Shape Grammars

Creative Systems (DESC9176)
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)
How do Shape Grammars Differ from Design Grammars?

- Shape grammars are spatial
- Shape grammars support emergence
- 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

Rule 1

Rule 2

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

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

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

Rule

Application

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

Rule

Application

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

Rule

Application

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

Example from: [http://www.mit.edu/~tknight/IJDC/](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/
Stages in Shape Grammar
Design

Shapes
Shapes Relations
Rules
Shapes Grammars
Designs
Shapes
Spatial Relations
Spatial Rules

Spatial Relation

Spatial Rule

[Diagram of spatial relations and rules]
Labels

Rule

Labelled Rule
Derivation
Examples
Chinese Ice-Ray Shape Grammar

Chinese ice-ray shape grammar (Stiny, 1977)

Source: MIT Open Course Ware
derivation of an ice-ray design
Palladian Villas
(Stiny and Mitchell, 1978)
Mughul Gardens

(Stiny and Mitchell, 1980)
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

```
[Diagram showing the derivation process with arrows and shapes]
```
Assignment 1

Rule-Based Generative Design
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 range rug design grammars based on a number of rug design templates.
Design Requirements

• The rug design grammars should make use of non-deterministic rules so that each grammar can produce multiple random 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
Rug Design Grammars

‣ 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
Distorted Checkerboard Rug

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

‣ A design document describing 2 different rug design templates, including any background research you have done and the process you went through designing your templates.

‣ A set of (at least) 3 rug design grammars for each of your 3 rug design templates.

‣ Each design grammar is to be submitted as a Context Free design grammar file.
Information and Files

Some more detailed information about this assignment, together with some helpful files and links to on-line resources are available at:

http://www.arch.usyd.edu.au/~rob/DESC9176/assignment1/