

Design by Grammar

Hybrid Applications of Grammar in Design Studio Projects

Birgul Colakoglu

Yildiz Technical University, Computational Design Unit, Turkey

<http://bom.yildiz.edu.tr/>

bigi@alum.mit.edu

The use of shape grammars in the context of architectural design project has not been widely explored. This paper describes hybrid analysis/original design applications of grammars in conjunction with student design projects and the issues in creating hybrid grammars that respond to a specific context.

Keywords: *Computational design methods; shape grammars; hybrid grammars; precedent base design.*

The use of shape grammar in design teaching

Shape grammars are both descriptive and generative and thus can be used in automatic generation of designs and as analytical tool to describe the generation of existing designs. In architecture, grammars have been used in design education through the use of concepts of formal composition. However, with few exceptions (Knight 1992, Colakoglu, 2003) their use has not been integrated into larger scale design projects.

Analytical shape grammars have been used as design aids to understand particular style (Mitchell, Stiny, 1978; Flemming, 1987; Koning, Eizenberg, 1987) and by modification of an existing grammar to demonstrate stylistic change (Knight, 1994).

Hybrid analysis/original applications of grammars unlike analytic grammars are intended for practical design purposes as well as educational ones (Colakoglu, 2000; Duarte, 2001). These grammars allow higher user interaction by allowing a user to input constraints and goals. A user can choose which

rule to apply and how to apply it in each step of a computation. In this application of grammars the user's role more closely approximates the role of a designer.

The studio methods of the designing are mostly intuitive. Stiny (1980), proposed a computational alternative to these methods. He described five stages in a constructive approach to grammar definition:

- Specify a vocabulary of shapes.
- Define spatial relations between elements in the vocabulary.
- Specify shape rules based on defined spatial relations.
- Define an initial shape from the vocabulary.
- Specify shape grammars based on shape rules.

Stiny's approach was expanded by Knight and integrated successfully in architecture programs at schools such as UCLA and MIT. (Knight, 1999) The experiments in this area have been developed by Flemming, (1987), Chase, (2000), and Colakoglu, (2006) respectively at Carnegie Melon, at University of Sydney, Faculty of Architecture and at Yildiz Technical University School of Architecture.

Design studio: New housing for Mardin

Architectural precedents have an important role in learning architectural conception. The design world of architects consists of references that embody implicitly architectural know-how. In this world, learning is effective when this know-how is used in constructionist way to create something new with it (Schön, 1988). The shape grammar method of precedents description and their interpretation through hybrid grammar that is proposed in this study is conceived to bring aforementioned characteristics to students in architectural design studio.

Shape grammars are descriptive, have constructive mechanism and make one understand “what one is doing”. Their use in architectural studio setting is informal. It corresponds more to traditional design studio where the process is not linear and where shapes, shape relations and rules are continually modified, new shapes and shape relations are added to meet the goals and constraints of a design.

The primary concern of graduate design studio “New Housing for Mardin” conducted at Yildiz Technical University, Computational Design program was to produce new house designs that will relate well to its surrounding and meet the constraints imposed both by the designer and the context. To promote the new design of dwellings in historic context, hybrid analysis/original application of shape grammars is proposed as an auxiliary design tool. New house types and housing settlements are developed for medieval city of Mardin, located in South-East of Anatolia. Here, precedents are used in constructive way of learning architectural design. The rules of grammar of an existing language are extracted through analysis of twenty house precedents. This grammar is then modified to create new designs. In this approach the grammars are based on the existing design and therefore they are more coherent as architectural spaces.

The process in the studio encompasses two steps. In the first step, Mardin house grammar developed by Ozbek, (2004) is used to teach spatial

typologies and compositional principles of Mardin house. In this step, shape grammars provided students with a concrete methodology for analysis and fostered their understanding of an architectural language of Mardin. In the second step, the students first used the grammar for developing rule-based house designs in Mardin style and then designed contemporary house designs for Mardin by modifying the grammar and by inserting the new design rules and constraints derived from various design considerations such as changes in social life of a family, climate, and available construction techniques in the area.

