# Crime Data Analysis and Neural Network Prediction

The aim of this project is to use the Crime and Disorder Data provided by the City of Calgary's data website to analyze the data and predict the number of crimes that will occur in the future. The data is from 2018 to 2024 and contains the number of crimes that occurred in Calgary for each month. After thoroughly analyzing the data, I will be building a neural network model and optimizing it to predict the number of crimes that will occur in the future.

## Strategy

1. Loading the data and understanding the data
2. Data Preprocessing - cleaning the data and preparing it for analysis
3. Exploratory Data Analysis - Analyzing the data to understand trends and patterns
4. Building a Neural Network Model
5. Optimizing the model
6. Training the model
7. Predicting the number of crimes that will occur in the future

```python
#Importing the Libraries
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
```

|   | Community | Category | Crime Count | Year | Month |
|---|---|---|---|---|---|
| **0** | 01B | Assault (non-domestic) | 1 | 2022 | 11 |
| **1** | 01B | Break & Enter - Commercial | 1 | 2019 | 6 |
| **2** | 01B | Break & Enter - Commercial | 1 | 2019 | 8 |
| **3** | 01B | Break & Enter - Commercial | 2 | 2020 | 3 |
| **4** | 01B | Break & Enter - Commercial | 2 | 2020 | 7 |

Here is the representation of the first 5 records of the data, which gives a brief information about the data. Since the dataset is alphabetically sorted by the community’s name, the data is not in chronological order.

## Data Preprocessing

```
#shape of the dataset
df.shape
```

```
(70661, 5)
```

Here we have barely 70661 records and 5 columns. Therefore, we have enough data for preparing an analysis and developing a model for prediction.

```
#checking for missing values
df.isnull().sum()
```

```
Community      0
Category       0
Crime Count    0
Year           0
Month          0
dtype: int64
```

The dataset is pretty clean and does not have any missing values.

```
#checking for the datatypes
df.dtypes
```

```
Community      object
Category       object
Crime Count     int64
Year            int64
Month           int64
dtype: object
```

Making sure that the columns have correct datatype, before I proceed with the analysis.

```
#Descriptive statistics
df.describe()
```

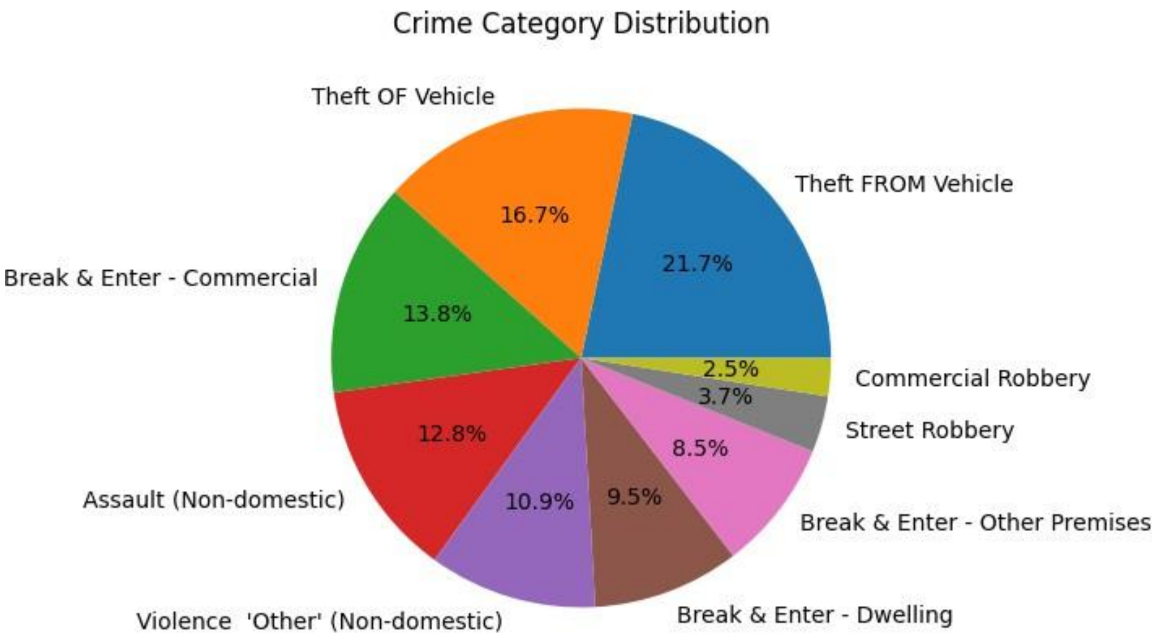
| | Crime Count | Year | Month |
|---|---|---|---|
| **count** | 70661.000000 | 70661.000000 | 70661.000000 |
| **mean** | 2.855748 | 2020.618616 | 6.369242 |
| **std** | 3.664965 | 1.825330 | 3.451445 |
| **min** | 1.000000 | 2018.000000 | 1.000000 |
| **25%** | 1.000000 | 2019.000000 | 3.000000 |
| **50%** | 2.000000 | 2021.000000 | 6.000000 |
| **75%** | 3.000000 | 2022.000000 | 9.000000 |
| **max** | 111.000000 | 2024.000000 | 12.000000 |

# Exploratory Data Analysis

In the exploratory data analysis, I will be analyzing the data to understand the trends and patterns in the data. Through this analysis, I will be able to understand the data better and build a better model for prediction.

