An urban grammar for Portuguese colonial new towns in the 18th century

Alexandra Paio
DAU - Departamento de Arquitectura e Urbanismo, ISCTE-IUL Lisbon University Institute, Portugal
alexandra.paio@iscte.pt

Benamy Turkienicz
SimmLab - Laboratory for the Simulation and Modeling in Architecture and Urbanism, Universidade Federal do Rio Grande do Sul, Brazil – benamy.turkienicz@gmail.com

Abstract. *This study describes the morphological urban order underlying Portuguese treatises and Portuguese urban cartographic representation produced from 16th century to 18th century. The historical documentation suggests that Pythagorean-Euclidian geometry appears to be a crucial ingredient for the understanding of Portuguese urban design-thinking and urban design-making. To unveil the genesis of the morphological urban order present in the Portuguese colonial plans of the eighteenth century, a descriptive method, Shape Grammar has been adopted. Shape Grammar, as method, supports the analysis of the form-making logic and has proved to be powerful in shape analysis, description, interpretation, classification, evaluation and generation of a design language.*

Keywords. *Urban Design; Knowledge-Based Model; Shape Grammars; Generative Systems.*

Introduction

Shape grammars have, over the past decades, been shown to be a powerful means of analyzing and generating languages of designs (Stiny and Gips, 1972). This paper focuses a generative parametric urban grammar computational model designed to produce derivations of Portuguese colonial new towns of the 18th century. The computational model is based in geometric principles embedding Portuguese treatises and practice at the time. During the model development, particular attention has been given to the similarities between the urban layout designed by Portuguese urban makers, up to the eighteenth century, and the actual process of urbanization. The depiction of similarities and differences has considered iconographic comparisons produced by several scholars in the last decade as a reference for this paper's final discussion. The research behind this paper is part of a larger ongoing project to develop a generative urban grammar for Portuguese colonial urban design from the 16th to 18th century.

The urban grammar proposed in this paper seeks to offer a new agenda addressed to the teaching of geometry and urban design in schools of architecture and urban design. First, by producing evidence that geometry is a fundamental cognitive tool for urban designers. Second, by describing some fundamental relations between geometry and urban elements (streets, urban blocks, main buildings an squares) and the relations between these elements.

This paper has four sections. The first, confronts traditional views based in iconographic evidence and historical data to a new and possible approach based in syntactical and non visual characteristics. The second section describes the Portuguese colonial urban design according to geometric and genetic principles. The third, introduces an urban grammar model capable of generating urban planimetric proportionate and symmetrical systems. The final section discusses the partial results of the research in relation to the existent body of knowledge concerning Portuguese colonial towns.

Knowledge-based Portuguese urban design

Scholars, mainly from Portugal and Brazil, have been trying to demonstrate that urban layouts of colonial towns evolved from structured thinking and urban maker's knowledge of geometry (Correia, 1997; Araujo, 1992, 2000; Menezes, 1998; Bueno, 2003). This knowledge is clearly present in the training lessons of skilled professionals and well documented in treatises, manuals, dissertations, cartographical and iconographical works produced in the eighteen century (Bueno, 2003; Paio, 2007). As Rossa puts it "Being able to colonise several parts of the world and code it in drawings was one of the major scientific accomplishments of Portuguese urban planners, and the acquisition of such knowledge demanded a unique ability for abstraction which could not have simply emerged out of nothing" (Rossa, 2001). Euclidian geometry, translated to simple and complex geometric constructs present in all the 30 analyzed treaties, played a fundamental role in the Portuguese urban planning design process (Pereira, 1999; Menezes, 2001).

This paper explores the descriptive potential of shape grammars to explain abstract underlying rules behind similarities and differences between cartographic representations of 75 Portuguese new towns. The methodology is described in table 1.

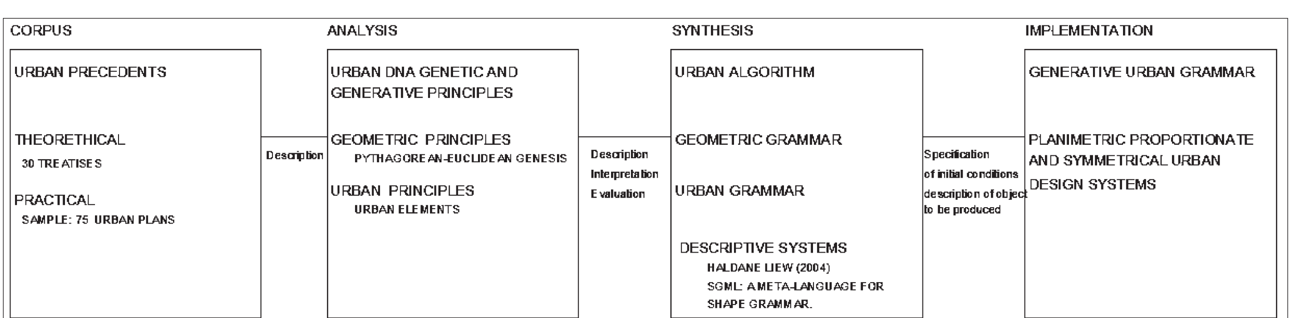

Table 1. Theoretical framework.

The development of the urban grammar computational model for the selected corpus has involved the analysis of 75 Portuguese urban plans and their reference to different treatises; the description of basic generative (geometric and urban) principles; the inference of shape rules and the specifications for the computational model capable to automatically generate planimetric proportionate and symmetrical urban designs according to Portuguese colonial principles.

