Modeling of Flowers with Inverse Grammar Generation Interface

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ABSTRACT

Flowers belong to one of the natural phenomena that cannot be captured completely, as there is enormous variety of shapes both within and between individuals. The authors propose a procedural modeling of flowering plants using an extension of L-Systems – a model based on three-dimensional generalized maps. Conventionally, in order to build a model the user has to write the grammar, which consists of the description of 3Gmaps and all the production rules. The process of writing a grammar is usually quite laborious and tedious. In order to avoid this the authors propose new interface functionality: the inverse modeling by automatic generation of L-systems. The user describes the flower he wants to model, by assigning the properties of its organs. The algorithm uses this information as an input, which is then analyzed and coded as L-systems grammar.

Keywords: 3Gmaps L-System, Flower Modeling, Grammar Generation, Inverse Modeling, L-Systems, Natural Phenomena

INTRODUCTION

Plants have always intrigued scientists as besides of its sheer importance for the earth, their beauty and enormous variety of shapes tempt to thoroughly inquire about its nature. One of the aspects of this inquiry is the creation of the virtual model in order to mimic real plants to a high degree of accuracy (Gielis & Gerats, 2004; Prusinkiewicz & Runions, 2012). The foci of our study are the flowering plants, which play a huge role in our life from nutritive and medical purposes to beautifying the environment. Obtaining an accurate geometrical model of a flower is quite useful as it plays an important role in the validation of the virtual model. Besides, the visualization of parameters not traceable directly in living flowering plants is a stand-by in studying their physiology. A huge biological diversity both within and between individuals provides a vast area of objectives which the image synthesis must challenge. Modeling virtual flowering plants have been performed by several methods, most of which are oriented
towards the output image and based on software related motivation. Here the task of modeling is undertaken mainly by the user describing a plant structure and its components and defining the required parameters. The degree of realism depends on the users skills. Such methods are quite intuitive for a common user, but have the inconvenience of creating each sample from scratch in case of generating a variation of slightly different flowers. However, some of the methods are pursuing biological plausibility, using procedural modeling. Most of them are based on L-systems, which can generate complicated multicellular structures from a small number of rules. They are able to get a lot of flower samples based on a single grammar by simply changing the parameter values. Although these methods can provide impressive results, the underlying algorithms are not so intuitive for common users.

The study of these methods points to look for another approach which can combine science with art, establishing interplay of the realism of the models and clearness for the users. Pursuing this goal we propose in this paper an application of the 3Gmap L-systems: flower modeling by growth simulation. Our approach combines L-systems grammar writing with interactive control of parameter settings. Here the L-systems operate with subdivision of volumes, namely 3Gmaps. The used L-systems grammars have a nested structure allowing to combine several grammars which represent the different flower organs. In order to avoid the laborious task of grammar writing we propose a new interface function: the inverse modeling by automatic generation of L-systems. The user describes the flower he wants to model by mentioning the properties of its organs. The algorithm uses this information as an input, which is then analyzed and coded as L-systems grammar.

The framework we propose in this paper offers several improvements with regard to previous methods:

- The user can control the final result by interactively setting the parameters of the grammar. These contributions make the task of a user more obvious and intuitive which in turn enables to create more accurate models.
- The way the model is built allows us to take into account its internal structure. As the flower tissue is non-homogeneous, this can be quite useful to render more accurate subsurface scattering.
- The result is stored as a grammar, which has an infinite variety of potential flower models.

This article is structured as follows. In the second section we summarize the related work on modeling plants and flowers. In the third section we sketch in a botanical structure of a flower, classifying its constituent parts. The fourth section describes our original method and its application in flower modeling. In the fifth section we explain the mechanism of our inverse interface. Later, the sixth section presents and discusses the obtained results. Finally, conclusion as well as a future work layout is given in the seventh section.

RELATED WORK

Plants were the object of intensive study and as flowering plants are among them we will have a look at diverse methods of plants modeling.

Plants are living organisms with the structure and developmental processes obeying to some internal rules, which the scientists are trying to reveal since always. One of such attempts was made by Aristid Lindermayer who proposed a formal description of plant development as a string rewriting mechanism, known as L-system, which has a recursive nature and leads to a self-similarity in plants. Since then it has been expanded into a very efficient mechanism, which is applied in modeling of growth processes of plant development and also in modeling of morphology of a variety of organisms (Prusinkiewicz & Lindenmayer, 1990).
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