In [ ]:
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Class - BE Artificial Intelligence and Data Science.
Roll No. - 37
Practical No. 06 - Implementation of Clonal selection algorithm using Python.
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In [1]:
```
# Import Required Libraries
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In [2]:
```
import numpy as np
import matplotlib.pyplot as plt
```

In [3]:
```
# Define the Objective Function
```

In [4]:
```
def objective_function(x):
    return x**2 + 3*x + 5  # Example function to minimize
```

In [5]:
```
# Initialize Population
```

In [6]:
```
def initialize_population(size, lower_bound, upper_bound):
    return np.random.uniform(lower_bound, upper_bound, size)
```

In [7]:
```
# Evaluate Affinity (Fitness)
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In [8]:
```
def evaluate_fitness(population):
    return 1 / (1 + objective_function(population))  # Inverse for minimization
```

In [9]:
```
# Select Best Antibodies
```

In [10]:
```
def select_best(population, fitness, num_best):
    sorted_indices = np.argsort(-fitness)  # Descending order
    return population[sorted_indices[:num_best]]
```

In [11]:
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# Clone Selected Antibodies
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In [12]:
```
def clone_population(best_population, num_clones):
    clones = np.repeat(best_population, num_clones)
    return clones
```

In [13]:
```
# Hypermutation (Random Mutation)
```

In [14]:
```
def mutate(clones, mutation_rate):
    mutation = np.random.uniform(-mutation_rate, mutation_rate, size=clones.shape)
    return clones + mutation
```

In [15]:
```
# Replace Worst Solutions
```

In [16]:
```
def replace_worst(population, new_population, num_replace):
    population[-num_replace:] = new_population[:num_replace]
    return population
```

In [17]:
```
#  Implement the Clonal Selection Algorithm
```

In [18]:
```
def clonal_selection_algorithm(pop_size=20, generations=50, num_best=5, num_clones=3, mutation_rate=0.
    lower_bound, upper_bound = -10, 10
    population = initialize_population(pop_size, lower_bound, upper_bound)

    best_fitness_history = []

    for generation in range(generations):
        fitness = evaluate_fitness(population)
        best_population = select_best(population, fitness, num_best)
```

```
        clones = clone_population(best_population, num_clones)
        mutated_clones = mutate(clones, mutation_rate)

        fitness_mutated = evaluate_fitness(mutated_clones)
        best_mutated = select_best(mutated_clones, fitness_mutated, num_best)

        population = replace_worst(population, best_mutated, num_best)

        best_fitness_history.append(np.max(fitness))

        if generation % 10 == 0:
            print(f"Generation {generation}: Best fitness = {np.max(fitness)}")

    return best_fitness_history, population
```

In [19]:
```
# Run the Algorithm
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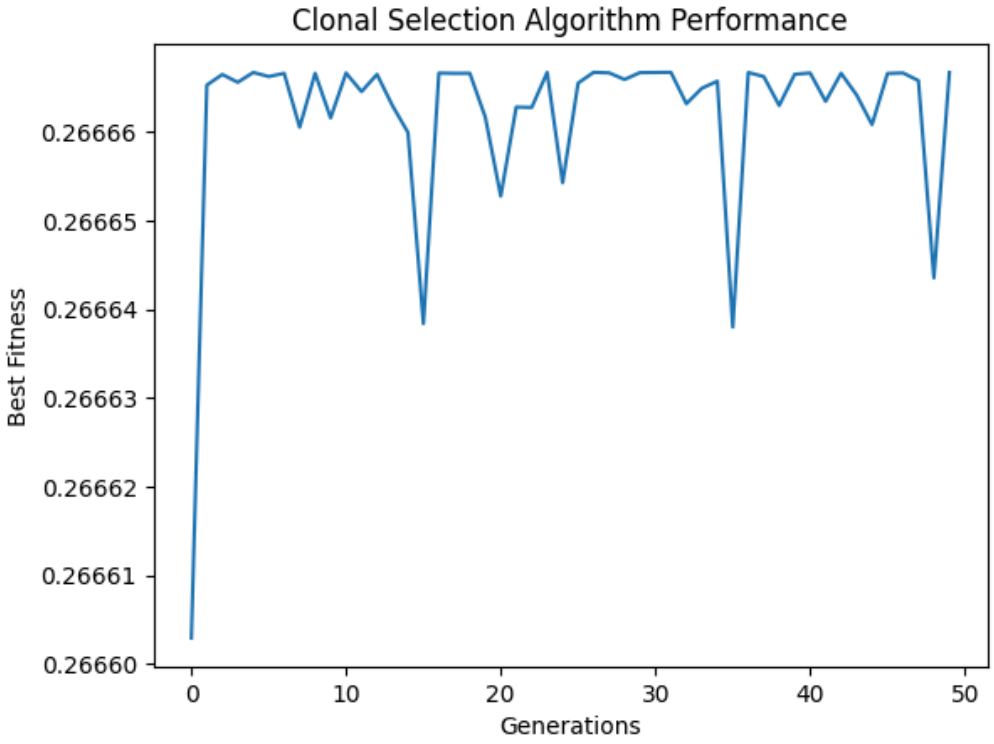
In [20]:
```
best_fitness, final_population = clonal_selection_algorithm()
```

```
Generation 0: Best fitness = 0.26660294930658407
Generation 10: Best fitness = 0.2666665928732328
Generation 20: Best fitness = 0.2666527224685652
Generation 30: Best fitness = 0.2666666506484063
Generation 40: Best fitness = 0.26666659323999936
```

In [21]:
```
# Plot the Results
```

In [22]:
```
plt.plot(best_fitness)
plt.xlabel('Generations')
plt.ylabel('Best Fitness')
plt.title('Clonal Selection Algorithm Performance')
plt.show()
```



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