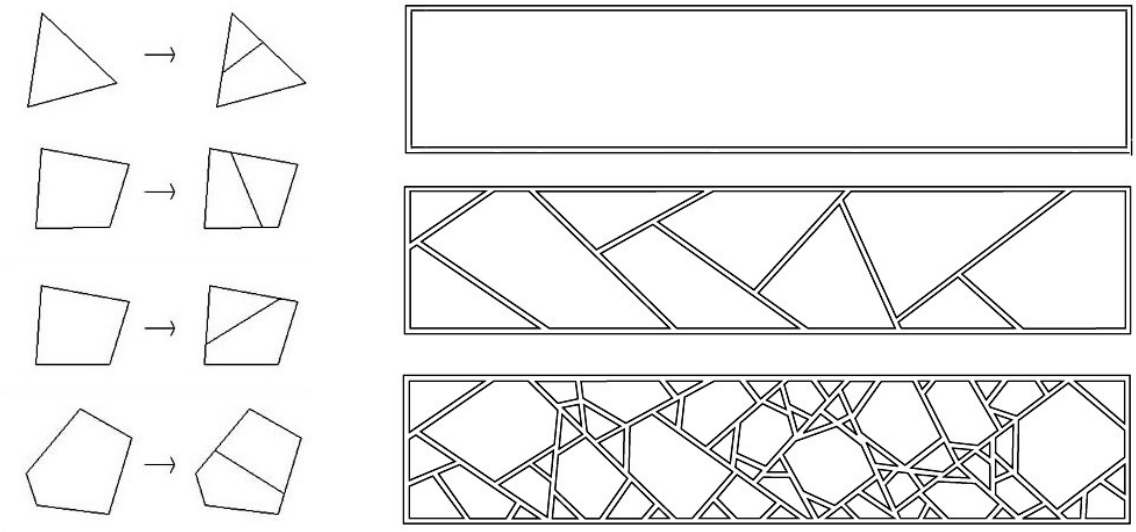
ARCH 4508 Shape Grammars
Thanos Economou, PhD
T/H 3:00 p.m. – 4:30 p.m.
COA 258
School of Architecture
Georgia Institute of Technology
Fall 2015

ARCH 4508: SHAPE GRAMMARS



Shape grammars is a powerful formal system for the generative description of designs. Their unique difference with all other generative systems is that they perform entirely *visual computations* rather than *symbolic computations*. Shape grammars are intended to form a basis for purely visual computation and in this sense they belong in the heart of design education and practice – both in precedent analysis and in a studio setting.

The course discusses the foundations of shape grammar formalism, provides a constructive understanding of the formalism through hands-on workshops and offers a generous overview of the history and logic of several of its applications in design research. A particular focus is given on a systematic exposition of basic rule schemas and the ways they are ordered and combined in sums and products to produce a compositional taxonomy of design.

Students are expected to attend the lectures, participate in the discussions, read the weekly readings and do two design studies and one final project. The grade for this course is divided in the following sections: attendance / participation: 10%; two studies: 25% each; and final project: 40%.

The course is open to students with an interest in formal (spatial / mathematical) analysis and composition. The class meets twice per week, Tuesday and Thursday 3.05 p.m. - 4.25 p.m. at COA 250.

Course description and objectives
Contemporary architecture discourse relies heavily on formal models for form generation. The underlying motivation for all proposed models is the quest for a constructive definition of families of designs rather than the construction of a single design. This shift from the one to the many requires a theory (or theories) that can explicitly specify how the set of designs may be constructed or generated. A simple presentation of a set of designs is not enough - even though this is the most traditional way of presentation of design options in a design inquiry: a catalogue of things exploring various design scenarios. A constructive understanding requires more; it requires an explicit specification of how the designs can be constructed or generated.

This course discusses in detail one of the most powerful systems for the generative description of designs, the shape grammars formalism. The unique difference of shape grammars with all other current generative systems is that they perform entirely visual computations rather than symbolic computations. And visual computations are the major machinery for design: instantiating, deleting, transforming and combining shapes, rapidly and erratically in design studio, or precisely and meticulously in formal design research, are the key mechanisms in both design (synthesis) and analysis. There is an incredible amount of things to be taught and to be tried out: What rule(s) to use? Where to use? How to use? When to use? Why to use? To these questions and all similar, the common denominator is that visual language guides the inquiry – the shapes, their materiality and the ways they capture and exemplify program, function, technology, and meaning. Shape grammars are indeed intended to form a basis for purely visual computation and in this sense they belong in the heart of design education and practice – both in precedent analysis and in a studio setting.

The course discusses the foundations of shape grammar formalism, provides a constructive understanding of the formalism through two hands-on workshops and offers a generous overview of the history and logic of several of its applications in design research.

Course Procedure and Organization
The course is divided in three parts consisting by two sessions of a hands-on workshop, a series of lectures on the fundamentals of the formalism, and a student-led discussion of applications of shape grammars. A brief description of these parts follows below.

