

Computer Graphics

Procedural Methods - L-Systems Part 2

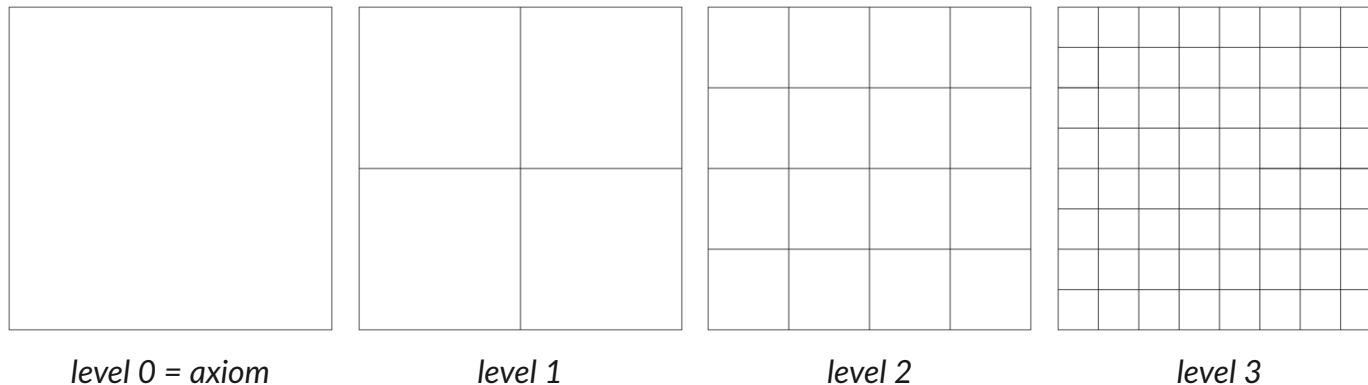
Mark Pauly

Geometric Computing Laboratory

Inverse Problem: Regular Grid

- Which L-System creates this output?

- define the axiom and the rule(s)



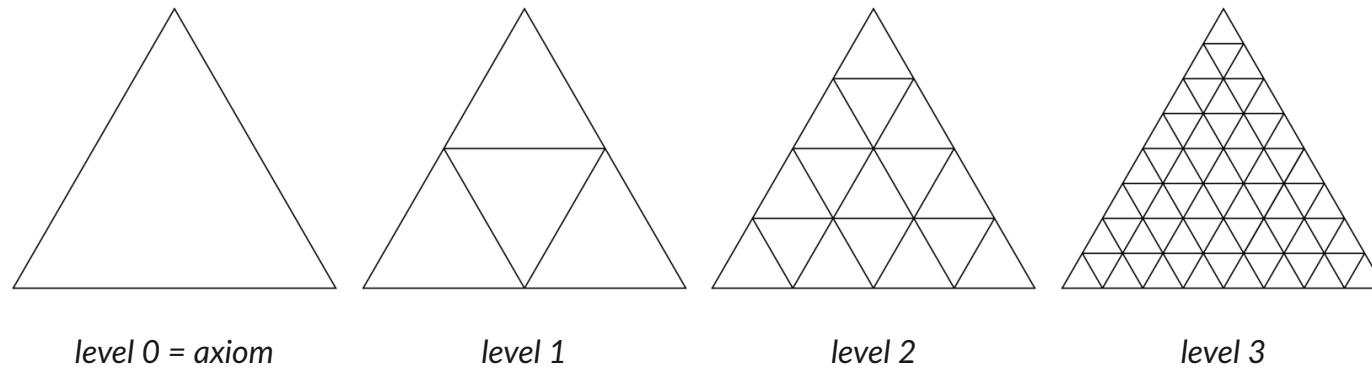
- Solution

- Axiom: $F + F + F + F + F$
 - Rule: $F \rightarrow F + F - -F + F$
 - Angle: 90

Inverse Problem: Regular Grid

- Which L-System creates this output?

- define the axiom and the rule(s)

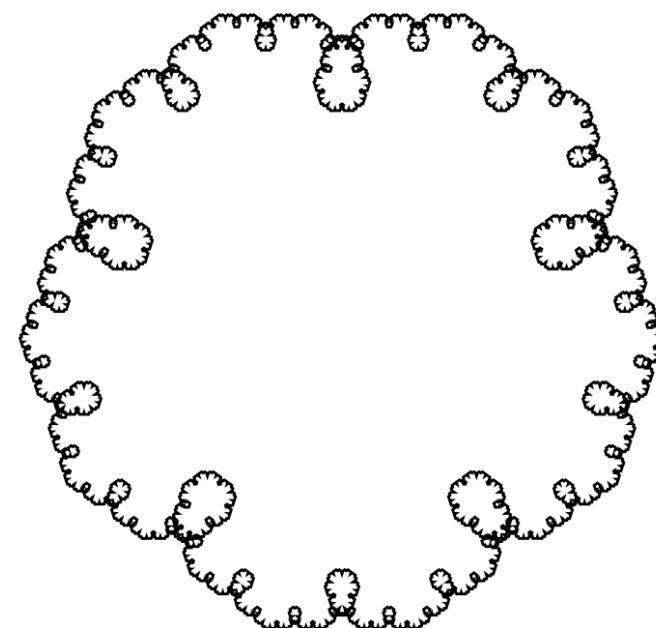


- Solution

- Axiom: $F + +F + +F$
 - Rule: $F \rightarrow F + +F -- - F + F$
 - Angle: 60

Inverse Problem: Penta Flower

- Which L-System creates this output?
 - define the axiom and the rule(s)