## Crime Category Distribution

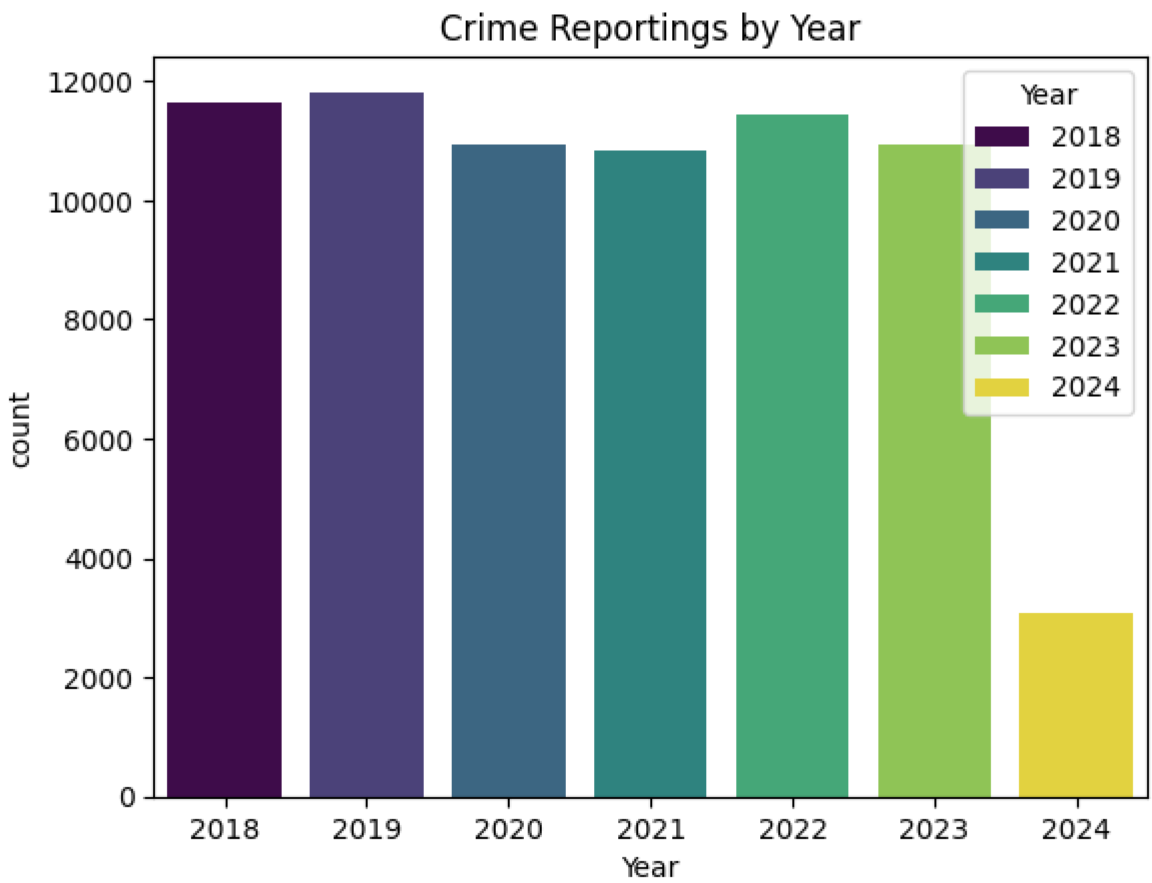
```
plt.figure(figsize=(5,  5))
df['Category'].value_counts().plot.pie(autopct='%1.1f%%')
plt.title('Crime Category Distribution')
plt.ylabel('')
```




This graph shows the distribution of crimes in each category by the number of crimes. The top crime category is Theft from Vehicle with 21.7% of the total crimes, followed by Theft of Vehicle with 16.7% and Break and Enter - Commercial with 13.8%. The least crime category includes commercial or street robbery.

## Crime Reporting Over the Years

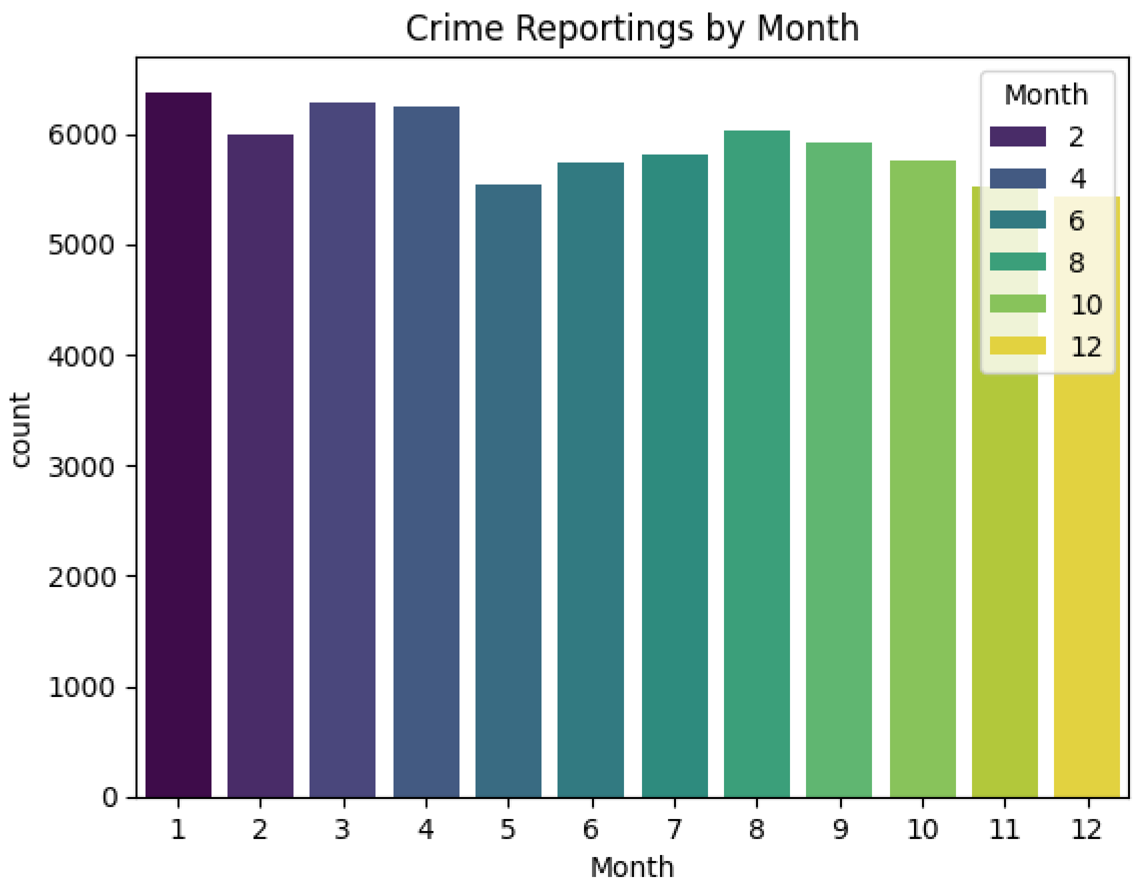
```
sns.countplot(x = 'Year', data = df, hue = 'Year', palette='viridis').set_title(
```




This bar graph shows the distribution of crimes reported in the year. The year 2019 had the highest reporting's of crimes followed by 2022 and 2018. The crime reporting in 2024 are less due to limited data till April 2024.

