



Statements

1 Introduction and rule of participation

Welcome to our junior WCCM-ECCOMAS hackathon 2021! The purpose of this hackathon is to apply your skills in computational mechanics and applied mathematics to solve a creative problem.

Following the guidelines you've been sent yesterday, the duration of the hackathon is **24h**, starting today (Thursday January 7, 2021) at 5:30p.m. (Paris time, UTC+1). As also written in the guidelines, teams for hackathon should be built, and their composition sent to workshopjunior@sciencesconf.org before Thursday 7, 11:00 pm (Paris time, UTC+1). A dedicated Team repl will then be created on repl.it (the IDE you will use during short-courses) to allow your team to work together on the same code.

On Friday 8 at 5:30p.m. (Paris time, UTC+1), the code written on your team repl will be frozen, and will be considered as your final proposition. In addition, you can send a very small resume of your work (approach and results) to workshopjunior@sciencesconf.org. The final ranking of teams participating to the hackathon will be given in the next 4 hours (at most).

2 Objective

The objective of this hackathon is to limit the viral propagation inside a country using a limited quantity of masks. To achieve this objective, three main steps are defined :

- a microscopic level on which you will detect contamination between people with or without mask ;
- an upscaling step to transfer the information from the microscopic scale to a macroscopic scale (the country) ;
- an optimization process, whose purpose is to distribute the most efficiently the masks in the country.

3 Microscopic scale

3.1 Population without mask

Let us model a living population in a square space, denoting some Elementary Cell (EC) at a local/micro scale, by a set of spheres of action with initial and constant velocities. A person is represented by a point (the center of the sphere) and a radius. One person can be either healthy or sick and we consider that there is no healing. The rule for contamination is the following : when an intersection between two circles is detected, if one of the two points is already sick, contamination occurs.

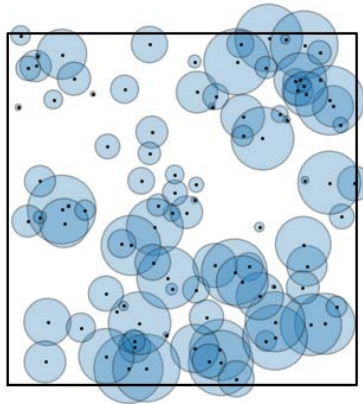


Figure 1: Sketch of the Elementary Cell (EC)

Periodic boundary conditions must be set on the whole boundary of the EC.

To help you to build this first simulation, an example result file is given to check if your result is correct regarding the corresponding input file. In this input ASCII file (named *input.data*), you can find initial 2D positions and velocities of people, their health condition (0 for healthy, 1 for sick) and their respective radii. For comparison, the evolution of sick people is given in the file named *result.data* and can be seen on figure (2). A video is also given for illustration in the Hackathon Teams channel.

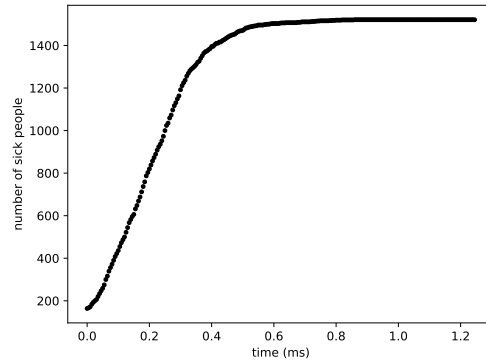


Figure 2: Evolution of the sick people during the example simulation.

Your main mission: get as fast as possible the contamination between people inside the EC. The performance of your implementation regarding this benchmark will be evaluated in the final ranking. In the *result.data* file, the computational time is given for information, try to do it faster!

3.2 Population with mask

We now consider people wearing a mask by a modification of the contamination rule:

- a sick person wearing a mask cannot contaminate anyone
- a healthy person wearing a mask cannot be contaminated

Each mask has a finite lifetime and is protective during only 50 contacts (whatever the health condition of the contact person). After 50 contacts, the person is considered unmasked.

