Long-Term Competition for Light in Plant Simulation

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Abstract. This paper presents simulations of long-term competition for light between two plant species, oaks and beeches. These artificial plants, evolving in a 3D environment, are based on a multi-agent model. Natural oaks and beeches develop two different strategies to exploit light. The model presented in this paper uses these properties during the plant growth. Most of the results are close to those obtained in natural conditions on long-term evolution of forests.

1 Introduction

The study of ecosystems is now deeply related to economic resources and their comprehension becomes an important field of research since the last century. P. Dansereau in [1] says that "An ecosystem is a limited space where resource recycling on one or several trophic levels is performed by a lot of evolving agents, using simultaneously and successively mutually compatible processes that generate long or short term usable products". This paper tries to focus on one aspect of this co-evolution in the ecosystem, the competition for a resource between two plant species.

In nature, most of the plants compete for light. Photosynthesis being one of the main factors for plant growth, trees, in particular, tend to develop several strategies to optimize the quantity of light they receive. This study is based on the observation of a French forest composed mainly of oaks and beeches. In [2] B. Boullard says : "In the forest of Chaux […] stands were, in 1824, composed of 9/10 of oaks and 1/10 of beeches. In 1964, proportions were reversed […] Obviously, under the oak grove of temperate countries, the decrease of light can encourage the rise of beeches to the detriment of oaks, and slowly the beech grove replaces the oak grove".

2 Plant Modeling

The plant model defined in this paper is based on multi-agent systems [3]. The main idea of this approach is to decentralize all the decisions and processes on several autonomous entities, the agents, able to communicate together, instead of on a unique super-entity. A plant is then determined by a set of agents, representing the plant organs, which allow the emergence of plant global behaviors by their cooperation.

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Each of these organs have their own mineral and carbon storage with a capacity proportional to its volume. These storages stock plant resources and are used for its survival and its growth at each stage.

During each stage, an organ receives and stocks resources, directly from ground minerals or sunlight, or indirectly from other organs, and uses them for its survival, organic functions and development. The organ is then able to convert carbon and mineral resources in structural mass for the growth process or to distribute them to nearby organs.

The simulations presented in this paper focus on the light resource. Photosynthesis is the process by which the plants increase their carbon storage by converting light they receive from the sky. Each point of the foliage can receive light from the sky according to three directions in order to simulate a simple daily sun movement.

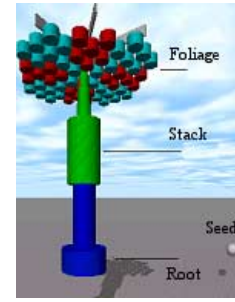

Fig. 1. Plant organs

As simulations are performed on the long-term, a reproduction process has been developed. At each stage, if a plant reaches its sexual maturity, the foliage assigns a part of its resources to its seeds, then eventually spreads them in the environment.

All the plants are disposed in a virtual environment, defined as a particular agent, composed with the ground and the sky. The environment manages synchronously all the interactions between plants, like mineral extraction from the ground, competition for light and physical encumbrance.

3 Conclusion

Two sets of simulations were performed to understand the evolution of oak and beech populations. They exhibit a global behavior of plant communities close to that of those observed in nature : oaks competing for light against beeches slowly disappear. Artificial oaks develop a short-term strategy to exploit light, while artificial beeches tend to develop a long-term strategy. The main factor to be considered in this competition was the foliage and stack properties of virtual plants, but simulation showed that another unexpected phenomenon occurred. The competition for light did not only happen in altitude at the foliage level, but also on the ground where seeds grow. Shadow generated by plants played a capital role in the seed growth dynamics, especially in the seed sleeping phase. In this competition, beeches always outnumber oaks on the long-term.

References

1. Dansereau, P. : Repères «Pour une éthique de l'environnement avec une méditation sur la paix.» In Bélanger, R., Plourde S. (eds.) : Actualiser la morale: mélanges offerts à René Simon, Les Éditions Cerf, Paris (1992).
2. Boullard, B.: «Guerre et paix dans le règne végétal», Ed. Ellipse (1990).
3. Ferber, J., « Les systèmes multi-agents », Inter Editions, Paris (1995).