

TRANSFORMING GRAMMARS OF HISTORICAL ARCHITECTURE FOR THE GENERATION OF CONTEMPORARY DESIGNS : With an Example from Islamic Courtyard Buildings

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Abstract. A primary issue facing architects of the Islamic world is the generation of contemporary designs based on architecture of the past. We discuss shape grammars as a framework for the design generation of plans of courtyard buildings of Islamic architecture and describe ongoing research for the transformation of grammars of historic Islamic building types to generate new, contemporary designs or design styles. We raise issues in the grammar transformation framework and discuss directions of exploration that could be relevant to the design methods of Islamic architecture.

1. Introduction

The contribution of the Islamic civilisation in the field of architecture is both vast and diverse. Spread across three continents from Southeast Asia to North Africa and Southern Europe from 750 AD till the present time, Islamic architecture adapted itself to local climate and materials, and thus portrayed a unique face in each region.

A prime issue facing architects in the Islamic world is the generation of a contemporary idiom—one that projects the society's identity and specificity by relating itself to historic architecture, whilst being modern and true to its time (Lewcock, 1988).

This paper addresses the aforementioned issue by presenting shape grammars (Stiny and Gips, 1972) as a methodology for the analysis and design generation of Islamic architecture. The focus of our work is the generation of contemporary designs by transforming grammars of historic courtyard buildings of medieval central Asian Islamic architecture. The courtyard is considered a major feature of the architectural tradition of Muslim societies and it is our belief that a study based on it would provide a useful starting point for a vast area of exploration.

2. Analysis and generation of Islamic architecture using shape grammars

One of the most important characteristics of Islamic architecture, which makes it

a subject amenable to the methods of rule-based analyses, was its basis on advanced concepts of geometry and mathematics and the use of modular design systems (Hillenbrand, 1994). Formal organisational principles such as symmetry, balance, hierarchy, rhythm and axially were used in the designs of Islamic architecture. Such formal compositional and visual correlates are believed to be effectively analysed using shape grammars and thus justify its use for the analysis of Islamic building types.

Shape grammars are a rule-based compositional methodology that has been in use for over three decades. The utility of shape grammars in design generation and analysis has been well documented. Grammars are both prescriptive and descriptive: the rules of a grammar generate designs but can also be considered descriptions of the forms of the designs.

Shape grammars have been used previously for the generation of new forms based on historic designs. The Queen Anne houses grammar (Flemming, 1987) demonstrates how a grammar that describes historic houses can be used to generate new forms that are compatible with traditional ones, in terms of parameters such as scale, volume and massing.

A promising application of shape grammars lies in their transformation. The transformation process as proposed by Knight (1994) involves the analysis of a design language and the creation of a grammar to describe it. The rules of such a grammar are then transformed into a new grammar, which would create a new style of design. Knight's model has been used to describe the historical evolution of known styles into succeeding ones, as demonstrated in the transformation of the Vantongerloo and Glarner grammars to reflect the development of De Stijl paintings.

We propose to further Knight's model by using grammar transformations to create new, contemporary designs. This involves a formal characterisation of a historic design style, defining a modified requirement analysis based on contemporary needs and the application of relevant transformation rules to generate a contemporary paradigm.

3. The courtyard model: Historic and Contemporary examples

The courtyard model was essentially a climatic response to hot and arid areas, with the courtyard acting as a venue for outdoor activities. It was adapted by Islamic architects for the design of small domestic buildings, as well as for large public buildings such as mosques, madrasas and caravanserais. Figure 1 shows different types of historic courtyard buildings of central Asia.

In contemporary Islamic societies, architectural discourse is fervently concerned with the generation of a contemporary idiom that is at once innovative, as well as in continuity with the architectural heritage of the past. These ideas are well illustrated in Nader Ardalan's design of the Iran Centre for Management Studies, Teheran as

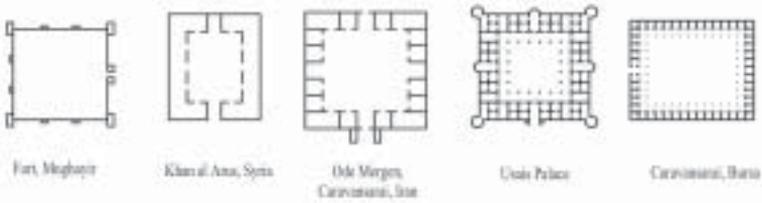


Figure 1. Types of historic courtyard buildings.

depicted in Figure 2(a). The concept of the building is traditionally rooted in its reference to the old madrasa structure with building clusters organised around a large courtyard and four gateways placed at the end of each axis. A similar reinterpretation of the courtyard model is followed in the design of the United Nations office in Riyadh, Saudi Arabia as depicted in Figure 2(b).

Such developments in contemporary design can be viewed as series of informal transformations to the inherited tradition of historic architecture. Shape grammars offer a formal framework to map such transformations and create new designs.

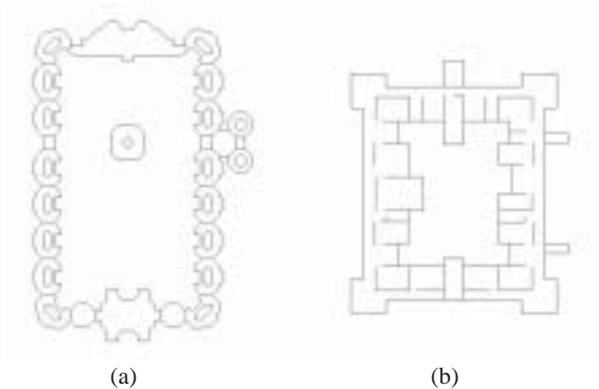


Figure 2. Examples of contemporary Islamic courtyard architecture.

(a) Ground Plan, Iran Centre for Management Studies (b) Ground Plan, UNO, Riyadh

4. Issues in deriving new design styles from old ones

This section discusses the stages proposed in the redesign framework and the primary issues involved therein.

4.1. CHARACTERISATION OF THE COURTYARD AS A STYLE

A corpus of courtyard buildings from the work of Hillenbrand (1994) was identified. The medieval Islamic courtyard building can be characterised as a building style with distinct, recognisable spatial features such as cells, entrances, towers, bastions and fortification walls organised around a set of orthogonal axes.

We have authored a parametric shape grammar to describe the design generation of the ground plans of central Asian caravanserais (Ahmad and Chase, 2005). Such a grammar offers the compositional machinery to design unknown/new buildings in the style that has been defined.

The grammar was based on an examination of design principles of Islamic architecture. This facilitated the development of a conjecture of the design process of historic Islamic buildings, and was deemed a vital factor for the computation of meaningful designs of future buildings. The shape grammar was structured in stages, which facilitates easy modifications thus making it possible to address new design criteria (Flemming, 1987).

4.2. DEFINING ASPECTS OF REDESIGN

Contemporary courtyard buildings differ significantly in their function and requirements from historic buildings. Figure 3 shows a preliminary analysis of a historic caravanserai illustrating the relationships between functions, spatial elements and their characteristics. Contemporary buildings are greater in complexity, as they often accommodate varied functions, with each space designated for specific activities such as working/living space, service zones and circulation space. This has a direct implication on the size and uniformity of the repetitive unit cell. Furthermore, a modern building might not require the historic function of protection from outside forces, but might have additional requirements of conformance to health and safety regulations.

