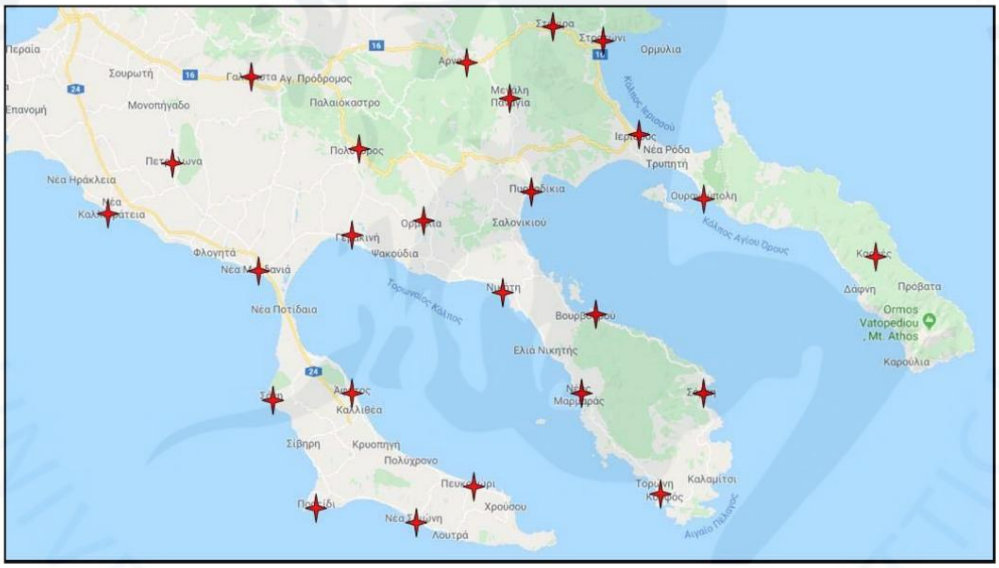
Department of Information & Computer Engineering

2022-2023 **5th Semester**

2nd paper for the Artificial Intelligence lab

Real-world application of genetic algorithm

The figure below shows 25 cities, towns and villages of the prefecture of Halkidiki. Let it be a mobile phone company, which wants to install a (single) station retransmission to some point in Halkidiki, so that it is cumulatively far from the smallest possible distance from all settlements (in a straight line, without taking into account relief of the area).



Mathematical formulation of the problem:

There are m fixed points A1, ..., ÿm in the plane (two-dimensional data). Find a point *X of the plane, such that the sum of the Euclidean distance of the point X from the constants points Ai to be minimal. This sum is given by the relation: D ÿ ÿ ÿÿ ÿ* $\left| \boldsymbol{X}\boldsymbol{A}\ \ddot{y}\ \boldsymbol{X}\ Am \right|$.

Table 1 shows the names of the 25 settlements, as well as their coordinates in

degrees (Halkidiki_25.txt file). The coordinates are given in decimal notation with 6 decimal places digits (GPS coordinates). For ease of distance calculations, let's assume that for the Greek space the Earth is spherical and the coordinates of the table are its points Cartesian plane (i.e. one degree difference in longitude corresponds to an equal distance with a difference of one degree of latitude).

Table 1

A/A	City/town/village	Geogr. width	Geogr. length
1	Negative	40.487386	23.596722
2	Aphytos	40.097854	23.437297
3	Vourvourou	40.187549	23.794397
4	Galatians	40.467818	23.276774
5	Gerakini	40.277924	23.444131
6	Priest	40.398178	23.878921
7	Curries	40.257182	24.245642
8	Deaf	39.970574	23.919930
9	Great Virgin Mary	40.444233	23.679360
10	New Kallikrateia	40.312016	23.063361
11	Nea Moudania	40.239382	23.283929
12	Nea Skioni	39.946193	23.531817
13	Neos Marmaras	40.095044	23.782260
14	Nikiti	40.217262	23.669855
15	Ormilia	40.293163	23.545274
16	Uranoupolis	40.325774	23.982267
17	Petrolona	40.369312	23.159980
18	Pefkohori	39.988786	23.614820
19	Polygyros	40.377528	23.441502
20	Poseidi	39.963767	23.380025
21	Minesweeper	40.334955	23.724034
22	Sani	40.091066	23.312003
23	Sarti	40.093456	23.978882
24	Drip	40.529959	23.751533
25	Barracks	40.513395	23.826336

The **state space** is the set of different positions (Cartesian coordinates) where point X can be found in 2D space. Because the strong positions are infinite, the state space is infinite **(no** physical constraints are imposed, e.g. coordinates of a sea point not to be accepted). The initial state can be any point on the level. The final state is that point for which the sum of its Euclidean distance from fixed points Ai is minimal.

In order to code the solutions, each point X can be coded as coordinate pair (x, y) in two-dimensional space, e.g. (39.365100, 23.068000). So every population chromosome will consist of two genes with real values (each gene will also corresponds to a coordinate).

The initial population will be generated by randomly generating a number (equal to size of the population) of chromosomes, with genes two real values corresponding to coordinates.