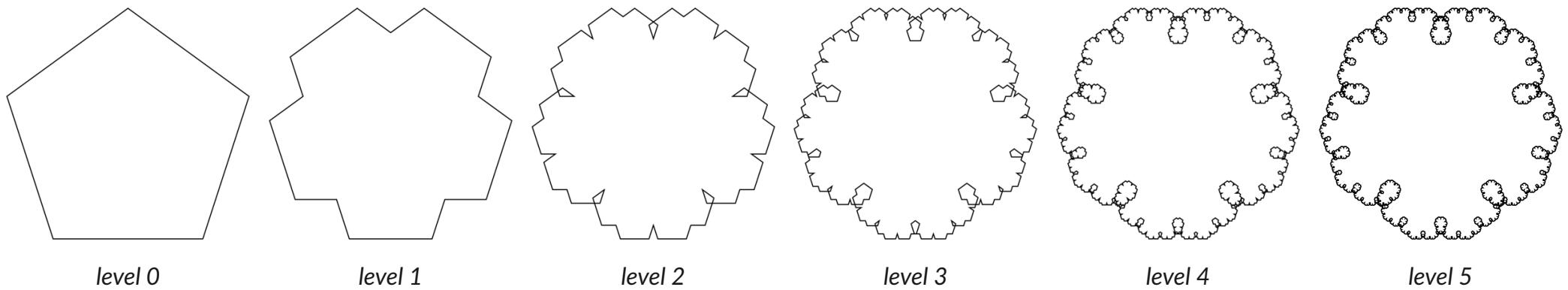


What??

Inverse Problem: Penta Flower

- Which L-System creates this output?

- define the axiom and the rule(s)