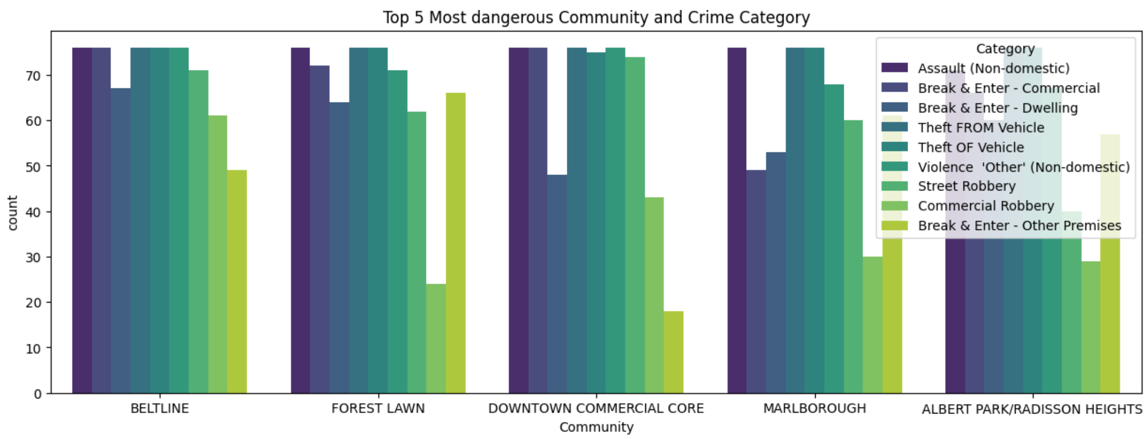
## Crime Reporting by Month

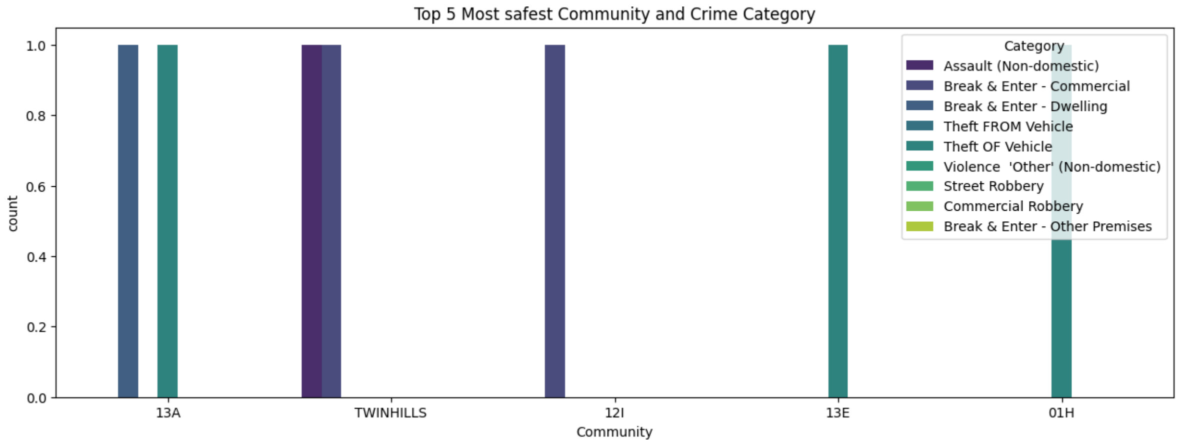
```
sns.countplot(x = 'Month', data = df, hue = 'Month', palette='viridis').set_titl
```




## Community and Category Analysis

```
plt.figure(figsize=(15, 5))
sns.countplot(x = 'Community', data = df, hue = 'Category', palette='viridis', o
sns.move_legend(plt.gca(), "upper right")
plt.figure(figsize=(15, 5))
sns.countplot(x = 'Community', data = df, hue = 'Category', palette='viridis', o
```

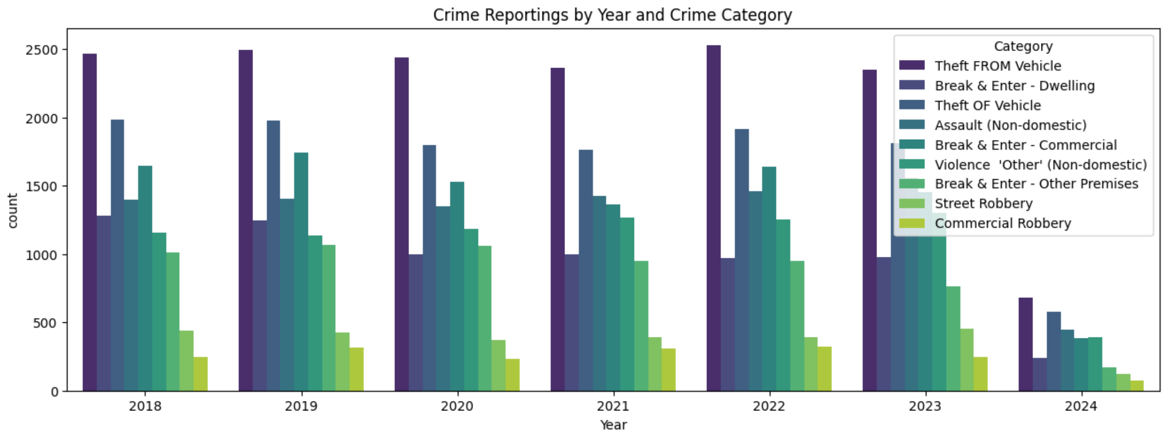





These two graphs show the analysis of communities with the crime category. This helps us to visualize the pattern of crime in each community. We can see that certain categories are more common in certain communities than others. In the top 5 dangers Community, Forest Lawn has the highest of Break & Enter - other premises, Malbrough has the lowest Commercial Robbery. These are the few examples of the analysis.

