Investigating the Impact of Obstacles on Cell Migration

Yvo Hu

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1 Introduction

The Cellular Potts Model (CPM)[1] is a computational framework used in the study of complex biological systems, particularly in the context of cell behaviour and tissue morphogenesis.

The behaviour of cells can vary wildly based on its intrinsic properties. The CPM allows for the customization for a great many of these to try and explain the behaviour of these cells. Things that might influence the behaviour of cells might be the presence of obstacles in its environment. Therefore, in this paper, we will examine the impact of obstacles on cell migration.

2 Experimental Design

2.1 Objective:

Investigate how obstacles influence collective cell migration dynamics using computational simulations based on the Cellular Potts Model (CPM).

2.2 Simulation Framework:

To simulate our model, We will utilize the artistoo framework [2], which is a library to build, share, and explore simulations of cells and tissues in the web browser.

In this experiment, we will analyze the behaviour of cells based on a few properties within the CPM. We will modify the properties of the CPM such as adhesion to other cells/objects, as well as potential effects on cell motility. And additionally the density of the obstacles within the grid.

$\text{Adhesion}_{\text{cell-matrix}}$	$\text{Adhesion}_{\text{cell-cell}}$	Volume	λ_{Volume}	Perimeter	λ_{P}	Max_{Act}	λ_{Act}	T	Framerate
20	0	200	50	180	2	20	200	20	5

Figure 1: Default CPM parameters

3 Results

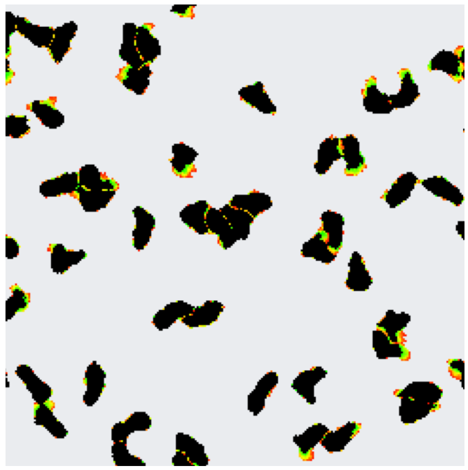

Figure 2: Initialization of the default setup

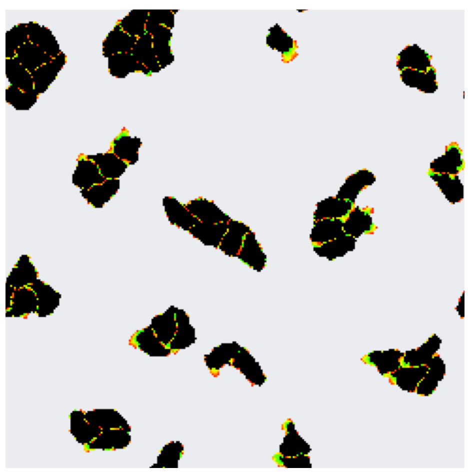

Figure 3: T = 1 min

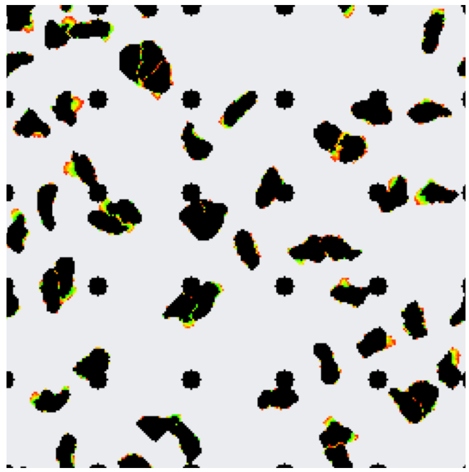

Figure 4: Initialization of the default setup with obstacles

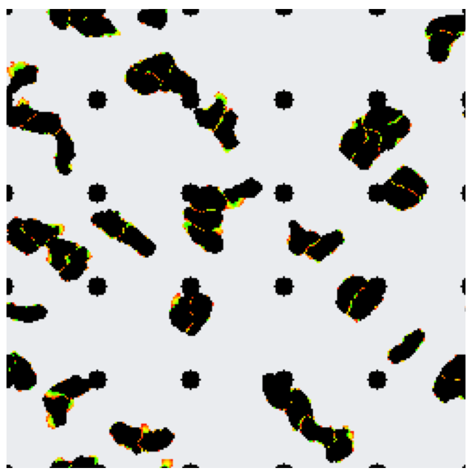

Figure 5: T = 1 min

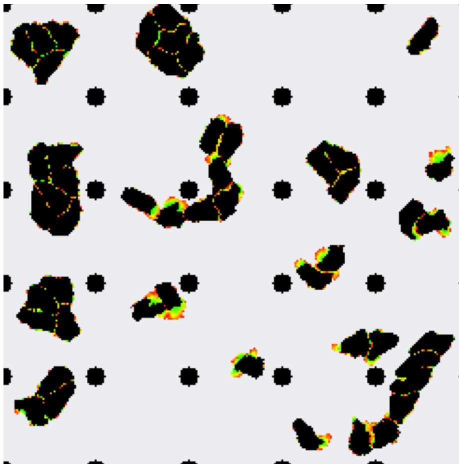

Figure 6: T = 1 min, with obstacle adhesion = 1000

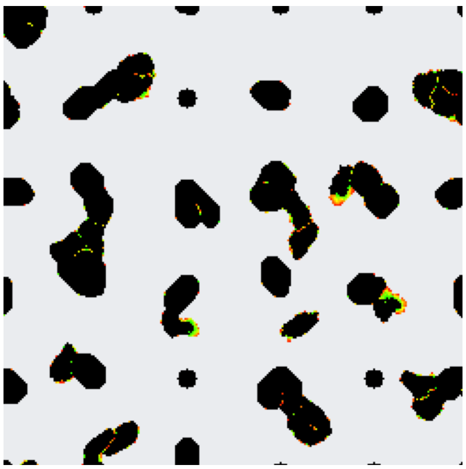

Figure 7: T = 1 min, with obstacle adhesion = -1000

4 Discussion

We see some interesting patterns emerging in the previous section. The cells will behave similarly in the presence of obstacles when there is no special interaction happening, other than decrease of space that the cell could move into.

However, with the modification of the adhesion parameter, the cells start to behave differently. We see in figure 6 with the adhesion parameter set to 1000 with respect to the obstacles, that the cells actively avoid the obstacles, and therefore are limited in the area in which they will move into. This results in a more densely packed pockets of cells.

On the other end, with the adhesion parameter set to -1000 with respect to the obstacles, we see that the cells actively converge on the obstacles. This limits the motility of the cell, as they don't care to migrate to other sections of the grid anymore.

5 Conclusion

The introduction of obstacles on a cellular grid, does indeed have an impact on the behaviour of cells. In particular when there are inter-cellular interactions involved that modify the behaviours of the involved cells.

6 Appendix

File, Figure numbers

MySimulation2 [2] [3]
MySimulation3 [4] [5]
MySimulation4 [6]
MySimulation5 [7]

References

[1] François Graner and James A. Glazier. Simulation of biological cell sorting using a two-dimensional extended potts model. *Physical Review Letters*, 69(13):2013–2016, 1992.

[2] Inge M.N. Wortel and Johannes Textor. An example paper title. *Journal of Example Research*, 10(2):100–120, 2020.