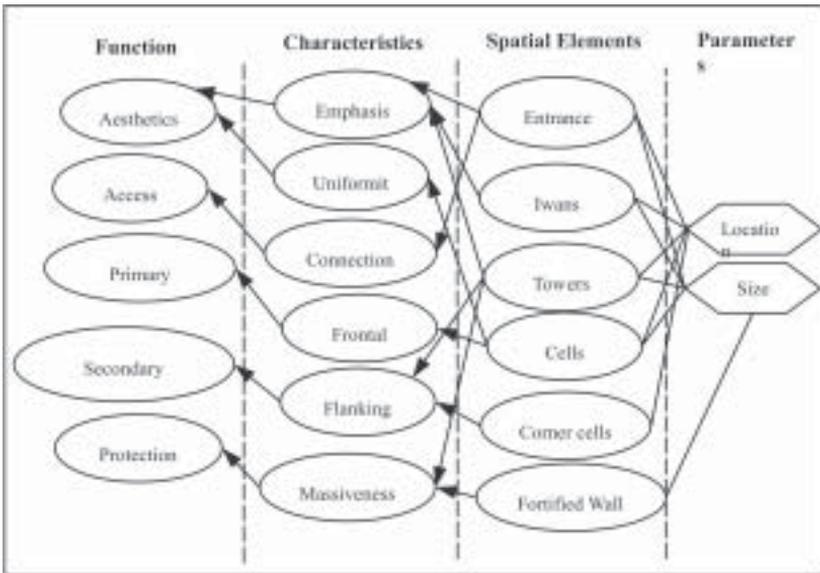


Figure 3. Functional analyses of historic caravanserais.

4.3. GRAMMAR TRANSFORMATION TECHNIQUES

We refer to Knight's (1994) method of grammar transformation for modifying a grammar by addition, deletion or modification of grammar rules, either by shape replacement or by modification of spatial relations. Such transformations can be made purposeful only if they are mapped to relevant changes in design criteria. This can be made possible by the insertion of a description scheme (Stiny, 1981) in the caravanserai grammar. It would then consist of rules which have geometric representation as well as descriptions associated with them. Grammar transformation rules could then be selected on the basis of their descriptions as per altered requirements.

Amongst the paradigms we consider for the transformation of our original grammars to ones for contemporary designs is the redesign framework using FBS grammars (Chase and Liew, 2001). This methodology encodes function, behaviour and structure in a grammar and facilitates redesign (the creation of a new grammar) based upon changing requirements.

4.4. CRITERIA FOR EVALUATING NEW GRAMMARS

In the final stage, any modified grammar would have to be tested for its suitability for a given purpose. Flemming (1987) lists *Expressiveness*, *Appropriateness* and *Correctness* as the criteria for the evaluation of a grammar. As in the case of the Queen Anne Grammar, any modified grammar would have to satisfy the criteria of 'appropriateness' rather than 'correctness', allowing the designer greater flexibility in the design process.

A fundamental issue that would arise in the generation of a contemporary courtyard building grammar is: how would the new, contemporary designs that are generated conform to the defined style of Islamic architecture? In other words, to what extent may the new grammar deviate from the grammar of historic courtyard buildings, and yet be recognised as its offspring? Incorporation of Chan's (1994) work on style recognition and distortion would aid in setting limits to the grammar transformation process.

5. Further work

We are also developing the concept of composite grammars (Chase, Ahmad 2005), created by merging two or more grammars. This method of design development is seen to be consistent with the methods of Islamic designers of the past, as a unique characteristic of Islamic architecture was that it developed by borrowing from various sources and was notable for the originality of its manner of combining diverse elements.

Finally, within any particular language it is necessary for the designer to be able to perform effective searches for discovering designs that have the desired interpretations. We are looking at SGGGA, a model that fuses the search methods of genetic algorithms with the design generation techniques of shape grammars (Loomis, 2002); and shape annealing, a computational design technique that combines shape grammars with directed stochastic search (Shea, 1997).

6. Summary

In this paper we discussed grammar transformation of historic building Islamic building types to generate new/contemporary designs or design styles and raised issues that could be of significance. We also discussed areas of further work that could be relevant to the design methods of Islamic architecture.

The grammar transformation approach for the generation of contemporary Islamic designs is different from conventional approaches in that it provides a formal framework for design/redesign and allows structured transformations. Moreover, the transformations in the shape grammar approach are more explicit and rigorous than conventional approaches. Grammar transformations as described here would allow changes in the structure of style, rather than mere visible changes to design elements. Such transformations would require only an elementary manipulation of rules and would result in the creation of a multiplicity of design languages.

Although grammar transformations have been used for the study of stylistic change (Knight, 1994), the methodology is—to our knowledge—yet to be used for the innovation of grammars for contemporary designs. Finally, Islamic design principles have inspired many a great modern architects and one foresees that grammar transformations of historic Islamic architecture as proposed here would find an audience not just limited to Islamic societies.

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