CS 154 : Project Report

Project Title: BiSym - Biological System Simulator

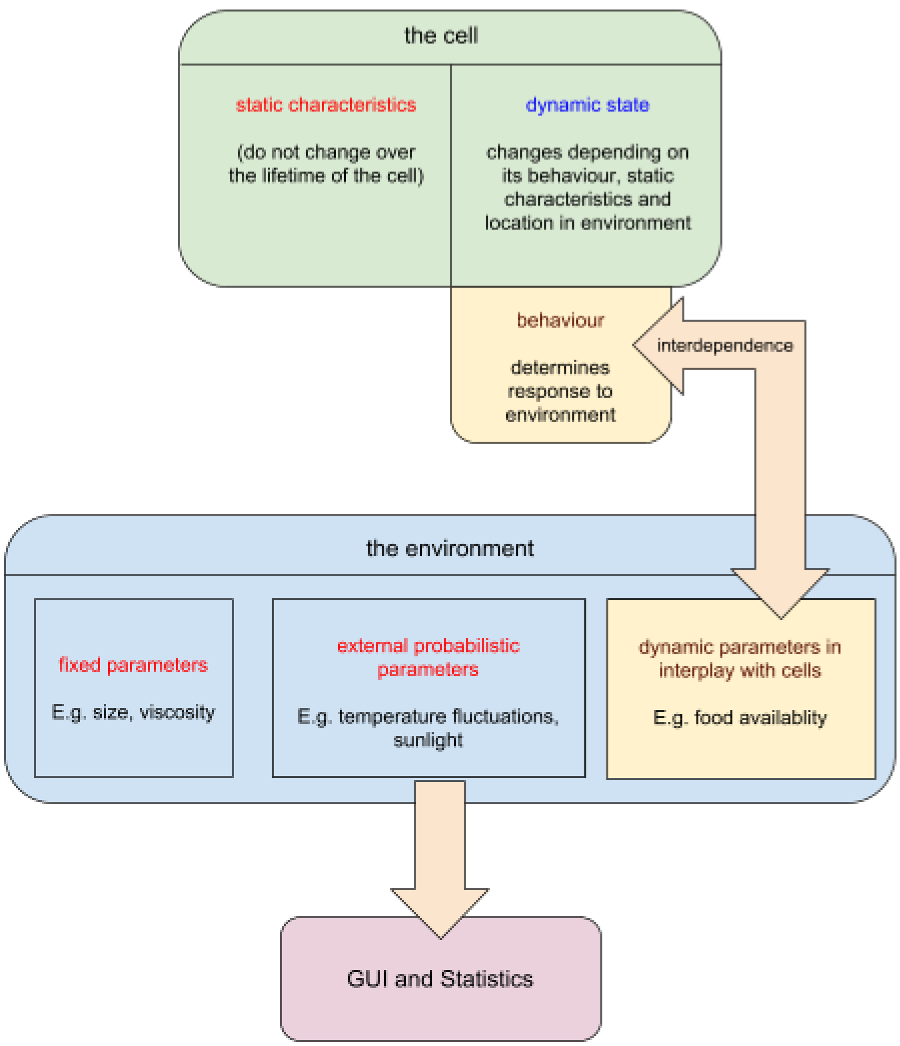
Problem Description:

Biological cells interact with the environment in a complex way. There are various parameters associated with the processes that these cells carry out. Our project is aimed at generated a simulation of a simplified model of this interaction.

By doing so we can clearly see phenomena such as **survival of the fittest**. Also we demonstrate that such systems have an inherent **stable equilibrium** which is achieved when the system is run for a long enough time.

Our simulator can be extended to include various other features such as autotrophic cells, variations in the environment with regards to temperature, viscosity, etc.

A layout of our project:



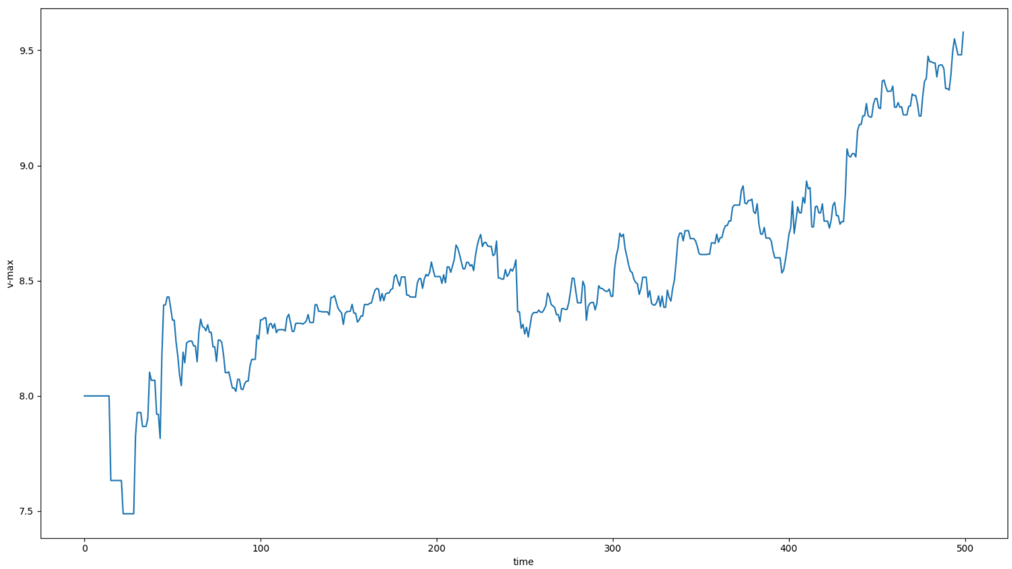
Components:

1. Cell: This houses all the characteristics of a cell. This includes fixed parameters, evolutionary parameters, dynamic variables and functions that describe the behaviour of the cell.
2. Environment: This captures the global information of all the cells. Also, variations of food, temperature can be included.
3. GUI: This displays the position of cells and also statistics related to the cell population.

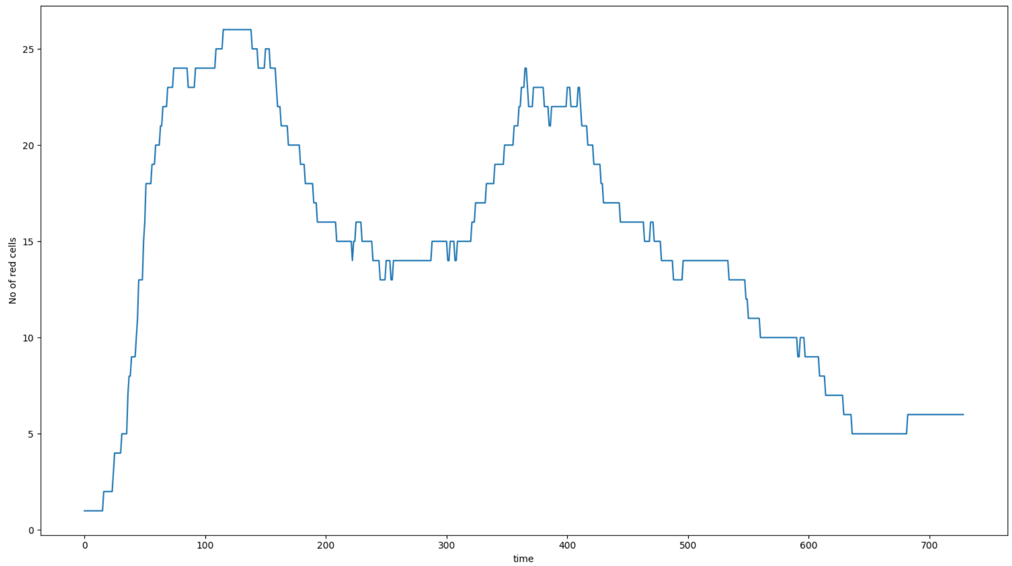
Sample Input/Output:

1. We have a dictionary of 4 cell types (called master-type). These define the initial values of all the parameters for the cell. These values are hardcoded, but they can be changed in the code-file.
2. While running the simulation, we can specify the number of cells of each type we want to start off with.
3. The output is in the form of an animation of cells. Also on the right panel we display statistics for each type of cell (i.e. count of cells, maximum velocity, loc-param, etc.).

We have attached here a few plots showing the outcome of our experiments:



Variation of average v-max with the time elapsed since beginning of simulation. We perturb v-max randomly when the cell reproduces. From this behaviour we can conclude that higher v-max cells are favoured as the average value of v-max increases.



Variation of the cell count of the recessive cell-type (red). We observe that initially the cell count increases as the cell-count of the dominating cell-type is also less and hence both have abundant supply of food. As cell-count of dominating cell-type increases, the food becomes scarce and the recessive cell-type dies out.

Limitations:

1. We face the dimensionality problem. Having too many parameters makes it difficult to set functions accordingly. The problem arises from the fact that we do not know very well how the parameters scale up against each other.
2. The model is very simplistic in the sense that motion is restricted to 2D plane and that too only in the 8 primary directions.
3. To showcase survival of the fittest we need a rather large difference in the parameters of the cells.

Future Improvements:

1. We have tried to set up tradeoffs in the parameters and behaviour that our cells exhibit. For example, a large value of velocity increases a cell's scanning horizon but at the same time causes it to consume energy faster. A large mass helps to endure phases of low food availability but again causes high consumption as compared to a smaller (more agile) cell. These tradeoffs can be made more realistic by setting up penalty functions so that an optimal value is exhibited.
2. Currently this behaviour is seen in some runs but the variance in the observations is large.

Other interesting points:

1. We have used threading for the simulation. We need to run the processing and simulation and at the same time we need to check whether the ‘stop’ or ‘reset’ buttons are pressed. This is done by starting thread that keeps on simulating and as soon as a button press is detected the thread is paused.