Group 5 Final Report

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1 Introduction

This report describes our approach and observations while working on the *Organisms* simulation problem. The simulation is a class of popular *Discrete Cellular Automaton* model, similar in spirit to *Conway's Game of Life*.

The simulation world is a finite grid in which virtual organisms occupy individual cells in the grid. These virtual organisms can choose to move, eat or reproduce in each discrete cycle of the simulation. They are also able to "see" the neighboring cells and are thus able to sense the presence of food and/or other organisms. The simulation is subject to various rules and constraints. Each organism has finite energy and there is a cap on maximum energy an organism can accumulate. Energy is replenished by consuming food and it is consumed in every cycle depending on organism's action - i.e. moving, reproducing or even staying still consumes some finite amount of energy. An organism ceases to exist when it's energy level drops to zero. Food may appear on any empty cell in the simulation world with some finite probability and it may increase by a unit with some finite probability. These probabilities are not known to the organism. The maximum amount of food that is available in any cell is also bound to a finite number. An organism may also "communicate" with nearby organisms by broadcasting an external state, that can used in a versatile manner. The simulation can be run in single-species mode or in multiple-species mode. The winning conditions are not concretely defined but some of the factors that can be considered while judging a winning strategy can be average energy per organism, average extinction rate, total number of organisms for a species vis-a-vis other species etc. after some finite number of rounds/cycles.

Our group came up with various approaches to the simulation and depending on results, we pivoted a few times. Initially, our approach focused primarily to maximize the average energy. We developed an organism brain which used different *threshold* levels to decide whether to move, reproduce or to stay still. The implementation assumed fairly high probability of food appearing on the board. However, the strategy fell flat in conditions where food was scarce. We then implemented a strategy in which the organisms tried to gauge the probability of food appearing and doubling, either individually or collectively using some means of communication. We also came up with mathematical equations to determine the "utility" of making a move, consuming food, moving or staying still in each cycle of the simulation. The utility functions allowed us to choose the "best" move for an organism.

However, the release of *"Sheep"* organism from the previous undertaking of this class completely changed our thinking of this game. We realized that our strategies were not agile enough to adapt to multi-species simulations and our organism species was being constantly starved into extinction by a fairly aggressive reference organism species. We discarded the old approaches in favor of a *"Flood"* based approach, which aimed to reproduce effectively in the simulation arena so as to avoid possible extinction by other organisms. To achieve balance, an organism initially tended to stay at one place, then it transformed to aggressive behavior and the older it got, it again preferred to stay at one place. We found this implementation to be quite effective against multi-species simulations and our implementation was even able cause extinction of the reference *"Sheep"* organism in all scenarios, even in the scenarios when it was outnumbered by 1:5 initially at the start of simulation. On the side, we also took cues from strategies used by other groups in the class and we particularly noticed that structured/patterned farming colony approaches were quite effective in increasing average energy of the organisms. We also implemented a *"Pattern-Maker"* organism brain which tried to form structured farming colonies, so as to achieve the sustainable balance between number of organisms in the simulation and food growth rate. We found this implementation quite effective in single-species simulation.

2 Initial Insights and Observations

3 Strategies and Concepts

3.1 Single Player

3.1.1 Surviving Mode

One thing we noticed is that for harsh environment(p = 0.1%), the organism will easily extinct if moving around too much, especially at the beginning of game. However, if we are able to let the food to grow for a while, the board will become abundant, which then allows the organism to make some move and maximize total power. Basically, we attempt to help our organism *Survive* the beginning couple hundred rounds(Stage One) and switch to energy miximizing mode(Stage Two). Note that the surviving mode is just one layer put at the beginning of the game. At some point(details in Implementation), when organism enters stage two, *any* algorithm for maximizing energy could be invoked. The two stages are totally decoupled.

Move or stay. During this surviving mode, apparently, reproduce is not a good action. The energy spliting makes the origanism weak and cost of stayput will doubled. The question remained to be whether the organism should just stay, waiting for food to appear in the neighbor cells or move around to explore food. We answer this question by introducing a probabilistic analysis over the benefit of moving or stay. More specifically, we will calculate the probability of finding food when you move and compare it with the probablity of finding food if those energy are used to stayput and wait, so as to determine the best action in each round.

Eat or wait. The idea above is focusing on finding one food. But once a food is found in neighbor cell, shall the organism just go ahead and eat it or wait for as long as it can. Our answer is the later, based the following three reasons.

1. This is single player mode, no one will appear and rob the food away.
2. The goal of this stage is to survive the beginning harsh environment, waiting is more suitable to this.
3. The expectation of food on that cell grows exponential to the time you wait(more details in Implementation).

3.2 Multiple Player

4 Implementation

5 Analysis and Results

6 Contributions

7 Future Direction and Limitations

8 Acknowledgments

9 Conclusion