Organisms: Group 3

Players: Blue Moon (1), Mr. Blue Sky (2)

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1.1 Overview

The problem of organisms trying to develop in an unknown and possibly harsh environment is equally intriguing and difficult. Devising a strategy that performs well in a wide variety of scenarios requires a deep understanding of the constraints within which the organism must exist, and requires a heuristic approach in forming a strategy. Having seen the work of the students from previous year's class, we were able to study their approaches and analyze their organisms' failings. By having a head start, we were able to concentrate on the essence of the problem at hand since we realized that simplicity is the key to having a successful organism. Such an organism must be easy to coordinate, have little need for communication or knowledge of the unknowns, and should be able to gauge the harshness of the environment and react accordingly based on a set of predefined rules. The primary aim of the organism is to survive, especially in a multi-organism environment, and if possible, retain a population with a maximum amount of energy, thus ensuring its survival. Given that the dimensions of the world, the number of competing organisms and the probability of food being found is unknown, the environment the organism will face within each run of the simulation may vary drastically. We looked to nature for inspiration because we believed that simple, real-life organisms face similar situations as presented by the simulation, even given the level of abstraction that the game imposes.

1.2 r and K Strategies

In Biology, there are two strategies concerning organisms that exist in unpredictable environments, which define a spectrum into which every organism, including the one we are simulating, falls. These are the **r and K** strategies. The names **r** and **K** come from a mathematical model of population growth, which is typically a sigmoid curve. For small populations, growth is exponential as represented by the **r** parameter, and as the population becomes larger the organism reaches the maximum carrying capacity, represented by the **K** parameter of the environment. The **r**-selected populations are typically far from their carrying capacity, and thus able to grow exponentially using an abundance of available resources. However, because of the dangers in the environments (diseases, predators, droughts, etc.) the population is regularly decimated so that it never actually reaches the theoretical maximum capacity. An **r**-type organism prefers quick reproduction, while a **K**-type invests in a prolonged development and long life in a stable environment. **K**-populations are well protected against such disasters and therefore remain close to their maximum possible population. In that regime, resources are limited, and there is strong competition among the members of the population. This competition allows only the strongest, largest, most developed or most intelligent members of the species to survive and reproduce.

1.3 Theory of ESS

In the field of game theory there is a concept that concerns organism living with strategy A surviving an invasion from organisms using strategy B. This is called the **Evolutionary Stable Strategy (ESS)**. An **ESS** depends on the idea of invasion, where a strategy-B player visits a population of strategy-A players. The new player is said to invade if, following strategy B, he scores better than the average strategy-A player.

2.1 Strategy

We have tried to adapt a little bit of both **r** and **K** strategies, mentioned above, into our players. We try to play the role of a more complex, and thus, less mobile and move conservative organism. Reproduction is influenced by various factors, such as presence of food, energy per food unit, maximum energy and cost of movement. Our organism typically lives longer than one that moves frequently or reproduces in large numbers early during the simulation.

Though we attempted to make an organism that behaves equally well in all conditions, we ended up being much stronger as the amount of food decreased, or the board was small, allowing for us to conserve our energy while biding our time. As enemy organisms will die out early on due to their aggressiveness, our theory is that we will survive in the long run, while appearing to be dormant early on. The organism's reproduction is not influenced by the presence of other organisms, but rather by the presence of food, which is essential to our reproduction cycles. These cycles are controlled heuristically and were tuned through off-line experimentation as well as simple mathematical derivations. Since ours is a high-level organism, we have adopted farming as the method for retaining a constant food supply. Thus, survival of a core population is possible even without the aggressiveness common to **r**-type organisms, provided that food is available, and rather than scavenging the game world for food, our organism will try to cultivate it. The obvious disadvantage of our strategy has is that if there are many competitors in a given scenario who are aggressive reproducers in a plentiful environments, our organism will be choked if it has not secured enough food early on.

2.2 Movement

Since moving is generally costlier than staying put, we improved the longevity of our organism by controlling the amount of movement that it would do base. Our organism follows very simple rules when deciding if it should move. If there is food in a nearby cell, the organism will move onto it, unless it will die in the process of moving there. Through external testing we found that for an organism to survive in harsher conditions than are default for the class, it needs to have a very low propensity to move. Thus, we conserve energy by only moving a small fraction of the time depending on how cheap movement is. The more expensive movement is, the less likely our organism will be to move, and the move energy it will conserve, hopefully being able to outlive the other competing organisms and then establish a larger population on a relatively sparser board. Though we are conservative in the sense that we move less often, we move as much as our energy allows. In addition, we experimented with having multiple movement strategies based on how long the game has been running, and had limited success with it. An organism that moved little early on, and increasingly more as it grew older worked well in a single player environment, but had a considerable disadvantage in multiplayer games due to the scarcity of food later in the game.

