The Development of a Shape-Generating System that Integrates Product Images and Rules of Shape Grammar

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Abstract: This research is for developing a system of computer-aided product design based on a shape grammar. The model of generating new shapes includes synchronized generation for shapes of different types via computer computations, which are based on the rules of the shape grammar. Further, a user may plan a basic model by selecting within a range of emotion parameters; the range of parameters can generate a series of useful shape prototypes by computations based on the shape grammar. This article illuminates the above idea by an example of kettle design. The shape grammar for pots is generated by collecting and analyzing current pot shapes, whereby a set of rules of three-dimensional shape grammar in parametric forms are deduced. A plurality of shape design concepts can be derived by systematic shape generation based on the three-dimensional shape grammar, as shown by a primitive system developed by us.

Key words: Kettle, Shape Grammar, Computer-Aided Design

1. Introduction

As computer technologies develop, the utilization of computers has significantly changed not only the way we work but also the way we think. In the domain of product design, computer technology changes the working mode of designers. In the stage of ideation in traditional product design processes, designers rely on metal black boxes for inspiration and intuition that breed new design ideas. The design development is therefore less predictable. In the past decade or so, new design theories and methods have facilitated design idea development, such as Morphological Analysis, Quality Function Deployment (QFD), structure variation method, morphing, SCAMPER method, Analogy [1], and shape grammar [3, 4]. Those methods directly influence the progression of design tasks. The ways that computers aid design include the digitalization of conventional design task, by which design modifications become much more convenient and accurate. It also includes the activation of design-knowledge transformation and innovative design ideation by the faculty of modern digital computing. If designers input a set of formatted design concepts into computers, and then the computers automatically produce a variety of configurations or shapes through rapid computations, the designers may have more room for imagination, or they may simply pick up suitable ones from the computer-generated ideas. We believe that computer design tools will eventually be welcome by designers, given the possibilities of computer facilitating

design. The final expression of a product design process is usually shapes, and therefore delivering good designs in the process of shape ideation is widely expected. Even many black boxes still exist in design processes, it is still interesting to study new methods to stimulate or train designers for delivering more innovative ideas of shapes.

A product shape configuration comprises many characteristics and shape elements. Many combinatory relations, called rules of shape grammar, exist among the shape elements, allowing computer processing for generating new shapes from those elements. Computation following the rules can in principle produced infinitely many shape variations. This study is focused on constructing rules of shape grammar for kettles. By systematic deduction from a set of representative kettles for rules of shape grammar, many possible shapes can be derived automatically, thereby facilitating designers to enrich the possibilities of innovative design concepts. Furthermore, by adjusting weights of emotional adjectives that restrict the computer shape generation, shapes of distinct styles and emotional effects can be generated for aesthetic consistency.

2. Research Methods

Taking kettles as an example, the present research converts rules of 3D shape grammar of kettles into parametric expressions suitable for the computer calculation. A variety of design ideas are deduced by systematically evolving for new shapes via the kettle shape grammar, thereby guiding designers in the stage of design ideation to enrich the diversity of design ideas. The research method used in this study is divided into several stages.

(1) We first adopted the method of Kansei Engineering for selecting representative kettles, collecting the associated shape adjectives and grouping the selected kettles.

(2) Kettle bodies are analyzed for identifying the basic components for building rules of shape grammar.

(3) 21 representative kettles are deconstructed and analyzed; thereby, a shape generating rule is assigned to each of the basic components.

(4) We then establish the correlation between Kansei Engineering database and the shape grammar, in which each of the kettles is provided with corresponding descriptive details and the associated parameters and rules for generating parametric shape grammar.

(5) An information system and its interfaces are constructed so that a user may tune the weights of a set of emotional adjectives via an interface and send the input data through the Internet to a server at the rear end. The system in turn generates a large amount of kettle shapes related to the selected emotional weights by rules of shape grammar implanted therein. The results are sent back to the user for visualization.

(6) Finally, the user may evaluate those shapes resulted from the design automation.

