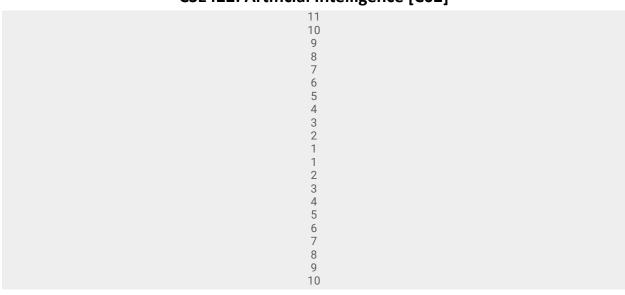
CSE422: Artificial Intelligence [C02]



Lab Assignment 2

Part 1 [7 points]

Brac University plans to optimize its course scheduling for the upcoming academic semester. The university offers a variety of courses across different disciplines, each with specific scheduling requirements and constraints. The university needs to find a way to schedule its courses into a limited number of timeslots per day while ensuring that each course is scheduled **exactly once** and **no timeslot has more than one course planned at the same time**.

You are tasked with optimizing the schedule for courses offered at Brac University using the popular *Genetic Algorithm*.

Chromosome Representation (Encoding):

Each chromosome will be a binary string that encodes the schedule of courses across different time slots. Here's how we will represent a chromosome:

- **Length of the Chromosome**: The length of a chromosome will be equal to NxT ($product\ of\ N\ and\ T$), where N is the number of courses and T is the number of timeslots.
- **Structure of the Chromosome**: Each chromosome will be divided into *T* segments, where each segment will be of length *N*. Each segment will represent a timeslot, and each bit within a segment will represent whether a particular course is scheduled in that time slot.

Fitness Calculation:

- The fitness function will evaluate each solution based on the number of course overlaps and consistency of a course.
- The fitness function evaluates the quality of a schedule based on minimizing course overlaps and making sure a course is scheduled exactly once:

$$Fitness(S) = -[Penalty_{overlap}(S) + Penalty_{consistency}(S)]$$

Here:

- S: Binary String representing schedule
- $Penalty_{overlap}(S): \Sigma$ (Number of courses overlap in schedule S in the same timeslot).
- $Penalty_{consistency}(S)$: $\sum (Number of times courses appeared more than once in schedule S)$

Overlap Penalty:

- For each timeslot, count the number of courses scheduled.
- If more than one course is scheduled in the same timeslot, add a penalty *equal to the number of extra courses*.

Consistency Penalty:

- For each course, check if it is scheduled exactly once.
- If a course is **not scheduled exactly once, add a penalty**.

Task Breakdown:

- 1. Model the course schedule array in a way suitable for the problem.
- 2. Implement the fitness function that penalizes overlapping courses and ensures each course is scheduled exactly once.
- 3. Choose two parents based on *random selection* for crossover. **Show it as a separate function.**
- 4. Perform *single-point crossover* to create **2 offspring** from each pair of selected parents. **Show it as a separate function.**
- 5. Write the **mutation function** to introduce random changes.
- 6. Create a population of randomly generated course schedules.
- 7. Run genetic algorithms on the population until the highest fitness has been reached and/or the number of maximum iterations has been reached.

<u>Input</u>

The first line has a number N denoting the number of courses and a number T denoting the number of timeslots for a particular day. It will be followed by N lines each having a string that represents a course code that needs to be scheduled where,

[In this problem statement, we are considering that 1 course will have only 1 section]

Output

The output should be a binary string denoting 1 for scheduled courses and 0 for not scheduled courses in each timeslot. A string consisting of all zeros won't be accepted. You also need to print the fitness value of the output string.

Example:

Sample Input

33

CSE110

MAT110

PHY112

Sample Output

110110010

-6

Explanation

<u>Chromosome Representation</u>

- N×T=3×3=9
- A chromosome of length 9 represents the schedule of courses across 3 timeslots.
- Each timeslot is represented by a segment of length N=3.

Fitness Calculation

Let's take the output chromosome: 110110010

- Timeslot 1: 110
 - CSE110: 1 (scheduled)
 - MAT110: 1 (scheduled)
 - PHY112: 0 (not scheduled)
- Timeslot 2: 110
 - CSE110: 1 (scheduled)
 - MAT110: 1 (scheduled)
 - PHY112: 0 (not scheduled)
- Timeslot 3: 010
 - CSE110: 0 (not scheduled)
 - MAT110: 1 (scheduled)
 - PHY112: 0 (not scheduled)

Interpretation of the Chromosome

- 1. Timeslot 1: CSE110, MAT110 are scheduled.
- 2. Timeslot 2: CSE110, MAT110 are scheduled.
- 3. Timeslot 3: MAT110 is scheduled.

Penalty Calculation

Overlap Penalty:

- Timeslot 1: 2 courses scheduled, penalty = 2-1=1
- Timeslot 2: 2 courses scheduled, penalty = 2−1=1
- Timeslot 3: 1 course scheduled, penalty = 1-1=0
- Total overlap penalty = 1+1+0=2

Consistency Penalty:

- CSE110: scheduled 2 times, penalty = |2-1|=1
- MAT110: scheduled 3 times, penalty = |3-1|=2
- PHY112: scheduled 0 times, penalty = |0-1|=1
- Total consistency penalty = 1+2+1=4

Total penalty = overlap penalty + consistency penalty = 2+4=6

Summary

• Chromosome 110110010 results in a penalty of 6. So Fitness will be -6

Part 2 [3 points]

For this part randomly select two parents from the initial population of your problem statement. Then perform a *two-point crossover* to generate two children. The two points have to be chosen *randomly*, but it has to be made sure the second point always comes after the first point.

Here is an example of how *two-point crossover* works:

Parent 1: 000111000 Parent 2: 111000111

For two points crossover, we have randomly chosen the following points:

1st point:- between index 2 and index 3 2nd point:- between index 6 and index 7

So the two resultant offsprings are, 000000100 & 111111011

[In this part, you just need to iterate once and print the resultant offspring after doing the crossover]

Part 3 [0 points]

In part 1, you selected parents through random sampling from the initial population. Another advanced technique for parent selection is known as *Tournament Selection*. Please take some time to research and understand this method at home. Might be helpful in the near future!