In [ ]:
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Class - BE Artificial Intelligence and Data Science.
Roll No. - 37
Practical No. 07 - To apply the artificial immune pattern recognition to perform a task of structure
Classification.
```

In [1]:
```
# Import Required Libraries
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In [2]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report
```

In [3]:
```
# Load and Prepare the Dataset
```

In [4]:
```
df = pd.read_csv(r"C:\Users\saira\Downloads\structural_damage_data.csv")
```

In [5]:
```
df.head()
```

Out[5]:

	Vibration_Frequency_Hz	Stress_Level_MPa	Crack_Length_mm	Displacement_mm	Temperature_C	Damage_Le
0	43.708611	364.172771	9.256646	5.238910	0.936455	
1	95.564288	291.243365	27.095047	4.843901	-0.241696	
2	75.879455	189.287427	43.647292	0.353856	52.500366	
3	63.879264	416.207759	36.611244	3.478353	-0.036304	
4	24.041678	358.129028	40.328057	3.863937	1.755978	

In [6]:
```
df.tail()
```

Out[6]:

	Vibration_Frequency_Hz	Stress_Level_MPa	Crack_Length_mm	Displacement_mm	Temperature_C	Damage_
495	41.801701	91.211933	33.410640	6.603856	19.386038	
496	62.529050	462.791109	30.974517	9.570485	26.182322	
497	16.996117	111.568384	23.174702	0.782684	49.246172	
498	97.695533	477.606809	18.989289	0.664842	58.459147	
499	98.758967	250.702598	43.166682	2.893652	12.606737	

In [7]:
```
df.isnull().sum()
```

Out[7]:
```
Vibration_Frequency_Hz    0
Stress_Level_MPa          0
Crack_Length_mm           0
Displacement_mm           0
Temperature_C             0
Damage_Level              0
dtype: int64
```

In [8]:
```
# Feature Selection and Spiltting data
```

In [11]:
```
X = df.drop('Damage_Level', axis=1)
y = df['Damage_Level']

# Split into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

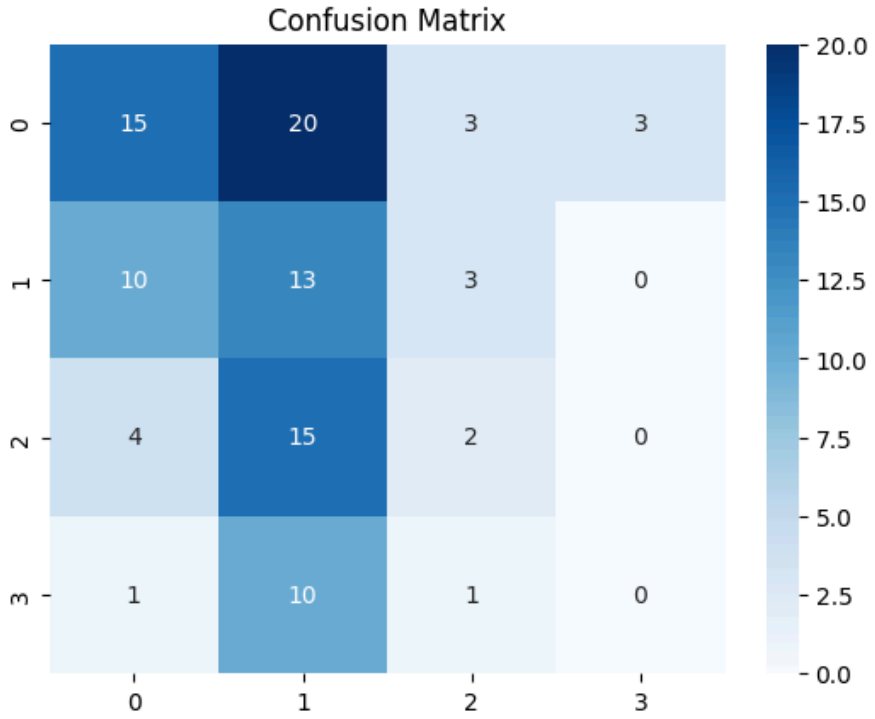
In [12]:
```
# Artificial Immune Pattern Recognition (AIPR) Algorithm
```

