Modeling plant development with L-systems

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Abstract

The development of an organism is a process based on self-organization, the main feature of which is the creation of global patterns and forms through local interactions of their components. These interactions are driven by local rules for the spatially distributed dynamic processes of *morphogenesis* – the development of the shapes of the organism and its parts – established by genes and molecular-level processes. Standard computational models lack the geometric concept of space needed to model this behavior. Therefore, *cellular automata* and *L-systems* inspired by them were introduced. Since then, L-systems have been a key concept for modeling plant development from molecular genetics and physiology to whole plant architecture and communities.

L-system could be described as a combination of cellular automaton and *context-sensitive grammar* with some additional features. The given initial string (*axiom*) is gradually overwritten using production rules applied in parallel synchronously to simulate uniform time progression throughout the entire evolving structure.

In this lecture, we first introduce the concept of cellular automata. On their basis, we further define L-systems, present some of their useful extensions, and highlight the differences between these two models. Next, we focus on the geometric interpretation of L-systems, since the incorporation of geometry greatly extends their modeling power, and we outline the impact of rule and interpretation changes on the resulting plant. Lastly, we mention the modeling of *phenotypic plasticity* – the impact of environmental conditions – and how tree development can be modeled.