Programming a New Sugarscape

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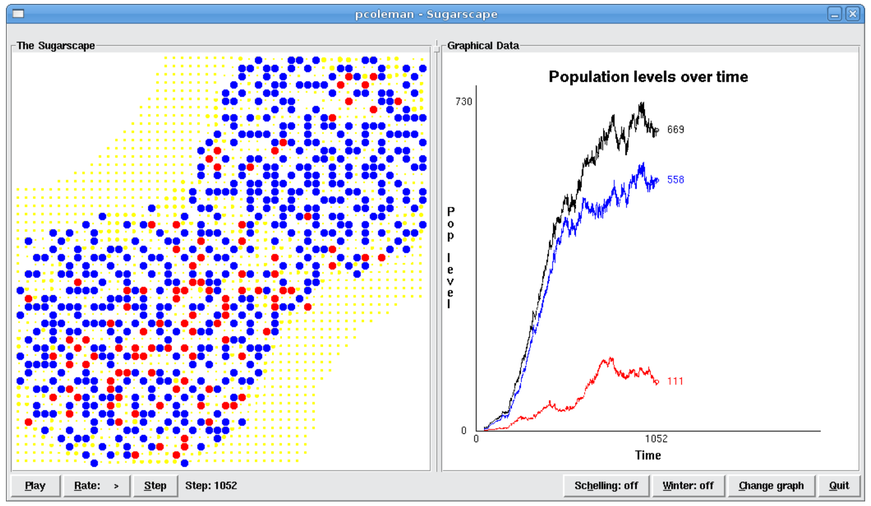

Figure 1: GUI during base case (no segregation/winters)