In the process of establishing the shape grammar, it is found that the kettle bodies are substantially formed by a number of basic contours; the contours are defined by a plane cutting through the kettle bodies. Therefore, the constitution rules for kettle bodies become generation of 3D surfaces by manipulating basic contours. The rules are so adjusted that they can simulate as many representative kettle shapes as possible (see Figure1). However, 5 of the 21 kettles selected by Kun-An Hsiao (2006) cannot be generated by our rules, mainly because their shapes are too unique [2].

Figure.1 Deconstructed and regenerated, by shape grammar found, representative kettles

3. System

In the present research, we intend to build software modules for generating shapes that are emotionally consistent. When designers want to generate large amounts of shapes, they have to input parameters for two selection modes. The first input is emotional values, which will be sent to a server for searching most satisfactory kettle shapes for the subsequent computation. The parameters defining the selected kettles will then be fine-adjusted to form a large amount of shapes respectively. Another input mode is for a user to select a kettle in the system database and to adjust its parameters manually. The system will adjust further and shuffle the parameters automatically, generating all possible shapes. After the automatic shape generation is done, the system will output the digital files of the shapes and simultaneously create .mel files for Maya application. The .mel files will drive a Maya software engine to render the shape into pictures, which will in turn be submitted to the client end for visualization (see Figure2).

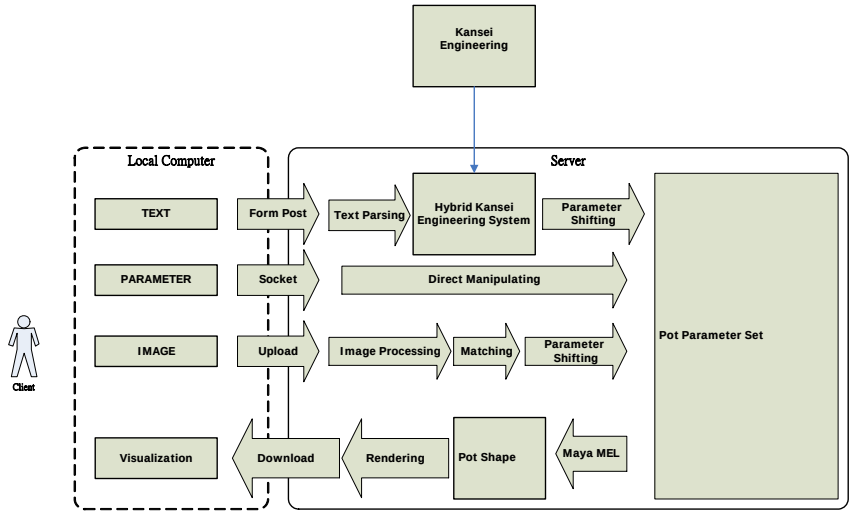

Figure.2 Plan for the computer system

4. Results of Computation

An initial result of the system under development is a series of kettle shapes as shown in the following Figure3.

Figure.3 A part of the shapes generated by rules of shape grammar

5. Summary

Establishing a set of rules by applying the principle of shape grammar is not easy. On one hand, too many restrictions from the rules would hinder the generation of new shapes. On the other hand, loose rules may not generate useful shapes. Therefore, to balance between the flexibility of grammatical rules and the efficacy of shape generation is the main concern. Further, for the purpose of design evaluation, to generate emotional factors upon the computerized shape generation is an interesting future task. With the faculty of automatic shape generation by rules of shape grammar, it is rather interesting for designers to seek for shapes of new styles or to stick to particular styles all the way in design processes. It is also possible that computers may even generate shapes following the classical design styles of a company. Implanting particular design styles within rules of shape grammar is an Interesting issue for future study.

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References

[1] Baxter, M., (1995) *Product Design, Practical methods for the systematic development of new products*, Chapman &Hall, London, ISBN: 0412632306

[2] Hsiao, K.A., Chen, L. L. (2006), Fundamental dimensions of affective responses to product Shape, *International Journal of Industrial Ergonomics*, 36(2006), Pp.553-564.

[3] Stiny G.: (1980), Introduction to shape and shape grammars, *Environment and Planning B*, Vol 7, pp 343-351

[4] Stiny, G. and Gips, J. (1972). Shape grammars and the generative specification of painting and sculpture, *In Information Processing* 71, C. V. Freiman (ed.), North-Holland, Amsterdam, pp. 1460-1465