THE SHAPE GRAMMAR OF RUDINARA RESIDENCE

MOHD ADIB BIN RAMLI

A thesis submitted in fulfillment of the
Requirements for the award of the degree of
Master of Architecture

Faculty of Built Environment
Universiti Teknologi Malaysia

MARCH 2010

To my beloved wife and daughter

ACKNOWLEDGEMENT

Alhamdulillah, praise to Allah as for His blessings and permission that this thesis can be completed within the stipulated time frame without any major hurdle. My greatest appreciation goes to my thesis supervisor, Associate Professor Dr. Mohamad Rashid Embi for his guidance, encouragement and comments as without it this thesis would not have been satisfactorily fulfilled. I am also very grateful to University Teknologi MARA, Shah Alam for funding my study under the Young Lecturer's Scheme including staffs at the Human Resource Development Department and the Faculty of Architecture, Planning and Survey for their assistance at various occasions.

To all my family members especially my beloved wife Fadhlina Ab Majid and my lovely daughter Julia Damia Mohd Adib who have been very supportive and understanding, patient and inspiring, I am very much indebted to all of them. And last but not least I would like to thank anybody that I have not mentioned here, wherever they are, who in any way has contributed to the accomplishment of this thesis.

ABSTRACT

This study aims to explore a new application of shape grammar formalism and to contribute to the existing body of knowledge as all the previous shape grammar projects only revolve around two issues. The first issue is on the shape of building plans they analyzed where all of them involve a rectangular plan or a form resulting from a combination of several rectangular shapes. The second issue is on the building category they chose which concerns with traditional or famous older styles. For that reason Rudinara residence was chosen as a subject for this study as it has triangular plans as well as contemporary architectural style. Shape grammar is a method used to analyze existing design language or style and subsequently using the design principles to create a multiple of new and diverse designs in the same style. In addition, it is also used to produce new and original languages of design as well as to transform an existing language into a new one. Therefore, two groups of data were required for this study with regard to the shape grammar formalism and also the existing design of Rudinara. Basic information regarding this method was presented prior to its application on Rudinara. Subsequently, three models of previous shape grammar applications which are comparable with this study were reviewed to give directions for the creation of the shape grammar of Rudinara. Then, the existing design of Rudinara was analyzed and the findings were successfully translated in terms of diagrammatical shape rules together with the explanations. The rules, totaling fifty altogether, describes the relationship and connection between each main building component. Later, the rules were applied to create new designs in the same language as Rudinara and as a result, a minimum of forty new and diverse designs were achieved. Six of the new designs were chosen to be described in detail afterwards. The step by step processes of applying the rules to create the new designs were presented as well as the detail plans and three-dimensional computer models. The purpose was to give clear impressions on how the new designs actually look like, thus they can be compared with Rudinara in terms of their design style. This study has contributed on the exploration of various design possibilities in the architectural style of Rudinara besides expanding the usage of this style in Malaysia's architectural landscape. Furthermore, this style as well as the application of shape grammar method in designing can be commercialized in a form of publication especially in Malaysia. Furthermore, courses and lectures on shape grammar can possibly be offered in local architectural schools to promote the use of this alternative method as well as encouraging students to establish their own style.

ABSTRAK

Kajian ini bertujuan untuk menerokai aplikasi baru kaedah tatabahasa bentuk selain menyumbang kepada pengetahuan sedia ada, memandangkan kesemua projek tatabahasa bentuk terdahulu hanya berkisar tentang dua perkara. Isu pertama ialah pada bentuk pelan bangunan yang dianalisis di mana kesemuanya memiliki pelan segi empat ataupun bentuk yang terdiri daripada kombinasi beberapa segiempat. Isu kedua pula ialah pada kategori bangunan yang dipilih yang terdiri daripada gaya tradisional ataupun gaya lama yang terkenal. Atas dasar tersebut Rudinara telah dipilih sebagai subjek bagi kajian ini kerana ia mempunyai pelan berbentuk segitiga selain gaya senibina kontemporari. Tatabahasa bentuk merupakan suatu kaedah yang digunakan untuk menganalisis bahasa atau gaya rekabentuk sedia ada dan seterusnya menggunakan prinsip-prinsip rekabentuk tersebut bagi menghasilkan pelbagai rekabentuk baru yang berbeza dalam gaya yang sama. Di samping itu ia turut digunakan untuk menghasilkan bahasa rekabentuk baru dan asli selain untuk mengubahsuai bahasa sedia ada menjadi baru. Untuk itu dua kumpulan data diperlukan dalam kajian ini yang berkaitan dengan kaedah tatabahasa bentuk dan juga rekabentuk Rudinara sedia ada. Maklumat asas berkenaan kaedah ini dipersembahkan terlebih dahulu sebelum kaedah ini diaplikasikan terhadap Rudinara. Seterusnya, tiga contoh aplikasi tatabahasa bentuk terdahulu yang dapat dibandingkan dengan kajian ini telah diteliti sebagai panduan bagi penghasilan tatabahasa bentuk Rudinara. Kemudian, rekabentuk Rudinara sedia ada telah dianalisis dan hasilnya telah berjaya diterjemahkan ke dalam gambarajah peraturan-peraturan bentuk beserta penerangannya. Peraturan-peraturan tersebut yang berjumlah lima puluh keseluruhannya menerangkan tentang pertalian dan hubung kait antara komponen-komponen utama bangunan. Seterusnya peraturan-peraturan tersebut telah diaplikasikan untuk menghasilkan rekabentuk-rekabentuk baru dalam bahasa yang sama dengan Rudinara dan didapati sekurang-kurangnya empat puluh rekabentuk baru yang berbeza dapat dihasilkan. Berikutnya enam daripada rekabentuk-rekabentuk tersebut telah dipilih untuk dipersembahkan secara terperinci. Proses pengaplikasian peraturan-peraturan tersebut secara langkah demi langkah untuk menghasilkan rekabentuk baru tersebut telah dipersembahkan, selain pelan terperinci dan model tiga dimensi janaan komputer. Ini bertujuan untuk memberikan gambaran yang jelas bagaimana ianya kelihatan, maka ia dapat dibandingkan dengan Rudinara dari segi gaya rekabentuk. Kajian ini telah menyumbang kepada penerokaan pelbagai kebarangkalian rekabentuk dalam gaya Rudinara selain mengembangkan penggunaan gaya ini dalam lanskap senibina Malaysia. Selain itu, gaya ini dan aplikasi kaedah tatabahasa bentuk dalam merekabentuk juga boleh dikomersilkan dalam bentuk penerbitan khususnya di Malaysia. Selanjutnya kursus dan kuliah berkenaan kaedah ini berkemungkinan dapat ditawarkan di sekolah-sekolah senibina tempatan bagi menggalakkan penggunaan kaedah alternatif ini selain menggalakkan pelajar untuk menghasilkan gaya mereka sendiri.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF TERMINOLOGY

Corpus	-	A large collection of building design examples of the usage of a particular design language, employed in design analysis
Computation	-	1) The calculating of something, or the result of a calculation. 2) The use of a computer, especially for calculation, or something calculated using a computer
Formalism	-	A method of aesthetic analysis that emphasizes structural elements and artistic techniques rather than content, especially in literary works
Grammar	-	The rules for composing or using a particular design style, or an analysis of the rules of a particular aspect of style
Interface	-	Software that links a computer with the set of commands, messages, images, and other features allowing communication between computer and user
Implementation	-	To put something into effect or action
Iteration	-	The repetition of a sequence of instructions in a computer program until a result is achieved
Loop	-	Set of instructions in a computer program that is repeated a particular number of times or until a specific objective has been achieved
Manual	-	Operated by a person rather than a computer, or by human effort rather than executed by computer
Parameter	-	A measurable quantity, e.g. length and height, that determines the result of a scientific experiment and can be altered to vary the result
Real time	-	The time in which a computer system processes and updates data as soon as it is received from some external source such as a user interface. The time available to receive the data, process it, and respond to the external process is dictated by the time constraints imposed by the process.