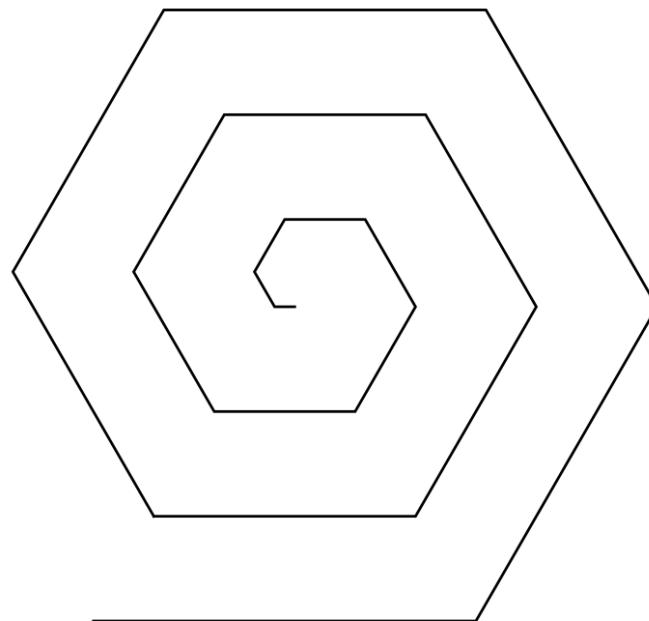


- Solution

- Axiom: $F + F + F + F + F$
 - Rule: $F \rightarrow -F + FF + F -$
 - Angle 72

Inverse Problem: Spiral

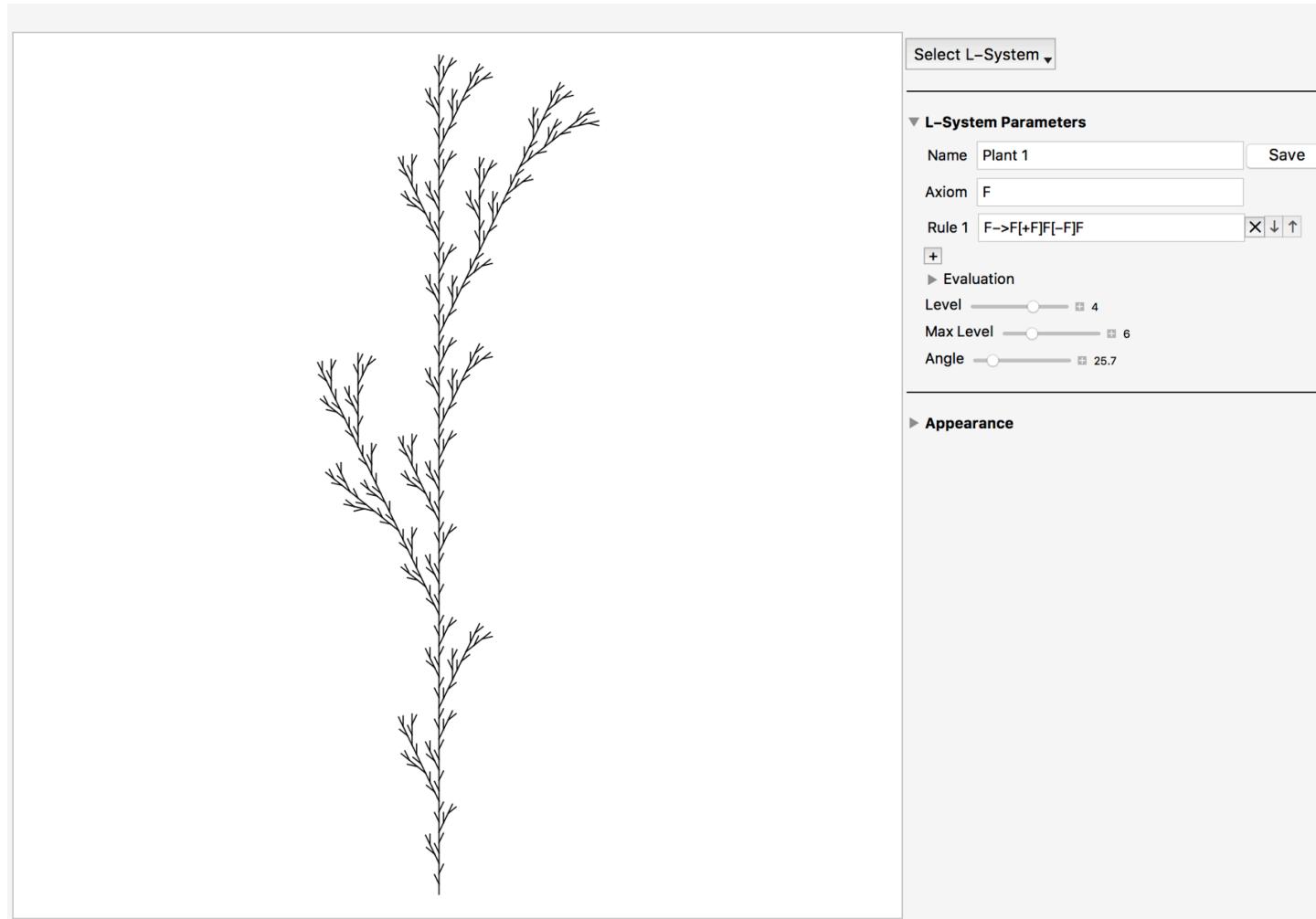
- Which L-System creates this output?
 - define the axiom and the rule(s)