In [16]:
```
class AIPR:
    def __init__(self, n_clones=20, mutation_rate=0.05, generations=100):
        self.n_clones = n_clones
        self.mutation_rate = mutation_rate
        self.generations = generations

    def fit(self, X, y):
        self.memory_cells = np.random.rand(self.n_clones, X.shape[1])
        self.labels = np.random.choice(np.unique(y), self.n_clones)

        for _ in range(self.generations):
            for i in range(self.n_clones):
                clone = self.memory_cells[i] + self.mutation_rate * np.random.randn(X.shape[1])
                clone_fitness = self._fitness(clone, X, y)

                if clone_fitness > self._fitness(self.memory_cells[i], X, y):
                    self.memory_cells[i] = clone

    def predict(self, X):
        preds = []
        for x in X:
            distances = np.linalg.norm(self.memory_cells - x, axis=1)
            pred = self.labels[np.argmin(distances)]
            preds.append(pred)
        return np.array(preds)

    def _fitness(self, antibody, X, y):
        distances = np.linalg.norm(self.memory_cells - antibody, axis=1)
        closest_label = self.labels[np.argmin(distances)]
        return np.mean(closest_label == y)
```

In [17]:
```
# Train and Evaluate the Model
```

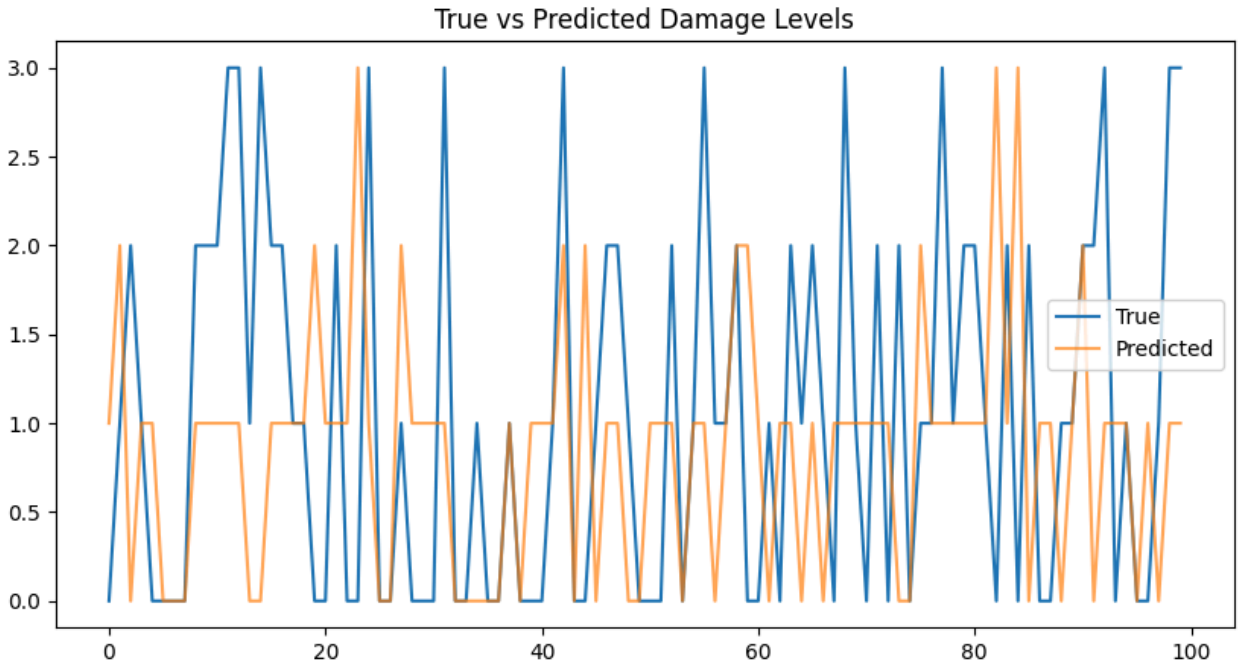
In [18]:
```
# Initialize and train the AIPR model
model = AIPR(n_clones=20, mutation_rate=0.05, generations=100)
model.fit(X_train.values, y_train.values)

# Make predictions
y_pred = model.predict(X_test.values)

# Evaluation
print("Accuracy:", accuracy_score(y_test, y_pred))
print("Classification Report:\n", classification_report(y_test, y_pred))

# Confusion Matrix
sns.heatmap(confusion_matrix(y_test, y_pred), annot=True, cmap='Blues')
plt.title('Confusion Matrix')
plt.show()
```

```
Accuracy: 0.3
Classification Report:
              precision    recall  f1-score   support

           0       0.50      0.37      0.42        41
           1       0.22      0.50      0.31        26
           2       0.22      0.10      0.13        21
           3       0.00      0.00      0.00        12

    accuracy                           0.30       100
   macro avg       0.24      0.24      0.22       100
weighted avg       0.31      0.30      0.28       100
```



In [19]:
```
# Visualize Result
```

In [20]:
```
# Compare true vs predicted damage levels
plt.figure(figsize=(10, 5))
plt.plot(y_test.values, label='True')
plt.plot(y_pred, label='Predicted', alpha=0.7)
plt.legend()
plt.title('True vs Predicted Damage Levels')
plt.show()
```


True vs Predicted Damage Levels
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
True
Predicted

In [ ]: