.042472      3.956189
min        0.0      0.0      0.0      0.0  …      0.000000      0.000000
25%        0.0      0.0      0.0      0.0  …      0.000000      0.000000
50%        0.0      0.0      0.0      0.0  …      0.000000      0.000000
75%        0.0      0.0      0.0      0.0  …      0.000000      0.000000
max        0.0      0.0      0.0      0.0  …    254.000000    254.000000

                776           777           778         779      780      781  \
count  60000.000000  60000.000000  60000.000000  60000.0000  60000.0  60000.0
mean       0.045633      0.019283      0.015117      0.0020      0.0      0.0
std        2.839845      1.686770      1.678283      0.3466      0.0      0.0
min        0.000000      0.000000      0.000000      0.0000      0.0      0.0
25%        0.000000      0.000000      0.000000      0.0000      0.0      0.0
50%        0.000000      0.000000      0.000000      0.0000      0.0      0.0
75%        0.000000      0.000000      0.000000      0.0000      0.0      0.0
max      253.000000    253.000000    254.000000     62.0000      0.0      0.0

           782      783
count  60000.0  60000.0
mean       0.0      0.0
std        0.0      0.0
min        0.0      0.0
25%        0.0      0.0
50%        0.0      0.0
75%        0.0      0.0
max        0.0      0.0

[8 rows x 787 columns]
```

[111]:
```
mnist_data.isnull().sum()
```

[111]:
```
Unnamed: 0    0
index         0
labels        0
0             0
1             0
             ..
779           0
780           0
781           0
782           0
783           0
Length: 787, dtype: int64
```

[112]:
```
mnist_data.shape
```

[112]:
```
(60000, 787)
```

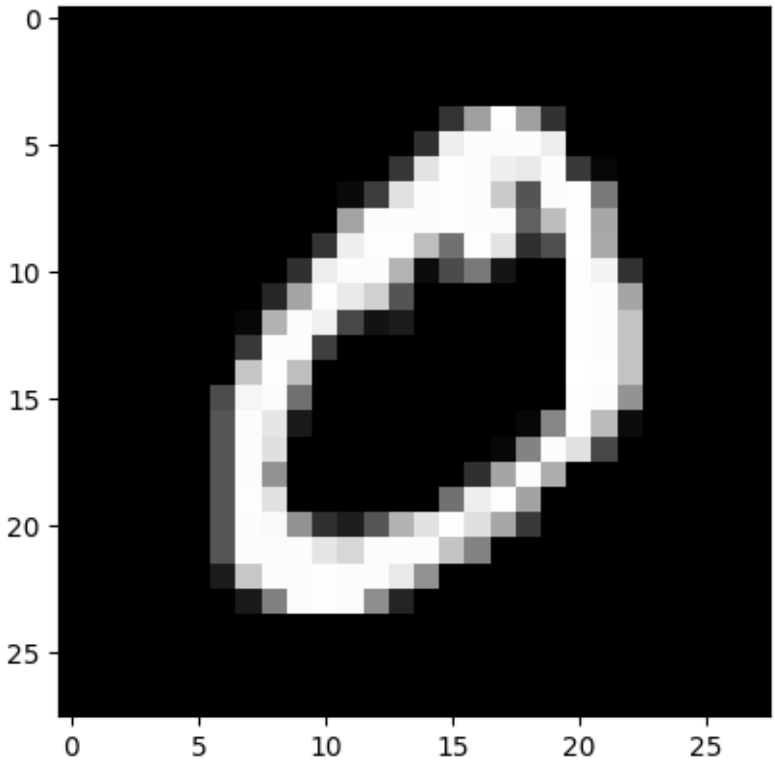
[113]:
```
mnist_data= mnist_data.drop_duplicates()
mnist_data.shape
```

[113]:
```
(60000, 787)
```

[114]:
```
columns_to_drop = ['Unnamed: 0', 'index', 'labels']
X= mnist_data.drop(columns=columns_to_drop).to_numpy()
X_test = mnist_test_data.drop(columns=columns_to_drop).to_numpy()
y = mnist_data["labels"].to_numpy()
y_test = mnist_test_data["labels"].to_numpy()
X
```

[114]:
```
array([[0, 0, 0, …, 0, 0, 0],
       [0, 0, 0, …, 0, 0, 0],
       [0, 0, 0, …, 0, 0, 0],
       …,
       [0, 0, 0, …, 0, 0, 0],
       [0, 0, 0, …, 0, 0, 0],
       [0, 0, 0, …, 0, 0, 0]])
```

[115]:
```
obs_1=X[1,:]
obs_1 = obs_1.reshape(28, 28)
plt.imshow(obs_1, cmap='gray')
plt.show()
```

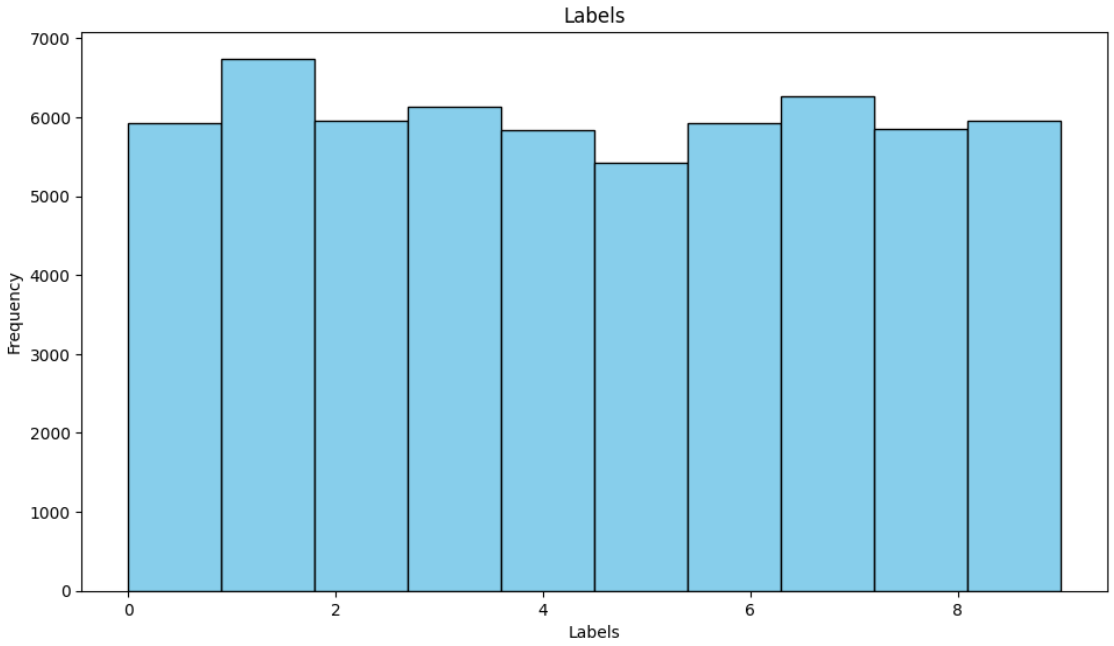


[116]:
```
# Function to plot variable distributions
def plot_variable_distributions(df):
    features = ['labels']
    plt.figure(figsize=(10, 6))