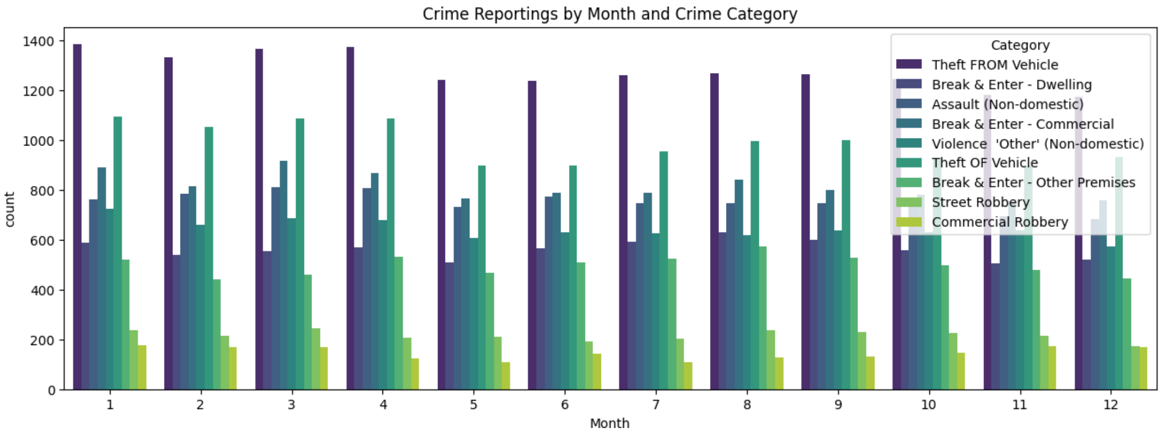
## Year and Category Analysis

```
plt.figure(figsize=(15, 5))
sns.countplot(x = 'Year', data = df, hue = 'Category', palette='viridis').set_ti
```




## Month and Category Analysis

```
plt.figure(figsize=(15, 5))
sns.countplot(x = 'Month', data = df, hue = 'Category', palette='viridis').set_t
```




From the above graphs, charts, and visualization I have studied the patterns, trends and relationships in the data. This will help me to build a better model for prediction.

# Data Preprocessing Part 2

```
from sklearn.preprocessing import LabelEncoder

#Label Encoding Object
le = LabelEncoder()

#Object type columns
object_type_columns = df.select_dtypes(include='object').columns

#Label Encoding
for col in object_type_columns:
    df[col] = le.fit_transform(df[col])
df.head()
```

| | Community | Category | Crime Count | Year | Month |
|---|---|---|---|---|---|
| **0** | 0 | 0 | 1 | 2022 | 11 |
| **1** | 0 | 1 | 1 | 2019 | 6 |
| **2** | 0 | 1 | 1 | 2019 | 8 |
| **3** | 0 | 1 | 2 | 2020 | 3 |
| **4** | 0 | 1 | 2 | 2020 | 7 |

# Building a Neural Network Model

```
# Prepare sequences for LSTM
def create_sequences(data, seq_length):
    xs = []
    ys = []
    for i in range(len(data) - seq_length):
        x = data.iloc[i:(i + seq_length)].to_numpy()
        y = data.iloc[i + seq_length]['Crime Count']
        xs.append(x)
```

```
        ys.append(y)
    return np.array(xs), np.array(ys)
```

```
seq_length = 3
X, y = create_sequences(df, seq_length)
```

## Train Test Split

```
from sklearn.model_selection import train_test_split
X_train, X_temp, y_train, y_temp = train_test_split(X, y, test_size=0.3, random_
X_val, X_test, y_val, y_test = train_test_split(X_temp, y_temp, test_size=0.5, r
```

## Building and Training the LSTM Model

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import LSTM, Dense, Dropout
from tensorflow.keras.optimizers import Adam
```

```
# Build the LSTM model
model = Sequential()
model.add(LSTM(50, activation='relu', input_shape=(seq_length, X_train.shape[2]))
model.add(Dropout(0.2))
model.add(Dense(1))

# Compile the model
optimizer = Adam(learning_rate=0.001)
model.compile(optimizer=optimizer,  loss='mse')

# Train the model
history = model.fit(X_train, y_train, epochs=100, validation_data=(X_val, y_val)
```

```
Epoch 1/100
3092/3092 [==============================] - 9s 3ms/step - loss: 368.3250 - val_l
oss: 12.2236
Epoch 2/100
3092/3092 [==============================] - 9s 3ms/step - loss: 13.1753 - val_lo
ss: 9.2046
Epoch 3/100
3092/3092 [==============================] - 7s 2ms/step - loss: 10.1402 - val_lo
ss: 5.4251
Epoch 4/100
3092/3092 [==============================] - 7s 2ms/step - loss: 6.6290 - val_los
s: 4.8992
Epoch 5/100
3092/3092 [==============================] - 7s 2ms/step - loss: 6.6735 - val_los
s: 4.9798
Epoch 6/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.6858 - val_los
s: 5.1378
Epoch 7/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.8741 - val_los
s: 5.0281
Epoch 8/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.6256 - val_los
s: 4.8595
Epoch 9/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.8799 - val_los
s: 5.1668
Epoch 10/100
3092/3092 [==============================] - 8s 2ms/step - loss: 5.6717 - val_los
s: 4.9109
Epoch 11/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.7738 - val_los
s: 5.1230
Epoch 12/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.8282 - val_los
s: 5.1127
Epoch 13/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.7929 - val_los
s: 4.7676
Epoch 14/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.6273 - val_los
s: 4.8039
Epoch 15/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.8839 - val_los
s: 4.8101
Epoch 16/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.6465 - val_los
s: 4.7539
Epoch 17/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.5960 - val_los
s: 5.1675
Epoch 18/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.4866 - val_los
s: 6.1844
Epoch 19/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5935 - val_los
s: 4.6616
Epoch 20/100
3092/3092 [==============================] - 8s 2ms/step - loss: 5.9473 - val_los
s: 5.1832
```

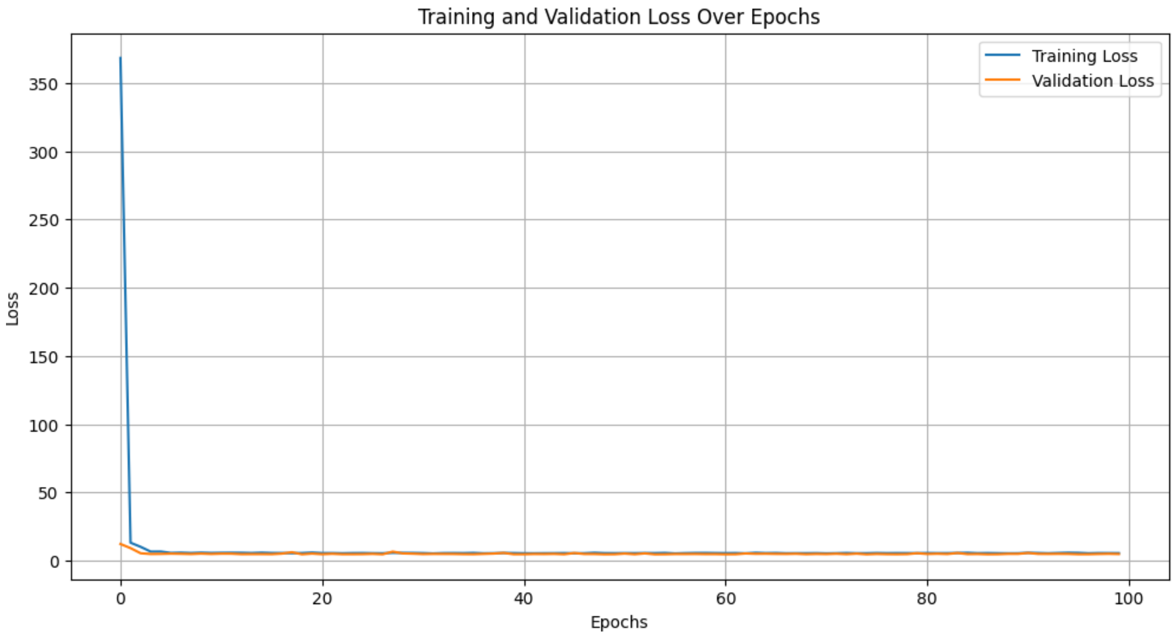
```
Epoch 21/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5673 - val_los
s: 4.7347
Epoch 22/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5726 - val_los
s: 5.0483
Epoch 23/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.4310 - val_los
s: 4.7352
Epoch 24/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5576 - val_los
s: 4.7369
Epoch 25/100
3092/3092 [==============================] - 8s 2ms/step - loss: 5.6070 - val_los
s: 4.7857
Epoch 26/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.4853 - val_los
s: 4.9823
Epoch 27/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.4301 - val_los
s: 4.6676
Epoch 28/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.7564 - val_los
s: 6.6096
Epoch 29/100
3092/3092 [==============================] - 8s 2ms/step - loss: 5.6978 - val_los
s: 5.3235
Epoch 30/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.6758 - val_los
s: 5.1226
Epoch 31/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.5496 - val_los
s: 4.8413
Epoch 32/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.3276 - val_los
s: 4.9500
Epoch 33/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5483 - val_los
s: 4.9332
Epoch 34/100
3092/3092 [==============================] - 8s 2ms/step - loss: 5.5993 - val_los
s: 4.9068
Epoch 35/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5452 - val_los
s: 4.7737
Epoch 36/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.7006 - val_los
s: 4.7271
Epoch 37/100
3092/3092 [==============================] - 8s 2ms/step - loss: 5.4117 - val_los
s: 4.9678
Epoch 38/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.4684 - val_los
s: 5.2002
Epoch 39/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.6481 - val_los
s: 5.6867
Epoch 40/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.5738 - val_los
s: 4.7146
```

