Assignment 1

Making a CPM of Collective Migration

Deadline February 11, 2024

Handout for the *Natural Computing* lecture, February 1, 2024

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In this assignment, you are going to use the cellular Potts modeling (CPM) framework to simulate collective cell migration *in silico*. The assignment builds on the self-study exercise, which you will need to complete before starting this assignment. You will design, implement, and analyze your own CPM experiment to investigate the impact of obstacles on collective migration, and submit your findings in a small report.

Objectives of This Exercise

1. Design and implement an experiment with the CPM to investigate the dynamics of collective cell migration *in silico*.
2. Visualize and describe your findings in a report.

For this assignment you will build your own CPM. We recommend that you use our framework Artistoo. Artistoo is written in JavaScript, but no background knowledge in JavaScript is needed to get started with this framework. (Of course, feel free to try implementing a CPM yourself in any programming language you wish if you prefer to do so – you should just realize that this could take you quite some time...)
You can find Artistoo at https://github.com/ingewortel/artistoo. It contains many methods allowing you to build and visualize CPMs, for which you can find documentation and some tutorials at https://artistoo.net (see "Manual" and "Documentation"). We also recommend having a look at the examples (https://artistoo.net/examples.html), for which you can find the code in the `examples/html/` folder of the code repository.

Assignment

In the self-study exercise, we have seen that "crowding" (having many cells close together) can impact movement under some conditions, but not others. We will now investigate how obstacles change collective cell motion on a densely packed grid.

1. How could you model an obstacle in the CPM? Hint: can you make a round obstacle by changing the CPM parameters in a certain way?
2. In self-study exercise 1.3, you examined two parameter sets and (hopefully) saw differences in collective migration behaviour. For your assignment, please first reproduce the simulation where cells kept moving even at large densities.
3. Use your answer to question 1 to design and implement an experiment to investigate the effect of obstacles. Hint: you can add obstacles by building a simulation with two kinds of cells, one of which is for the obstacles – see e.g. `Cellsorting.html`, `ManyCellsPrefDir.html`, or `examples/html/EpidermisWithTCells.html` in the `examples/html/` folder.
4. Analyze your simulations visually. What happens when you place obstacles between the cells? Do they still move? What happens if you increase the number of obstacles? *Please use obstacles with half the size of the cells for this exercise, and place them on the grid with regular spacing between them.* Think about which obstacle densities you consider and why (Hint: You will have to modify the `initializeGrid` method of your simulation. Have a look at the `seedCellAt` method and the `examples/html/CancerInvasion.html` example).
5. Use your simulations to answer the question: how do obstacles change the collective migration behaviour of cells?
6. Do check your simulations carefully; getting rid of obvious bugs/artefacts is also part of simulation research...

If you encounter any problems or questions, please let us know and we will get back to you as soon as possible. From the above, it should be obvious what you have to do – if it is taking you unreasonably long, do reach out in time!

Report

Write a brief report (in pdf, at most ~ 4-5 pages) on this assignment. In your report, ensure that:

- your report is comprehensive and follows a logical structure with an introduction containing the problem statement, methods, results, discussion and conclusion.
- you clearly answer the question how obstacles change collective cell migration. Observe closely. What do you see? Did you expect that? What are your main conclusions?
- you have thought about your experimental design: which different simulation(s) did you make to answer the research question? Are they sufficient to answer the question? What are your controls? Which other factors in the simulation might be affecting your conclusions?
- you support your findings with evidence; how can you best show your point? For example, you can use screenshots in a figure to illustrate the behavior you see. Think about how colors, annotations, etc can help bring your message across. You can also try to quantify the motion of the cells. What do you need to show to convince a reader of your conclusions?
- if you upload any movies of your simulation(s) with your assignment: please ensure that you use some generic video format that can be opened from any computer. Please don't embed them in the pdf file as this can be tricky with portability. Don't rely on videos only; some (non-moving) visualization of your main results should be clearly visible in the report itself.
- you specify precisely how you built your simulation, for example, by reporting parameters in a table. We should be able to reproduce your work from the report alone – without having to look at any code! You should also discuss how you have implemented the obstacles in the CPM.

The deadline for submission is February 11 (see Brightspace). This first version will only get a pass/fail grade, but please do the best you can. You will later get feedback on your work and get an opportunity to improve your report for your final grade. The more thought you put into your first version, the better your final work will be!