On the applicability of L-Systems and Iterated Function Systems for grammatical synthesis of 3D models

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Abstract. The elegance, beauty, and relative simplicity of the geometric models that characterize plant structure have allowed researchers and computer graphics practitioners to generate virtual scenes where natural development procedures can be simulated and observed. However, the synthesis of these models resembles more an artistic process than a scientific structured approach. The objective of this project is to explore the feasibility of constructing a computer vision system able to synthesize the 3D model of a plant from a 2D representation. In this paper we present the results of different authors' attempts to solve this problem, and we identify possible new directions to complement their development. We are also presenting the extent of applicability of L-systems and iterated function systems for solving our problem, and present some ideas in pursue of a solution in this novel manner.

1 Description and motivation

Modelling of complex objects is clearly a very important issue from a scientific, educational and economic viewpoint. As a result, we are able to simulate and observe features of natural organisms that can't be directly studied. Plants are a special case of "complex objects" that develop in a time-dependant manner. Computer-aided representation of these structures and the processes that create them combines science with art.

From a practical point of view, the detailed study of a plant (or of a set of plants from a field) is a precious source of information about their health, the treatments that the field has undergone and, consequently, about the schedule of treatments required. However, there is a physical impossibility in bringing all the specialized equipment needed to perform such a study. A novel approach to solve this constraint is to build a detailed model of the plant in order to make a detailed study with computer methods. So, the question of how to model a plant in a detailed manner (in a geometric, structural, or mathematical way) is an important point. The most commonly used models are called L-Systems, which are grammatical rewriting rules introduced in 1968 by Lindenmayer [2] to build a formal description of the development of a simple multicelular organism. This grammatical system is so expresively powerful that there exist languages that can be described by context-free L-Systems, but can't be described by Chomsky's context-free class of grammars.

Because plant development and growth are highly auto-similar, L-Systems are used as a tool for modelling their immense complexity. Particularly, L-Systems have been devoted to study superior plants. With these ideas and a simple representation model (based on the LOGO *turtle*) researchers have been able to represent a large set of natural phenomena.

2 General and specific goals

L-systems allows complex objects to be described with a very reduced number of rules; however, the construction of a grammar that represents a specific structure is not a trivial task. We feel, just as Prusinkiewicz and Hanan in [5], that "*(...)it is advantageous to have a more systematic approach to the modelling of plants*". This defines the limits of a very specific problem, the *inverse problem*: can we define an automatic method to synthesize a grammar to represent a specific form?

The main goal of this project is to systematically explore different methods to do the reconstruction of 3D objects from partial 2D information. Jurgensen, Lindenmayer and Prusinciewicz (in [1], [3] and [4]) have proposed answers to this question. But no method is general enough, nor good enough. In this work we present the comparison of the 3 solutions, and we identify possible new directions to continue their development. We are also presenting the extent of applicability of L-systems and iterated function systems for solving our problem, and present some ideas in pursue of a solution in this novel manner.

References

1. H Jurgensen and A Lindenmayer. Modelling development by 0l-systems: inference algorithms for developmental systems with cell lineages. *Bulletin of Mathematical Biology*, 49(1):93–123, 1987.
2. A Lindenmayer. Mathematical models for cellular interaction in development. parts i and ii. *Journal of Theoretical Biology*, 18:280–299 and 300–315, 1968.
3. A Lindenmayer. Models for multicellular development: characterization, inference and complexity of l-systems. *Lecture Notes in Computer Science 281: Trends, techniques and problems in theoretical computer science*, 281:138–168, 1987.
4. A Lindenmayer and P Prusinkiewicz. Developmental models of multicellular organisms: a computer graphics perspective. In C. Langton, editor, *Artificial Life: proceedings of an interdisciplinary workshop on the synthesis and simulation of living systems*. Addison-Wesley, Los Alamos, 1989.
5. P Prusinkiewicz and Jim Hanan. Visualization of botanical structures and processes using parametric l-systems. In D. Thalmann, editor, *Scientific Visualization and Graphics Simulation*, pages 183–201. J. Wiley and sons, 1990.

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