LOOKING DEEPER: SHAPE GRAMMARS IN 3D
(Paper)

Topic: (Architecture)

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Abstract
Since shape grammars have been introduced by Stiny and Gips (1972), research on the idea had gradually gained recognition. In architecture and engineering, shape grammars have led to shape computation as a formal generative way of design approach. Yet, most of the current shape grammar applications are realized in specific limitations, such as designs in two dimensional space. The aim of this paper is to search for the probable emergence in three dimensional space.
In architecture, spatial and visual reasoning are important. Since two dimensional mediums are tend to be planar, people may observe length and width. But in the third dimension, there is depth as well, so that the object has a more realistic appearance and the spatial reasoning may be enriched and stronger in terms of visual and spatial perception for this particular area.
Despite the wide implementations, many studies have been limited to the two dimensional environment. There are few works constituted three diensional grammars. Because new grammars must be adapted to the traditional computing environment, representations of the grammars needs extensive work in coding environment. Therefore shape grammars are not extensively applied through programming too.
The aim of this paper is to highlight how shape grammar examples can be in three dimensional environment including embedding and what these shapes can offer to the field of desing, different from two dimensional environment.
This paper first presents the existing projects with 3D environments. Then, explains the development of approach is given, including rules based on the defined spatial relations. The latter part is a case study to test the implementation and investigate shape grammars in this broader universe with the discussions of future work and the limitations.

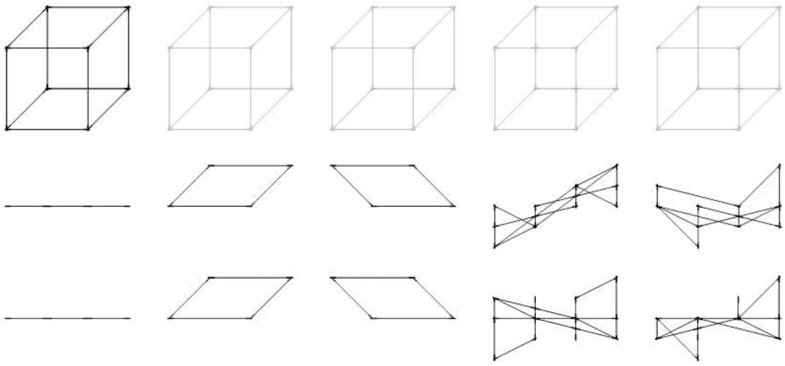

Figure: Restatement of the possible depths from a simple visual.

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Key words: shape grammars, spatial reasoning

Main References:

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Looking Deeper: Shape Grammars in 3D

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Premise

Since shape grammars have been introduced by Stiny and Gips [1], research on the idea had gradually gained recognition. In architecture and engineering, shape grammars have led to shape computation as a formal generative way of design approach. Despite the wide implementations, many studies have been limited to the two dimensional environment. Because new grammars must be adapted to the traditional computing environment, representations of the grammars need extensive work in coding environment. Therefore shape grammars are not extensively applied through programming too.

In architecture, spatial and visual reasoning are important. Since two dimensional mediums tend to be planar, people may observe length and width. But in the third dimension, there is depth as well, so that the object has a more realistic appearance and the spatial reasoning may be enriched and stronger in terms of visual and spatial perception for this particular area.

The aim of this paper is to search for the probable emergence and highlight how shape grammar examples can be in three dimensional environment including embedding and what these shapes can offer to the field of design, different from two dimensional environments.

1. Introduction

Since shape grammars have been introduced by Stiny and Gips [1], research on the idea had gradually gained recognition. In the original study, shape grammars were proposed through paintings, but many applications can be seen in the areas of architecture, visual design and engineering [2].

Despite the wide implementations, many studies have been limited to the two dimensional environment. There are few works constituted three dimensional grammars. Because new grammars must be adapted to the traditional computing environment, representations of the grammars need extensive work in coding environment. Therefore shape grammars are not extensively applied through programming too.

