Functional Tree Models Reacting to the Environment

Jing HUA∗, MengZhen KANG†
LIAMA, NLPR
Key Laboratory of Complex Systems and Intelligence Science
Institute of Automation, Chinese Academy of Science

Figure 1: (a) two trees with different spacing  (b) two neighboring trees with light competition

1 Introduction

Visually realistic tree images competing for light and space have been created previously [Paubicki et al. 2009]. Here we present a method of generating tree forms reacting to the environment based on several biological hypothesis. In this method, a tree is composed of functional organs playing roles of sources and/or sinks of biomass. Each tree is a stand-alone artificial life with internal feedback between its structure and functioning.

We tested two hypothesis of controlling bud breakout: source sink ratio and light availability. In both cases, the tree form show adaptation to the environment without human interaction.

2 Method

The mathematical model underlying our system can be referred to [Mathieu et al. 2009]. Basically, the functional feature of our system lies in the computation of biomass availability and its partitioning inside tree structure. Therefore, organ size is the result of internal competition instead of being defined independently [Paubicki et al. 2009]. The ratio between available biomass and plant demand (sum of organ sink strength) is called source sink ratio.

To obtain varying tree forms under different planting conditions, we tested two hypothesis. One hypothesis is that bud breakout takes place when source sink ratio is over a threshold. Another hypothesis is that bud fate is decided by light availability. A simple light model was implemented in our system. For each ray, we counted leaves that this ray encounters (assuming n). The visibility of this ray is calculated as $t^n$, where $t$ is the light transmittance of leaf. Finally, the visibility of a leaf is estimated using the mean value of visibility of all rays emitted from this leaf mesh. A threshold controls the fate of the axillary bud linked to this leaf.

3 Results and Future Work

Two examples of our method are illustrated in Fig.1. The same set of functional and structural parameters controlled each pair of trees. Fig.1 (a) shows two trees with different spacing conditions. Denser spacing limited biomass availability, gave lower internal source sink ratio and finally less forks. Fig.1 (b) shows two neighboring trees competing for light. As buds located at inner side see less light, fewer branches were produced, giving unsymmetrical tree structure. The two trees are different in structure because of the randomness in ray emission. Finally, the differences in tree size come from their different source and sink evolutions.

This work can serve for providing virtual tree models as required by 3D scene environment. Future work includes collision detection with environment, accurate and efficient calculation of light distribution in tree canopy, and using elaborated photosynthesis model for biomass computation.

Acknowledgements

We thank Philippe de Reffye for his full support in plant modeling. This study was supported by 863 Program of China (2008AA10Z218) and NSFC (60703043).

References