Your main mission: include this new feature in your code.

4 Macroscopic scale

4.1 Upscaling

Let us now follow a multiscale approach. **Your main objective is to propose a consistent upscaling process to upscale the information (contamination state) from the micro scale to the macroscopic scale.** You are free to use any modelling (discrete/continuous). The choice of the size of the EC is a part of the upscaling process (remember, the example given in the previous section is ONLY an example).

4.2 Simulation at the macroscopic scale

At the macroscale, the boundary conditions must be null flux (to model closed borders). The initial quantities and the geometry of the problem at the macroscale will be given in the next section. You are free to use any numerical discretization (FEM, BEM, DEM, ...) to solve your macroscopic problem. All the tools you have been given during short-courses can be used for this purpose, the codes (deal.ii, freefem, etc) as well as the HPC computing platform Qarnot (A particular token is reserved for these computation, contact Jeremie.GIRARDOT@ensam.eu to obtain this token).

5 Optimization

Once the direct problem is set (the simulation of the propagation of the virus at the macroscale), the objective of is to limit as much as possible the viral propagation inside a country, or more precisely to repel a lock down situation, considered as 30% of the population being sick. The density of population is supposed to be uniform in the country.

To this end, a finite and limited quantity of masks is made available in the country, which can be delivered to the population in a certain way in both space and time. More precisely, at the beginning of the epidemic, the stock of masks is such that masks are available for 5% of the population. Remember that each mask has a finite lifetime and you cannot produce or import new masks (borders are closed).

6 Given data for the hackathon

The geometry of the country (macroscale) is given by the following closed 2D domain parametric equations:

$$\begin{cases} x = \cos(t + \pi/4) + \frac{1}{20}\cos(5t + \pi/4) \\ y = \sin(t + \pi/4) - \frac{1}{20}\sin(5t + \pi/4) \end{cases} \quad (1)$$

The initial condition is written on the *primal field* you'll have identified at the macroscale $F(x, y)$ is given within the computational domain, to initiate the viral propagation:

$$\begin{cases} A(x, y) = \sum_i \left[\exp\left(-\frac{(x-\bar{x}_i)^2}{0.01}\right) \times \exp\left(-\frac{(y-\bar{y}_i)^2}{0.01}\right) \right] \\ B(x, y) = A(x, y) - \min(A(x, y)) \\ F(x, y) = \frac{B(x, y)}{\max(B(x, y))} \end{cases} \quad (2)$$

where values of indices \bar{x}_i and \bar{y}_i are taken from the following sets :

$$\begin{cases} \bar{x} = \{-0.05, -0.5, 0.5, 0.55, 0.9, -0.6\} \\ \bar{y} = \{0.5, -0.4, -0.2, -0.7, 0.5, 0.25\} \end{cases} \quad (3)$$

The figure 3 shows a plot of this function.

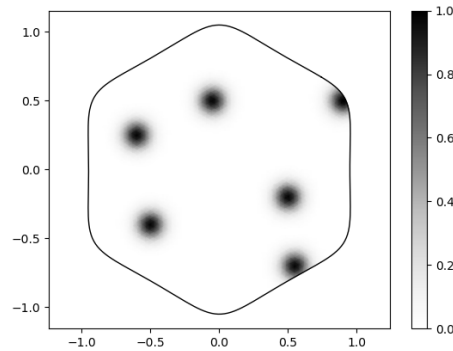


Figure 3: Plot of the initial condition in the computational domain (*country*)

Some illustration of the virus propagation within the country is also shown in figure 4.

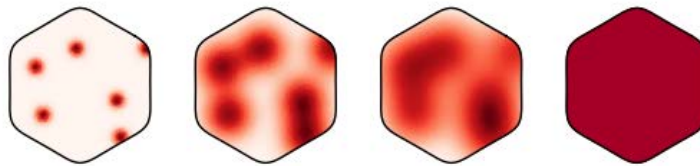


Figure 4: Sketch of the evolution of the virus in the *country*

!! GOOD LUCK AND ENJOY !!