```
Epoch 41/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.4375 - val_los
s: 4.7131
Epoch 42/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.4098 - val_los
s: 4.8912
Epoch 43/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.4567 - val_los
s: 4.8491
Epoch 44/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5003 - val_los
s: 4.9664
Epoch 45/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5602 - val_los
s: 4.6880
Epoch 46/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.4180 - val_los
s: 5.6115
Epoch 47/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.4679 - val_los
s: 4.8983
Epoch 48/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.8144 - val_los
s: 4.8802
Epoch 49/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.5283 - val_los
s: 4.6533
Epoch 50/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.4935 - val_los
s: 4.7072
Epoch 51/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5349 - val_los
s: 5.1914
Epoch 52/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.4986 - val_los
s: 4.6977
Epoch 53/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5809 - val_los
s: 5.3368
Epoch 54/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5513 - val_los
s: 4.6322
Epoch 55/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.6919 - val_los
s: 4.6831
Epoch 56/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.3303 - val_los
s: 4.8628
Epoch 57/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5249 - val_los
s: 4.8582
Epoch 58/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.6541 - val_los
s: 4.9105
Epoch 59/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.6767 - val_los
s: 4.8064
Epoch 60/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5925 - val_los
s: 4.8082
```

```
Epoch 61/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.5196 - val_los
s: 4.6729
Epoch 62/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5900 - val_los
s: 4.7126
Epoch 63/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.3842 - val_los
s: 5.2713
Epoch 64/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.8055 - val_los
s: 5.0269
Epoch 65/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5551 - val_los
s: 5.0761
Epoch 66/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.6513 - val_los
s: 4.9608
Epoch 67/100
3092/3092 [==============================] - 7s 2ms/step - loss: 5.4326 - val_los
s: 4.9216
Epoch 68/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.4771 - val_los
s: 5.0531
Epoch 69/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.4703 - val_los
s: 4.7350
Epoch 70/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5293 - val_los
s: 4.9257
Epoch 71/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.3698 - val_los
s: 4.8255
Epoch 72/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.4702 - val_los
s: 5.0725
Epoch 73/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.6325 - val_los
s: 4.7330
Epoch 74/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.4535 - val_los
s: 5.1479
Epoch 75/100
3092/3092 [==============================] - 10s 3ms/step - loss: 5.4698 - val_lo
ss: 4.6433
Epoch 76/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.6245 - val_los
s: 4.9227
Epoch 77/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5196 - val_los
s: 4.7539
Epoch 78/100
3092/3092 [==============================] - 8s 3ms/step - loss: 5.5683 - val_los
s: 4.6994
Epoch 79/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5508 - val_los
s: 4.7919
Epoch 80/100
3092/3092 [==============================] - 9s 3ms/step - loss: 5.5035 - val_los
s: 5.4767
```

```
Epoch 81/100
3092/3092 [==============================]  - 8s 3ms/step - loss: 5.5963 - val_los
s: 4.9065
Epoch 82/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.5145 - val_los
s: 5.0828
Epoch 83/100
3092/3092 [==============================]  - 10s 3ms/step - loss: 5.5162 - val_lo
ss: 4.8715
Epoch 84/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.6411 - val_los
s: 5.6281
Epoch 85/100
3092/3092 [==============================]  - 8s 3ms/step - loss: 5.7950 - val_los
s: 4.8154
Epoch 86/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.5023 - val_los
s: 4.8846
Epoch 87/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.5841 - val_los
s: 4.6612
Epoch 88/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.4837 - val_los
s: 4.7223
Epoch 89/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.4101 - val_los
s: 4.9879
Epoch 90/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.4269 - val_los
s: 4.9915
Epoch 91/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.7826 - val_los
s: 5.6587
Epoch 92/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.6136 - val_los
s: 4.9782
Epoch 93/100
3092/3092 [==============================]  - 8s 3ms/step - loss: 5.4317 - val_los
s: 4.9384
Epoch 94/100
3092/3092 [==============================]  - 10s 3ms/step - loss: 5.6433 - val_lo
ss: 5.0109
Epoch 95/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.8415 - val_los
s: 4.9563
Epoch 96/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.7377 - val_los
s: 4.7079
Epoch 97/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.4252 - val_los
s: 4.7204
Epoch 98/100
3092/3092 [==============================]  - 10s 3ms/step - loss: 5.5803 - val_lo
ss: 4.9075
Epoch 99/100
3092/3092 [==============================]  - 9s 3ms/step - loss: 5.5518 - val_los
s: 5.0284
Epoch 100/100
3092/3092 [==============================]  - 8s 3ms/step - loss: 5.5170 - val_los
s: 4.8733
```

