CSE 354N - ASSIGNMENT 8

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Question 1

```
!pip install prettytable
```

```
Requirement already satisfied: prettytable in /usr/local/lib/python3.11/dist-packages (3.15.1)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.11/dist-packages (from prettytable) (0.2.13)
```

```python
import random
import math
import matplotlib.pyplot as plt
import numpy as np
from prettytable import PrettyTable
```

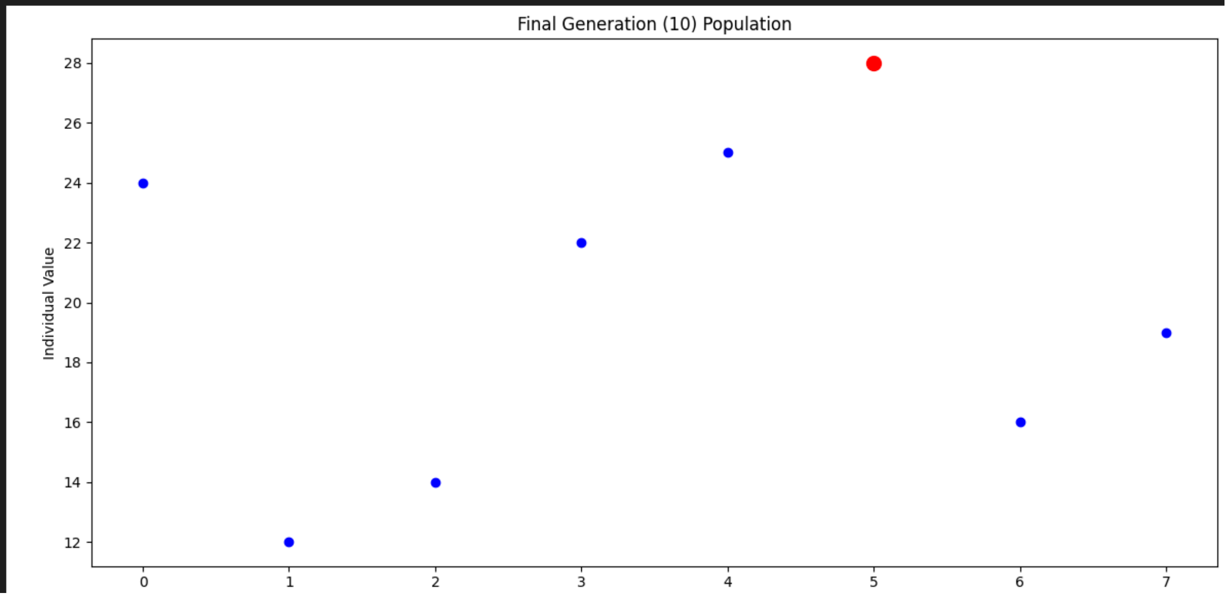
```python
# Function to maximise
def fitness_function(x):
    return x**2 + x**3

def binary_to_decimal(binary):
    return int(binary, 2)

def decimal_to_binary(decimal, bits):
    return format(decimal, f'0{bits}b')

def roulette_wheel_selection(population, fitnesses):
    total_fitness = sum(fitnesses)
    pick = random.uniform(0, total_fitness)
    current = 0
    for i, fitness in enumerate(fitnesses):
        current += fitness
        if current > pick:
            return population[i]

def single_point_crossover(parent1, parent2):
    crossover_point = random.randint(1, len(parent1) - 1)
    child1 = parent1[:crossover_point] + parent2[crossover_point:]
    child2 = parent2[:crossover_point] + parent1[crossover_point:]
    return child1, child2
```

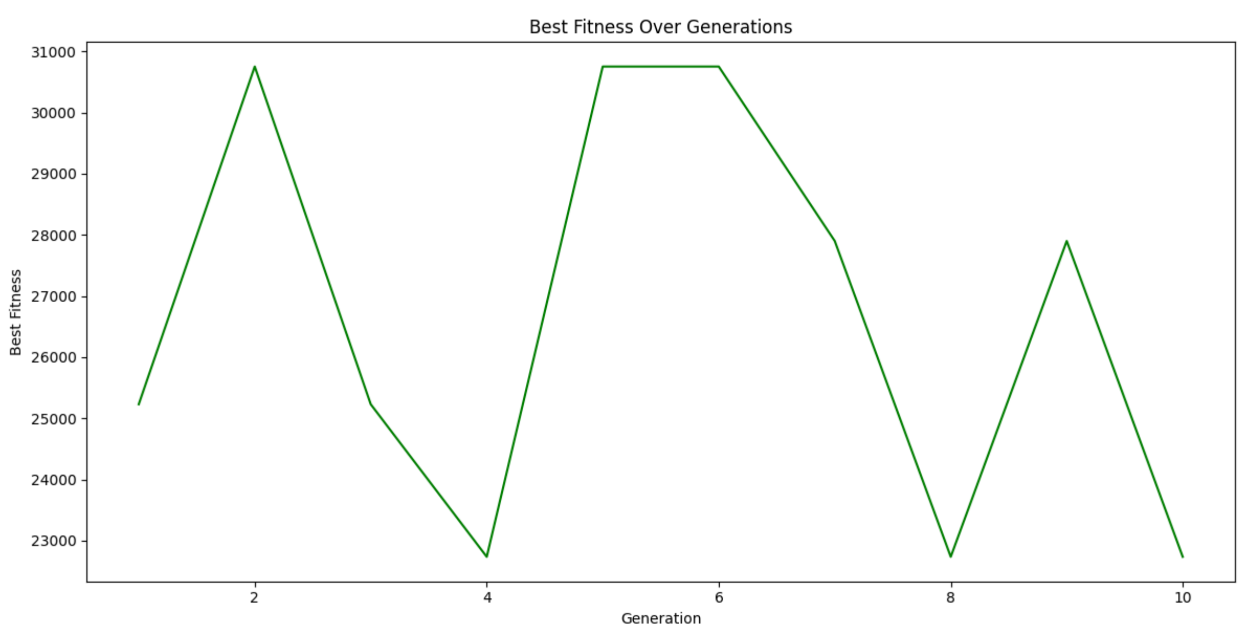
```python
def mutate(individual):
    index_to_mutate = random.randint(0, len(individual) - 1)
    new_individual = list(individual)
    new_individual[index_to_mutate] = str(1 - int(new_individual[index_to_mutate]))
    return ''.join(new_individual)

def create_initial_population(population_size, bits):
    return [''.join(random.choice('01') for _ in range(bits)) for _ in range(population_size)]

def genetic_algorithm(population_size, bits, generations):
    population = create_initial_population(population_size, bits)

    fig, axs = plt.subplots(3, 1, figsize=(12, 18))
    best_performers = []
    all_populations = []

    table = PrettyTable()

    table.field_names = ["Generation", "Population", "Best Individual", "Fitness"]

    for generation in range(generations):
        fitnesses = [fitness_function(binary_to_decimal(ind)) for ind in population]

        best_individual = max(population, key=lambda ind: fitness_function(binary_to_decimal(ind)))
        best_fitness = fitness_function(binary_to_decimal(best_individual))
        best_performers.append((best_individual, best_fitness))
        all_populations.append(population[:])

        population_str = ", ".join([str(binary_to_decimal(ind)) for ind in population])
        table.add_row([generation + 1, population_str, binary_to_decimal(best_individual), best_fitness])

        new_population = []
        for _ in range(population_size // 2):
            parent1 = roulette_wheel_selection(population, fitnesses)
            parent2 = roulette_wheel_selection(population, fitnesses)
            child1, child2 = single_point_crossover(parent1, parent2)
            new_population.extend([mutate(child1), mutate(child2)])

        population = new_population

    print(table)
    world = [i for pop_i in all_populations for i in pop_i]
    # Plot the population of the last generation
    final_population = [binary_to_decimal(ind) for ind in all_populations[-1]]
    final_fitnesses = [fitness_function(ind) for ind in final_population]
```

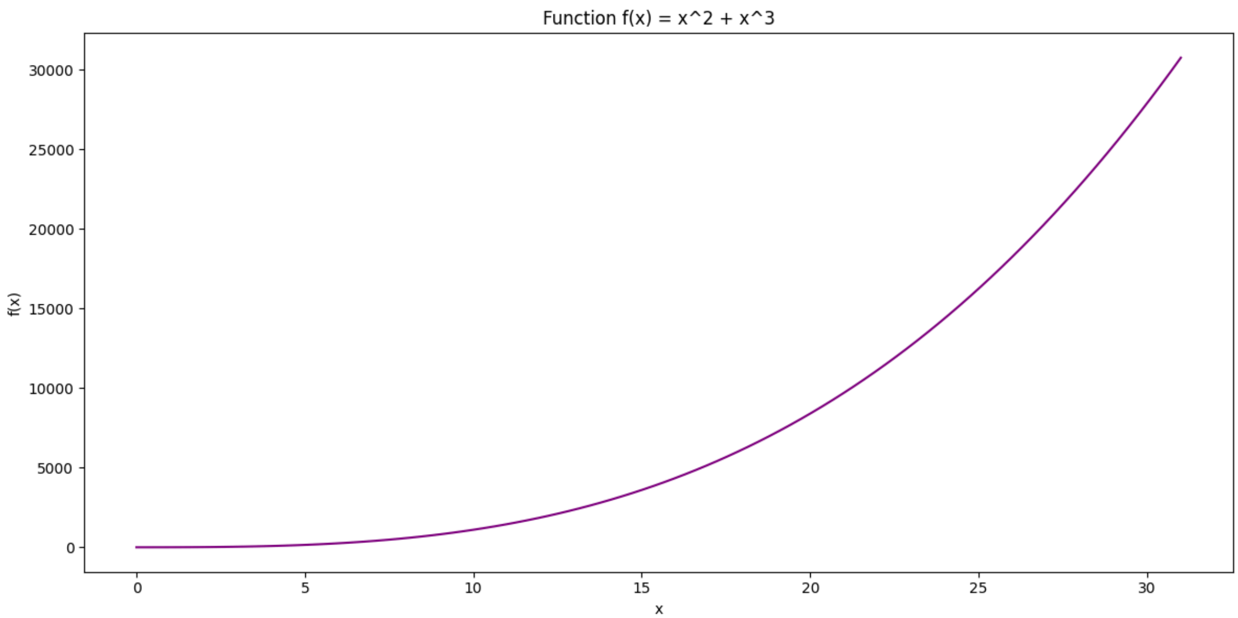
```python
    best_solution = max(world, key=lambda ind: fitness_function(binary_to_decimal(ind)))
    print(f"Best solution found: x = {binary_to_decimal(best_solution)}")
    print(f"Fitness of best solution: {fitness_function(binary_to_decimal(best_solution))}")

    axs[0].scatter(range(len(final_population)), final_population, color='blue')
    axs[0].scatter([final_population.index(max(final_population))], [max(final_population)], color='red', s=100)
    axs[0].set_ylabel('Individual Value')
    axs[0].set_title(f'Final Generation ({generations}) Population')

    # Plot the best fitness over generations
    generations_list = range(1, len(best_performers) + 1)
    best_fitness_values = [fit for _, fit in best_performers]

    axs[1].plot(generations_list, best_fitness_values, color='green')
    axs[1].set_xlabel('Generation')
    axs[1].set_ylabel('Best Fitness')
    axs[1].set_title('Best Fitness Over Generations')

    x_range = np.linspace(0, 31, 100)
    y_values = [fitness_function(x) for x in x_range]

    axs[2].plot(x_range, y_values, color='purple')
    axs[2].set_xlabel('x')
    axs[2].set_ylabel('f(x)')
    axs[2].set_title('Function f(x) = x^2 + x^3')

    plt.tight_layout()
    plt.show()
```

```python
# Parameters for the genetic algorithm
population_size = 8
bits = 5
generations = 10

genetic_algorithm(population_size, bits, generations)
```

```
+------------+-------------------------------+----------------+---------+
| Generation |           Population          | Best Individual | Fitness |
+------------+-------------------------------+----------------+---------+
|     1      |   6, 29, 5, 25, 2, 12, 10, 8   |       29       |  25230  |
|     2      | 13, 13, 17, 31, 13, 31, 13, 25 |       31       |  30752  |
|     3      |  23, 15, 15, 29, 7, 13, 28, 3  |       29       |  25230  |
|     4      | 21, 20, 27, 22, 28, 12, 9, 23  |       28       |  22736  |
|     5      | 12, 30, 31, 5, 27, 20, 22, 30  |       31       |  30752  |
|     6      | 28, 31, 11, 28, 28, 19, 26, 31 |       31       |  30752  |
|     7      | 24, 27, 30, 24, 23, 30, 10, 29 |       30       |  27900  |
|     8      | 26, 26, 8, 28, 26, 22, 26, 26  |       28       |  22736  |
|     9      | 10, 24, 27, 18, 24, 29, 18, 30 |       30       |  27900  |
|     10     | 24, 12, 14, 22, 25, 28, 16, 19 |       28       |  22736  |
+------------+-------------------------------+----------------+---------+
Best solution found: x = 31
Fitness of best solution: 30752
```






Function f(x) = x^2 + x^3
f(x)
x
30000
25000
20000
15000
10000
5000
0
0
5
10
15
20
25
30

Extension Code:

```python
def genetic_algorithm():
    func = input("Enter function (use x as variable): ")
    range_min = int(input("Minimum value: "))
    range_max = int(input("Maximum value: "))
    binary_size = int(input("Binary string length: "))
    maximize = input("Maximize? (y/n): ").lower() == 'y'
    generations = int(input("Number of generations: "))
    crossover_type = input("Crossover type (single/two): ")
    mutation_bits = int(input("Mutation bits: "))

    def fitness_function(x):
        return eval(func)

    def binary_to_decimal(binary):
        return int(binary, 2)

    def decimal_to_binary(decimal, bits):
        return format(decimal, f'0{bits}b')

    def roulette_wheel_selection(population, fitnesses):
        total_fitness = sum(fitnesses)
        pick = random.uniform(0, total_fitness)
        current = 0
        for i, fitness in enumerate(fitnesses):
            current += fitness
            if current > pick:
                return population[i]

    def crossover(parent1, parent2):
        if crossover_type == 'single':
            point = random.randint(1, len(parent1) - 1)
            child1 = parent1[:point] + parent2[point:]
            child2 = parent2[:point] + parent1[point:]
        else:
            point1, point2 = sorted(random.sample(range(1, len(parent1)), 2))
            child1 = parent1[:point1] + parent2[point1:point2] + parent1[point2:]
            child2 = parent2[:point1] + parent1[point1:point2] + parent2[point2:]
        return child1, child2

    def mutate(individual):
        for _ in range(mutation_bits):
           index_to_mutate = random.randint(0, len(individual) - 1)
           new_individual = list(individual)
           new_individual[index_to_mutate] = str(1 - int(new_individual[index_to_mutate]))
        return ''.join(new_individual)
```

```python
    population = [''.join(random.choice('01') for _ in range(binary_size)) for _ in range(8)]

    all_populations = []
    for generation in range(generations):

        fitnesses = [fitness_function(binary_to_decimal(ind)) for ind in population]
        if not maximize:
            fitnesses = [-f for f in fitnesses]

        best_ind = max(zip(population, fitnesses), key=lambda x: x[1])
        print(f"Generation {generation + 1}: Best solution = {binary_to_decimal(best_ind[0])}, Fitness = {abs(best_ind[1])}")
        all_populations.append(population[:])

        new_population = []
        for _ in range(4):
            parent1 = roulette_wheel_selection(population, fitnesses)
            parent2 = roulette_wheel_selection(population, fitnesses)
            child1, child2 = crossover(parent1, parent2)
            new_population.extend([mutate(child1), mutate(child2)])

        population = new_population

    fitnesses = [fitness_function(binary_to_decimal(ind)) for pop_i in all_populations for ind in pop_i]
    world = [i for pop_i in all_populations for i in pop_i]
    if not maximize:
        fitnesses = [-f for f in fitnesses]
    best_ind = max(zip(world, fitnesses), key=lambda x: x[1])
    print(f"\nBest solution found: x = {binary_to_decimal(best_ind[0])}")
    print(f"Fitness of best solution: {abs(best_ind[1])}")
```

```python
genetic_algorithm()
```

```python
genetic_algorithm()
```

```
Enter function (use x as variable): x
Minimum value: 0
Maximum value: 31
Binary string length: 5
Maximize? (y/n): y
Number of generations: 10
Crossover type (single/two): single
Mutation bits: 1
Generation 1: Best solution = 31, Fitness = 31
Generation 2: Best solution = 30, Fitness = 30
Generation 3: Best solution = 31, Fitness = 31
Generation 4: Best solution = 29, Fitness = 29
Generation 5: Best solution = 31, Fitness = 31
Generation 6: Best solution = 30, Fitness = 30
Generation 7: Best solution = 31, Fitness = 31
Generation 8: Best solution = 31, Fitness = 31
Generation 9: Best solution = 25, Fitness = 25
Generation 10: Best solution = 31, Fitness = 31

Best solution found: x = 31
Fitness of best solution: 31
```

Question 2

```python
import random
import time

SIMILAR_MAP = {
    'A': ['A', '4', 'Λ', 'Δ'],
    'B': ['B', 'ß', 'β', '8'],
    'C': ['C', '(', 'ᑕ', 'c'],
    'D': ['D', 'Đ', 'Ɖ'],
    'E': ['E', '3', '€', 'ε'],
    'F': ['F', 'Ƒ'],
    'G': ['G', '6', 'ɢ'],
    'H': ['H', 'ʰ', 'Ħ'],
    'I': ['I', '1', 'ɪ', '!'],
    'J': ['J', 'ʝ'],
    'K': ['K', 'Ķ', 'ӄ'],
    'L': ['L', '1', 'Ⱡ', 'Ł'],
    'M': ['M', 'ʍ', 'ɱ'],
    'N': ['N', 'ɴ', 'η'],
    'O': ['O', '0', 'Ø', 'Φ'],
    'P': ['P', 'Ᵽ', 'ρ'],
    'Q': ['Q', 'Ɋ', 'φ'],
    'R': ['R', 'ʀ', 'Я'],
    'S': ['S', '5', '$', '§'],
    'T': ['T', '7', 'ɟ'],
    'U': ['U', 'µ', 'ʋ'],
    'V': ['V', 'ʋ', 'ᴠ'],
    'W': ['W', 'ш', 'Ш'],
    'X': ['X', '×', '×'],
    'Y': ['Y', 'ʏ', '¥'],
    'Z': ['Z', '2', 'Ƶ'],
}

def get_variants(char):
    if char.upper() in SIMILAR_MAP:
        variants = SIMILAR_MAP[char.upper()]
        if char.islower():
            variants = [v.lower() for v in variants]
        variants[0] = char
        return variants
    else:
        return [char]
```

```python
def initialize_population(original_text, pop_size):
    population = []
    variant_sets = [get_variants(c) for c in original_text]

    for _ in range(pop_size):
        chromosome = []
        for variants in variant_sets:
            rand_index = random.randint(0, len(variants) - 1)
            chromosome.append(rand_index)
        population.append(chromosome)
    return population

def compute_fitness(chromosome, original_text):
    replaced_count = sum(1 for gene in chromosome if gene != 0)
    return replaced_count

def roulette_wheel_selection(population, fitnesses):
    total_fitness = sum(fitnesses)
    if total_fitness == 0:
        return random.choice(population)

    pick = random.uniform(0, total_fitness)
    running_sum = 0.0
    for ind, fit in zip(population, fitnesses):
        running_sum += fit
        if running_sum >= pick:
            return ind
    return population[-1]

def single_point_crossover(parent1, parent2):
    if len(parent1) <= 1:
        return parent1[:], parent2[:]

    point = random.randint(1, len(parent1) - 1)
    child1 = parent1[:point] + parent2[point:]
    child2 = parent2[:point] + parent1[point:]
    return child1, child2

def mutate(chromosome, original_text, mutation_rate):
    for i in range(len(chromosome)):
        if random.random() < mutation_rate:
            variants = get_variants(original_text[i])
            chromosome[i] = random.randint(0, len(variants) - 1)
    return chromosome
```

```python
def obfuscate_text_ga(original_text,pop_size=10,generations=10,crossover_rate=0.7,
                      mutation_rate=0.05):
    # Initialize population
    population = initialize_population(original_text, pop_size)

    best_individual = None
    best_fitness = float('-inf')

    for gen in range(generations):
        # Evaluate fitness
        fitnesses = [compute_fitness(ind, original_text) for ind in population]

        # Track best
        for ind, fit in zip(population, fitnesses):
            if fit > best_fitness:
                best_fitness = fit
                best_individual = ind[:]

        print(f"Generation {gen} | Best fitness so far: {best_fitness}")

        # Create new population
        new_population = []
        while len(new_population) < pop_size:

            parent1 = roulette_wheel_selection(population, fitnesses)
            parent2 = roulette_wheel_selection(population, fitnesses)

            if random.random() < crossover_rate:
                child1, child2 = single_point_crossover(parent1, parent2)
            else:
                child1, child2 = parent1[:], parent2[:]

            child1 = mutate(child1, original_text, mutation_rate)
            child2 = mutate(child2, original_text, mutation_rate)

            new_population.append(child1)
            if len(new_population) < pop_size:
                new_population.append(child2)

        population = new_population

    fitnesses = [compute_fitness(ind, original_text) for ind in population]
    for ind, fit in zip(population, fitnesses):
        if fit > best_fitness:
            best_fitness = fit
            best_individual = ind[:]

    return decode_chromosome(best_individual, original_text)
```

```python
def decode_chromosome(chromosome, original_text):

    result_chars = []
    for i, gene in enumerate(chromosome):
        variants = get_variants(original_text[i])
        result_chars.append(variants[gene])
    return "".join(result_chars)
```

```python
[ ] random.seed(time.time())

    text_to_obfuscate = "HELLO GA"

    POP_SIZE = 10
    GENERATIONS = 10
    CROSSOVER_RATE = 0.7
    MUTATION_RATE = 0.1

    best_obfuscation = obfuscate_text_ga(text_to_obfuscate,
                                          pop_size=POP_SIZE,
                                          generations=GENERATIONS,
                                          crossover_rate=CROSSOVER_RATE,
                                          mutation_rate=MUTATION_RATE)

    print("\nOriginal text:    ", text_to_obfuscate)
    print("Best obfuscation:", best_obfuscation)
```

```
Generation 0 | Best fitness so far: 7
Generation 1 | Best fitness so far: 7
Generation 2 | Best fitness so far: 7
Generation 3 | Best fitness so far: 7
Generation 4 | Best fitness so far: 7
Generation 5 | Best fitness so far: 7
Generation 6 | Best fitness so far: 7
Generation 7 | Best fitness so far: 7
Generation 8 | Best fitness so far: 7
Generation 9 | Best fitness so far: 7

Original text:    HELLO GA
Best obfuscation: ʰεŁŁΦ GΔ
```

```python
[ ] print(best_obfuscation)
```

```
ʰεŁŁΦ GΔ
```

Code

https://github.com/arnavjain2710/Computational-Intelligence-Lab-CS354N/tree/main/LAB%208