Modeling Plant Life in Computer Graphics

Overview

Siggraph 2016 Course

Sören Pirk, Bedrich Benes, Takashi Ijiri, Yangyan Li, Oliver Deussen, Baoquan Chen, Radomír Měch
Plants in Computer Graphics

• Biologically-based simulations

• Plant is a modular system – basic elements (leaves, internodes, etc.)

• Ecosystems consider entire plant communities (a plant is a module)

• Plant geometry is the result of interaction of the modules
Plant Modules

- leaf
- branch
- segment
- lateral buds
- apical bud
Plant Growth

- Growth is biologically-based
- Uses plant modules to control the growth
- Primary growth – apex extension
  - Apical bud
  - Lateral buds
    - Initially dormant
    - Activated after some time
Plant Growth

- Secondary growth (cambial growth)
- Branch is getting thicker
- Annual rings formation
Generic Plant Modeling System
Plant Definition

• Ramification (branching)

• Biological model

• Bud lifespan

• Plant sensitivity to external impetus
Ramification

Continuous

Rhythmic

Image from (de Reffye et al 1988)
Axis (branch) order

Image from (de Reffye et al 1988)
Biological Model

Corner

Massart

Leeuwenberg

Rauh

Images from (de Reffye et al 1988)
Light and Phototropism

• plant growth is driven by buds ("plant engines")

• each bud evaluates its illumination

• determines the brightest spot (bending)

• % of illuminated buds on a branch determines its fate
Illumination

• Phototropism
  • Branches tend to grow toward the light
  • Calculate the total illumination on a bud $i$
    \[ E_i = \frac{n_i}{m} \]
    • $n_i$ – no. of positive samples
    • $m$ – no. of all samples

• Find the brightest spot
  • Bend the direction
Light and Phototropism
Gravity

• Gravitropism
  • Branches tend to grow against gravity
Competition for Resources

• Branches tend to avoid each other

• Honda model [Honda67]
  • A buds has a sphere of interest
  • Two spheres cannot overlap
  • If two spheres collide – do something
Competition for Resources

• a small ecosystem fighting for space on bud level
Competition for Resources
Competition for Space

• Branches compete for space
Competition for Resources

• at the level of an ecosystem

Ecosystems

• A module, so far, was a part of a plant

• An entire plant can be thought of as a module

• Plants compete for resources (Extended Phenotype – Dawkins)

• Result of the competition are ecosystems
Ecosystems

25 years

75 years

100 years

125 years
Urban Ecosystems
Cambial (Secondary) Growth

Cambial (Secondary) Growth

• Uses deformable simplicial complexes

• Propagate vertices based on growth function

• Detection of collisions and self-intersections

• Adds cracks
Cambial (Secondary) Growth
## Used References