Model Construction

Adam Finkelstein
Princeton University
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Modeling

How do we ...

- Represent 3D objects in a computer?
- Construct such representations quickly and/or automatically with a computer?
- Manipulate 3D objects with a computer?

Interactive Modeling Tools

- User constructs objects with drawing program
  - Menu commands, direct manipulation, etc.
  - CSG, parametric surfaces, quadrics, etc.

Model Construction

- Interactive modeling tools
  - CAD programs
  - Subdivision surface editors :)
- Scanning tools
  - CAT, MRI, laser, magnetic, robotic arm, etc.
- Computer vision
  - Stereo, motion, etc.
- Procedural generation
  - Sweeps, fractals, grammars

Example: Mechanical CAD
Model Construction

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  - CAD programs
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- Scanning tools
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Scanning tools

- Acquire geometry of objects with active sensors
  - CAT/MRI
  - Laser range scanner
  - Magnetic sensor
  - Robotic arm
  - etc.

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Laser Range Scanning

- Example: 70 scans
  - Volumetric reconstruction
Model Construction

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Computer Vision

- Infer 3D geometry from images
  - Stereo
  - Motion
  - Constraints
  - etc.

Procedural Modeling

- Goal:
  - Describe 3D models algorithmically
- Best for models resulting from ...
  - Repeating processes
  - Self-similar processes
  - Random processes
- Advantages:
  - Automatic generation
  - Concise representation
  - Parameterized classes of models
Procedural Modeling

- Sweeps
- Fractals
- Grammars

Example: Seashells

- Sweep generating curve around helico-spiral axis

Helico-spiral definition:

\[
\begin{align*}
\Theta_{i+1} &= \Theta_i + \Delta \theta \\
r_{i+1} &= r_i \lambda \\
z_{i+1} &= z_i \lambda
\end{align*}
\]

Example: Seashells

- Connect adjacent points to form polygonal mesh

Model is parameterized:

- Helico-spiral: \( z_0, \lambda, r_0, N_0, \Delta \theta \)
- Generating curve: shape, \( N_c, \lambda_c \)

Example: Seashells

- Create 3D polygonal surface models of seashells

Example: Seashells

- Generate different shells by varying parameters

Example: Seashells
- Generate different shells by varying parameters

Example: Seashells
- Generate many interesting shells with a simple procedural model!

Procedural Modeling
- Sweeps
- Fractals
- Grammars

Fractals
- Defining property:
  - Self-similar with infinite resolution

Fractals
- Useful for describing natural 3D phenomenon
  - Terrain
  - Plants
  - Clouds
  - Water
  - Feathers
  - Fur
  - etc.

Fractal Generation
- Deterministically self-similar fractals
  - Parts are scaled copies of original
- Statistically self-similar fractals
  - Parts have same statistical properties as original
Deterministic Fractal Generation

- General procedure:
  - Initiator: start with a shape
  - Generator: replace subparts with scaled copy of original

Deterministic Fractal Generation

- Apply generator repeatedly

Koch Curve

Deterministic Fractal Generation

- Useful for creating interesting shapes!

Mandelbrot Figure X

Deterministic Fractal Generation

- Useful for creating interesting shapes!

Mandelbrot Figure 46

Deterministic Fractal Generation

- Useful for creating interesting shapes!

H&B Figures 75 & 109

Fractal Generation

- Deterministically self-similar fractals
  - Parts are scaled copies of original

- Statistically self-similar fractals
  - Parts have same statistical properties as original
**Statistical Fractal Generation**

- General procedure:
  - Initiator: start with a shape
  - Generator: replace subparts with a self-similar random pattern

**Random Midpoint Displacement**

**Example: terrain**

**Useful for creating mountains**

**Useful for creating 3D plants**

**Procedural Modeling**

- Sweeps
- Fractals
- Grammars
Grammars

- Generate description of geometric model by applying production rules

\[
\begin{align*}
S & \rightarrow AB \\
A & \rightarrow Ba \mid a \\
B & \rightarrow Ab \mid b
\end{align*}
\]

ab
babaab
abaab

Grammars

- Useful for creating plants

Tree \rightarrow Branch Tree \mid Leaf
Branch \rightarrow Cylinder \mid [ Tree ]

C[CL]C[CL][CL][CL][CL][CL]
C[^*][^*][^*]

Summary

- Interactive modeling tools
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  - Subdivision surface editors :)
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Constructing 3D models is hard!