EAI 320

Practical Assignment 3

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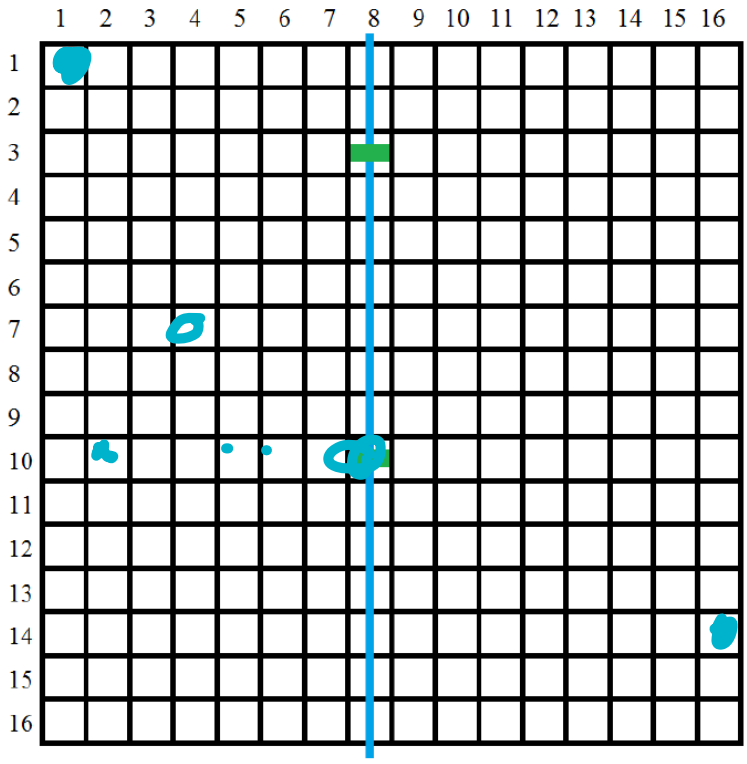
1 Scenario

A new hospital is to be built within the city where you reside. The city council has asked you to help determine the optimal location of the new hospital. The objective is to place the hospital at a location such that the response time to any medical emergency is minimised. A medical emergency could occur anywhere in the city. The city is divided up into a 16 × 16 grid as illustrated below.



There is a river that flows through the city as indicated by the blue line. There are two bridges over the river at locations $[3, 8]$ and $[10, 8]$. These are illustrated by the green markers.

You have been provided with the results of a survey. The results include number of medical emergencies in each block over a period of a year. This data is provided in the following Numpy array:

```
w = np.array(
[[2, 1, 7, 9, 1, 9, 3, 12, 12, 2, 13, 12, 11, 10, 8, 12;
1, 1, 2, 4, 8, 6, 2, 12, 5, 4, 17, 16, 8, 6, 10, 8;
4, 1, 7, 12, 6, 10, 1, 2, 2, 2, 7, 4, 15, 1, 5, 10;
7, 12, 7, 2, 6, 6, 13, 9, 12, 4, 23, 14, 15, 12, 1, 8;
10, 11, 8, 7, 8, 7, 8, 7, 16, 15, 2, 15, 3, 14, 6, 10;
8, 1, 4, 1, 7, 6, 2, 9, 3, 13, 10, 15, 6, 3, 8, 7;
5, 8, 5, 5, 10, 6, 8, 10, 2, 8, 12, 10, 1, 8, 8, 10;
6, 12, 5, 5, 12, 2, 7, 2, 2, 11, 3, 5, 6, 10, 10, 7;
11, 4, 8, 12, 10, 4, 5, 12, 1, 4, 6, 1, 6, 2, 9, 12;
8, 1, 7, 4, 6, 11, 8, 7, 10, 6, 5, 2, 5, 1, 12, 2;
4, 5, 8, 6, 1, 11, 5, 12, 6, 5, 7, 4, 12, 6, 8, 11;
7, 10, 2, 6, 12, 6, 4, 8, 7, 8, 11, 11, 6, 2, 11, 2;
11, 8, 8, 11, 5, 8, 4, 2, 8, 12, 5, 12, 10, 12, 2, 10;
2, 6, 10, 1, 10, 10, 5, 1, 11, 4, 8, 6, 8, 12, 11, 6;
11, 12, 5, 10, 11, 2, 1, 1, 2, 10, 12, 12, 11, 12, 12, 8;
2, 1, 5, 7, 11, 7, 5, 2, 4, 7, 11, 1, 4, 12, 4, 5]])
```