Rule	-	1) An authoritative principle set forth to guide behavior or action. 2) A mathematical procedure for performing an operation or solving a problem
Shape	-	An arrangement of basic elements in space, anything from a point or a symbol, a line, a hatched area or a three-dimensional object
Schema	-	A diagram or plan showing the basic outline of something. *Plural:* Schemata
Script	-	A sequence of automated computer commands embedded in a program that tells the program to execute a specific procedure when an interface is clicked
Transform	-	To change something completely, especially improving their appearance
Vocabulary	-	All the elements used in a design language as a whole

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Preface

Much had been written about shape grammars and numerous researches and applications were produced in relation to this formalism in the recent past when studies on the role of computers and computational process in design gained its recognition especially among academics and practitioners. Shape grammar is a formalism for generating designs and understanding existing compositions using computational approach, specifically computations with shapes. It consists of an initial object and a rule or a set of rules which specify the way to transform or combine the object with another object. Detail description of shape grammar is presented in Chapter 3 of this thesis.

Shape grammars have been utilized to solve problems in several areas of design including graphic design, industrial design and architectural design. In graphic design, the method was employed for example in creating original paintings (Stiny, 1972), transformations of De Stijl paintings (Knight, 1989) and procedural modeling of buildings (Muller *et. al*., 2004) while in industrial design it was utilized for instance to create a variety of coffee maker designs (Agarwal and Cagan, 1998) and the Hepplewhite-style chair-back designs (Knight, 1980). The most significant contribution of this method however, is towards architectural design, judging by a considerable number of projects and researches in the subject. One of the primary applications of shape grammar formalism in architecture is to analyze existing design language or style and to create new designs in the particular style. To name a few

examples of shape grammar in this type of application are the language of Frank Lloyd Wright's prairie houses (Koning and Eizenberg, 1981), the grammar of Queen Anne houses (Flemming, 1987), the grammar of Taiwanese traditional vernacular dwellings (Chiou and Krishnamurti, 1995), the language of traditional Turkish houses (Cagdas, 1996) and the grammar of Alvaro Siza's houses at Malagueira (Duarte, 2005). In Malaysia shape grammar formalism is still relatively new with the only study using this method excluding this research, perhaps, is on the grammar of the traditional Malay houses. It is aimed to represent the form and style of the traditional Malay houses, in particular the *bumbung panjang* (long roof) type, in a digital form to enable proper coding and compilation of the various built forms in a computing environment (Said and Embi, 2007).

1.2 Problem Statement

Two general resemblances can be identified between all the above shape grammar examples as well as other similar projects. Firstly, the initial object in these grammars is a rectangle or an object with rectangular elements such as a cube or a cuboid. It normally represents the shape of a room in plan or section, as typical in conventional buildings. Secondly, the historical and traditional nature of the design languages which were analyzed, except for the grammar of Siza's houses at Malagueira and only a few other projects which are quite recent. Almost all of the designs are dated back nearly a century ago (Downing and Flemming, 1981; Flemming, 1981) and beyond (Said and Embi, 2007; Chiou and Krishnamurti, 1995; Brelinckx, 1993; Stiny and Mitchell, 1993; Cagdas, 1996). Furthermore, since the design languages are long-established, creation of these grammars were based on the analysis of several models or a corpus of existing designs, typically more than ten.

Until now, there has been no report of any study on shape grammar formalism to analyze an existing design language which has a different shape of the initial object due to scarcity of a plan type other than rectangular-shaped especially in historical buildings. Owing to the historical and traditional disposition of most of the languages, the new designs created by the grammars will most probably never be

materialized in actual built form as they contradict with current values and environment of living as well as architectural context. Furthermore, these grammars have only educational potential, for examples, in learning about the work and style of accomplished designers as well as understanding the design strategies represented by the grammars (Knight, 2006[a]). Aside from that, none of the previous grammars address the language of more recent and contemporary architecture of a distinctive building.

1.3 Aim of Study

The aim of this study is to explore a new application of shape grammar and to contribute to the existing body of knowledge by moving away from the two issues repeated in previous projects. This study intends to develop a shape grammar on a building which has unique floor plans in a shape other than a rectangle with contemporary architectural style. Therefore, Rudinara residence was chosen to be the subject in this study as it impeccably meets all the above criteria. The photographic image of Rudinara is shown in figure 1.1 and a complete description on the building is presented in Chapter 5.

1.4 Objective of Study

Three main objectives have been outlined to achieve the aim of this research:

i) To identify the design principles and building elements based on the building systems

ii) To analyze previous shape grammar projects which are comparable with this study

iii) To identify the shape rules of Rudinara based on the shape grammar fundamentals

1.5 Significance of Study

This study is important as it adds new variety to the existing researches on shape grammar applications which generally circulate on the same type of subject - historical and traditional design language. It complements the previous study on the grammar of the traditional Malay houses by implementing this method to a modern Malay house (Said and Embi, 2007). There are a lot of contemporary designs out there where the languages and principles are yet to be understood, and consequently can be applied to or simply inspire future projects. The new designs created by the shape grammar of Rudinara can also be materialized in actual built forms to diversify the local landscape of architecture. In addition, this study is expected to encourage the utilization of shape grammar formalism especially in this country, in architectural education and practice, as they have many benefits and advantages.

1.6 Scope of Study

As shape grammars are referred to as formalism, therefore it explains the scope of this study. The term formalism in general as described in Wikipedia, a free online encyclopedia is:

> **…** the activity or its product which rigorously follows a set or system of rules previously defined and usually known.

While in art, which is the closest subject and one of the foundations of architecture, the term formalism is described as:

> ...the concept that a work's artistic value is entirely determined by its form – the way it is made, its purely visual aspects, and its medium. Formalism emphasizes compositional elements such as color, line, shape and texture rather than realism, context and content.

Hence, the concern of this study is in producing a shape grammar implementation which will create external geometrical design elements and the overall form of the

house with some enhancements on the facade. Other factors influencing the development and architectural expression of a building such as economic, functional, technical, sociological, and other disciplines are not of interest in this study.

1.7 Constrain and Limitation

The shape grammar created is solely based on the design of the one and only Rudinara residence where no other building in the same style has ever been created. Thus, it limits the study to only examine a single building which disables the data gathered to be cross-checked with other designs. This is in contrast with other projects where the shape grammars were created based on several existing designs in the same style. In addition, the design of the shape rules is limited to only manual framework rather than programmed using a computer. During the development of this grammar, standard user interfaces of several computer applications are utilized, which pretty much involve personal intuition in the whole process. On the other hand if the grammar is computer-programmed, the shape rules are encoded using a computer programming language while the computer will execute the commands and do the task of generating designs according to the rules. Unfortunately it cannot be achieved in this study due to inadequacy of programming knowledge and time constraint in learning a scripting language.

1.8 Thesis Organization

This thesis is divided into eight sections which clearly explain the different topics and stages in the study. After introducing the whole background of the study in this chapter, Chapter 2 follows by stating the methodology used in this research which consists of the procedure for conducting the study, resources of data and the method of analyzing the data. Chapter 3 introduces the shape grammar formalism including the history, detail description and different applications of shape grammar in the discipline of architecture. Then, the chapter introduces briefly on computer

implementations of shape grammar, focusing on the computer softwares and programming languages used to create them. This leads to the presentation of two experiments on shape grammar computer implementations together with its results. The experiments were conducted in conjunction with this research to witness the potential and capability of shape grammars when implemented by computer. Chapter 3 also emphasizes the benefits and advantages of using the method as opposed to the traditional methods of designing. Later, in Chapter 4 three models of previous shape grammar projects that relatively comparable to Rudinara are presented to give an overview of the process and provide the framework for creating shape grammars.

Chapter 5 on the other hand dwells on the Rudinara residence, which include the background of the house and review of the existing design with the aid of plans, elevations, schedules and perspective drawings. Then, the design is analyzed according to four subdivisions of the building system namely space system, structure system, envelope system and circulation system (Ching and Radziah, 1995). Chapter 6 presents the hypothetical model of the shape grammar of Rudinara which is represented by shape rule schemata for the design language. A variety of new basic Rudinara-style designs are presented with captions beneath some of them to indicate the origin of design for Rudinara and the detail designs which will be presented in Chapter 6. At the end of this chapter, application of the shape grammar is demonstrated through step-by-step process of applying the rules to recreate the existing design of Rudinara.

Chapter 7 subsequently reveals the detail design of six new Rudinara-style houses which are originated from the basic designs in Chapter 6 together with descriptions of the rules applied which is later simplified in diagrammatic form alongside the plans and perspective images. This is to give clear impression to the look of the finished designs so they can be easily compared with the existing design. Finally, Chapter 8 concludes the whole study and discusses the implications of the study and proposes future directions.

Reference

Agarwal, M., Cagan, J. (1998). *A blend of different tastes: the language of coffeemakers*. Environment and Planning B: Planning and Design 25(2) 205 – 226.

