Species-Level Tree Biomechanical Models

Like Gobeawan[1]*, Calvin C.W. Lim[1], Alex T.K. Yee[2], Sum Thai Wong[1], Daniel J. Wise[1], Yi Su[1], Ervine S. Lin[3], Abhishek Tandon[2], Hee Joo Poh[1]

[1] Institute of High Performance Computing - A*STAR, Singapore
[2] National Parks Board, Singapore
[3] National University of Singapore, Singapore
* Corresponding author's email: gobeawanl@ihpc.a-star.edu.sg

Abstract

In order to perform virtual environmental simulations on impact of trees at a city-scale, we attempted to represent - physically and botanically - trees of various species with specific structures, sizes, and characteristics as distinct 3D biomechanical models that can grow over time (Gobeawan et al. 2019). The work was a part of an initiative to model all city trees at various levels of detail for Virtual Singapore (Gobeawan et al. 2018) with a field measurement work to obtain statistics (Lin et al. 2018) and a data structure proposal (Lin et al. 2019). Subsequently, this paper presents our formulated growth rules (Figure 1) to model tree species procedurally in 3D using L-system.

[Conditions if any]	[Rule]	[Conditions if any]	[Rule]
	Seed → Seed		Node → Node
Germination:	Seed → Root Shoot	Cell division:	Node → Leaf [Bud] Node
	Root → Root	Leaf growth:	Leaf → Leaf
		Leaf fall:	Leaf →
	Shoot → Bud		
			Flower → Flower
	Bud → Bud	Flower fall:	Flower →
Primary growth:	Bud → Node Internode	Pollination, fertilisation:	Flower → Fruit
Bud			
Reproduction:	Bud → Flower	Ripening:	Fruit → Fruit
Aborting:	Bud →		Fruit →
Terminal branching:	Bud → [Bud] [Bud]	Spreading seeds:	Fruit → Seed Fruit
Secondary growth:	Internode → Internode		

Figure 1. Tree growth rules

We incorporated aspects of the plant architecture (Barthelemy & Caraglio 2007) such as growth process, branching process, tropism, and phyllotaxy into the L-system growth rules. The rules mimic the plant cell growth phases of meristematic/formative, enlargement/elongation, and maturation through primary and secondary growths. Thus, the rules govern the tree transformation stages from seed to seedling, sapling, mature, reproduction, decline, and death. As a result, our formulated growth rules may generate all varieties of tropical tree species models according to Halle-Oldeman-Tomlinson architectural models. In this modeling, we focused mainly on the permanent growth and branching structure of trees, while ignoring seasonal components of trees (such as leaves, flowers, and fruits) and those components with unattainable data (such as root).

We show that the resulting dynamic species models represent various tree species morphologically (Figure 2). Given actual measurement and species data, actual trees can be modeled in a large scale by automation. In practice, these models will be adapted to simulation-ready mesh models (Lim et al. 2020) for various simulation purposes, such as wind-tunnel simulation, tree fall, and urban planning.

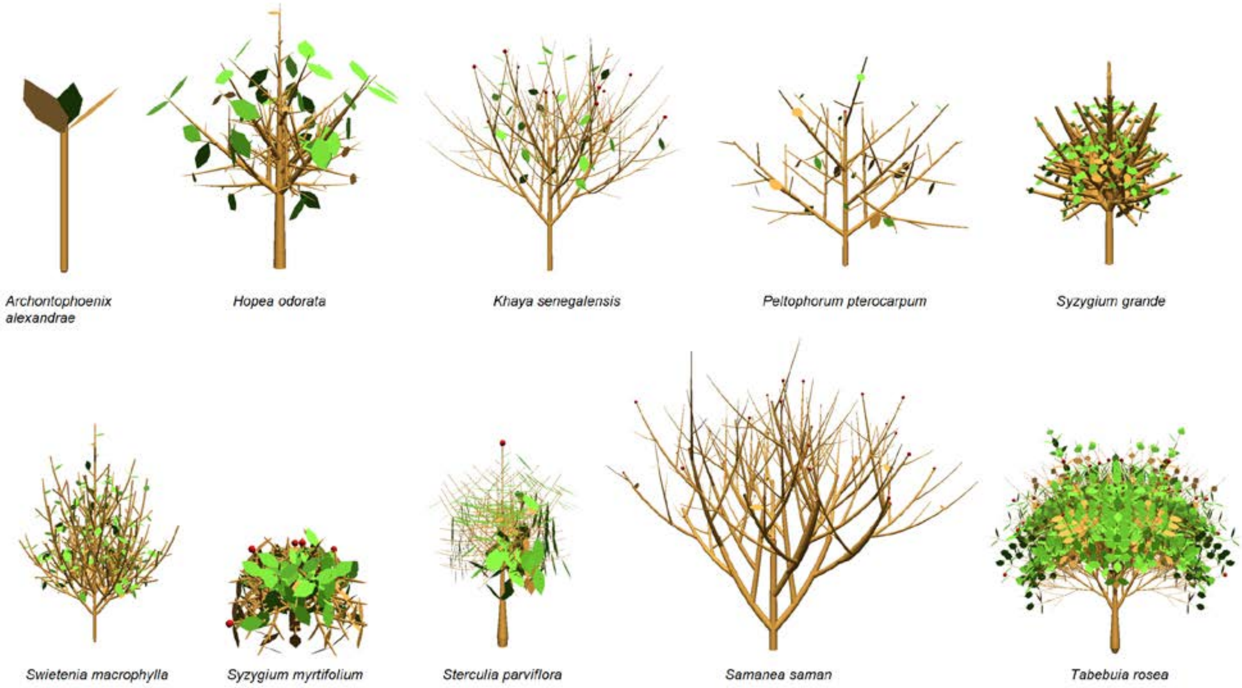

Figure 2. Example of species models

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Preferred session/format

Trees as biological/engineering structures