Shape Grammars
Generative Design Systems (DECO2013)
What Do You See?
What is a Shape Grammar?

“A shape grammar is a set of shape rules that apply in a step-by-step way to generate a set, or language, of designs. Shape grammars are both descriptive and generative. The rules of a shape grammar generate or compute designs, and the rules themselves are descriptions of the forms of the generated designs.”

Shape Grammars in Education and Practice: History and Prospects (Terry Knight, 1999)
What makes Shape Grammars Special?

‣ Shape grammars are spatial
  ‣ They deal with shapes directly, no translation or interpretation from symbols is required.

‣ Shape grammars support emergence
  ‣ The emergence of shapes is an important part of how shape grammars work.

‣ Shape grammars match non-deterministically
Spatial Rules

- Shape grammars are spatial, rather than textual or symbolic
  - The elements of the shape grammar rules are shapes: points, lines, planes, or volumes
  - Shape grammar rules use shape operations of addition and subtraction, and spatial transformations, e.g. translation, reflection, and rotation
Some Simple Rules

Example from: http://www.mit.edu/~tknight/IJDC/
Emergence

- Shape grammars treat shapes as non-atomic elements that can be decomposed and reassembled as required.
  - This allows the application of rules to shapes that emerge from any parts of the shapes generated through the application of rules.

- Support for emergence distinguishes shape grammars from other design grammars.
Initial Shape

Example from: http://www.mit.edu/~tknight/IJDC/
Step 1

Rule

Application

Example from: http://www.mit.edu/~tknight/IJDC/
Step 2

Rule

Example from: http://www.mit.edu/~tknight/IJDC/
Step 3

Example from: http://www.mit.edu/~tknight/IJDC/
Example from: http://www.mit.edu/~tknight/IJDC/
Step 5

Example from: http://www.mit.edu/~tknight/IJDC/
Final Shape

Example from: http://www.mit.edu/~tknight/IJDC/
Non-Determinism

- Even with a single rule for each shape the application of rules is non-deterministic because they can be applied to multiple shapes within a figure.
Initial Shape

Example from: http://www.mit.edu/~tknight/IJDC/
Alternative Step 1

Example from: http://www.mit.edu/~tknight/IJDC/
Alternative Step 2

Example from: http://www.mit.edu/~tknight/IJDC/
Alternative Step 3

Example from: http://www.mit.edu/~tknight/IJDC/
Alternative Step 4

Example from: http://www.mit.edu/~tknight/IJDC/
Alternative Step 5

Example from: http://www.mit.edu/~tknight/IJDC/
Alternative Final Shape

Example from: http://www.mit.edu/~tknight/IJDC/
3D Shape Grammars

- Shape grammars can be used to generate 3D form in much the same way they can be used to generate 2D forms.
- The number of ways that a single rule can be applied increases with the additional axes of symmetry, leading to complex structures from very simple rules.
A 3D Shape Grammar

Initial Shape

Rule

Example from: http://www.mit.edu/~tknight/IJDC/
Rule Application

The one rule can be applied in 16 different ways

Example from: http://www.mit.edu/~tknight/IJDC/
Generated Designs

Example from: http://www.mit.edu/~tknight/IJDC/
Shapes
Spatial Relations
Spatial Rules

Spatial Relation

Spatial Rule
Derivation
Chinese Ice-Ray Shape Grammar

Source: MIT Open Course Ware
derivation of an ice-ray design
Palladian Villas

(Stiny and Mitchell, 1978)
Mughul Gardens

Source: MIT Open Course Ware
Japanese Tearooms

(Knight, 1981)
Further Reading

- In *Shape*, George Stiny argues that seeing shapes—with all their changeability and ambiguity—is an inexhaustible source of creative ideas. Understanding shapes, he says, is a useful way to understand what is possible in design.
Lab Exercises

- Calculate the derivation of applying the following rules
Lab Assignment
Designing with Context Free
Design Brief

‣ A rug manufacturer wants to be able to offer its customers a wide range of designer rugs in different styles.
  ‣ In particular, the manufacturer would like to offer stochastically generated rug designs, some based on fractal designs.

‣ Your task is to use the Context Free software to create a rug design grammar.
Design Requirements

† The rug design grammars should make use of non-deterministic rules so that each grammar can produce multiple designs.

† Some of the rug design grammars should use rules that call themselves to produce self-similar (fractal-like) designs.
Rug Design Templates

- To develop your rug design grammars you should first design a rug design template to help you plan your grammar.

- Each rug design template describes the basic layout of a rug in terms of different regions that go to make up a rug, e.g. corner regions, border regions and a central region.
A Checkerboard Rug Template

TILE TYPE 1

TILE TYPE 2
A Bordered Rug Template

CORNER TILE

BORDER TILE

CENTER TILE
Designing Templates with “Marked” Shapes

Each tile is an instance of a MARKED_SQUARE included from the file marked_shapes.cfdg
Every rug design template describes a space of possible rug design grammars
Each rug design grammar provides designs for the regions identified in the template.
A rug design grammar should provide multiple design rules for each type of region in a template so that it can produce a wide range of randomly generated rug designs.
Simple Checkerboard Rug Grammar
Fractal Checkerboard Rug Grammar
Distorted Checkerboard Rug

Grammar
Simple Bordered Rug Grammar
“Vines” Bordered Rug Grammar
“I Curves” Bordered Rug Grammar
Submission

- Upload your rug design grammar and some images of the rugs that it can generate to your Ning blog.

- Helpful files and links to on-line resources are available at: