Evolutionary Computing (2023)

Assignment (2):

Road alignment problem

Shiraz University

<u>Due date: 24/November (2023)</u>

1 Introduction

The problem of road alignment involves determining the optimal layout and orientation of a road network to efficiently connect locations while considering factors such as terrain, environmental impact, and cost. It is a challenging optimization problem that requires balancing various conflicting criteria, such as minimizing construction costs and environmental disruption. Road alignment is critical for transportation infrastructure planning, and finding the optimal alignment involves complex trade-offs to create a safe, sustainable, and cost-effective road network.

In this assignment you'll have to implement a genetic solution for a simplified road alignment problem.

2 Problem statement

In this problem you are given a simplified surface roughness map like the one shown in Figure 1. Surface roughness, also terrain or topographic roughness in geomorphology, is directly connected to the unevenness of surface elevation values. Darker colors on the map indicate higher levels of roughness.

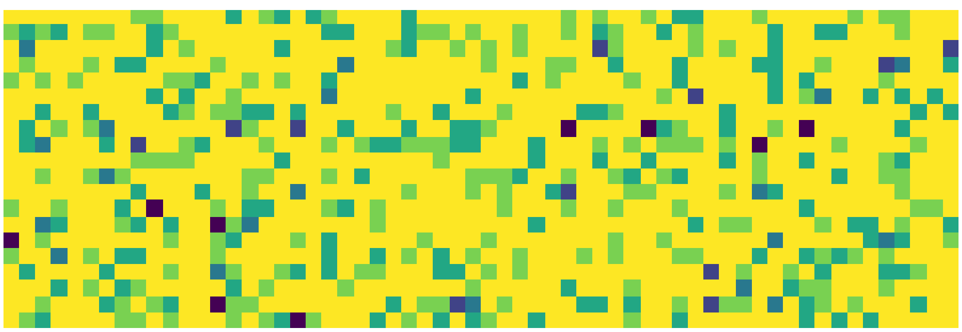

Figure 1: a simplified roughness map

Using genetic algorithm, you should find a solution to find an optimal path with minimum cost from the right side to the left side of this map. Figure 2 shows a solution found a by genetic algorithm.

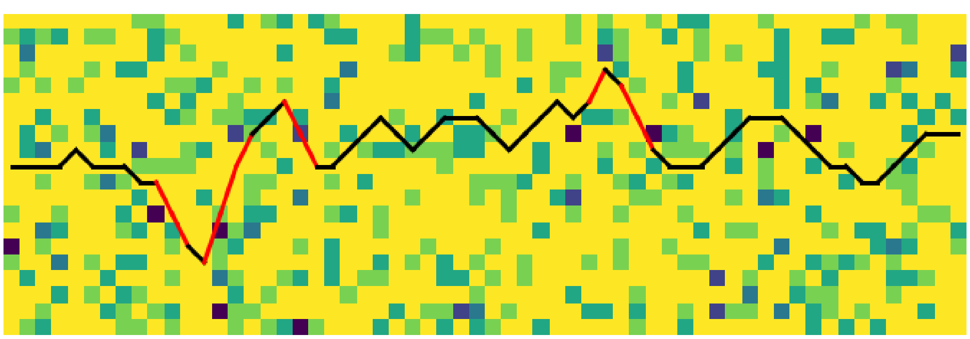

Figure 2: a road solution found by genetic algorithm

2.1 Fitness evaluation

A road is defined by coordinates (x, y), where a road can be directly built between two coordinates if they are in square adjacency; otherwise, a bridge or tunnel is required to be built., In Figure 2 roads are depicted in black, while tunnels or bridges are represented in red color.

Each coordinate in grid (surface roughness map) has a value (= level of roughness) which indicates roughness, we use this as a cost (= level of roughness) to build a road in that coordinate if the next coordinates is in square adjacency. But if two coordinates are not in square adjacency, you must calculate the **squared** Euclidean distance between them and use this value as the cost to build a tunnel/bridge. The final fitness function is the sum of total all costs associated with constructing a road from any y-axis coordinate on the left side of the map to any y-axis coordinate on the right side.

3 Tasks

1. Find a suitable representation for each individual (chromosome) in the context of this problem.
2. Identify appropriate mutation, crossover, survival and parent selection operation for this problem. You should also find the optimal rates for each of these operations.
3. Implement 3 different setups to solve this problem. A different setup means using different mutation or crossover or representation to solve this problem. What you change is up to you. You also have the flexibility to design new mutation or crossover.
4. You should run your setups on provided grid (map.npy) as your simulated map. And create a new one of size (30, 75) featuring 7 distinct levels of surface roughness. The probability of each roughness level is provided in Table 1.

Table 1: probability of having roughness levels in road

Level	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Probability	0.7	0.15	0.09	0.02	0.02	0.01	0.01

5. For your results, visualize the final answer. Run your setup 7 times, and plot the best fitness value and average fitness value per generation for each run, along with their overall averages.

Notes:

- Allowed programming languages: Python, MATLAB
- Any sign of cheating would result in a zero grade for this assignment.
- You should upload your submissions at:
  https://quera.org/course/add_to_course/course/14736/
  All of the files should be in a ZIP file named in this format: “Lastname-SudentNumber.zip”
  Ex: “Zamani-4023040.zip”
- Your reports should be in a PDF file including: key points of your implementation, explanation of your chosen approach, reports of your final results and answers of assignment questions (if given).
