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Inference of structural plant growth from discrete samples

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Highlights: We present an approach for the rapid generation of plant growth models from a series of explicit growth stages. Multiple structural plant descriptions, which can be gained from 3D scans, are automatically inferred to an L-system grammar. Morphological leaf features are incorporated into this model by parameterization of the structural description.

Keywords: grammar inference, L-systems, plant growth modeling

Modern phenotyping systems like sheet-of-light scanners allow the accurate acquisition of plant geometry, from which a description of the branching structure can be extracted (see Bucksch et al. 2010). An explicit description of the structural development over time can be gained by measuring a plant at different growth stages. L-systems are commonly used to formally describe plant structure and its development during growth (Prusinkiewicz et al. 1990). However, the development of a growth model recreating specific plant structures requires expert knowledge and is often accomplished by time-consuming trial-and-error. We present an approach to computationally infer an L-system from feature vectors describing the structure of plants at successive growing stages. The aim of our approach is to close the gap between measured data and the plant growth model.

The approach consists of an inference step to model structural plant growth, which is amended by leaf morphology features in a parameterization step. The plant structure is derived from linear sequences of feature vectors (e.g. extracted from 3D scans) using a variation of the SEQUITUR-algorithm as introduced by Nevill-Manning (1996). In the course of this derivation, the inferred rules are unified to an L-System grammar with only a small set of rules. In order to incorporate leaves into the branching structure the L-system is parameterized with morphological leaf features, which can be imported from real measurement data. Intermediate plant growth stages can be created by parameter interpolation.

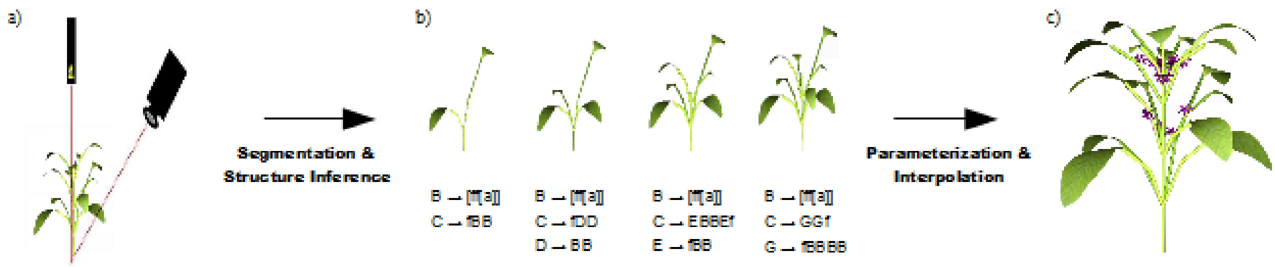

Fig. 1. Overview of the approach: a) Acquiring structual and morphological input e.g. by measurements. b) Result of the inference step (grammar and 3D-visualization). c) Final result: Parameterized plant model at one growth stage.

The generated parameterized L-system can be used as a basis for more sophisticated functional-structural plant models. Furthermore, the growth model can directly be used as input for system design tools in order to minimize occluded parts in the measurement data (Uhrmann et al. 2011).

LITERATURE CITED

Bucksch A, Lindenbergh R, Menenti M. 2010. SkelTre. *The Visual Computer* **26**: 1283-1300, *Springer*

Nevill-Manning, CG. 1996. Inferring Sequential Structure. *Ph.D. Thesis, University of Waikato, New Zealand.* 55 p.

Prusinkiewicz P, Lindenmayer A. 1990. The Algorithmic Beauty of Plants. *Springer* 40 p.

Uhrmann F, Seifert S, Scholz O, Schmitt P, Greiner G. 2011. Improving Sheet-of-Light Based Plant Phenotyping with Advanced 3-D Simulation, *Microelectronic Systems*, *Springer.* 247-258