Furthermore, it is found that the average response time in minutes is $2.4 + 4.5d$, where d is the Euclidean distance from the hospital to the location of the emergency. With this information, a suitable cost function for a proposed location is given by

$$C_{loc} = \sum_{i}^{16} \sum_{j}^{16} w_{i,j} \cdot T_R \tag{1.1}$$

where $w_{i,j}$ is the number of medical emergencies in block i, j, and T_R is the average response time.

The cost function represents the *total* cost associated with a specific location for the hospital. Each possible hospital location will have a different cost.

Question 1

Create a function in Python to compute the distance between a block in the city and the hospital, taking into account the river and bridges. To cross a bridge, you will calculate the Euclidean distance from a block to the bridge, and then from the bridge to the hospital.

Create a function in Python that implements the cost function presented in equation 1.1. Plot the three dimensional cost surface for equation 1.1 over the grid space. Note where the global minimum is. To do this, you will iterate through the entire search space, placing the hospital in each possible location, and then evaluating the cost.

Question 2

Implement a genetic algorithm (GA) to search for the solution of the optimal hospital location. Your population will exist out of a set of different possible locations for the

hospital. It is up to you to decide the population size, and the mutation rate of the algorithm, as well as how to repopulate the population after elimination of the weak genes, and crossover has been done.

Please ensure that you indicate the following in your report:

1. How the chromosomes are represented.
2. The size of the population used.
3. How the selection step in the GA is performed.
4. How the crossover step in the GA is performed.
5. How the mutation step in the GA is performed.
6. The number of algorithm iterations required to find a solution.
7. The optimal location for the hospital.

Include any possible changes you would have/could have made if you chose to approach the problem differently.

Report

You have to write a short technical report for this assignment. Your report must be written in LaTeX. In the report you will give your results as well as provide a discussion on the results. Make sure to follow the guidelines as set out in the separate questions to form a complete report.

Reports will only be handed in as digital copies, but a hard copy plagiarism statement needs to be handed in at the following week's practical session (on the final day of the practical submission).

Deliverables

- Write a technical report on your finding for this assignment.
- Include your code in the digital submission as an appendix.

Instructions

- All reports must be in PDF format and be named report.pdf.
- Place the software in a folder called SOFTWARE and the report in a folder called REPORT.
- Add the folders to a zip-archive and name it `EAI320_prac3_studnr.zip`.

- All reports and simulation software must be e-mailed to **up.eai320@gmail.com** no later than 16:00 on 01 March 2018. No late submissions will be accepted.
- Use the following format for the subject header for the email: EAI 320 Prac 3 - studnr.
- Upload your report *without* the plagiarism statement to TurnItIn before 16:00, 01 March 2018.
- Bring your plagiarism statement to the practical session on Thursday, 01 March 2018, where they will be collected.
- No hard-copy of the report is required.

Additional Instructions

- Do not copy! The copier and the copyee (of software and/or documentation) will receive zero for both the software and the documentation.
- For any questions or appointments email me at **up.eai320@gmail.com**.
- Make sure that you discuss the results that are obtained. This is a large part of writing a technical report.

Marking

Your report will be marked as follow:

- 60% will be awarded for the full implementation of the practical and the subsequent results in the report. For partially completed practicals, marks will be awarded as seen fit by the marker. **Commented code allows for easier marking!**
- 40% will be awarded for the overall report. This includes everything from the report structure, grammar and discussion of results. The discussion will be the bulk of the marks awarded.