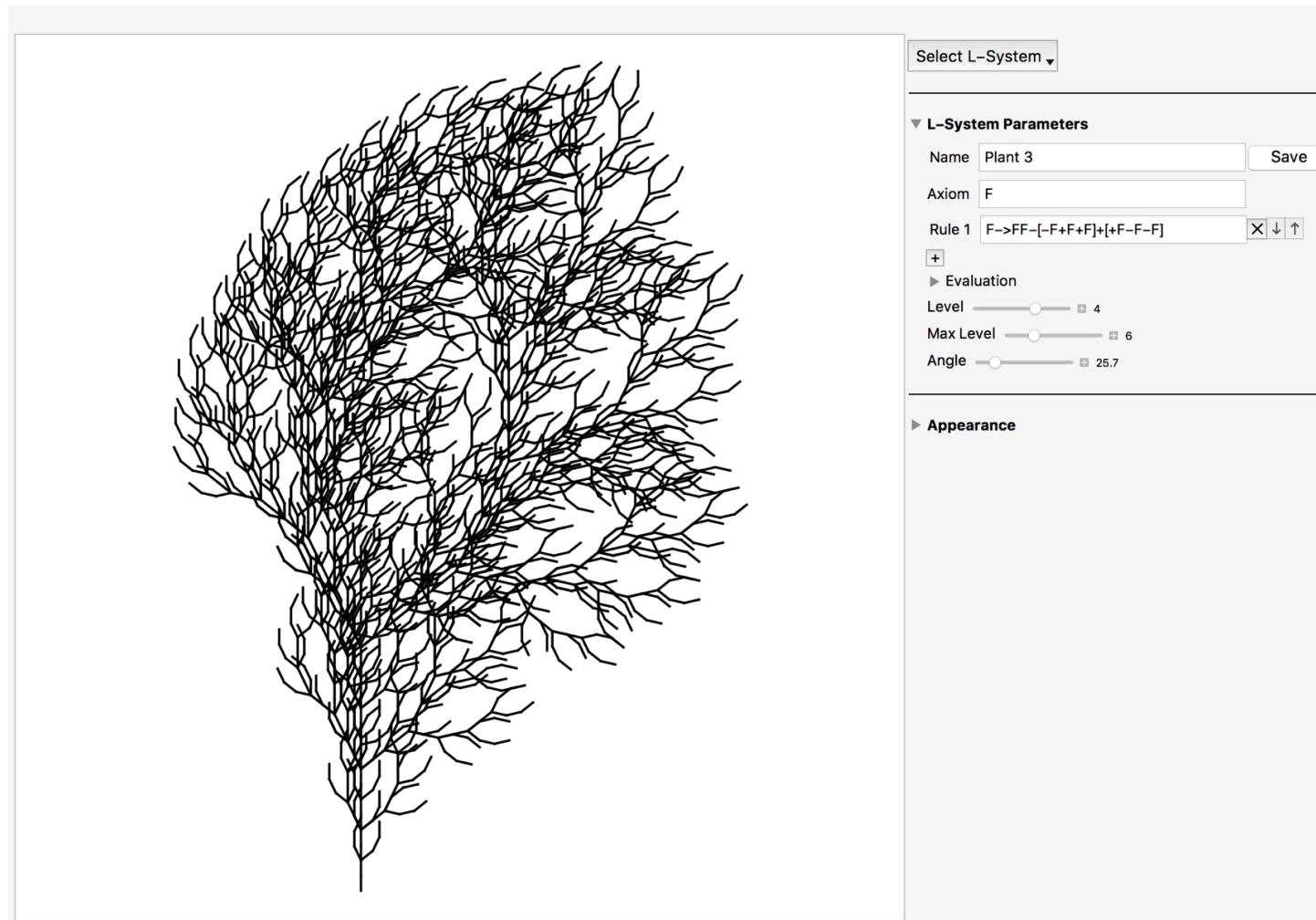
Branching Structure

- Branching is prevalent in plants
- Bracketed L-Systems introduce two new symbols: [and] to push and pop turtle's state
- Example: $F[+F][-F[-F]F]F[+F][-F]$

Examples



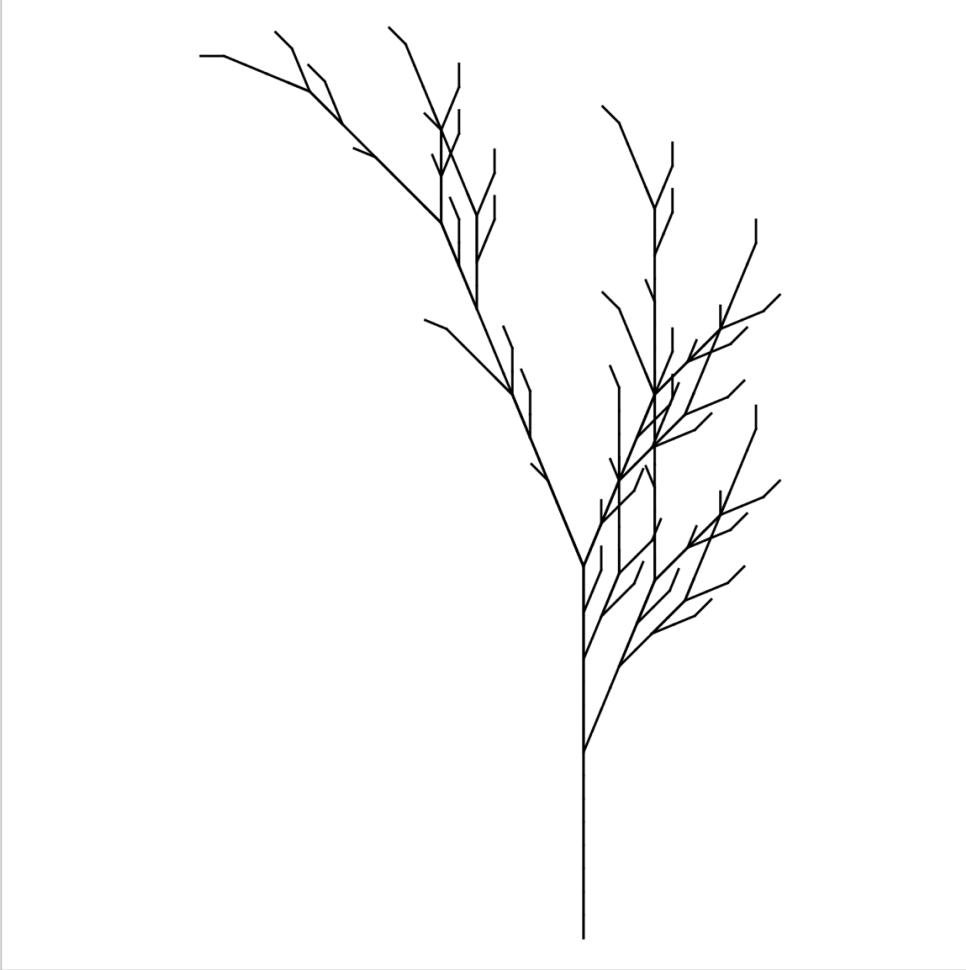
Examples



The screenshot displays a user interface for a L-System generator. On the left, a large, intricate fractal tree structure is rendered in black lines against a white background. On the right, a configuration panel is shown with the following details:

- Select L-System ▾**
- L-System Parameters**
 - Name: Plant 3
 - Axiom: F
 - Rule 1: F->FF-[-F+F+F]+[+F-F-F]
 - Level: 4
 - Max Level: 6
 - Angle: 25.7
- Appearance**

Examples



The image shows a L-System generated fractal tree diagram. The tree has a single vertical trunk on the right that branches out into several smaller trunks, which further branch into a dense network of twigs. The branches are thin and black, set against a white background.