It should be noted that shape grammars are not used alone in defining design but rather as an auxiliary tool for learning architectural design.

Mardin

Mardin is a city located in south-eastern Anatolia known by its unique stone architecture. It is renowned for its sustained cultural heritage. The city as a whole with its religious and vernacular architecture and its terraced urban pattern is the best preserved example of that region. Mardin houses have a distinguished place in the housing architecture of Turkey with their unique plans (figure 1). They surround the narrow, steep and winding streets of Mardin. The houses are inward looking courtyard buildings



Figure 1
Mardin houses

developed on a 4 x 4 grid. They are surrounded by high walls reflecting all characteristics of a closed-in way of life.

Mardin house is composed of open spaces in the form of courtyards and terraces, semi open spaces eyvan – closed on three sides and the top-arcades, and closed places. Courtyard and terraces are private quarters, surrounded by rooms, eyvans and/or high walls. They are the center of family leaving.

Step 1: Extracting the grammar of Mardin house

Mardin house grammar is developed by analyzing twenty traditional house designs. The reason for choosing these designs is twofold. First, Alioglu, (2001) book that analyzed Mardin architecture in depth provided a source of drawings for chosen house designs. Second, the plans are chosen for their different configurations so that Mardin house grammar could be generalized. The aim of extracting the grammar is to explore spatial typologies as well as compositional and tectonic solutions of Mardin house.

The drawings of houses and on site analyses are used for defining the principles of traditional dwelling architecture of Mardin. First, the vocabulary of Mardin house then spatial relations between vocabulary elements and their rules are identified. The vocabulary of house is grouped into three groups; *open spaces*: stairs, terraces, courtyards, *closed spaces*: living room, working room, bathroom, kitchen, and storage, *semi-open spaces*: arcade, balcony, and eyvan (figure 2).

The design principles of Mardin house are classified in ten groups:

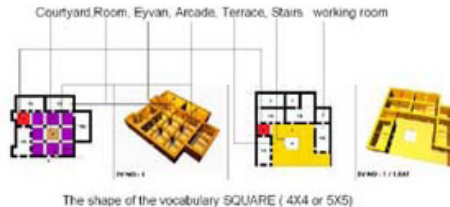


Figure 3
Entrance rules

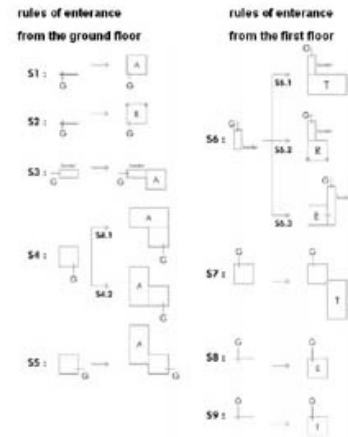


Figure 2
The vocabulary of Mardin house

1 – House expansion; 2 – Living space; 3 – Working-living space relation; 4 – Eyvan; 5 – Arcade; 6 – Balcony; 7 – Terrace; 8 – Stair; 9 – Entrance; and 10 – First floor formation rules. Sixty eight design rules of Mardin house are identified. Due to length constraints of the paper only entrance rules are illustrated to show working principles of the rules (figure 3). The analyses of Mardin house revealed that the designs are very systematic and it is straightforward to encode them into shape grammars.

Houses in the chosen design set are classified according to their courtyards by two types, TYPE A – houses with single courtyard, and TYPE B – houses with multiple courtyards. Within given set of designs four types (L, H, I, U) with single courtyard and three types with multiple courtyards are identified. Figure 4 illustrates the abstraction of U sub-type and figure 5, subtypes of TYPE A.

The grammar gave the design process a certain discipline by defining what could be generated within the existing rules and spatial relations, and which constraints, additions and changes might be required for developing a contemporary house.

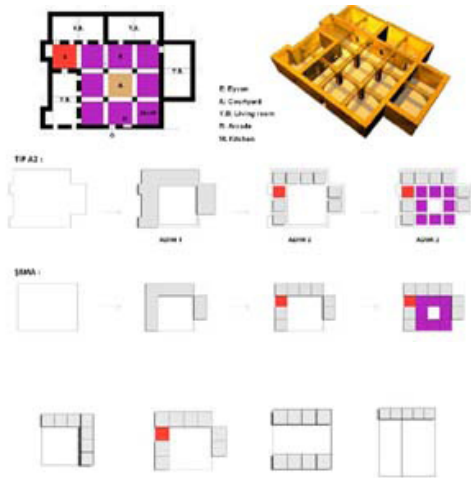


Figure 4
Abstraction of TYP A1

Step 2: Using hybrid grammar as teaching tool in studio setting

The aim of hybrid grammar applications is not to produce design in a given language but rather to generate new designs. In this paper the notion of hybridity has been used to describe the blending of diverse designing approaches in the composition. Here, hybrid grammar applications comprise of two phases: analyses and synthesis. The analyses phase is descriptive, embody the general design strategies that users can learn and use in their own work. The synthesis phase allows designer higher interaction with the grammar. The designer can combine various rule sets or insert his/her design rules, and constraints into the grammar to create the 'hybrid' grammar.

In the analyses phase of "New housing for Mardin" studio the students used Mardin house grammar as a learning tool for understanding language of Mardin architecture, in the synthesis phase they created hybrid grammars and used them as auxiliary instrument in the designing of contemporary Mardin house. Two different student approaches of using grammars -formal and informal- in design process are briefly explained.

Formal approach was applied by a student who wanted to explore computer implementations of

grammars. Here, already developed Mardin house grammar rules were used as base for creating hybrid grammars. The grammar was modified by introducing some constraints and new rules such as direction, placement of Eyvan, ground and first floor relations. Then by applying this grammar four new abstract house types were created. The vocabulary of these new types were interpreted as 4x4 cubes colored in different colors each indicating different function. In order to generate house settlements new house relationships rules between these four new house types were defined. These rules were encoded in 3DMax script environment. By running random application of these rules various abstract housing settlements were explored.

The designs were developed in two steps. In the first step, abstract house settlements were generated on a hypothetical site (figure 5). Then, among these the most appropriate composition was chosen for further development (figure 6). Although, the student decision making process was intuitive, some design principles of Mardin house given in an analytical grammar such as the balance between open, closed and semi closed spaces in other words solid & void spaces had influence on her decision making. In the second step, by replacement of 4x4 colored cubes with corresponding spaces that had already been defined, design process was switched from an abstract to a real state (figure 7).

