Assignment 1A

Making a CPM of Collective Migration

Deadline February 10, 2025

Handout for the *Natural Computing* lecture, January 30, 2025

TA for this exercise: Lin Wouters

In this assignment, you are going to use the cellular Potts modeling (CPM) framework to simulate collective cell migration. 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. At this stage, you are submitting a draft that will not yet be graded – you will first receive feedback and get a chance to revise your work before the final submission.

Objectives of This Exercise

1. Design and implement an experiment with the CPM to investigate the dynamics of collective cell migration *in silico*.
2. Analyze and interpret your experiment appropriately in a written 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.

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 lecture and 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 crowded 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. *Please use obstacles with roughly half the size of the cells for this exercise, and place them on the grid with regular spacing between them.*
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? 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. This first version will not be graded yet, 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!
Assessment criteria:

- Experimental design: to what extent does the setup of your experiment(s) allow you to answer the question(s) as posed in the assignment, or did you miss relevant factors?
- Methodology/implementation: there should be no major bugs/artefacts in your simulation and the way you implement obstacles and collective migration, and the details of your implementation should be clear from the written report without referring to the code (although you may still do that).
- Analysis: how well is the report supported by visualizations and/or quantitative analyses, and are they appropriately chosen? For example, you can use screenshots in a figure to illustrate the behavior you see. Think about how colors, annotations, figure organization, 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? (For the draft version we recommend to prioritize the visualization, but you can add more quantitative analyses at a later stage).
- Interpretation: How did you interpret your results? Did you clearly answer the question, and are all your claims backed up by evidence in the form of visualizations and/or quantitative analyses (depending on the claim made)?
- Reporting: does your report meet basic standards of a research report? It should be comprehensible and follow a logical structure with an introduction containing the problem statement, methods, results, discussion and conclusion.
- 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.

The deadline for submission is February 10 (see Brightspace).