Select L-System ▾

▼ L-System Parameters

Name: Plant 6 Axiom: X

Rule 1: X->F-[[X]+X]+F[+FX]-X

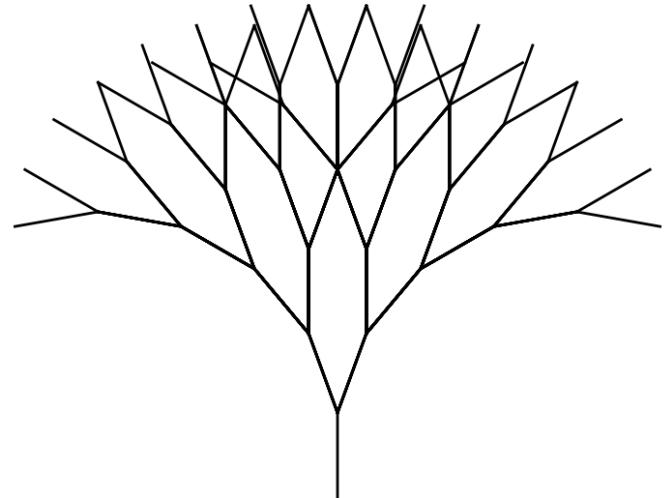
Rule 2: F->FF

+ Level: 4 Max Level: 7 Angle: 22.5

► Appearance

Inverse Problem: Tree

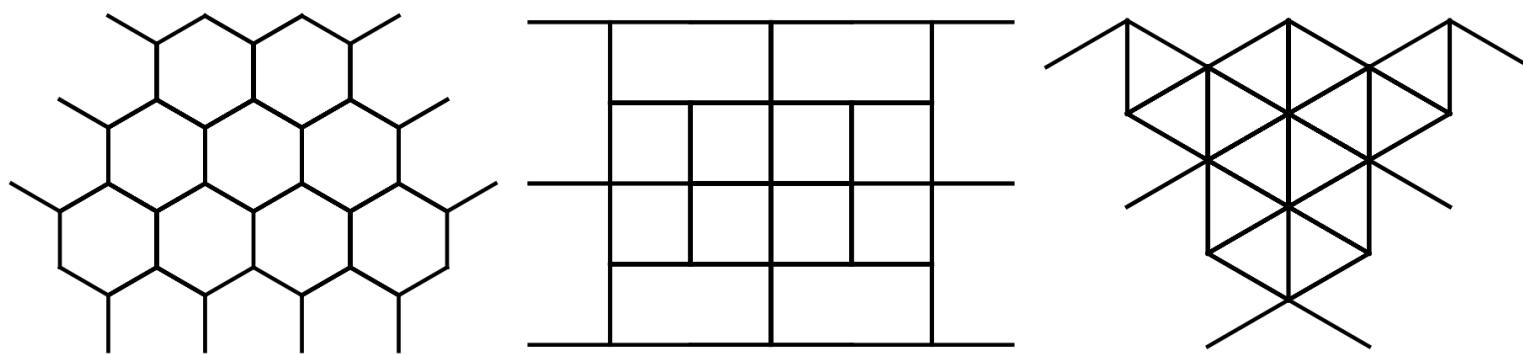
- Which L-System creates this output at level 5 for angle 20?
 - define the axiom and the rule(s)



- Solution
 - Axiom: F
 - Rule: $F \rightarrow F[+F][-F]$

Inverse Problem: Tree

- Which L-System creates this output at level 5 for angles 60, 90, 120, resp.?
 - define the axiom and the rule(s)



Stochastic L-Systems

- **Problem:** All plants generated by the same deterministic L-System are identical.
 - We want specimen-to-specimen variations that will preserve the general aspects of a plant but will modify its details.
- **Solution:** Stochastic L-Systems provide a probability for each production rule. Production rules are chosen according to this probability distribution