In architecture, spatial and visual reasoning are important. Since two dimensional mediums tend to be planar, people may observe length and width. But in the third dimension, there is depth as well, so that the object has a more realistic appearance and the spatial reasoning may be enriched and stronger in terms of visual and spatial perception for this particular area.

The aim of this paper is to highlight how shape grammar examples can be in three dimensional environment including embedding and what these shapes can offer to the field of design, different from two dimensional environments.

This paper first presents the existing projects with 3D environments. Then, explains the development of approach is given, including rules based on the defined spatial relations. The latter part will be a case study to test the implementation and investigate shape grammars in this broader universe with the discussions of future work and the limitations.

1.1 Existing 3D Shape Grammar Implementations

From the time the first shape grammar implementation was presented [3], majority of the works are focused on the 2D implementations. Moreover studies conducted are mostly

based and depended on prototypes that never get wide spread usage. An overview of both 2D and 3d implementations can be traced in the paper of Chau et. al. [4].
As 2D implementations, 3D implementations are mostly case oriented prototypes. Genesis interpreter of Heisserman is a piping design for Boeing [5].
The shape grammar interpreter designed by Piazzalunga and Fitzhorn was using solid kernels [6]. Through visual interaction the designers were to apply rules without much programming.
In [4] Chau et al. presented a shape grammar including curvilinear elements in 3D environment. In this approach, shapes and the rules were predefined and stored to be applied later.
The 3DShaper of Wang and Duarte is enabling preadjusting the rules before implementation to define the relations. The results are to be opened after the registration of rules [7].
All these attempts in the field are missing the sub shape detection and emergence [8].

2. Shape Grammars and Visual Reasoning

The Necker Cube is the visual model of what is abstract and simplified. The representation also holds the potential of flexibility by being abstracted and simplified. Since the correlations and their visualizations start originally in mind, the projection becomes ambiguous and what is perceived visually may vary from one person to another.

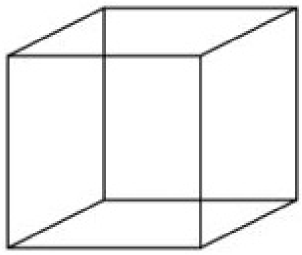

Figure 1: Necker cube, representing ambiguous projection of more than one cube pose.

When Necker Cube is shown to people for the first time, one of the alternatives of seeing the cube pops up in the mind. As two dimensional drawings are more planar, they may observe length and width but in three dimensional perception, there is depth as well so that the visual may constitute a different affordance than 2D. As a result the reasoning is enriched in terms of visual perception.

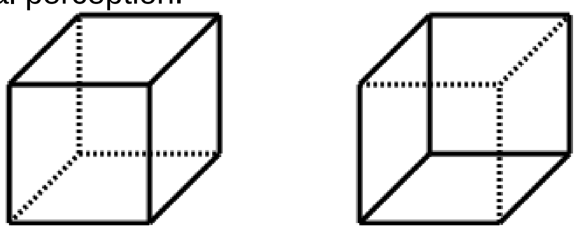

Figure 2: Alternatives of the same two-dimensional image.

Latter, some people may realize that this two dimensional drawing actually appear to be the visual model of more than one three dimensional shape. This very moment of discovery changes the flow of the process. With alternating perception, people may start to see more than one alternative as their answer to what they see in the given visual. They derive insights in the process of seeing and alternatives start to coexist and also what is perceived. An example of this issue can be seen in Figure 3.

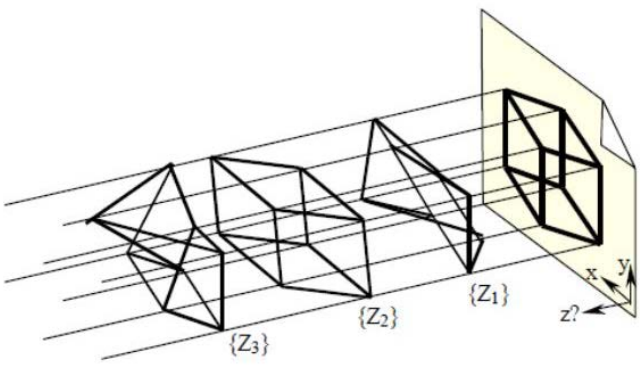

Figure 3: Thee-dimensional figures projecting into the same two-dimensional image. Figure from Lipson et al [9].

3. Shape Grammars and U3

There are numerous issues to be discussed in shape grammar implementations. For example, using maximal representation of a shape to enable sub shape recognition and eventually computation and emergence, allowing spatial rules and the third dimension. This paper will focus on the affordances of visual reasoning while working in two dimensional environment arguing that in fact visuals perceived two dimensional, could also be interpreted/perceived as 3D to approach the emergence in design from a different view.

The visual reasoning creates effective arrangements relating to what is perceived in terms of use and spatial and topological relations of our perceived life, meaning that people are inclined to perceive these aspects in the third dimension.

Since people begin to understand, transform and manipulate in 3D environment rather than 2D, there can be more perceivable alternatives to the shape grammar visual showed in Figure 4 than its current state.

Figure 4: Visual taken from Shape [10].

4. Implementation

This study tries to present the previously stated perceivable alternatives by converting visual of a 2D shape in 3D environment; both in the form of wireframes - U13 and surfaces - U23. The trials were conducted in three main phases.

First, as shown in Figure 5, the possible depths in 2D visuals are restated in 3D environment. the plan view remained unchanged (x,y), while the third coordinate (z) were intentionally varied.

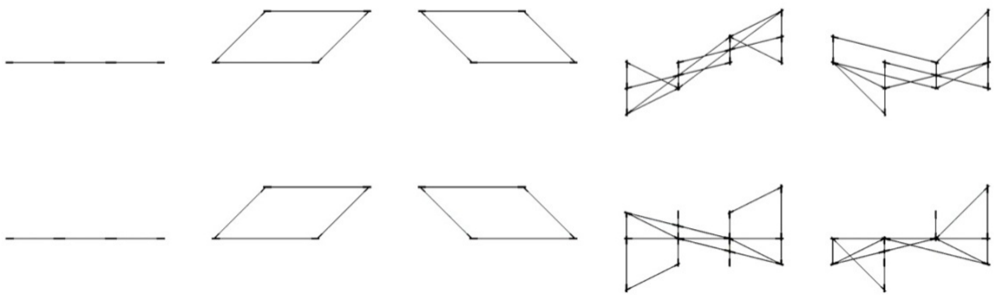

Figure 5: Restatement of the possible depths in 2D visuals.

Second, a rule is applied to certain geometry in Grasshopper environment. Different states of same originator can be seen in Figure 6. Later, the rule is applied to all four states in the form of both wireframe - U13 and surface - U23 (Figure 7).

Figure 6: Different states of same originator.

Figure 7: All states in the form of both surface - U23 and wireframe - U13.

Despite the pool of numerous alternatives to single originator in universes U13 and U23, this phase did not actually corresponded to the aim of the study. The trials did not present the same visuals as their top view. On the other hand, the visuals are related to presence of light and shadows in shape grammars and may contribute perception in these limits.

In the third step, the top view was fixed to prevent changes in the pattern, while two new attributes were added to vary the depth of the structures in 3D. Traces of these rules can be observed through the elevations in Figure 8. Codes under each visual define the varying states of attributes.

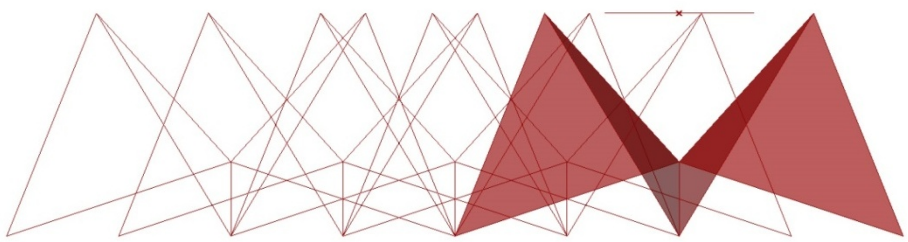

Figure 8: Elevation of the originator.

