MM560 – Introduction to Programming – 2023

Lecturer:	Benjamin Jäger	E-Mail: jaeger@imada.sdu.dk
Tutor:	Sofie Martins	E-Mail: martinss@imada.sdu.dk

Exam Project 1 - MATLAB

Submission deadline 23.59 on the 07.04.2023

Submission

As announced before, we allow for project submission in teams of (at most) two. The idea is to exchange ideas and solutions to problems rather than codes. You can work on the code together, but both should work on both projects. However, each team member has to submit the project code individually through ItsLearning. Include your name and the name of your team partner (if applicable) in the header of every code file that you submit.

For example:

```
% Name: <Your Name>
% Team partner: <Your team partners name>
%
% (Additional comments...)
% code starts here
```

Submit the code to ItsLearning (if it is more than one file, please compress it into a zip file). If you have any problems, contact me (before the deadline).

Code without comments will be considered nonexistent, so please add comments to **all** parts of the code.

1) SIR model [50 Points]

The SIR model is an example of a compartmental model. It is used to model infectious diseases, for instance, Covid-19. To do so the population is divided into three categories S, I, or R (Susceptible, Infectious, or Recovered):

- S: The number of susceptible individuals, i.e. the number of people that can get the disease.
- I: The number of infectious individuals. They can spread the disease to close contacts.
- R: The number of recovered. These individuals have recovered and are now immune to the disease.

We assume that the whole population is susceptible to the disease, so everyone starts in this compartment.

Here we simulate this model using MATLAB and a lattice setup. We consider that all individuals live on a square grid and this allows us to simply use a matrix A for it. The position of an

individual is given by the matrix row i and column j. I suggest to use a matrix of size 100×100, so our population is 10000. Instead of using the letters S, I or R, we use the numbers 0 for susceptible, 1 for infected and 2 for recovered.

We iteratively (using a loop) will change the infection behaviour over discrete time steps (t = 1, 2, ...). You can think about those being days. Let us consider 200 time steps / days. The infected have a small chance $\beta = 14\%$ to infect their direct neighbours, i.e. the right, left, top and bottom neighbours in the matrix. The infected also have a small change $\gamma = 7\%$ to recover from the disease.

(a) Create a 100×100 matrix with all entries set to 0. Randomly set two entries to 1, i.e. infect two individuals. [5 Points]

(b) Set up three loops that run over the time t, the row i of matrix A and j for the column of matrix A. (Hint: All loops are inside of each other. The outermost should be the time loop. All loops can be "for" loops are the number of iterations is known.) In a summary, for each day we go through the entire matrix. [5 Points]

(c) Implement the infection steps (there are four: one for up, down, right and left):

- First check that the potential neighbour is still inside the matrix.
- Check if the current matrix element is infected, i.e. $A(i, j)$ is one **and** if the neighbour is susceptible.
- Create a uniform random number between 0 and 1 and check if it is smaller than β. If that is the case, infect the neighbour by changing the matrix of the neighbour entry to 1. [25 Points]

(d) Implement the recovery step (You only need to look at the current matrix element):

- Check if the current matrix element is infected, i.e. if $A(i, j)$ is one.
- Create a uniform random number between 0 and 1 and check if it is smaller than γ. If that is the case, recover the current position by changing the matrix entry to 2. [13 Points]

(e) To visualise it, you can use the command pcolor(A) to show a 2D plot of the current state of the matrix. To make it an animation, add a pause of 0.1 s to see the progress of the simulation. This command should be at the end and outside of the i and j loops, but inside the t loop. [2 Points]

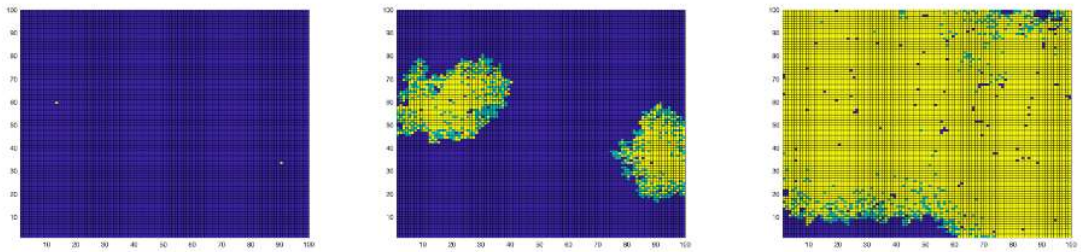

Figure 1: The matrix A at t = 1 (left), 65 (middle) and 200 (right) with the random number seed of 2023.