Sharing cars to get to work: A Local Search approach

Artificial Intelligence

Carlos Bergillos, Roger Vilaseca, Adrià Cabeza

March 26, 2019

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Contents

1 Introduction

2 Description of the problem

The calculation of the distance between two points of the city will be made using the following function:

$$d(i,j) = \mid i_x - j_x \mid + \mid i_y - j_y \mid$$

where i_x and i_y are the coordinates x and y of the i point in the grid.

3 Representation of a problem state

4 Generating an initial solution

We have to make a representation fo the initial state, which at the same time is a solution state(MIRAR PQ EN AQUESTA MAYBE NO). We have thought in several possibilities:

5 Analysis of our operators

Once we have defined the structure we will work with, we have to decide which operators will modify our structure to move from one solution state to another. To do this, we must take into account several factors, so that when executing our algorith, the best possible solution is found in a failry reasonbale execution time.

Our operators indicate all the possible paths that can be taken given a solution state and with the objective that his becomes a solution state with some favorable characteristics. This is called a branch factor and it changes the way it is applied depending on which algorithm we are using. In the **Hill Climbing**, we generate all the successors and the heuristic decides if it is good enough to stay with him, in the **Simulated Annealing** we generate a successor status in a random way and the heuristic decides if it is good enough to stay with him.

It is really important to cover all the space of solutions with our operators because if we are not doing it, there may exist solutions that will be lost, which could prevent us from reaching an optimal solution. Also we be cautious about creating repeated solutions because our execution time would be affected.

At the beginning of everything we made a brainstorming session with all the operators we could think of, which we believed that could be useful and serve for something. We came up with...

6 Generating successor states

7 Representation of the Goal State

8 Heuristics Function

Once the representation of the solution state has been defined, the generation of the initial solution state and the operators on which we are going to work, we proceed into analysing the heuristic function.

In order to solve the two solution criteria stated in the statement of the wording (nse com dir-HO), we must perform two different heuristics, because the final result that must be returned has different priorities. The heuristic function that will solve the first criterion will be called Heuristic Function 1, and the one that resolves the second, Heuristic Function 2.

8.1 Heuristic Function 1

The criterion that this function must follow is quite simple, the objective is to minimize the sum of all the distances that each car has to do.

To follow this criterion, we...

8.2 Heuristic Function 2

For the second heuristic we have added another criterion in order to minimize also the number of cars that are driving.

9 Experiment 1

In this experiment we will decide which is the best operator of the different ones we have created using the *Heuristic Function 1.* In order to perform it, we have set the initial state generator for all the samples performed. The initial state generates a set of cars....

10 Experiment 2

We did this experiment in order to know which was the most suitable way to generate our initial solution. In this experiment we will use the ALGO operators we have discussed in the previous experiment which as we have shown are the best ones...

11 Experiment 3

A really important part about this project is to be able to determine the parameters thata are going to be used for the **Simulated Annealing algorithm**, so

that its results are the best possible, that is, the minimum number of cars driving the shortest amount of distance and everybody getting to their workplace in a reasonable execution time.

The algorithm works with 4 parameters:

1. **Steps**: The total number of iterations that the algorithm will perform.

2. **Number of iterations for each temperature change**: Whenever there is a temperature change, a constant number of iterations will be made in which the probability of choosing a worse successor is kept.
Each time this number of iterations is executed, the probability of choosing a worse state decreases.

3. **k**: parameter of the state acceptance function that affects the probability of choosing a worse succesor state. We know that the higher the value of the parameter, the longer it takes for the probability of staying with a worse successor state to decrease.

4. λ: Another parameter of the state acceptance function that affects the probability of choosing a worse successor. The higher the value of λ, the less it will take to decrease the probability of accepting a worse successor state.

12 Experiment 4

13 Experiment 5

14 Experiment 6

15 Experiment 7

16 Especial Experiment

At this point we have degined the best initial state, its operators, the heuristic algorithm and Hill Climbing and Simulated Annealing with the most appropiate parameters, so we can proceed to compare algorithms.

16.1 Hill Climbing

The experiment was made configuring our environment with 200 people, 100 drivers and seed 1234.

We would like to add that these results are a valid solution because no car drives more than 30 km and there is not any moment where a car carries more

than 2 people.

	Time
#1	6054 ms
#2	3258 ms
#3	2896 ms
#4	3561 ms
#5	4529 ms
#6	3788 ms
#7	3817 ms
#8	3503 ms
#9	3356 ms
#10	3589 ms

Table 1: Hill Climbing execution time

Mean Time	Nodes expanded	Cars	Distance
3835 ms	17	92	1834.3 km

Table 2: Results of our experiments with Hill Climbing

16.2   Simulated annealing

The experiment was made configuring our environment with 200 people, 100 drivers and seed 1234.

	Time	Cars	Distance	Solution
#1	2596 ms	62	1671.3 km	Yes
#2	1218 ms	64	1678.2 km	Yes
#3	1044 ms	67	1753.3 km	Yes
#4	1088 ms	65	1734.8 km	Yes
#5	1058 ms	63	1731.1 km	No
#6	1131 ms	65	1685.2 km	Yes
#7	1029 ms	65	1720.5 km	Yes
#8	1067 ms	66	1777.1 km	Yes
#9	1088 ms	64	1657.6 km	Yes
#10	2596 ms	65	1688.5 km	Yes

Table 3: Results of our experiments with Simulated Annealing

The mean time of our executions using Simulated Annealing is 1709.76 ms.