Simulation of biological behaviors of living organisms in an ecosystem using genetic algorithm

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1 Introduction

Ecosystems are geological areas where biotic and antibiotic factors together form a bubble of life. Living organism in an ecosystem shows certain behaviors and follows some rules to survive in the world. The type of life in a system heavily depends on the surrounding environment as well. The search for food for growth, reproduction after a certain age, and death are common features that we can find in most living organisms. In this project, these biological features have been implemented. To make it less complicated, an imitation of an organism is rendered and given the option to find food to eat so it can grow like any other being. After a certain amount of time, the organism "dies" as it reaches its limit. This is a very simple demonstration of the very complex ecosystem that we live in. The reproduction of these "organisms" follow the genetic algorithm which determines which individual is best fit to survive more than others in the given environment depending on its features which are selected randomly. The organism with a poor combination of parameters will die out sooner from the lack of food or if it reaches its limit.

2 Related works

In this paper[4], a framework has been introduced to show the simulation of an afforestation process while determining tree distribution. They created a natural-looking environment that is biologically inspired where trees grow in communities and their number increases exponentially. While doing the simulation they always took 3 sub steps and they were, getting rid of dead trees, and creating new trees and their growth.These are the 3 main processes of the simulation which are implemented as software agents and which act stochastically. They kept in mind the difference in replication of each tree species and thus implemented the creation of new trees differently in each sub step by using different parameters every time. In this project, several environmental properties were considered while combining computer animation and AI. For visualizing the trees, an adaptable and flexible procedural 3D model was used. Basically, this simulation determined the distribution of individual trees across a terrain which was based on the living conditions within that terrain.

Ecosystem simulations have been quite popular over the age and many projects have been developed simulating certain properties of an ecosystem or solving one of the many problems one system might have. A similar and more complex project than mine was developed by Sebastian Lague mentioned in [2]. In this project, the author simulated "bunnies" with the properties of hunger, thirst, and reproduction. The bunnies roam around in an environment looking for food and water. They have a bar over their heads for each property to show the percentage. The author also implemented certain genes in the bunnies such as sensory distance, reproduction urge (only in female bunnies), speed, and desirability(only in male bunnies). The fur of the male bunnies turns redder according to their percentage of desirability and a female bunny can choose her partner to create offspring. The offspring inherits the properties of its parents and after birth, they're initially vulnerable as it takes time to gain speed and sense of sight.

There's another very interesting project named "predator vs prey", the link given in [1], where there are two entities. The predators can eat the prey and split itself in two after eating enough. But their health gets lower the more they move. The prey needs to stay still to gain health and they can also split in two if they stay alive long enough. Entities also have a neural network of their own. In [3], a simulation of an ecosystem has been implemented with a certain number of resources and animals in it. Moreover, the characteristics of these entities affect the trait of the animals over time. They also implemented a genetic algorithm for reproduction and it showed that the use of this algorithm helped to keep the environment more stable. They mentioned in their paper that the decision of choosing a genetic algorithm was inspired by natural selection.

3 Methodology

The project I have done uses similar methodology like some of the projects I have studied. I created an environment with food which can be eaten by the entity I created to show the natural process of an ecosystem. For the sake of simplicity, I assigned a certain maximum age for each entity. They have their own perception radius with which they can identify nearby food if it comes within their range. Then they consume it to become more healthy and survive but they will automatically die after reaching the initially set age for them. Their color ranges gradually from green to red to indicate that they're aging and becoming more unhealthy. If an entity goes below the set value of minimum health, then it dies as well. The entities can move around the given window to look for food while trying to survive in the system. They also have the ability to reproduce after crossing a given age but it is not guaranteed that they'll have an offspring. This is set by a probability value that one entity might or might not create an offspring after crossing the age threshold. I programmed the simulation in such a way that it'll end if all the entities die. The genetic algorithm is applied in the reproduction part of the program where the features of the offspring get different values and their surviving time is also different from one another. Genetic algorithm helps to show the randomness of actual living beings. The mutation is only done during the birth of a new entity.

4 Results

After the simulation we can see that the maximum time each entity can survive is 20 second and after 3 seconds they get the ability to reproduce. It is seen that if an entity consumes less food its color get redder by time and it dies even before reaching its time limit. Each entity is created with a different radius of perception and most of the entities die at different times.