    for i, feature in enumerate(features, 1):
        plt.subplot(1, 1, i)
        df[feature].hist(grid=False, color='skyblue', edgecolor='black')
        plt.title(feature.capitalize(), fontsize=12)
        plt.xlabel("Labels", fontsize=10)
        plt.ylabel("Frequency", fontsize=10)
        plt.xticks(rotation=0)

    plt.tight_layout(pad=2.0)
    plt.suptitle("Variable Distributions", fontsize=16, y=1.05)
    plt.show()

plot_variable_distributions(mnist_data)
```



[117]:
```
X= X/255
X_test = X_test/255
X
```

[117]:
```
array([[0., 0., 0., …, 0., 0., 0.],
       [0., 0., 0., …, 0., 0., 0.],
       [0., 0., 0., …, 0., 0., 0.],
       …,
       [0., 0., 0., …, 0., 0., 0.],
       [0., 0., 0., …, 0., 0., 0.],
       [0., 0., 0., …, 0., 0., 0.]])
```

[118]:
```
class KNNClassifier():
    def fit(self, X, y):
        self.X = X
        self.y = y

    def predict(self, X, K, epsilon=1e-3):
        N = len(X)
        y_hat = np.zeros(N)

        for i in range(N):
            dist2 = np.sum((self.X - X[i])**2, axis=1)
            idxt = np.argsort(dist2)[:K]
```

```
            gamma_k = 1 / (np.sqrt(dist2[idxt] + epsilon))

            y_hat[i] = np.bincount(self.y[idxt], weights=gamma_k).argmax()
        return y_hat
```

[119]:
```
def accuracy(y, y_hat):
  return np.mean(y==y_hat)
```

[120]:
```
MNIST_KNN = KNNClassifier()
MNIST_KNN.fit(X, y)
y_pred = MNIST_KNN.predict(X_test, K=5)
accuracy(y_pred, y_test)
```

[120]: 0.9691

[122]:
```
mnist_data_sampled= mnist_data.copy()
min_class_size = mnist_data_sampled['labels'].value_counts().min()
sampled_df = mnist_data_sampled.groupby('labels').apply(lambda x: x.
 ↪sample(n=min_class_size)).reset_index(drop=True)
X_sampled = sampled_df.drop(columns=['labels', 'Unnamed: 0', 'index']).
 ↪to_numpy()
y_sampled = sampled_df['labels'].to_numpy()
X_sampled = X_sampled/255.0

MNIST_KNN_resampled = KNNClassifier()
MNIST_KNN_resampled.fit(X_sampled, y_sampled)
y_pred_resampled = MNIST_KNN_resampled.predict(X_test, K=5)
accuracy(y_pred_resampled, y_test)
```

[122]: 0.9686