2.3 Reproduction

Our organism reproduces only when there is food involved, or if it has enough energy to sustain itself. If its energy level is higher than 20% of the total energy per organism, both of the resulting organisms can stay alive for enough rounds to stay alive, and move enough to capture a free food source. If the organism is sitting on food and there appears food in a nearby cell, then reproduce onto the new cell. The organism will split onto food in all cases.

2.4 Search

Searching for food in an unstable environment can be tricky. There is no one-search technique that can fit various scenarios. So, we have come up with two search techniques. Our Player 1 users a spiral movement to search for food, and Player 2 uses a combination of spiral and stair movements.

We tried random motion, i.e. to have the organism select the direction in which to move at every turn using a random key. But this action did not do well in medium to scare scenario and was not very advantageous in high p situations. We observed a player from last year - 'Hunters and Farmers' and found that this player moved in spiral motion, and seemed to be doing decent in most situations. This encouraged us to adopt the spiral.

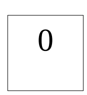
However, towards the end of the project we found other teams that were spreading across the board in numbers and thus hindering the spiral motion. This prompted us to work on an alternative. Out player 2 uses a combination of spiral and stair movements. The direction of the stair is determined randomly.

2.4 Farming

We implemented farming as a way of maintaining a core population in conditions when food is plentiful (***p*** is large and ***q*** is moderate). This allowed us to keep a certain number of self-contained communities, which ensured the survival of our organism, while still being able to spawn explorers who would search for food and possibly start outposts if conditions allowed for the creation of farms. We chose to stick with size-1 farms (that is, farms with 4 organisms to sustain, each one located at the orthogonal directions to the food cell) since we found these to be the most robust and required the least amount of communication, and were also the least susceptible to foreign penetration. Farming is integrated into our organism, and it will try to create a farm if there is enough food. Since the exact number of food needed was not clearly evident, we derived the formula for the total energy of each of the 4 organisms.

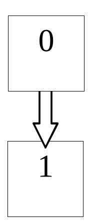
It is worth noting that farming is mostly implemented for the sake of having to survive in single player mode. Since in multiplayer environments it is difficult to capture a cell with more than the required number of food units, and is further difficult to actually form a farm around that food cell, since there might not be enough space to expand into the farm.

1.



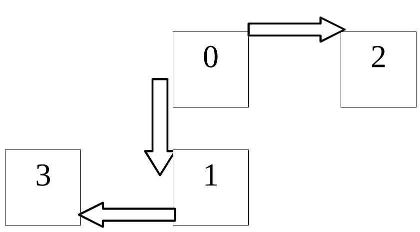
Initial Energy = **E**

2.



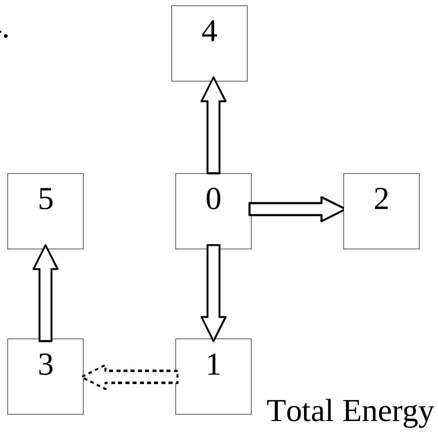
Energy (0, 1) = (E – v + u) / 2

3.



Energy (0, 2) = (E(0, 1) – v + u) / 2
Energy (1, 3) = (E(0, 1) – v) / 2

4.



Energy(1) = E(1, 3) – 1
Energy(2) = E(0, 2) – 1
Energy(4) = E(0, 2) – v + u
Energy(5) = E(1, 3) – v

Total Energy after farm completion = **E + 3u – 5v – 2**

We use the above formula as the basis for our farming. The formula implies that creating a farm results in a net loss of energy in comparison to the original organism's energy. Furthermore, it can be seen that 3 units of energy will be consumed in the worst case (assuming that the original organism is not ***M*** – 3***u*** > E), thus, most of the time, a farm can only be feasible if there are more than 3 units of food present on the square. Even if a farm runs out of food, the organisms will retain their formation around the empty food square for ***v*** turns in hopes of food appearing in that same spot, allowing them to resume farming. Even with the knowledge of the value of ***q***, this formula will hold true, since you will be consuming 3 units of food while creating the farm, and thus not allowing the food to grow.

2.5 Communication

Our organism has an external state that we try exploit in order to create a basic communication mechanism between them. This presented various challenges. First, we are limited to only 8 bits for communication and also we had to prevent implementing a scheme that could be easily spoofed by other players, who simply echo back the state of an organism hoping that they are sending a harmful command to it. Also we wanted our scheme to be simple so it could be easily extended. We decided to use a basic encryption mechanism and the use of communication handshakes to effectively communicate. We also take advantage of the parent-child communication, which allows for 32 bits to be transferred from the parent to the child. This is mostly used to delegate farming stage responsibilities.

2.5.1 Parent Children Communications

When creating a farm, its essential that each organism can communicate with the other organisms. The parent organism uses the key to pass information to the children indicating the stage of the construction and the next move they are expected to perform. to provide the location of the farming node and the step of the construction they are currently performing. Assigning states to each of our organisms we where able to easily manage the food between all of them and significantly extended the lifespan of the community. We attempted to create larger farming groups, but we did not have the time to complete the full communication protocol to maintain the expanded farm.

2.5.2 Encryption Scheme

The encryption was based on a random key. This key is generated when organism is born. The key is a random value from 0 to 3, and it is used to conceal the message from the other player in the board and as authentication on subsequent messages. When communicating between the organisms, the key is stored and used to authenticate further messages come form the same organism.

2.5.3 Messages

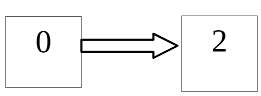
In order to ensure our players are not spoofed, we used a handshaking protocol for our communications. While it takes a couple of turns to complete a conversation, it allows a friend to be verified as such, and for enemies to be simply ignored with no harm done to our organism. To implement this, every message that we use has an appropriate response that is validated before performing the accorded tasks. The messages are specified in a fixed table with a maximum length of 64. The messages are used to show the current player state and to perform the handshake. Not all messages require handshake since many of them are used for farming, as explained above.

2.5.4 Food Sharing and Group Farms

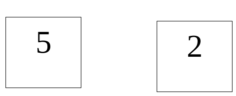
The way this communication works is that a player identifies a situation in which he may begin a farm or notices a friendly organism that is in need of food. They change their external state to ask the other organism to perform the desired task. When the other player sees this state he decides whether to perform the action or just ignores the messages. If the player chooses to accept the message he changes his state to reflect he read the message and agrees with the task to be performed. The original organism reads this state and confirms the task is starting. Food sharing turned out to be a helpful idea, as when compared to Player 1 (our original player), Player 2 performed better having the communication system in place. This can be seen when comparing the average energies of the two players in our test runs.

2.5.4.1 Food Sharing

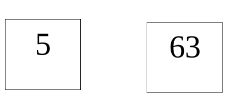
In order to better utilize the food resources, we implemented a food sharing algorithm. This enhancements proved to significantly improve our organism performance in almost all scenarios. We only permitted organism to share food to friend if they where to the south or east, these way we could guarantee that as soon as the organism left the food a friendly organisms be in position to take. We made this restriction to prevent losing the food to the enemy. Also the organism has to be sitting in more than 2 units of food, to have time to complete the handshake.

1. 

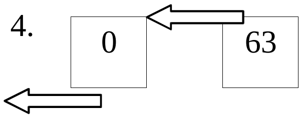
Organisms is sitting on more than two food units and sees hungry organism.

2. 

Organism changes state to ShareFood

3. 

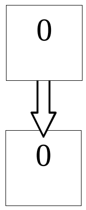
Organism see a Share Food state and says HI

4. 

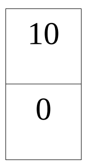
Organism sees confirmation and leaves the food which is taken by the intended organism

2.5.4.2 Group Farming

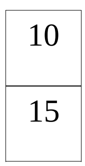
In an attempt to make farming more attractive, we implemented group farming. In this model instead of having one organism create all the farmers, we use two organisms to create the farm.

1. 

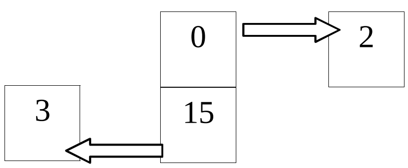
Organism has more than 2 food units and spots a friendly organism.

2. 

Organism changes its state to Start Farm

3. 

Organism sees the Start Farm state and resposnes with OK

4. 

Organism sees the OK and they proceeds to create children to create farm as described above.