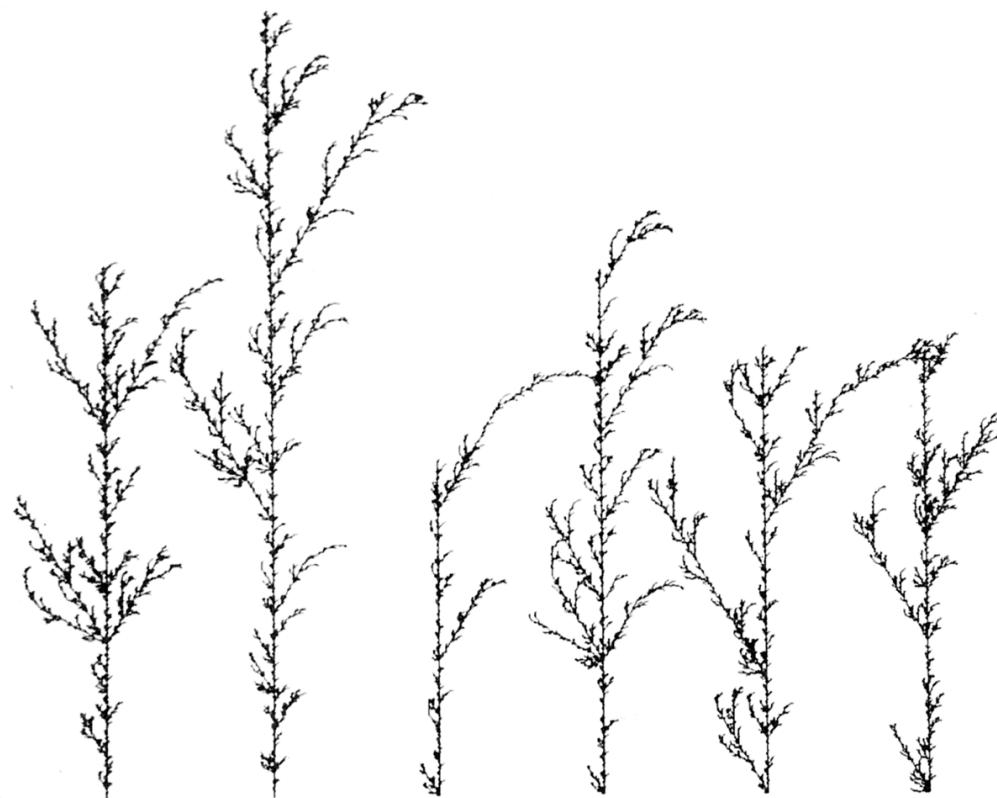
$$\omega : F \quad (1)$$

$$p_1 : F \xrightarrow{.33} F[F + F]F[-F]F \quad (2)$$

$$p_2 : F \xrightarrow{.33} F[F + F]F \quad (3)$$

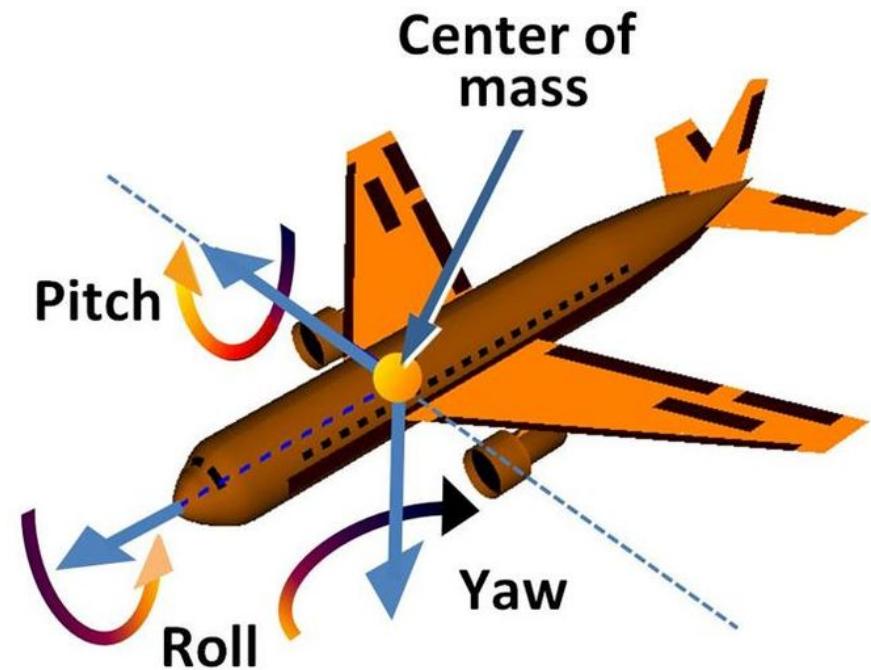
$$p_3 : F \xrightarrow{.34} F[-F]F \quad (4)$$

