



Procedural Modeling of Cities

Yoav Parish
ETH Zurich
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Central Pictures
Switzerland

SIGGRAPH
2001

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The City Engine System

Procedurally creates complex city models.

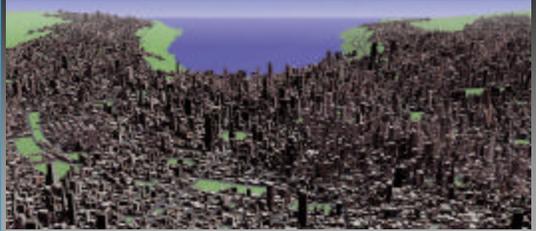
Cities consist of:

- Street maps
- Buildings
- Facade textures

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Example Zurich-London-Paris



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Example Manhattan



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Example Manhattan 2259



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Overview

1. Introduction
Motivation and system pipeline
2. L-Systems
From streets to buildings
3. Textures and results
Rendering of the results

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Motivation

- Many applications in entertainment, simulation and visualization
- Cities as virtual „backdrops“ are hard to model by hand
- Procedural methods have been used to model complex environments

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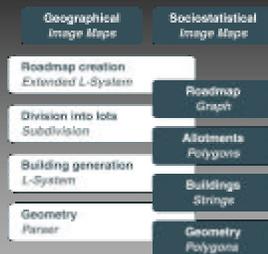
Related Work

- Mostly satellite-imagery based systems
e.g. Henricsson, Streilein, Gruen; 1996
- Work on visualization of large data sets
e.g. Davis, et al.; 1999
- Similar projects are still in the making
Yap; 1998

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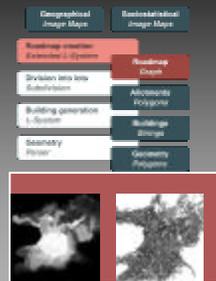
System Pipeline



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Module 1: Streetmap Creation



Input:
Image maps, parameters for rules

Output:
A street graph for interactive editing

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Module 2: Division into Lots



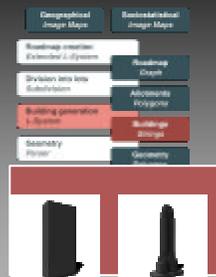
Input:
Street graph, area usage map

Output:
Polygon set of allotments for buildings

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Module 3: Building Generation



Input:
Lot polygons, age map and zone plan

Output:
Building strings with additional info

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Module 4: Geometry and Facades



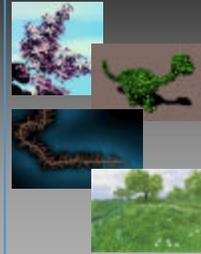
Input:
Strings and building type

Output:
City geometry and facade texture (procedural shader)

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L-Systems



Generation of plants
Prusinkiewicz, Lindenmayer; 1990

Environment-sensitive
Prusinkiewicz, James, Mech; 1994

Interaction (Open L-System)
Mech, Prusinkiewicz; 1996

Ecosystems
Deussen, et al.; 1998

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L-Systems for Streets



- Grouping parameters of different street patterns
- Hierarchical influences: global goals and local constraints

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Extended L-Systems

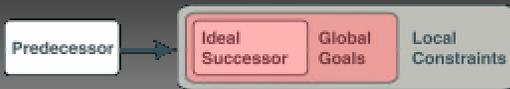


- Template successor defines 3 branches
- Parameters fields are unassigned

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Extended L-Systems



- Initial parameter settings
- Design goal

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Extended L-Systems

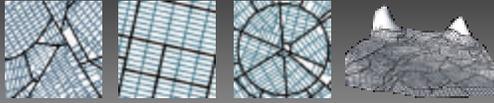


- Parameter value correction
- Influenced by local environment

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Global Goals



- Could be a planned urban design
- Different goals in the same city
- Controlled by image map (user input)

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Local Constraints

Proposed parameters
↓
Placed parameters



- Environment-sensitivity for legal streets
- Self-sensitivity for closed loops

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Division into Lots



Lot area depends on:

- Land Use map
- Building height
- Population density
- Access to street

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Procedural Buildings



- Modeled with a common L-System
- L-System modules consist of geometric operations like extrusion

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Facade Textures

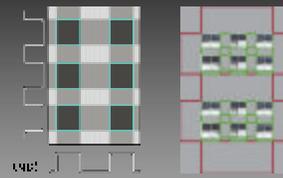


- Division into simple grid-like structures
- Structures can be layered

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Layered Textures

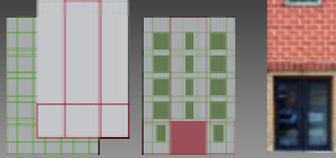


- Two base functions form a layer
- Every layer defines a facade element

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Layering of Planes



- Stacked layers for facade texture
- Functions between layers model relation between facade elements

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Animated Examples

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Future Work

- Temporal development of an urban area
- Function based grammar of buildings
- Bring life into the cities

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