**Literature Survey**

for

Synthetic Silviculture: Multi-Scale Modeling of Plant Ecosystems

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CIS 660 – Advanced Topics in Computer Graphics and Animation

Instructor: Dr. Stephen Lane

The authors of this paper drew inspiration from a number of sources in the graphics world. Modeling plants on a large scale has been a longstanding challenge in the field. Early works were like those of Prusinkiewicz, Lindenmayer, Oppenheimer, Aono and Kunii, which primarily focused on fractal patterns and on L-systems. The field has advanced considerably since then, though, and there are now more advanced methods. Among these are sketch-based methods such as those of Okabe et al, Wither et al., and Ijiri et al. There are also data-oriented methods which can be efficient for higher complexity with acceptable levels of detail. Another technique is optical-based methodologies including through photographs and through lidar, such as the work by Hu et al., Xie et al., Hu et al., Tan et al., Neubert et al., and Bradley et al. This work also has inspiration in the field of biology, and high accuracy requires such a level of consideration. This has ranged from growth simulations, to modeling plant interaction with wind and water using fluid dynamic techniques. Such techniques include the works of Zhao and Barbic, Quigley et al., and Habel et al. There have also been considerations of the architectural supports of climbing plants such as that of Hadrich et al. Creating biological systems on the scale of ecosystems while maintaining the level of detail of variations in individual plants involves significant complexity. Foundational methods essentially combined plant geometry and plant distribution as separate processes brought together after processing each half. The foundational work of Lsystems by Prusinkiewicz and Lindenmayer has been a common method of the former. Work on scales of rendering of ecosystems like that of Decaudin and Neyret and Boulanger and Pattanaik are examples of methods to address the latter. However, the authors of this paper look to move forward, and combine these factors in a more dynamic and detailed way. They would like to consider the creation of ecosystems at the level of detail of the growth patterns of individual plants so that interaction between plants as they grow can be considered. Some of the more recent work on the topic has addressed the growth of ecosystems on this level. Specifically, the work of Benes et al has looked at ecosystem growth with this level of detail. The next concern is the rendering of the scene at a level of detail which is appropriate to balance quality and detail with performance and memory. They reference methods that exist to represent plants at far distance efficiently including the work of Gilet et al. and Jaeger and de Reffye. They also discuss methods to reduce memory usage on the level of individual plant geometry. Another point that they highlight as a precursor is the work of de Reffye et al. which utilizes the fact that individual parts of trees and plants tend to be self-similar. Additionally, the technique of retaining detail for properties which highlight the differences of species while simplifying general foliage helps improve efficiency as well. The authors synthesize many of these techniques to find a harmony between level of detail and efficiency of processing. They also emphasize their use of ecological research from fields like forestry and botany in order to create a model which retains close basis on reality. This includes modeling on an ecological level to consider factors such as changing climates, the productivity of specific plant species, the diversity of species within a given region, and the availability and competition for resources between plants. In considering these, they reference the work of Keenan, Zhang et al., Heydari and Mahdavi, and Drever. Using this research as a foundation allowed them to combine and synthesize many prior techniques in order to draw upon advantages of each and tailor them to the goals. Specifically, they use the right balance of techniques to allow for ecological accuracy at the ecosystem level while maintaining detail and biological fidelity at the sub-plant level, all in an efficient and useable form.

**Research Evolution of Select Significant Papers**

Diagram

Description automatically generated

**Chronology of Ecologically-Related Papers**

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**Chronology of Graphics-Related Papers**

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