EVALUATION OF THE APPLICATION OF SHAPE GRAMMARS IN ARCHITECTURAL DESIGN

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ABSTRACT

The aim of this report is to present the evaluation of the previous application of shape grammar in design generation. Three works in this area have been evaluated that is Queen Anne houses done by Flemming, African Ndebele homesteads done by Herbert et al, and English row houses done by Çağdaş. It is found that all those works follow similar procedure that is: firstly, analysed the houses style, then transform it to the grammars, and finally use certain rules to generate design style. However, they were differ in the way they used shape grammar to generate known design style. The result of this evaluation is used to propose the future application of shape grammar in design generation especially in architectural design.

Keywords: shape grammars, design generation, architectural design.

INTRODUCTION

Stiny (1976 cited in Knight, 2001) has described ‘two exercises in formal composition’ that become the basis of application of shape grammars. The first exercise shown how shape grammars could be used in generating new design style. The second exercise shown how shape grammars could be used to analyze known or existing style. This paper concern the applications of shape grammars in generating new design and evaluate some works have been done in this area.

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There are several works have been done regarding the application of shape grammar in design generation. Some examples of them in architectural design are villas of Palladio (Stiny and Mitchell, 1978), Frank Lloyd Wright’s Prairie houses (Koning and Eizenberg, 1981), Queen Anne houses (Flemming, 1987), African Ndebele homesteads (Herber, et al, 1994) and English row houses (Çağdaş, 1996).

**EVALUATION OF SOME WORKS IN THE APPLICATION OF SHAPE GRAMMARS IN ARCHITECTURE**

This report examines three of those and tries to present the future of application of shape grammars in architectural practice. In particular, the report will evaluate how shape grammars have been used to generate design in certain style and propose the direction of the implementation of shape grammar in architectural practice nowadays and in the future. This study cover the last three works mentioned above, Queen Anne houses, African Ndebele homesteads and English row houses.

There are several similarities and differences between those works. This will be explaining in discussion section. Basically, all works follow similar procedure that was analysed certain style of architecture and transformed design style into shape grammars formalism and defined the rules that would be applied on generating some variations of arrangement of the styles. If the shape grammar can match all the existing variations of the style, so it also possible to use that shape grammars to generate many other alternatives of the style, or even other styles.

**Queen Anne House**

This study examined Queen Anne houses style that dominated residential architecture in the United State of America in the 1880s. The writer used of examples of typical for Pittsburgh’s historic Shadyside district. A shape grammar is used to generate this type of houses by analysing the plan organization and exterior articulation. This study has been emphasized on aspects of geometry and overall design that is how individual parts and features are related to each other (Flemming, 1987).

The author analysed the characteristic of this house style and transformed it into the grammars. The first step of this study is application of shape
grams in spatial organization. In the spatial organization, Flemming (1987) presents the key factor in organizing plan type. He grouped the plan into four groups: side hall, corner hall, centre hall, and corner room. It was appears that most of these plan types determined by the position of hall. All other rooms are arranged around the hall according to well-defined rules.

Flemming (1987) used 3D shape grammars to articulate the exterior of the house. An envelope of the house is generated by application of several defined rules. In this step, he generated wall, roof and the element of the house such as windows, chimneys and porches.

Gambar 1. Queen Anne’s House (Environmental and Planning B, 1987)

Flemming’s work is very detail, because it not only covers the 2D shape grammars and plan organization, but also covers the 3D and the element of the houses. He shows how the each rule applied in generating the house style. The process of how the grammars are used to generate the plan, exterior and element of the houses is very clear.

African Ndebele Homesteads

This study intends to assess the possibility of using shape grammar to define a layout of linear Ndebele homesteads in Africa. Shape grammars that performed from this assessment can be used to generate other alternatives of Ndebele homesteads that follow all social customs and structural of traditional settlement (Herbert et al, 1994).
To do this, the writers first defined the grammar of Ndebele homesteads based on six plans that have been recorded by Rich (1991 cited in Herbert et al, 1994). The six plans were analysed by comparing them with basic house plans created by Schneider (1986, cited in Herbert et al, 1994). The writers found that there are similarities between those. Schneider’s plans show the progressive growth occurred from single, L/Plan, U/Plan, E/Plan to Cluster. The grammar is defined from these plans.

Herbert et al (1994) used a computer program to generate lay out plan, as a result there were 384 plans generated. They found that some of plans are match to current homestead, therefore the grammar is rational, even though it is not possible to determine whether all element of Ndebele homesteads are covered or not. They conclude that structured growth such as home can be modelled by using shape grammar.


This work covers the very simple application of shape grammars, because it was only dealt with the layout arrangement of the design style. This work is far from complete because the writer cannot conclude that whether all element of Ndebele homestead cover or not. However, this works, at least, have demonstrated how the shape grammar used to generate alternatives that match with the existing style by providing the process of lay out generation.
English Row- Houses

This study aims to analyse the application shape grammar that has capability to generate design in conjunction with reasoning capabilities of knowledge-based systems and the integration of prototype. The study especially focused on English row-houses (Çağdaş, 1996).