Stochastic L-Systems

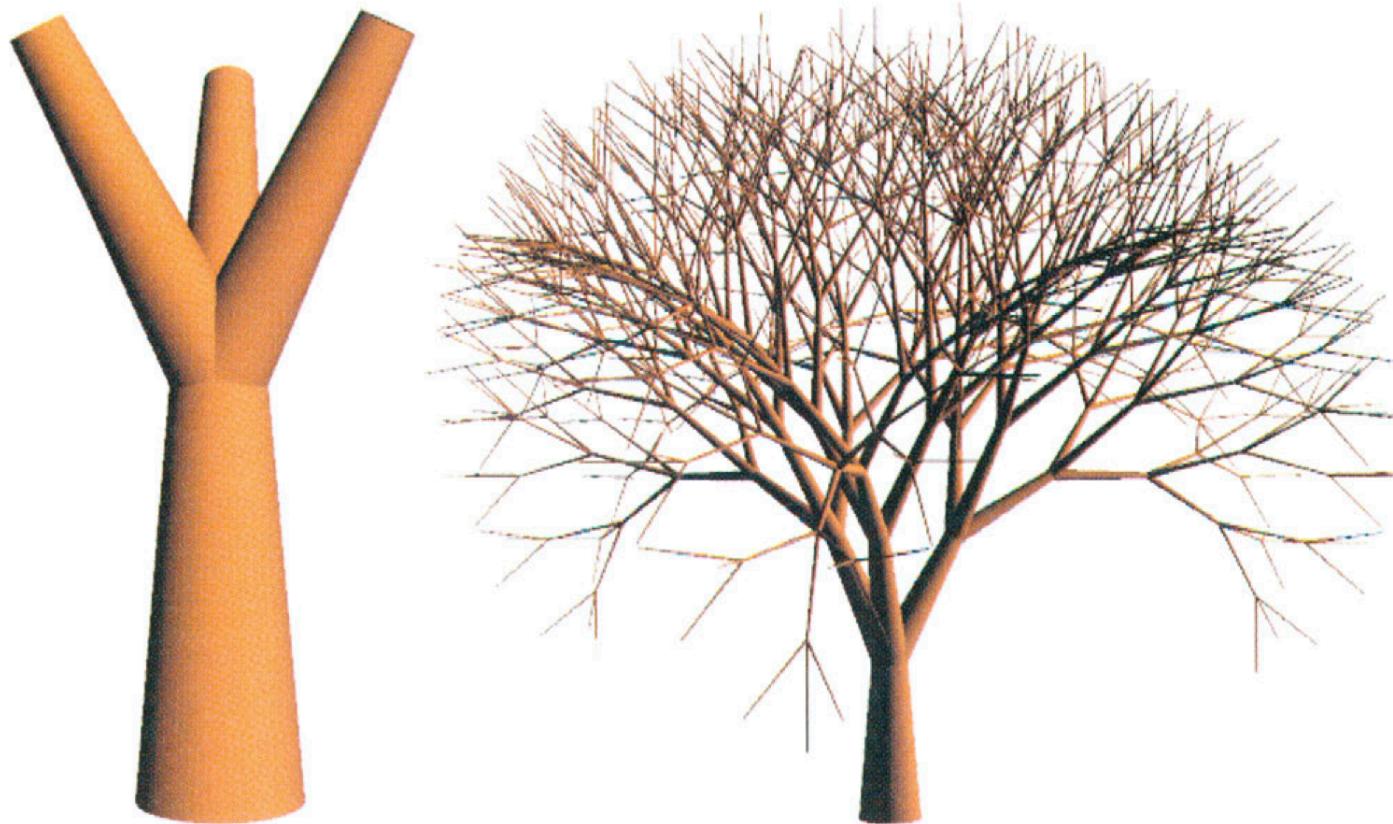


3D L-Systems

- Position is now $(x, y, z, \alpha, \beta, \gamma)$.
- \wedge : Pitch up by angle δ
- $\&$: Pitch down by angle δ
- $/$: Roll right by angle δ
- \backslash : Roll roll left by angle δ
- $|$: Turn around