2.6 Official Tournament Analysis

After reviewing the results of the official tournament, we were not surprised that our organism had not fared so well in favorable conditions. We'd been led to believe that the tournament will test to see the organism's ability to survive in increasingly harsh environments. However, the tournaments had only mildly scarce conditions, and predominantly favorable ones. In the favorable ones we did not do so well, since we were choked by the large number of organisms on the relatively small boards. Due to the fact that our organism is conservative in its movement, it was not able to secure large amounts of food early on, and thus was not able to survive for prolonged periods of time. In harsher conditions, our organism fares much better than the official results led one to believe.

2.6.1 Interpretation

Judging from the results of the scenarios in which our player was able to survive, it is clear that we very consistent in terms of the ratio of energy to population. Regardless of the conditions, we are able to maintain that ratio unless we are completely choked. Our Player 2 was able to adapt better to these favorable conditions due to the farming and food sharing enhancements which were added, and our Player 1 served as the control of the experiment. This allowed us to evaluate how the various enhancements in Player 2 allowed it to outperform Player 1 in most situations. This justifies our claim that food sharing was in fact feasible, and that communication was possible.

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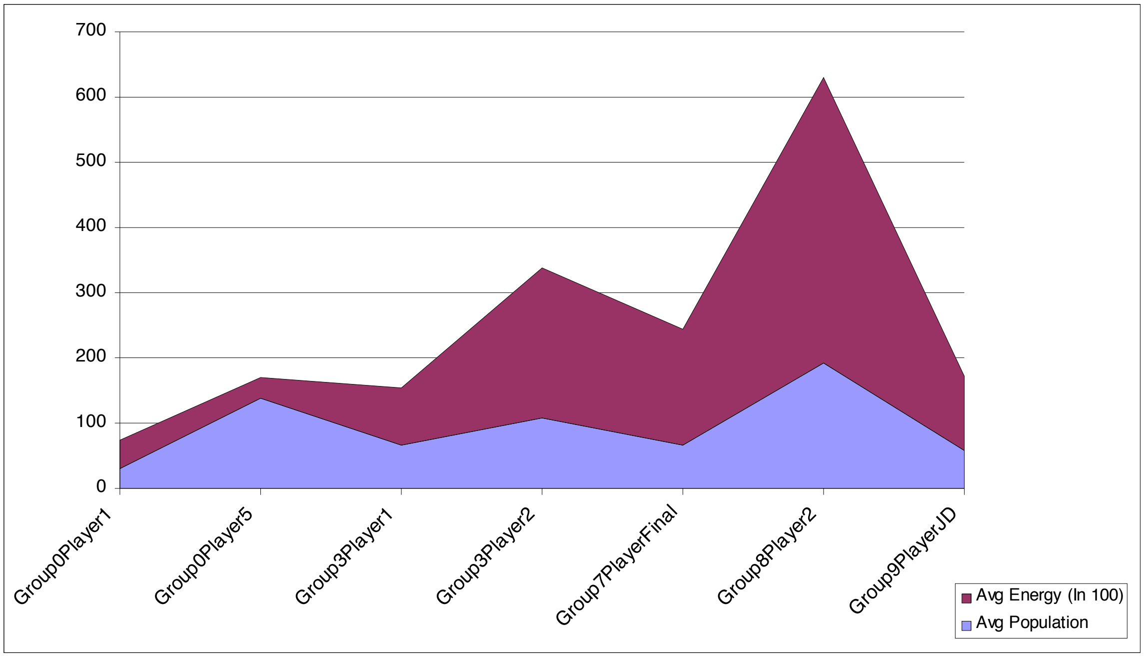
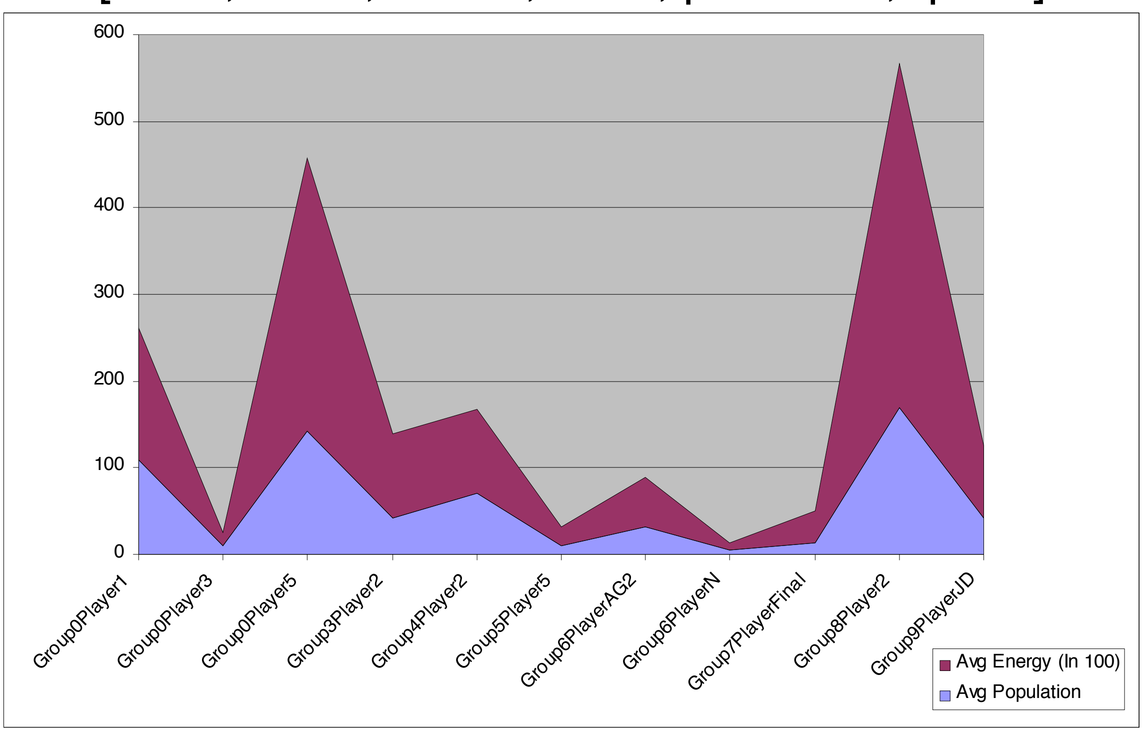


[X=50, Y=50, u=100, v=10, p=0.0050, q=0.0]



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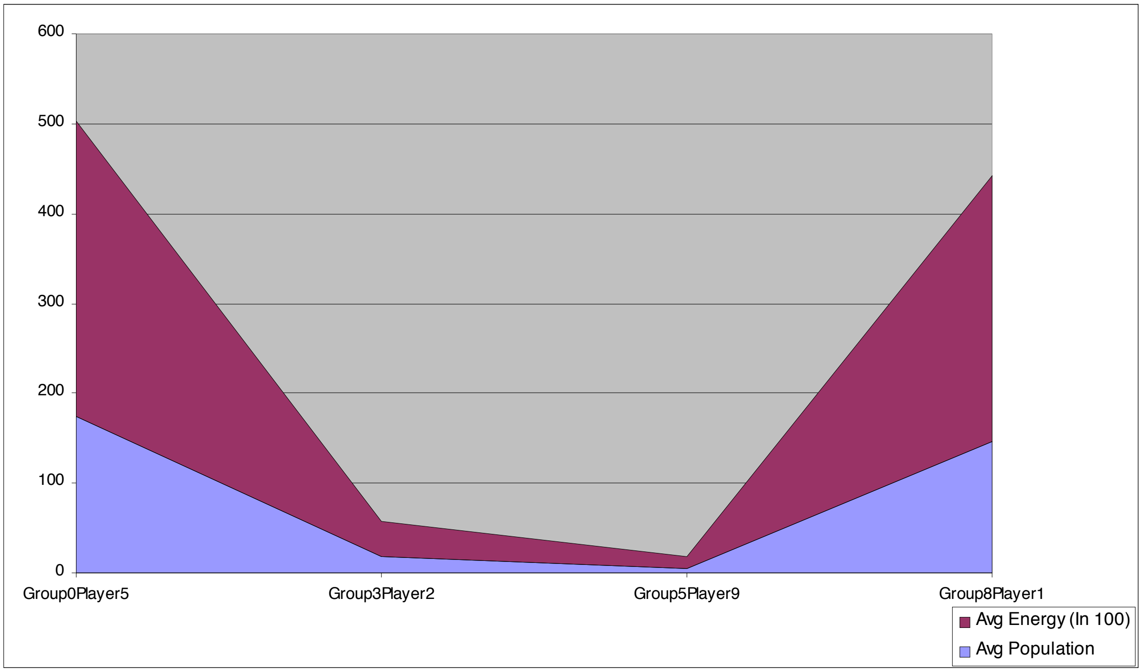

[X=100, Y=100, u=100, v=7, p=0.02, q=0.2]