```
plt.figure(figsize=(12, 6))
plt.plot(history.history['loss'], label='Training Loss')
plt.plot(history.history['val_loss'], label='Validation Loss')
plt.title('Training and Validation Loss Over Epochs')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.grid(True)
plt.show()
```




```
# Evaluate the model
test_loss = model.evaluate(X_test, y_test)
print(f'Test Loss: {test_loss}')

# Predictions
y_pred = model.predict(X_test)


print(f'Predictions: {y_pred.flatten()}')
print(f'True Values: {y_test.flatten()}')
```

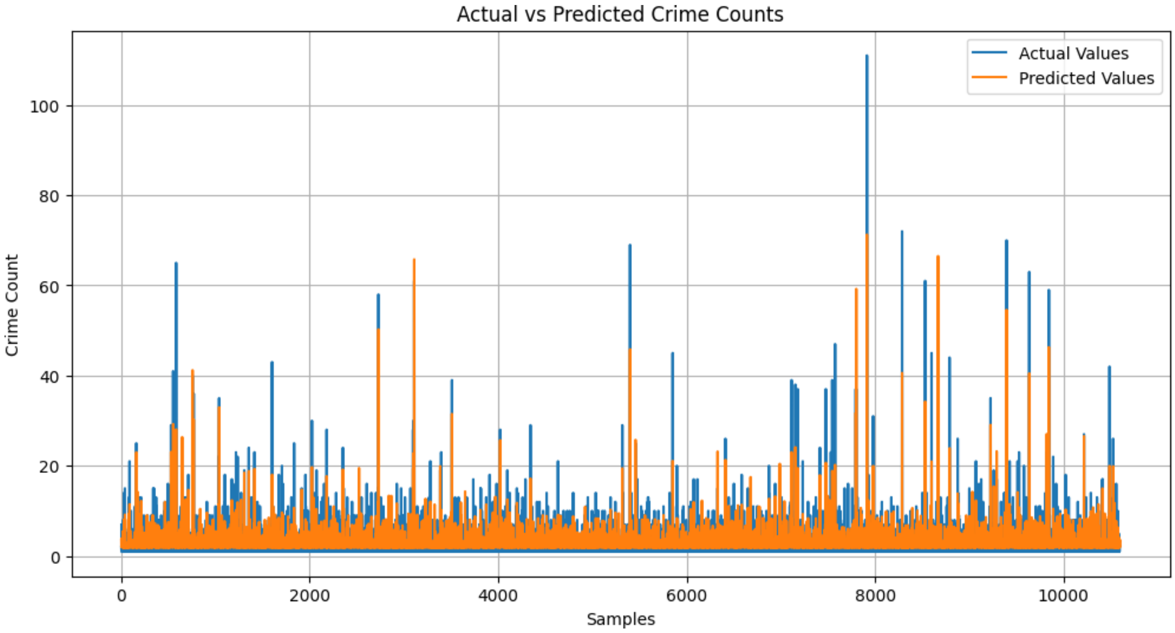
```
332/332 [==============================] - 0s 1ms/step - loss: 4.8978
Test Loss: 4.897756576538086
332/332 [==============================] - 1s 1ms/step
Predictions: [3.5760155 2.0850606 2.3349957 ... 3.710539  1.8771566 3.2992563]
True Values: [2 1 1 ... 1 2 2]
```

# Model Evaluation

## Actual vs Predicted Values

```
# Plotting Actual vs Predicted Values
plt.figure(figsize=(12, 6))
plt.plot(y_test, label='Actual Values')
plt.plot(y_pred, label='Predicted Values')
plt.title('Actual vs Predicted Crime Counts')
plt.xlabel('Samples')
plt.ylabel('Crime Count')
```

```python
plt.legend()
plt.grid(True)
plt.show()
```




## Residual Plot

```python
# Calculating residuals
residuals = y_test.flatten() - y_pred.flatten()

# Plotting residuals
plt.figure(figsize=(12, 6))
plt.plot(residuals, label='Residuals')
plt.title('Residuals (Actual - Predicted) Over Samples')
plt.xlabel('Samples')
plt.ylabel('Residuals')
plt.legend()
plt.grid(True)
plt.show()
```