Figure 5
Sub-types of TYP A

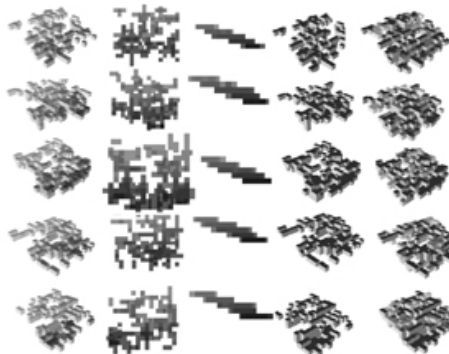


Figure 6
Abstract housing settlement generations

Figure 7
Chosen housing settlement
and its four level layout
configurations

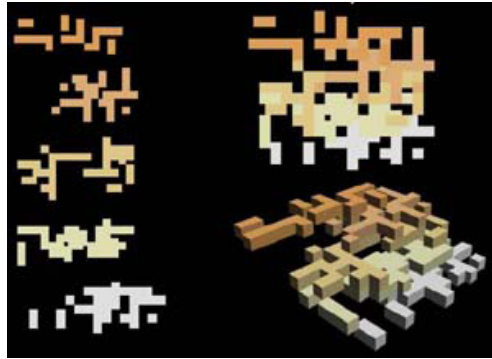


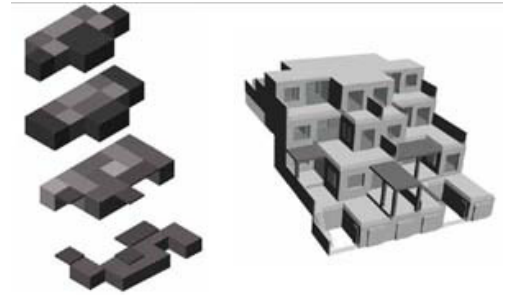
Figure 8
Transition from an abstract to
a real state

Informal approach was applied by a student who was interested more with systematic approach and generative power of grammars. His design process also consisted of two steps: In the first step Mardin house grammar helped him to learn “how to design” a Mardin house. By applying the rules of the grammar he explored possible house layout variations. In the second step, the grammar was transformed by modifying some existing rules and inserting the new ones. Then by using these rules seven new abstract house types for a flat site were generated (figure 8). The new house types have different ground-first floor relations however, they consist of an interpreted spaces and space relations of a traditional Mardin house. For example, arcade surrounding the courtyard in a traditional house is interpreted as entrance arcade that creates shadow for a living room located behind it. Among these seven abstract house types three were chosen for further development. After deciding preliminary house layouts, adjacency relations between the houses were defined. Following these relations row housing settlements were created (figure 9).

Figure 9
New house types

Concluding remarks

Precedents have an important role in architecture. However, they are not used in full potential in design studio projects. It was observed that when students refer to precedents during their design projects they



face two main problems: 1 – they could not grasp the essential characteristics-the architectural know-how-of precedents. This remains often hidden. 2 – even if they can comprehend the essence they are not able to transfer know-how into their own project.

In this paper, the shape grammar method of a precedent description that can be used by students in architectural studio is proposed. Such a description ensures a plausible encoding of historic design process, which can be used as a formal method for evolution of hybrid grammars.

Architectural design continually undergoes transformations under the influence of social

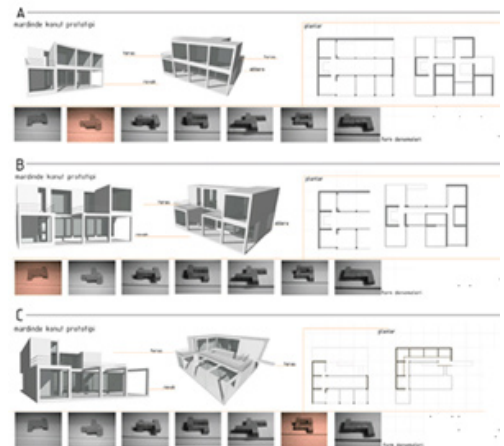




Figure 10
New housing settlements

changes in cultures, new construction techniques and building traditions it comes across with. Hybrid grammars offer a methodology that allows one to study such transformations in the designs.

In the studio, architectural ideas embedded in precedents are translated into grammars. Two approaches – formal, informal – of shape grammar applications are explored. In both cases working with grammars helped students to produce in a constructive way their own unique interpretation of the contemporary Mardin house. They applied careful, deliberate kind of thinking that helped them make sense out of what they have experienced and what they had learned from the precedents.

Rather than restricting their designs, hybrid grammars assisted students in clarifying architectural ideas, articulate them precisely and test them through generation of new designs. They also addressed the issue of analysis of historic architecture, with an emphasis on the creation of contemporary designs.

The utilization of hybrid grammars developed from analysis of traditional styles has the potential to offer a new computational method for the design of contemporary architecture in historic context.

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