Alamuddin, H. (1998). *Technical review of Salinger residence*. The Aga Khan Award of Architecture. Spain.

Aminaton Marto. *Problem Formulation*. Research Methodology Course Lecture Notes, Universiti Teknologi Malaysia.

Baxter, P., Jack, S. (2008). *Qualitative case study methodology: Study design and implementation for novice researchers*. The Qualitative Report, 13 (4), 544 – 559. Retrieved from http://www.nova.edu/ssss/QR/QR13-4/baxter.pdf

Brelinckx, H. (1993). *Wren's language of City church designs: a formal generative classification*. Environment and Planning B: Planning and Design 20(6) 645 - 676.

Cagan, J., Mitchell, W.J. (1993). *Optimally directed shape generation by shape annealing*. Environment and Planning B: Planning and Design 20(1) 5 – 12.

Cagdas, G. (1996). *A shape grammar: the language of traditional Turkish houses*. Environment and Planning B: Planning and Design 23(4) 443 – 464

Chase, C.S. (1989). *Shape and shape grammars: from mathematical model to computer implementation*. Environment and Planning B 16(2) 119 - 248

Ching, F.D.K., Radziah Hashim (penterjemah) (1995). *Senibina – Bentuk, Ruang dan Tertib Susun Atur*. Kuala Lumpur: Dewan Bahasa dan Pustaka

Chiou, S.C., Krishnamurti, R. *(*1995). *The grammar of Taiwanese traditional vernacular dwellings*. Environment and Planning B: Planning and Design 22(6) 689 –720

Colakoglu, B. (2005). *Design by grammar: an interpretation and generation of vernacular hayat houses in contemporary context*. Environment and Planning B: Planning and Design 32(1) 141 – 149

Curl, J.S. (2005). *Dictionary of Architecture*. U.K.: Grange Books

Davidson, Cynthia C. (ed). (1998). *Salinger Residence*. In *Legacies for the Future: Contemporary Architecture in Islamic Societies*. London: Thames and Hudson, 82-95.

Digital Design Fabrication Group. MIT Department of Architecture. Retrieved from http://ddf.mit.edu/projects/PALLADIO/p_villas_home.html

Downing, F., Flemming, U. (1981). *The bungalows of Buffalo*. Environment and Planning B 8(3) 269 – 293

Duarte, J.P. (2005). *Towards the mass customization of housing: the grammar of Siza's houses at Malagueira*. Environment and Planning B: Planning and Design 32(3) 347 – 380

Flemming, U. (1981). *The secret of the Casa Giuliani Frigerio*. Environment and Planning B 8(1) 87 – 96

Flemming, U. (1981). *Structure in bungalow plans*. Environment and Planning B: Planning and Design 8(4) 393 – 404

Flemming, U. (1987). *More than the sum of parts: the grammar of Queen Anne houses*. Environment and Planning B: Planning and Design 14(3) 323 – 350

Formalism. Retrieved from http://en-wikipedia.org/wiki/Formalism-(art)

Gips, J. (1999). *Computer implementation of shape grammars***.** In *Workshop on Shape Computation*, United Kingdom: Boston College

Ismail, A. H. *(*1988). *Formal Approach to Composition in Computer-Aided Architectural Design*. Masters of Philosophy Thesis. University of Sheffield

Knight, T.W. (1980). The *generation of Hepplewhite-style chair-back designs*. Environment and Planning B 7(2) 227 – 238

Knight, T.W. (1981). *The forty-one steps*. Environment and Planning B 8(1) 97 –114

Knight, T.W. (1989). *Transformations of De Stijl art: the paintings of Georges Vantongerloo and Fritz Glarner*. Environment and Planning B: Planning and Design 16(1) 51 – 98

Knight, T.W. *(*1994). *Shape grammars and color grammars in design*. Environment and Planning B: Planning and Design 21(6) 705 – 735

Knight, T.W. (1995). *Constructive symmetry*. Environment and Planning B: Planning and Design 22(4) 419 – 450

Knight, T. (1999). *Applications in Architectural Design, and Education and Practice*. Report for NSF/MIT Workshop on Shape Computation. Massachusetts Institute of Technology.

