Heuristic optimization lab

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Guidelines

You have several optimization exercises to choose from, according to your interests and preferences.

- Work in groups of 2, one delivery per group (with the names of all participants)
- You have to solve and deliver **exactly** 2 exercises
- Note that each exercise has a maximum mark, depending on its difficulty level
- Deliver one Jupyter notebook per exercise
- Explain your approaches, analyze the results, explore different options, compare them. All of this will improve your mark
- Of course you are welcome to try all the exercises just for learning+fun!

Ex1 (3p). Local vs global

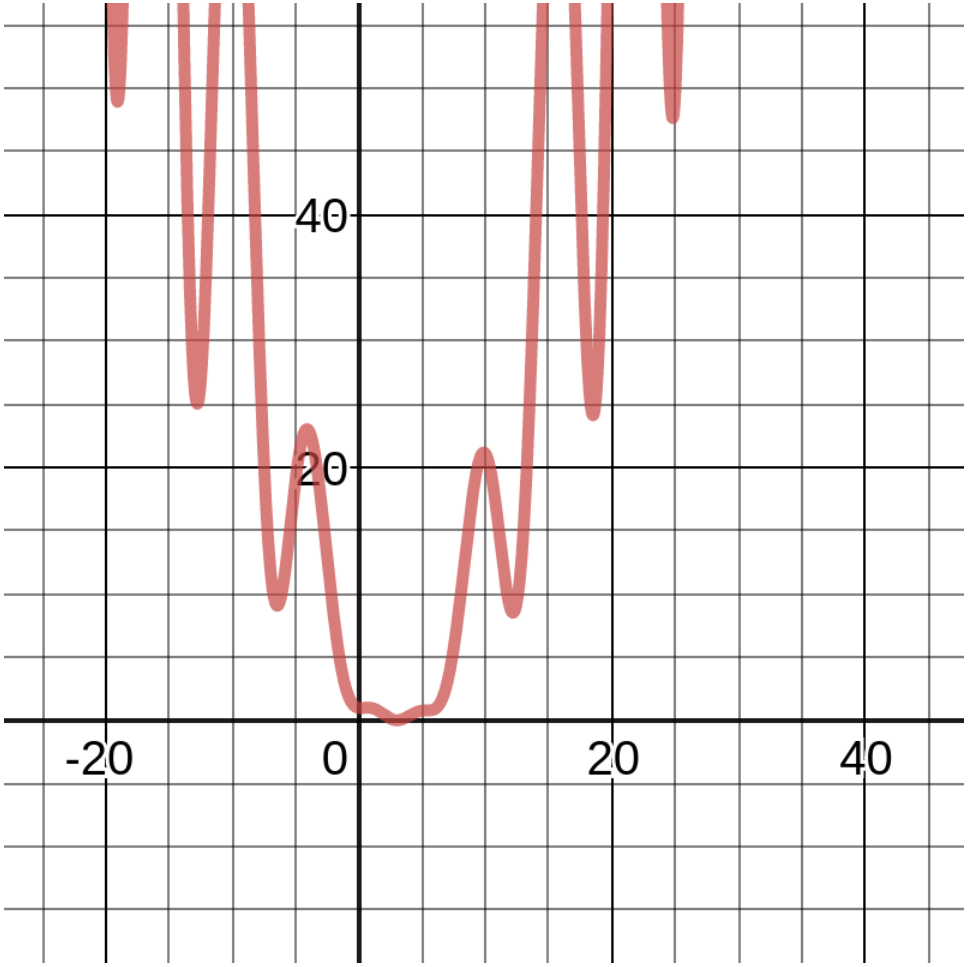
The following function has several local minima and one global minimum.

$$0.2 \cdot \big(1.5 + \sin(x+5)\big) \cdot (x-3)^2$$

Tasks:

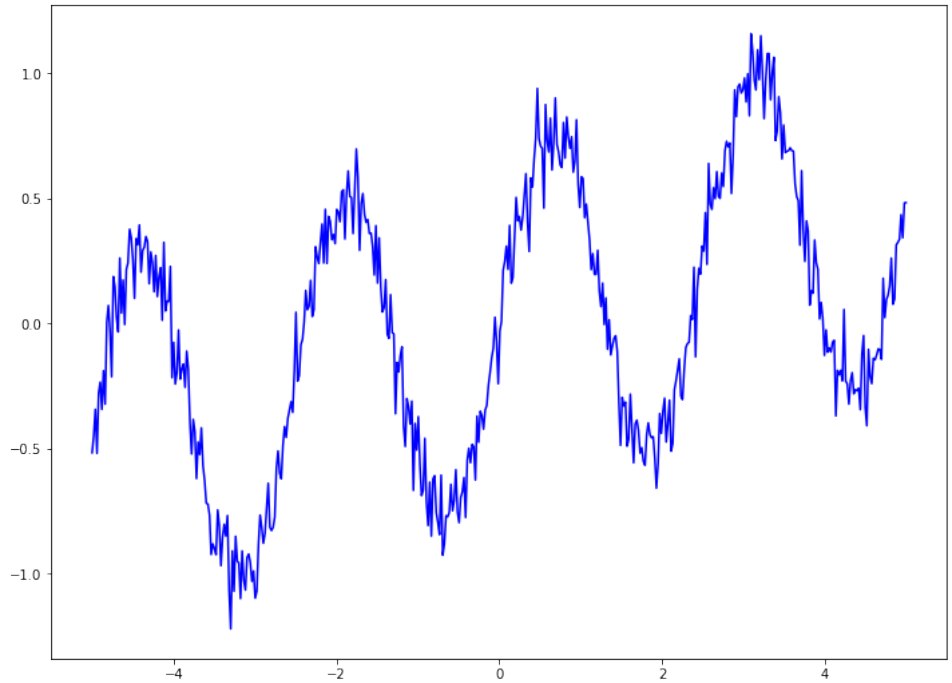
- Find out (analitically) the global minimum (x and y)
- Write and program the gradient of this function
- Use gradient descent to find the minima. Try different starting points, analyze the results

Ex1 (cont)