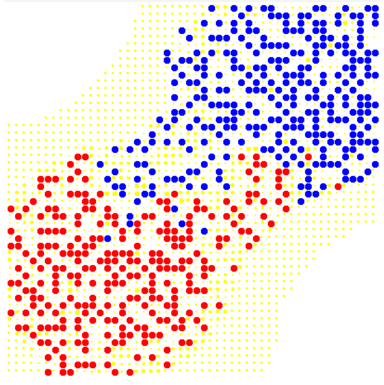

Figure 2: Schelling segregation

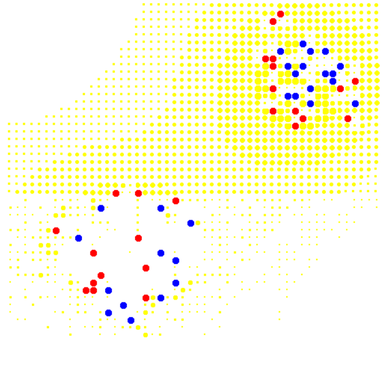

Figure 3: hemispherical gradual winters

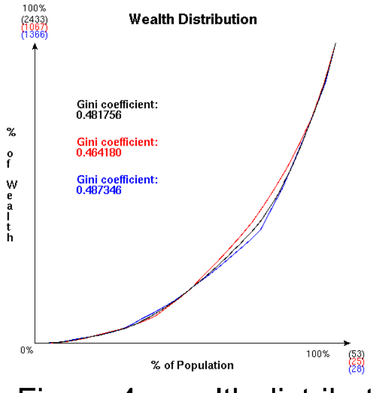

Figure 4: wealth distribution with Gini coefficients

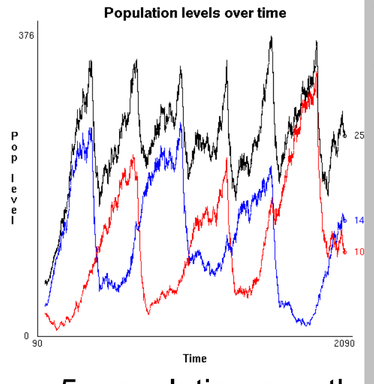

Figure 5: population growth with oscillation from winters

Abstract

This project studies artificial societies, especially the Sugarscape and the Schelling segregation model. To implement the Sugarscape, a display of the sugar-filled environment with agents is outputted. The simulation allows agents to harvest sugar, consume sugar, die of starvation, and die of old age and allows the environment to grow back at a given rate. To implement the Schelling segregation model, two distinct groups of agents are added to the environment with a preference for neighbors of their own kind to determine the effects of the individual preferences on the society at large. The reasons these two projects are being implemented is because while both are often compared, the two models in their original forms have not been combined and analyzed in a single simulation. In addition to displaying the environment, graphs showing the population growth and wealth distribution are displayed. These graphs analyze what is occurring in the simulation. Agents asexually reproduce. Seasons are implemented to analyze agent migration. The program code is broken up into files: a main file, an environment file, an agent file, a location file, a display file, and a simulation file. The conclusions show that the the model conforms to Axtell and Epstein's models in the areas which were implemented. But more importantly, it shows that the simulation conforms to real world phenomena reasonably well.

Process

--Language: Ruby (with Tk for graphics)
--Graphical User Interface: A visual representation of the environment is shown, displaying all agents and sugar at each location. In addition, graphs of population growth and wealth distribution are shown, with data for red, blue, and all agents. Gini coefficients of equality are shown as well. There are buttons to play, pause, and step the simulation and to change the graphical display. Also, winters and segregation can be toggled on and off.
--Agents: Agents can do five things: move, harvest, consume, breed, and die. Agents will pick a location to move to by judging the four directions as far as they can see for quantity and distance of sugar. Locations that are occupied or are off the edge of the environment are excluded. Locations where neighbors will not be mostly ones own color are excluded according to Schelling segregation. Harvesting sugar consists of removing the sugar from the environment and adding it to the agents wealth. Consuming sugar draws from the wealth based on the agents metabolism. There is a small chance that agents will asexually reproduce and place a single, same-colored agent in an adjacent location. Agents can die of starvation or old age.
--Environment:The environment consists of the array of agents and the matrix of locations.
--Locations: Manage the sugar they contain, and know when they are occupied by an agent. During winters, the manner of regrowth is changed. Locations furthest from the equator will lose sugar first.

Background

This project draws primarily from two different sources. The Sugarscape is modeled after the original which was described in *Growing Artificial Societies* by Axtell and Epstein. The significant differences are that reproduction is asexual and no variable information is passed as genetic inheritance and that spice trade and combat were not implemented. Also significant is that this project has never been done in Ruby. The implementation of Schelling's segregation, which was originally described in his book *Micromotives and Macrobehavior*, has a few significant differences from his model. Most importantly, agents are always trying to move so that they can consume sugar. Schelling had agents only move if they were unhappy. The rules of segregation (more than 50% must be the same color) are more strict than Schelling's original one third. Also the environment does not wrap around the edges. Multi-agent systems is a new and emerging field. Other research often concerns communication between agents, but the goal is always to model real world behavior for social science.

Results

--By analyzing the population growth graph, it was determined that the environmental carrying capacity was about 750 and the carrying capacity for a single hemisphere was 375. The forced migration due to continual winters prevents the carrying capacity from being reached. The graph has a logarithmic shape, typical of population graphs. Also there are oscillations as the population numbers level out.
--The wealth distribution graph shows unreasonably high equality among the agents. The value of the Gini coefficient of just below 0.5 is higher than a similar real world number would be. Also, it is almost impossible to determine actual wealth in America, so income is studied more often. As the population size approaches zero, changes in the Lorenz curve are much more frequent because a single agent has more of an effect.
--When winters do not force agents to migrate and mix, the two different colors of agents are almost completely segregated. Each hemisphere has one circle of high density sugar, each of which becomes occupied by a different colored agent. And because winters separate agents into the different hemispheres, one group of agents will always eventually die out as long as there are regular winters. The gradual winters also create a distinct migration pattern. First the high density sugar is harvested and agents move out in all directions. Then the agents move towards the equator. When the environment is not crowded there is little segregation. This is because locations where an agent won't be in the majority compared to his neighbors won't be chosen, but with fewer agents there are more alternatives. One sugar grows each turn. Metabolism is how much sugar an agent must eat to survive. Once an agent is surrounded, it won't move and will harvest one sugar per turn until it dies after some time depending on its metabolism.