Çağdaş (1996) divided this study into three levels. The first level is to form the vocabulary of architectural language of English row houses by analysing the houses syntactically and formally. In this level, he found that there are four type of English row-houses’ plan: I plan, L plan, T plan, and Z plan. Each plan consists of several types. This analysis based on the orientation of the house against the street. He also studied the functional and dimensional requirements. Formal requirements are shape and configuration of plan layout, plan type, garden type, number of stories, zoning of plan, circulation area, etc.

Gambar 3. English Row Houses (Design Studies, vol. 17, issue 1, 1999)

Second step is to transform the vocabulary of row houses into shape grammar. In this step, the author formed several schemata that including generation of star point, schemata of how garden located in the plan, zonings of the plan, location of circulation areas, locating the space, locating the sanitary rooms, locating the entrance door (Çağdaş, 1996).
The third step is the generation process using the schemata that already defined in step two. In this step the author utilize the reasoning capability of knowledge-based system and integration with prototype. He used computer interface to generate the alternatives of row-houses plan (Çağdaş, 1996).

Actually, this is a very interesting work in the area of design computing, because it used shape grammars and knowledge-based system and the integration with prototype to generate the alternatives of design style. It has a great possibility to support design process. However it does not show how the grammar is use to generate the design style rather than provides schemata.

DISCUSSIONS

The three works are presented above have several similarities and differences in the way they used shape grammars in generating design of all selected house styles. Firstly, all of the studies have examined each house style and transformed them to shape grammars. They examined all styles by using the available plan of each style. The grammars then used to generate the house style.

Another similarity is all works just tried to generate some plan or part of the house and matched them with current condition. Actually, they did not reach the step of generation the new house in the same style rather than examined the possibility of using shape grammars to generate known style. As Knight (1981) has demonstrated how to form a new design based on known styles.

The differences between those works, Flemming (1987), Herbert, et. al (1994) and Çağdaş (1996) can be described as follows:

1. In the Queen Anne houses, Flemming presented the use of shape grammars to generate four different types by using spatial organization and exterior articulation. Herbert et al use computer program to generate a lot of alternatives, which some of alternatives were similar to the current Ndebele homesteads. Çağdaş, on the other hand, using the capability of shape grammars in generating design together with the application of knowledge-based system that have integrated with prototype.
2. Herber et al. focused on the spatial layout and the relation with social condition, while Fleming and Çağdaş focused on the spatial arrangement and the element of the house such as windows.

3. Herbert et al. and Çağdaş use 2D shape grammars, Flemming, on the other hand used not only 2D but also 3D shape grammars. Flemming used 3D shape grammars to generate the walls and roofs of the house and also in generating the elements of the house such as windows, chimneys and porches.

All three studies have demonstrated how shape grammars as generative language used to generate alternatives within a given design style. In particular, they had shown how shape grammars that are based on known style have been used to create alternative spatial arrangement within a given style. Based on this fact, we can also possible to generate a new style as Knight (1981) demonstrated. Knight shows shape grammars that based on known style can be used to generate a new style.

However, those works did not demonstrate how shape grammars could be used to generate new and original design. In order to study this application, we can refer to the work done by Knight (1994). In this study, Knight presents the development of original shape grammars and designs as well as the development of original colour grammars.

THE FUTURE APPLICATION OF SHAPE GRAMMARS

Smyth and Edmonds (2000) point out that the successful of design mostly depend on how well the designers in dealing with alternatives and communicate the idea. In this context, shape grammar can be used to perform many alternatives based on known styles, so the designers can choose from those alternatives the best solution for design problems.

From those works described above, we can see that the work done by Flemming and Çağdaş may be the most suitable application of shape grammars in supporting design process. This is similar what Smyth and Edmonds (2000) try to explore the application of computer to support design process based on shape grammars. In this case shape grammars are used because they have the capability to generate many alternatives. However, according to Smyth and Edmonds (2000) the alternatives must be meet two requirements that is it should include ‘unexpected’ solution and they should be reasonably likely to be judged as ‘good’ solution.
If we combine these works with the work done by Maher and Zhao (1993), it is possible to use shape grammars to generate alternatives by using shape grammar interpreter such as Prolog that can be stored in knowledge-based systems as prototype. Therefore, it is possible to use the prototype to support design process. Designers or architects can use this methods to gain possible solution for their given design problems. In this methods there must be interactive process that allow the users adapt and if possible to create a new design.

**CONCLUSION**

The three works, which are evaluated in this paper show that the application of shape grammars in generating alternatives of known design styles. Therefore, we can not find a new design style from those works. However, these works provide the demonstration of how shape grammars can be used to generate new design. By following the same procedure, we can generate many alternatives solution for certain design problem.

The works done by Flemming and Çağdaş can be expanded in order to use shape grammars to support design process and it may lead to the creative design work. This is an interesting point because his work combined the capability of shape grammar to generate many alternatives, which are according to Smyth and Edmonds (2000) must be ‘unexpected’ and can be judged as ‘good’ solutions with the reasoning capability of Knowledge-based systems. However, further research it is needed to make shape grammars are able to support design process and may lead to creative design.

**REFERENCES**


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