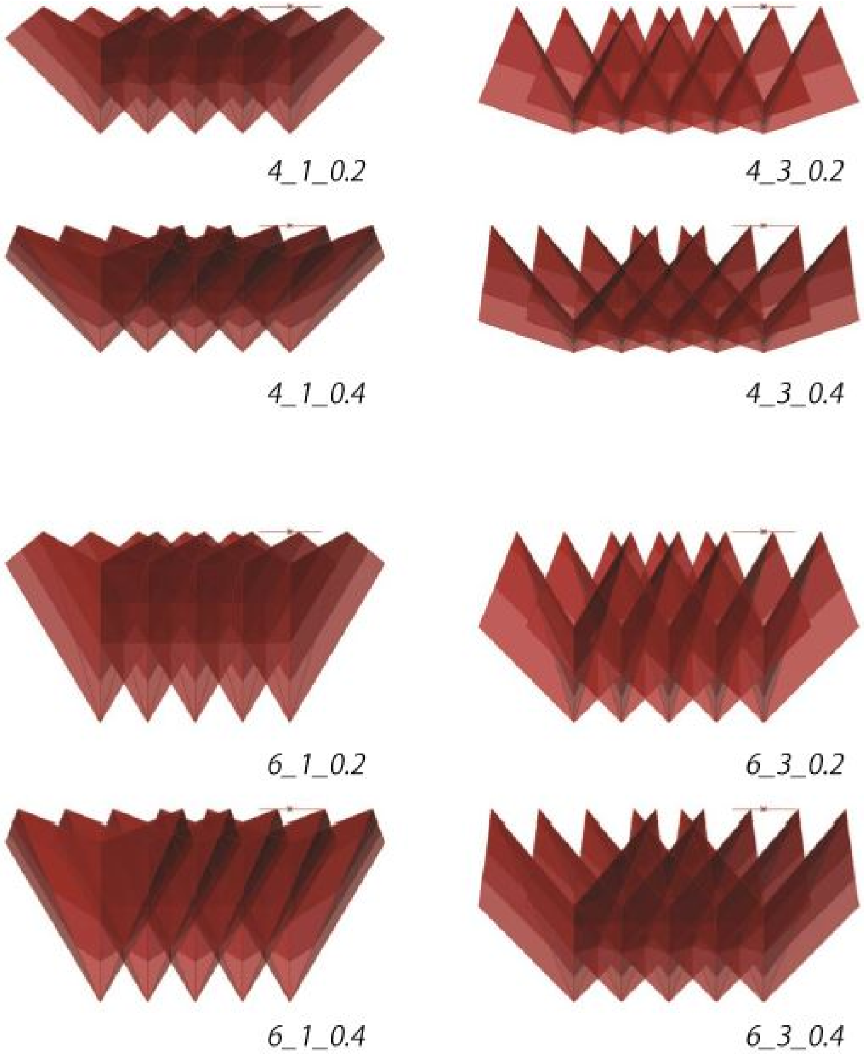

Figure 9: Elevation of the originator.

5. Discussion and Conclusion

This It can be seen that the current state of the trials are still missing the perceived depth and whole perception of 3D systems, rather they are somehow extensions of the given initial pattern in a more planar medium with limited depth. The trials should be extended and varied to build a better understanding of how to see deeper in two dimensional patterns.

In the end, despite the limited trials, the proposed works may lead different kinds of approaches by designers and the students, to see beyond what has been given or presented. In the age of computing data with zeros and ones, recognition or in a sense making inferences may have led shape grammars and all coding trapped in the two dimensional environment. Eventually, this question may lead self-reorganizations in itself.

Acknowledgements

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