The first part starts with a workshop to promote a constructive, hands-on understanding of recursion, one of the two fundamental characteristics the shape grammar formalism. The workshop focuses on tactile, physical, recursive computations with the Froebel kindergarten blocks to show the resources and conventions of the shape grammar formalism using the single rule schema $x \rightarrow x+t(x)$ and various assignments on the schema. A series of lectures on the theoretical foundations of the shape grammar discourse provides the basic theoretical discourse of the module. The module concludes with a student-led presentation of a series of generative 3d weaves.

The second part starts with a workshop too to promote a constructive, hands-on understanding of emergence, the second of the two fundamental characteristics of the shape grammar formalism. The workshop focuses on digital recursive computations with shapes in *Grape*, a computational system to facilitate computation using recursion and embedding in shape grammars. The series of lectures on the theoretical foundations of the shape grammar discourse continues with a systematic exposition of the rule

schemas and in the ways schemas are ordered and combined to produce a compositional taxonomy of design. The objective of this second part is to reflect upon pictorial illustrations of the basic schemas, their inverses and their combinations in sums and products, in terms of symbolic rules, shape rules, parametric rules and spatial examples. The module concludes with a student-led presentation of design studies exploring systematically the rule schemata discussed in the class.

The third part discusses applications of shape grammars in different fields including architecture, landscape, painting and decorative arts. The topics are student led and review various applications in the field including the shape grammars for Palladian villas, Mughul gardens, Frank Lloyd Wright prairie houses, Giuseppe Terragni facades, Alvaro SIza's housing, and several others. This part of the course is accompanied by a final project on the design of a final project on a complete authoring of a shape grammar. The project can be built on any of the previous two studies or it can explore an entirely new theme.

The class meets twice per week, Tuesday and Thursday 3:05 p.m. - 4.25 p.m. All readings and presentations are posted at the site of the course in T-Square.

Course requirements
Students are expected to attend the lectures, participate in the discussions and do the classwork/homework. The grade for this course is divided in the following sections:

Attendance / Participation: 10%
Two studies: 25% each
Final project: 40%

Course schedule
The course schedule is given below.

			INTRODUCTION
T	20	Aug	Introduction | Requirements | Expectations
H	22	Aug	Shape grammars: Overview | Rule schemas and shape rules Knight T and G Stiny, 2001. Classical and non-classical computation.
			FUNDAMENTALS
T	27	Aug	Workshop: Kindergarten grammars (One shape A - symmetry 8)
H	29	Aug	Workshop: Kindergarten grammars (One shape A - symmetry 8) *Study 1: 3D Weaves*
T	03	Sep	Shape and shape arithmetic
H	05	Sep	Symmetry and rules Study 1: 3D weaves. First review and discussion
T	10	Sep	Algebras of shape U_{ij}
H	12	Sep	Constructing spatial relations
T	17	Sep	Spatial relations and shape rules
H	19	Sep	Study 1 Final review

SHAPE RULES AND RULE SCHEMATA

T	24	Sep	Workshop: Authoring visual grammars (Grape)
H	26	Sep	Workshop: Authoring visual grammars (Grape) *Study 2: From rule schemata to shape rules and back*
T	01	Oct	Shape rules and rule schemata: Recursive definitions
H	03	Oct	*Aggregation rules:* $x \rightarrow x + t(x)$; $x \rightarrow x + \sum t(x)$
T	08	Oct	*Parametric rules:* $x \rightarrow t^*(x)$; $x \rightarrow x+t^*(x)$; $x \rightarrow \sum t^*(x)$;
H	10	Oct	*Division; Boundary and part operations:* $x \rightarrow div(x)$; $x \rightarrow p(x)$; $x \rightarrow b(x)$
T	15	Oct	*Fall Break*
H	17	Oct	Study 2 Final review

APPLICATIONS

T	22	Oct	Palladian villas *Final Project: Design a shape grammar*
H	24	Oct	Mughul gardens
T	29	Oct	Frank Lloyd Wright's Prairie homes
H	31	Nov	Japanese tea houses
T	05	Nov	Hepplewhite chairs
H	07	Nov	Terragni apartments
T	12	Nov	Siza's Malagueira's housing
H	14	Nov	Steven Hall dormitories
T	19	Nov	Wren's churches
H	21	Nov	*Thanksgiving*
T	26	Nov	*Final Project:* Third review and discussion
H	28	Nov	*Final Project:* Fourth review and discussion
T	3	Dec	*Studio Week*
H	5	Dec	*Studio Week*
T	10	Dec	-
H	12	Dec	Project delivery

(*) Subject to change to individual meetings throughout the day because of GT IUCC meetings

Evaluation Criteria / Policy on Absences

Attendance, participation, timely completion of work, depth of engagement, craftsmanship and completeness in all submitted work. More than three unexcused absences result in a letter grade reduction.

Required Readings

Knight T and G Stiny, 2001. Classical and non-classical computation. ARC: Architectural Research Quarterly (Vol. 5: 04)

Mitchell, W. 1990. “Languages of Architecture” in The Logic of Architecture. MIT Press, Cambridge.

Stiny, G. 2006. Shape: Talking about Seeing and Doing. MIT Press, Cambridge

Study 1 Readings

Economou A, 1999, "The symmetry lessons from Froebel building gifts" Environment and Planning B: Planning and Design 26(1) 75 – 90. Peprinted in Critical Concepts in Architecture: Digital Architecture – 100 Major papers, M. Burry (ed), Routledge, forthcoming: 2015.

Stiny G, 1980, "Kindergarten grammars: designing with Froebel's building gifts" *Environment and Planning B: Planning and Design* 7 409-462

Study 2 Readings

Economou, A, Kotsopoulos, S, 2014. “From Shape Rules to Rule Schemata and Back.” in Design Computing and Cognition DCC’14. J.S. Gero and S. Hanna (eds), Springer 2014, pp. 419-438.

Grasl T, Economou A, 2013. “From topologies to shapes: Parametric shape grammars implemented by graphs” Environment and Planning B: Planning and Design, pp. 138-156.

Stiny, G 2011. “What Rule(s) Should I Use?” Nexus Journal: Architecture and Mathematics, Volume 13, Number 1, pp.15-47.

Study 3 Readings (Selected)

Downing F and Flemming U, 1981,"The bungalows of Buffalo" Environment and Planning B: Planning and Design 8 269-293

Duarte J P, 2005, "Towards the mass customization of housing: the grammar of Siza's houses at Malagueira" Environment and Planning B: Planning and Design 32(3) 347 – 380

Flemming U, 1987, "More than the sum of parts: the Grammar of Queen Anne houses" Environment and Planning B: Planning and Design 14 323-350

Flemming U, 1981, "The secret of Casa Guiliani Frigerio" Environment and Planning B: Planning and Design 8 87-96

Knight T W, 1989b, "Transformations of the De Stijl art: the paintings of Georges Vantangerloo and Fritz Glarner" Environment and Planning B: Planning and Design 16 51-98

Knight T, 1990, "Mughal gardens revisited" Environment and Planning B: Planning and Design 17 73-84

Knight T, 1989, "Transformations of the De Stijl art: the paintings of Georges Vantangerloo and Fritz Glarner" Environment and Planning B: Planning and Design 16 51-98

Koning H, Eizenberg J, 1981, "The language of the Prairie: Frank Lloyd Wright's Prairie houses" Environment and Planning B: Planning and Design 8 295-323

Kotsopoulos S, 2010. “From design concepts to design descriptions” International Journal of Architectural Computing, issue 03. V.06, pp. 335-360

Flemming U, 1987, "The role of shape grammars in the analysis and creation of designs" in Kalay Y E (ed.) Computability of Designs (New York: John Wiley amp; Sons) 245-272 (AE)
Grasl, T and A Economou, 2013, “Unambiguity: Difficulties in communicating shape grammar rules to a digital interpreter”, eCCADe Conference Proceedings, Delft. 1-6
Grasl, T and A Economou, 2011, “GRAPE: Using graph grammars to implement shape grammars” Symposium on Simulation for Architecture and Urban Design, SimAUD: 45-52
Stiny G, 1976, "Two exercises in formal composition", Environment and Planning B 3 187 – 210
Stiny G, 1980, "Introduction to shape and shape grammars" Environment and Planning B: Planning and Design 7 343-351
Stiny G, 1980, "Kindergarten grammars: designing with Froebel's building gifts" Environment and Planning B: Planning and Design 7 409-462
Stiny G, 1977, "Ice-ray: a note on Chinese lattice designs" Environment and Planning B: Planning and Design 4 89-98
Stiny G, Mitchell W J, 1978, "The Palladian Grammar" Environment and Planning B: Planning and Design 5 5-18
Stiny G, Mitchell W J, 1980, "The Grammar of paradise: On the generation of Mughal gardens" Environment and Planning B: Planning and Design 7 209-226

Web references www.shapegrammar.org
http://www.mit.edu/~tknight/IJDC/frameset_abstract.htm
http://iaaa.nl/cursusAA&AI/stiny.html

Appendix

1) Students with disabilities requiring special accommodations must obtain an accommodations letter from the ADAPTS Office [www.adapts.gatech.edu] to ensure appropriate arrangements.

2) Georgia Tech aims to cultivate a community based on trust, academic integrity and honor. Students are expected to act according to the highest ethical standards. For policy information on Georgia Tech's Academic Honor Code, please see [http://www.catalog.gatech.edu/rules_regulations/#18].

3) All cell phones should be turned off during class and when entering the classroom.

4) In case of emergency (i.e. fire, accident, criminal act), please call the Georgia Tech Police at 894-2500. Please note that Perry Minyard, IT Support Administrator is also a firefighter and an Emergency Medical Technician (EMT) certified in performing CPR.