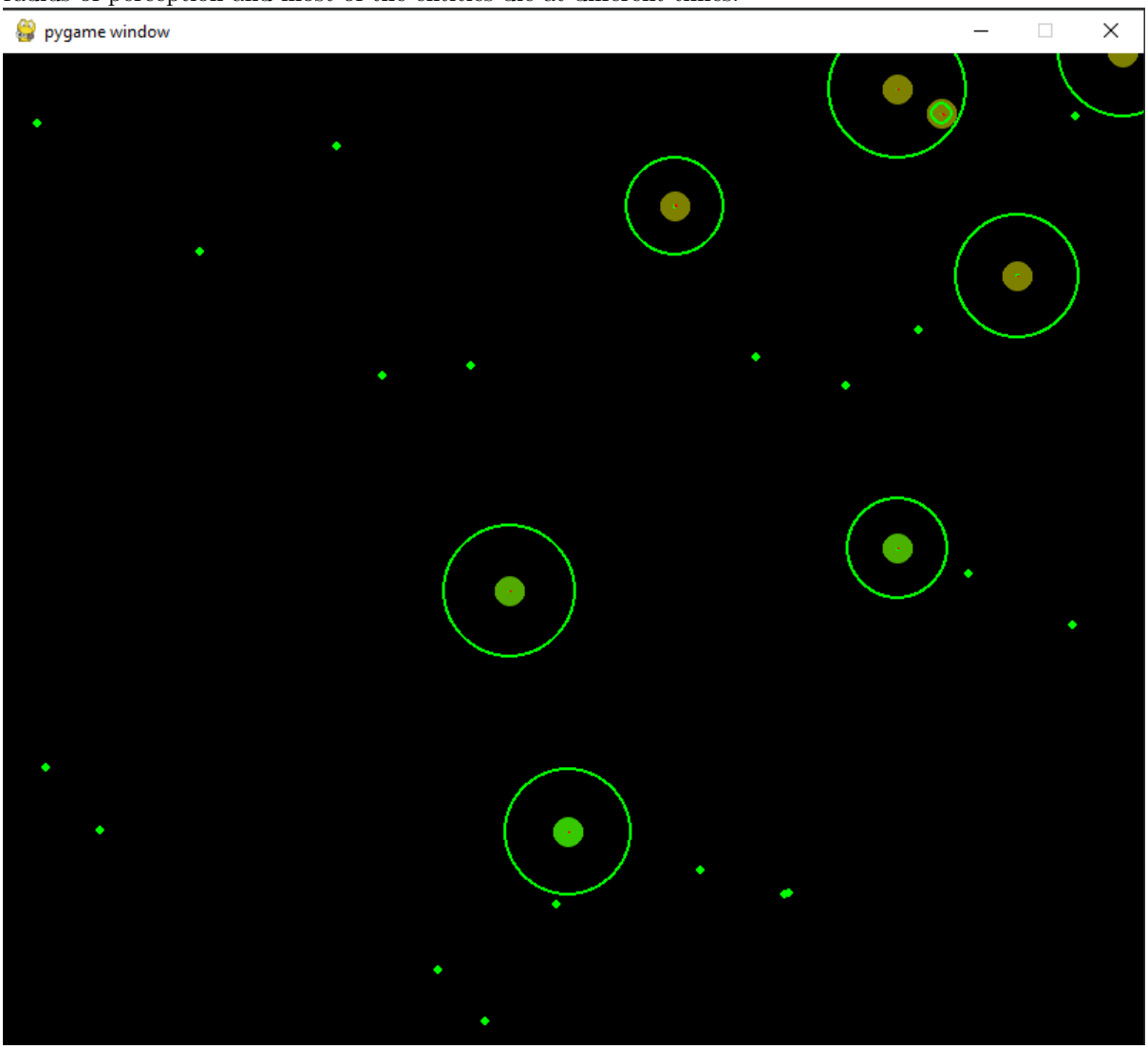

Figure 1: randomly generated entities

5 Discussion

Biological features vary from species to species and one species is different from the other. But there are certain features that can be seen in almost all the species. These common features can be seen in this simulation as well. Due to using the genetic algorithm, in each iteration the entities are created differently with a different set of parameters and certain parameters are always the same as maximum health, reproduction rate, perception radius etc. After each time, the total time passed is different. For example for consecutive 5 iterations, the total elapsed time were 49567, 30748, 45412, 28044, 38993. The average time was around 38553. I changed a few parameters like the number of food and the time entities can survive the most, and that affected the total time elapsed as well. The more time entities survive, the more food they tend to consume and the reproduction chances also increase if they're given more time to survive.

6 Conclusion and Future Work

There can be many improvements to the project I've made. It is true that most living beings die at a certain point but a certain number is not fixed for every organism. So, this feature completely violates the rules of an ecological system. So, for further improvements I can randomly assign the time they'll live. Also, more organisms can be introduced like predators. Usually, in an environment there are predators and preys. moreover, there can be diseases and certain environmental factors that can affect the growth and the reproductions of this organisms.

References

[1] https://www.youtube.com/watch?v=qwrp3lb-jkq.

[2] S. Lague. https://github.com/seblague/ecosystem-2.git.

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[4] A. Zamuda, J. Brest, N. Guid, and V. Zumer. "modelling, simulation, and visualization of forest ecosystems". In *EUROCON 2007-The International Conference on" Computer as a Tool"*, pages 2600–2606. IEEE, 2007.