The evaluation objective function of the population members will be its sum Euclidean distance of the point X corresponding to each chromosome (population member) from the fixed points Ai. Thus the Ck chromosome yield of the population (which we can consider that it corresponds to the point Ck) will be given by the relation:

$$Fitness(Ck) = \sum_{i=1}^{m} |A_i - Ck|.$$

In the files simpleGA_new.c and simpleGA_new.h is the code that implements a simple genetic algorithm to solve the problem.

Work requirements (in steps) and instructions for documentation

Run the algorithm for the parameter values shown in Table 2 and fill it out. At the point with the minimum distance you will report its coordinates of the point. Consider 1000 generations as the maximum number of generations.

Calculate the average of all the solutions of the previous question and to locate where the station should be placed. Comment on the solutions given by Genetic Algorithm.

Comment on whether paradoxical solutions occurred (eg sea point or off point of the prefecture). In this case, justify whether these are due to incompleteness formulation of the problem and suggest constraints that should be placed on

genetic algorithm (approach it only theoretically, as you are not asked to implement it your suggestions).

Table 2

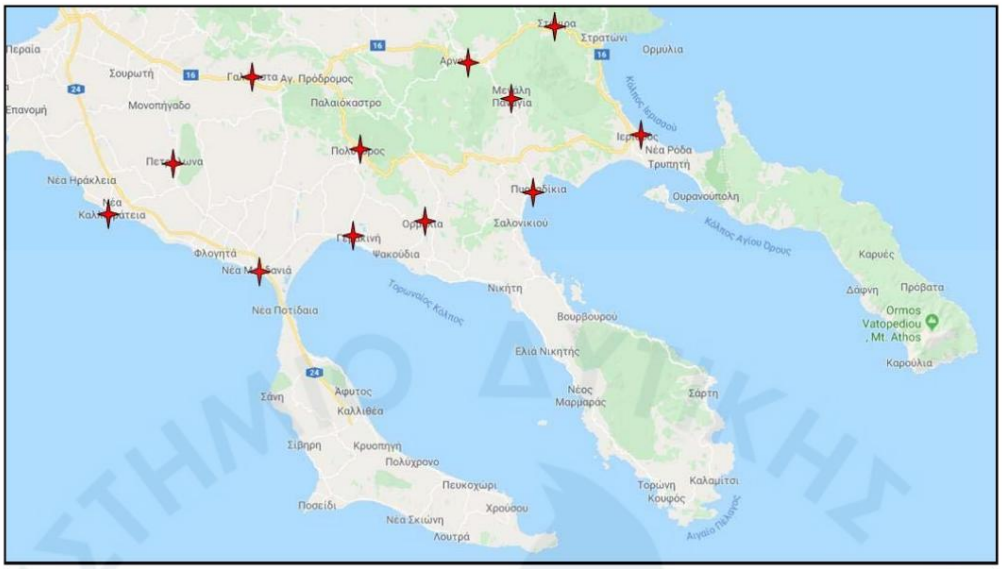
N/A	Size population	Chance intersection	Chance mutation	Point with minimum distance	Minimal distance
1	10	0.1	0.05		
2	10	0.5	0.1		
3	20	0.1	0.05		
4	20	0.5	0.1		
5	50	0.1	0.05		
6	50	0.5	0.1		
7	100	0.1	0.05		
8	100	0.5	0.1		
9	1000	0.4	0.1		

CAUTION: Because Genetics are stochastic algorithms and do not guarantee the same performance in each run, for each set of their parameters the algorithm should be run at least ten times and in the table note the average of the solutions and the distances.

Table 3

A/A	City/town/village	Geogr. Width	Geogr. length
1	Negative	40.487386	23.596722
2	Galatians	40.467818	23.276774
3	Gerakini	40.277924	23.444131
4	Priest	40.398178	23.878921
5	Great Virgin Mary	40.444233	23.679360
6	New Kallikrateia	40.312016	23.063361
7	Nea Moudania	40.239382	23.283929
8	Ormilia	40.293163	23.545274
9	Petrolona	40.369312	23.159980
10	Polygyros	40.377528	23.441502
11	Pyrgadicia	40.334955	23.724034
12	Drip	40.529959	23.751533

Re-fill Table 2 using the data from Table 3 (file Halkidiki_12.txt). There are variations in the solutions in relation to the results that obtained with the data in Table 1? If so, where do you attribute these differences?



In both cases of populations, the various solutions are proposed to be checked through Google Maps and, optionally, captured in an image to make it more understood the operation of the Genetic Algorithm.

The work is compulsory and individual. It will be delivered by 23/1/2023, 23:59 via e-learning platform eclass.uniwa.gr. Deliverable will be compressed file (zip or rar) with file name SurnameÿAM.zip (eg Tselentiÿ2434233.zip) which will include the documentation of work in pdf format.

The grade of this paper will contribute 20% to the final grade of the course, for them following the PADA program.

For those following a TEI program, the grade of this paper will contribute 50% to the final grade of the laboratory part of the course.

Explanation-Analysis of the job requirements: during the theoretical course

Support for the implementation of the work: every Monday 16:00-18:00, room K10.022