Knight, T. (2006 a). *Shape Grammars in Education and Practice: History and Prospects*. Retrieved from http://www.mit.edu/~tknight/IJDC/

Knight,T. (2006 b). *MIT Public Lecture Series on Computational Design*. Microsoft Power Point Presentation.

Koning, H., Eizenberg, J. (1981). *The language of the prairie: Frank Lloyd Wright's prairie houses*. Environment and Planning B 8(3) 295 – 323

Liew, H. (2002). *Descriptive Conventions for Shape Grammars*. Massachusetts Institute of Technology.

Lim, J.C.S. (1998). *The Architect's Record of Salinger Residence*. The Aga Khan Award of Architecture. Spain.

McCarter R. (1997). *Frank Lloyd Wright*. London: Phaidon Press

Meng, T.K. (ed). (2000). *The Architecture of Humility*. In *Asian Architects Vol.1*. Singapore: Select Publishing, 188 - 191

Rasdi M.T., Ismail A.S. (2002). *Teori Senibina Frank Lloyd Wright*. Prentice Hall

Müller, P., Wonka, P., Haegler, S., Ulmer, A., Gool, L.V. (2004). *Procedural Modeling of Buildings.* Proceedings of ACM SIGGRAPH 2006 / ACM Transactions on Graphics

Said S., Embi M.R. (2007) *Towards A Digital Representation of Vernacular Architecture – The Traditional Malay Houses In Perspective.* Proceedings of 12th ICCAAD Research in Asia, Nanijing. pp 211- 218

Salinger, R. (2007). *Rudinara – The Story of the Handmade House*. Malaysia: Marshall Cavendish

Sass, L. (2005). *Wood Frame Grammar: CAD scripting a wood frame house*. MIT

Sass, L. *A (*2007). *Palladian construction grammar – design reasoning with shape grammars and rapid prototyping*. Environment and Planning B: Planning and Design 34(1) 87 – 106

Schnier, T., Gero, J.S. (1998). *From Frank Lloyd Wright to Mondrian: Transforming Evolving Representations*. Australia

Schirmbeck, E. (1987). *Idea, Form and Architecture – Design Principles in Contemporary Architecture*. USA

Seidel, J.V. (1998). *Qualitative Data Analysis*. In the manual for The Ethnograph V4. Retrieved from http://www.qualisresearch.com/

Self Directed Learning Resource. (2001). Learning Resource Centre, Learning Development. University of Wollongong

Shape grammar. Retrieved from http://en-wikipedia.org/wiki/Shape_grammar

Shape grammars. Retrieved from http://www.shapegrammar.org/

Shuttleworth, M. (2008). *Qualitative research design*. Greece,. Retrieved from http://www.experiment-resources.com

Soy, S.K. (1997). *The case study as a research method*. Unpublished paper, University of Texas at Austin.

Stiny, G., Gips, J. (1972). *Shape Grammars and the Generative Specification of Painting and Sculpture. Proceedings of IFIP Congress71*, Amsterdam: North- Holland, 1460-1465.

Stiny, G. (1977). *Ice-ray: a note on the generation of Chinese lattice designs*. Environment and Planning B 4(1) 89 – 98

Stiny, G. (1980). *Introduction to shape and shape grammars*. Environment and Planning B 7(3) 343 – 351

Stiny, G. (1980). *Kindergarten grammars: designing with Froebel's building gifts.* Environment and Planning B 7(4) 409 - 462

Stiny, G., Mitchell, W.J. (1980). *The grammar of paradise: on the generation of Mughul gardens*. Environment and Planning B 7(2) 209 – 226

Stiny, G., Mitchell, W.J. (1993). *The Palladian Grammar*. Environment and Planning B: Planning and Design 5(1) 5 – 18

Tapia M. A., (1999). *A visual implementation of a shape grammar system* Environment and Planning B: Planning and Design 26, 59–73.

Tellis, W. (1997). *Introduction to case study*. The Qualitative Report [On-line serial], *3*(2), Retrieved from http://www.nova.edu/ssss/QR/QR3-2/tellis1.html

Tugu cinta Rudinara – Rumah kayu tanpa paku. (2007,25 Feb.) In *Kosmo! Extra!* Malaysia: Utusan Melayu, 26 – 27

Wainwright, J., Lyric Media. (2008). *Autodesk® 3ds Max® 2008 MAXScript Reference*. USA: Focal Press