Artificial Intelligence

2022/2023 – 2nd Semester

PROJECT – PICKING, COLLECTING PRODUCTS IN WAREHOUSES

1. Problem description

The goal of the project is to develop an application that allows to optimize the collection of products from the shelves of a warehouse, o process known as picking. The goal of the system consists in distributing the picks (products) by the agents in charge of the collecting them, as well as defining the order by which each agent should collect the products that have been assigned to it in order to minimize the delivery time of the last product being delivered in the delivery point. It is also intended also to minimize the total travelled distance by the agents and the number of collisions between them.

The application should allow the user to first choose the problem to be solved. Each problem is saved in a text file. The figure bellow shows an example of one of these files.

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19, 21
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1
1 0 2 1 0 1 1 0 2 1 0 1 1 0 1 1 0 1 1 0 1
1 0 1 1 0 1 1 0 1 1 0 2 1 4 1 2 0 1 1 0 1
1 0 2 1 0 1 2 0 1 1 0 1 1 0 1 1 0 1 1 0 1
1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1
1 0 1 1 0 1 1 0 1 1 0 2 1 0 1 1 0 1 1 0 1
1 4 1 1 0 1 2 0 1 2 0 1 1 0 1 1 0 1 2 0 1
1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1
1 0 1 1 0 1 1 0 1 1 0 1 1 0 2 1 0 1 1 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1
1 0 1 1 0 1 1 0 1 2 0 1 1 0 1 1 0 1 1 0 1
1 0 1 1 0 1 1 0 1 1 4 2 2 0 2 1 0 2 1 0 2
1 0 1 2 0 1 1 0 1 1 0 1 1 0 1 2 0 1 1 0 1
1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0 1
0 0 0 0 0 0 0 0 0 0 3 0 0 0 0 0 0 0 0 0 0
```

The first line indicates the length and the width of the warehouse; This line is followed by a matrix that defines the structure of the warehouse, the positions of the products, the position of the delivery spot and the initial. The values have the following meaning: 0 corresponds to an empty space where the agents can move into; 1 represents to an empty shelf; 2 represents a shelf with a product to be collected; 3 represents the delivery point; 4 represents an agent.

Once the products have been distributed by agents, each agent must go to the first product to be picked up, then to the second and so on until the last one. After collecting the last product, the agent must go to the delivery point. All routes performed by the agent must be optimal routes. At each step of a route, the agent can move to one of the adjacent cells North, South, East, West, as long as the cell exists or is not occupied by a shelf. It is considered that the agent collects a product when it is the turn of that product to be collected and the agent passes in the cell adjacent to the cell where the product is located.

Two agents are considered to collide if they try to occupy the same cell at the same time. Note that in this project it is not intended that the application tries to find an alternative path when there is a collision between two agents. It is intended “only” that collisions are detected and that solutions are penalized depending on the number of collisions that occur. The objective is that the evolutionary process favours solutions without collisions in the attempt that the best solution found does not imply the occurrence of collisions.

2. Trabalho a realizar

The main goal of this project is the development of an application that uses genetic algorithms and the A* search algorithm to solve problems like the one described above. Each genetic algorithm solution must represent a possible distribution of products by the agents, as well as the order in which the agent must collect the products assigned to it. The A* algorithm must be used to calculate the path between the initial position of each agent and the first product to be picked up, between the positions of successive products to be picked up and between the last product and the delivery point.

The application to be developed should allow the user to view the simulation of the best solution found.

The project provided with this project sheet is based on the projects developed in the classes and already contains some aspects implemented, such as reading the files that contain the problems (datasets) and the application GUI, and others partially implemented, such as the representation of the problem , the state, the A* algorithm and the genetic algorithm.

The project consists of carrying out the following tasks:

1. Development of the class that allows representing a state of the problem (WarehouseState class);

2. Development of the class that represents the problem, to be used by the A* algorithm (WarehouseProblemSearch class);
3. Development of a heuristic for the problem, to be used with the A* algorithm (HeuristicWarehouse class);
4. Development of a class that represents the problem, to be used by the genetic algorithm (WarehouseProblemGA class);
5. Development of a class that allows representing an individual of the genetic algorithm (WarehouseIndividual class);
6. Development of two recombination operators suited to the problem and the representation used for the individuals (classes Recombination2 and Recombination3);
   Note: a recombination operator is already available (class RecombinationPartialMapped).
7. Development of two mutation operators suited to the problem and representation used for individuals (Mutation2 and Mutation3 classes);
   Note: a mutation operator is already available (class MutationInsert).
8. Carrying out test to study the following aspects:
   - The effect of varying population size and number of generations;
   - Relative performance of different genetic operators;
   - The effect of varying the probabilities of the genetic operators used;
   - The effect of varying tournament size.

The project report should include:

- The state description;
- The heuristic description;
- The description of the representation of individuals used in the genetic algorithm;
- The description of the evaluation function (fitness function) used;
- The description of the initial population creation method;
- The description of the developed genetic operators;
- The presentation and discussion of the results obtained in the tests carried out;
- Other aspects considered relevant for a good understanding and evaluation of the work carried out.

Some of the most important factors in evaluating the report are:

- Clarity in the description of application components;
- The way test results are compiled and the clarity with which they are presented (the use of, but not limited to, tables and/or graphs can help);
- The statistical significance of the results (which depends on the number of runs performed);
- Analysis and discussion of results.

3. Assessment

20% - Tasks 1 e 2
5% - Task 3
30% - Tasks 4 e 5
10% - Tasks 6 e 7
25% - Task 8 and Report (all experiments files must be delivered)
10% - Extras

Suggested extras:

- Penalize collisions by how long it would take to avoid them, not by their number. It can be considered, for example, that to avoid a collision, one of the agents has to wait next to an intersection for the other agent to pass;
- Implementation of other meta-heuristics;
- Use a clustering algorithm to assign picks to agents and use the genetic algorithm only to define the order in which agents pick products.

4. Deadlines, dates, rules and instructions

1. Project delivery deadline: June **27th 2023**.
2. Oral exam date: **July 3rd 2023**.
3. The project should be developed in groups of 2 students. Groups with more than 2 students are not allowed. Students that want to develop the project alone should as kit through email to the theoretical classes teacher. Only in well fundamented situations this will be allowed.
4. The report should be written using the template provided in the course Moodle page.
5. The project should be delivered as a zip, rar or 7z file containing all the project elements, including the report. The file name should follow the format IA_Projeto_#1_#2.(zip/rar/7z), where #1 and #2 should be replaced by the student numbers of the group elements. The report should be in the pdf format and its name should follow the same format (with pdf extension).