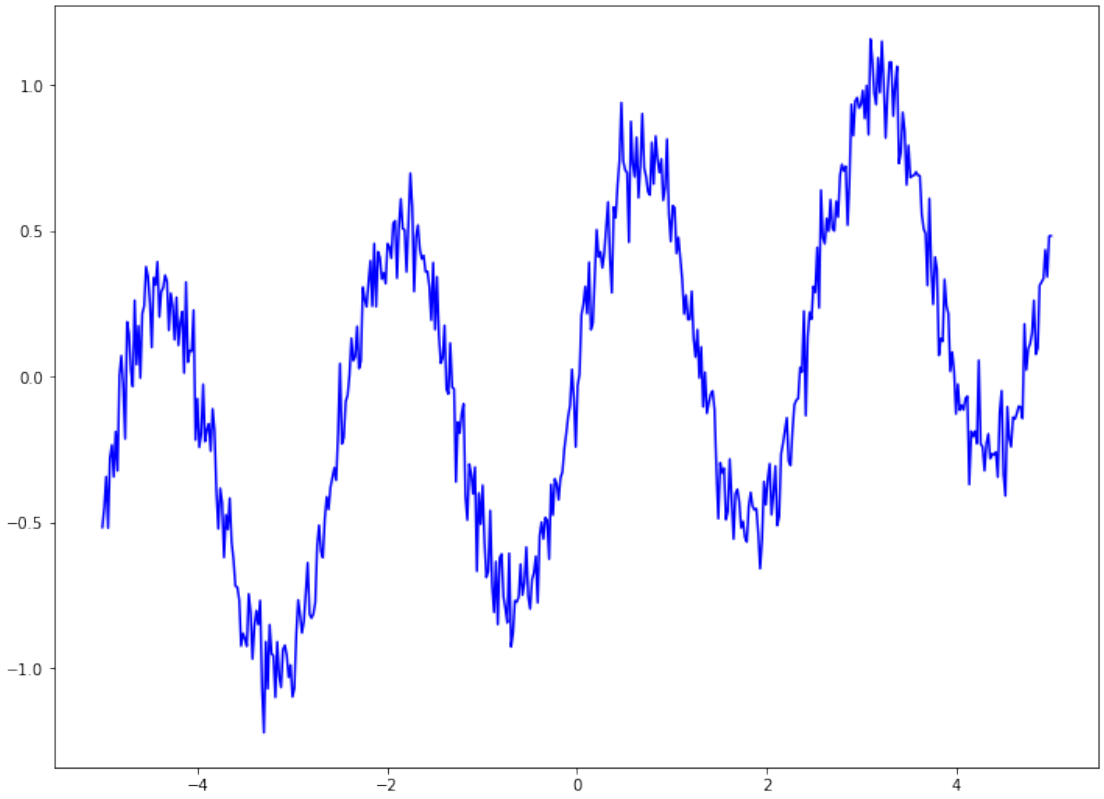
Ex2 (4p). The signal

You receive the following signal (file signal2.csv) from a distant galaxy. Think of a mathematical function that can approximate the signal and apply gradient descent to find the parameters of the function that minimize the approximation error.



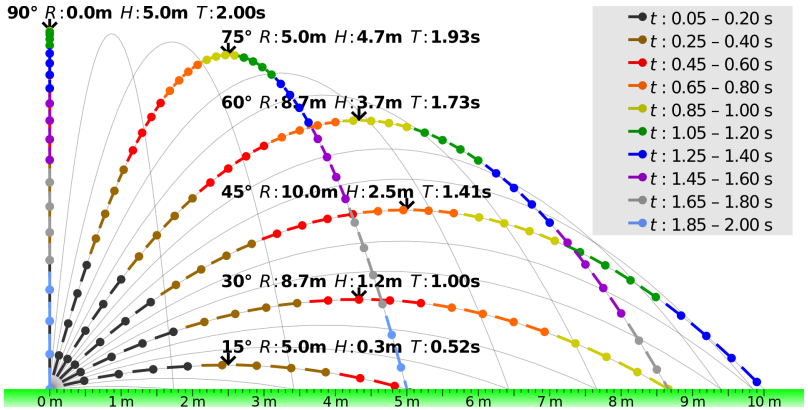
Ex3 (3p). The signal again

The same as before but using genetic algorithms.



Ex4 (4p). Parashooting

You want to launch a ball to a distance exactly 100 meters away from its starting position. You need to adjust two parameters: initial speed (v_0) and angle (θ). Find an optimal combination of v_0 and θ using gradient descent.



$$d = \frac{v_0^2 sin(2\theta)}{g}$$

Ex5 (5p). Gift card

You have a gift card worth 100€ that is about to expire. There are several items in the catalog and you can pick any combination of items, even repeat some, with two conditions:

- You cannot spend more than 100€
- You should spend as much of your money as possible (ideally 100€)

Please follow these steps to solve the exercise:

1. Choose a format for the solutions
2. Design and program the objective function
3. Use DEAP to solve this problem (genetic algorithm)
4. Explore different hyperparameters: population size, generations, mutation rates... (at will)

Ex5 (cont)

Item	Price (€)
SD Card	14.55
Pen	0.68
Sunglasses	35.27
Watch	49.60
Headphones	27.85
Charger	8.75
Screen protector	1.44
Phone case	14.89
Wireless charger	40.55
USB-C cable	4.30
Tablet	95.79

Ex6 (5p). Containers

We have to fill four shipping containers (load capacity 240 kg) with packages that weigh: 25, 46, 25, 11, 34, 48, 85, 120, 111, 70, 87, 35, 61, 102, 94, 131, 73, 9, 142
The goal is to pick a combination of packages to maximize the overall load of the containers using GAs. There is just one package of each type.

Ex7 (5p). Taxis

You manage a fleet of t taxis and receive calls from c clients. The GPS system tells you the ETA (expected time to arrive) of each taxi to each client, as in this table:

Taxi/Client	**C1**	**C2**	**C3**	**C4**	**C5**
T1	5	7	3	5	8
T2	3	2	1	4	6
T3	2	10	8	6	7
T4	4	6	4	5	9
T5	5	8	2	8	8

Your goal is to assign one taxi to each client so that the average waiting time of the clients is as low as possible.

Ex7 (cont)

Ex8 (4p). Propose an optimization problem

Describe an optimization problem that you can think of from your own academic/professional experience. You do not have to solve it, just propose the problem.

1. Describe the problem with enough detail
2. Propose a format to encode solutions for this problem
3. List the constraints that apply
4. Propose an objective function (not necessary to program it, you can simply describe it)

Please do not pick problems from the Internet!!!