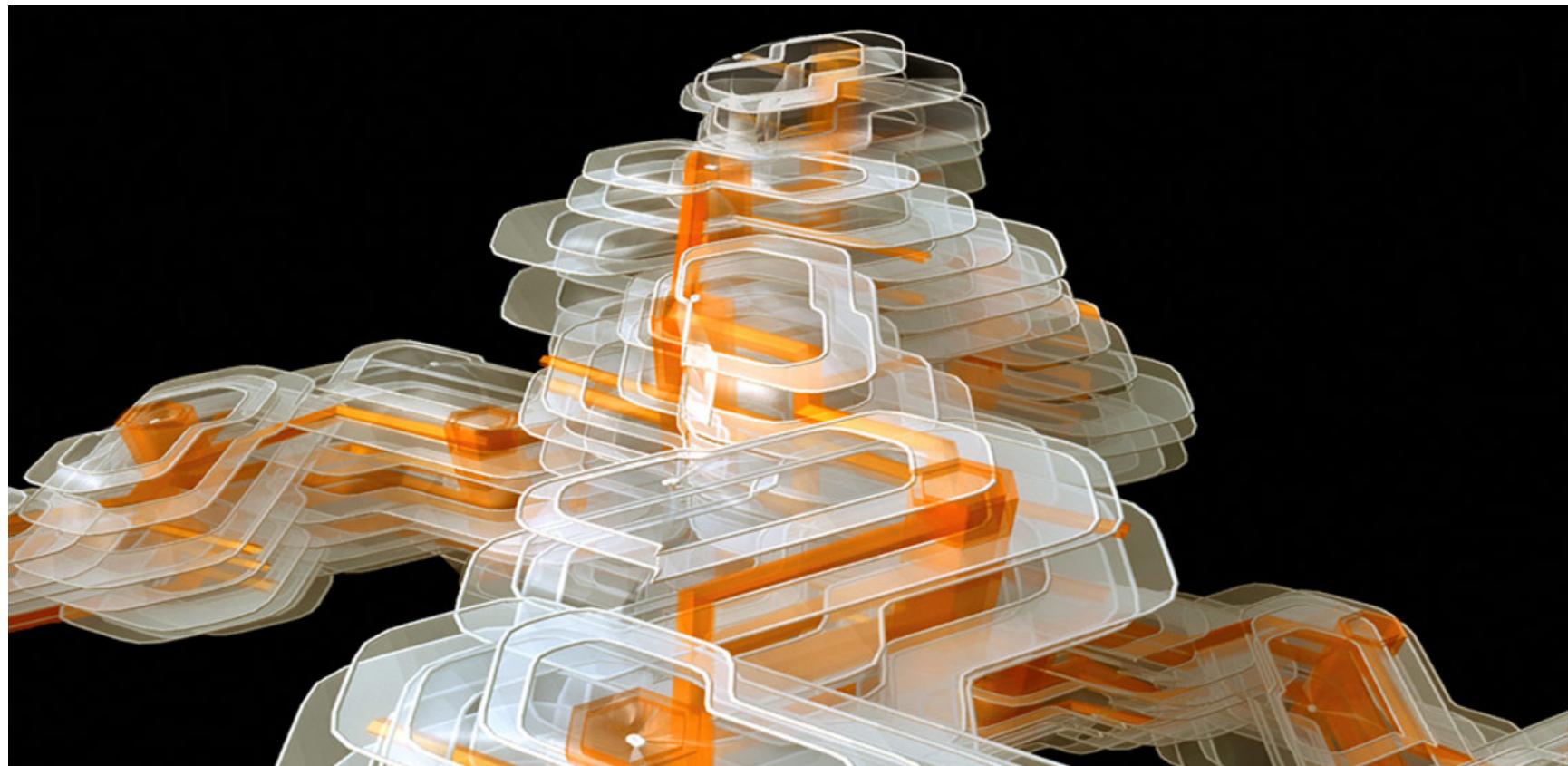
3D L-Systems



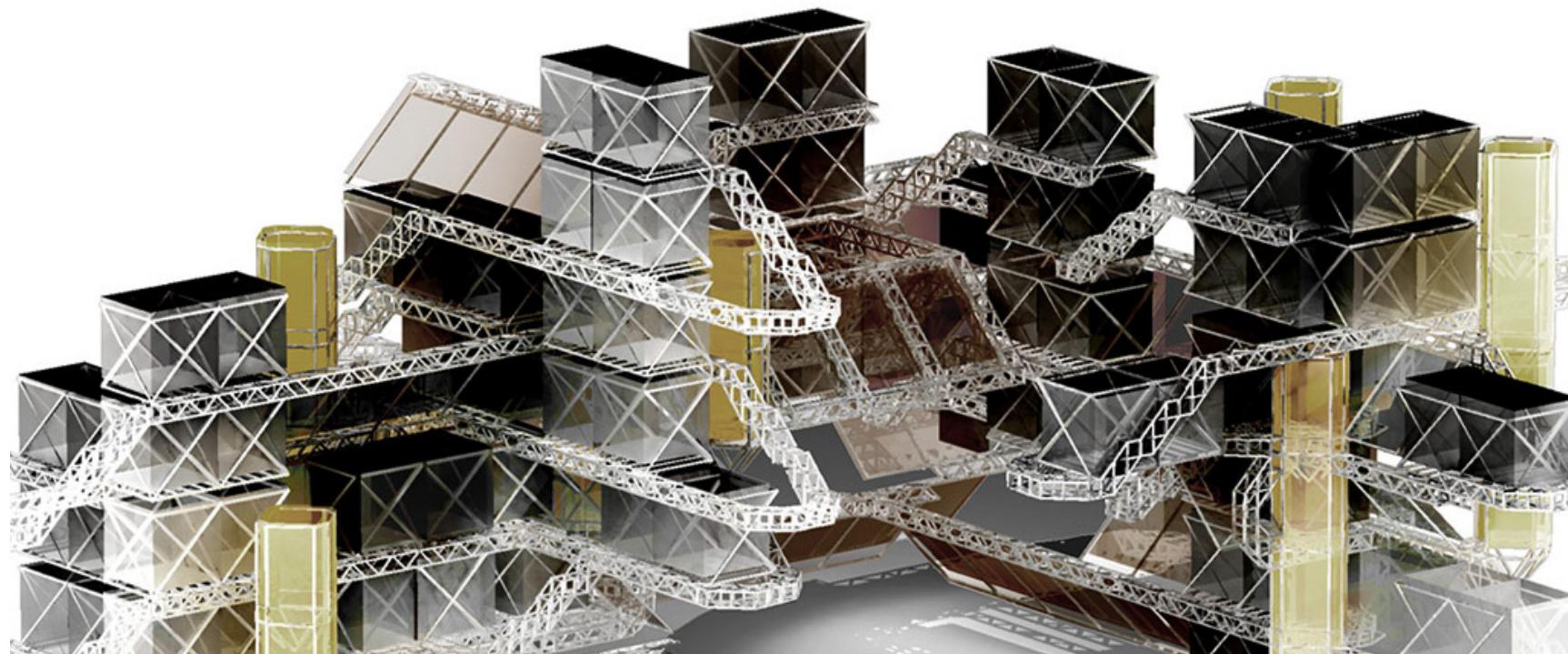
3D Stochastic L-Systems



L-Systems in Architecture



L-Systems in Architecture



Other Extensions

- Context-sensitive L-Systems
- Accessibility of light/competing for light
- Influence of gravity
- etc.

Literature