The Portuguese urban design genesis: geometric and generative principles.

Through the analytical decoding of the sample's grammar, it was possible to progressively depict geometric and topological attributes and to establish two sets of categories and classes (Mitchell, 1998). These were geometric-configurational and topological-functional (Table 2.). Each category was divided in four classes. The geometric-configurational category is strongly Euclidean knowledge-based and constituted by 5 different elements: Position, Direction, Limit, Diagonal and proportion and symmetry (Paio and Turkienicz, 2009). The topological-functional category is related to urban elements: Streets; Urban Blocks; Main Buildings and Squares (Table 2). The two categories are related in that it is possible to associate the category's four classes one to another.

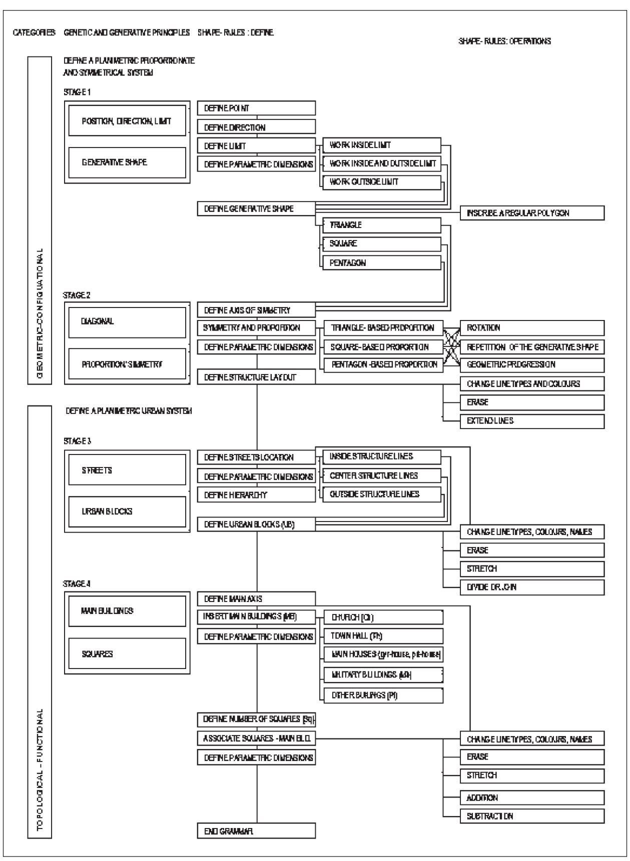

Table 2. Geometric-configurational and topological-functional.

Classes of the geometric-configurational category were used to generate symmetrical and proportional lay out where the diagonal has been deployed to generate streets and urban blocks. The definition of the point (geometric center), the direction (vertical and horizontal axis), allowed operations such as rotation and, further on, the positioning of the church and town hall (or military buildings) and the location of one or more than one squares (Figure 2.).

An Urban grammar for Portuguese colonial new towns: defining the basis for a computational model to generate urban planimetric proportionate and symmetrical systems.

Urban grammars have been developed in the past, (Teeling, 1996, Beirão and Duarte, 2005, Duarte et al, 2007) using the shape grammar formalism to define languages of urban design.

In this study, the proposed urban grammar is a parametric shape grammar defined in the algebras U12 V12 W12. The U algebra represents generic shapes, points, lines, planes. The V algebra represents labeled shapes, and W algebra represents the weight shapes. The generation of an urban derivation develops over four stages, two to generate the planimetric proportionate and symmetrical system and two to generate a planimetric urban system (Table 2.): (1) define position, direction and limit; (2) define the rules of proportion and symmetry; (3) define streets and urban blocks; (4) insert main buildings and squares. Each stage has a specific set of shape-rule schemata. These stages are sequential, using a step-by-step process to generate a colonial Portuguese urban plan. Transitions between sequential rules application and stages are controlled by the descriptive conventions of Shape-Grammar Meta-Language (SGMT) by Haldane Liew. SGMT's established an alternative method to write grammars for design introducing seven descriptors for shape grammar language. These explicitly determine the sequence through which a set of rules is applied, do restrict rule application through a filtering process and use context as to guide the rule matching process (Liew, 2004). The descriptors modify the conditions (rule selection, drawing state, matching conditions and application method) surrounding the process of applying a rule in shape grammar. Due to length restrictions, it will not be possible to describe in detail all rules of the proposed urban grammar.

Stages of the Urban Grammar developing process

The Urban grammar presented here is still limited in that it only partially describes the universe of Portuguese colonial urban plans. Specifically, it produces urban planimetric proportionate and symmetrical systems, orthogonal streets, urban blocks, main buildings (church, town hall, priest's house, governor's house, director's house and military buildings) and squares. Other elements such lots, houses and topographical features have been omitted. Since the grammar is designed as a sequence of stages, the omitted elements can be further inserted into the grammar as an additional stage. In order to demonstrate the urban grammar developed so far, an example of a Brazilian derivation process is illustrated (Figure 2.) and described.

Initial Shape

The initial shape for the Portuguese urban grammar is a point with a par coordinates (0,0).

Stage 1: Define position, direction and limit.

In the first stage of the urban grammar, the user defines the basic geometric generative principles of the planimetric proportionate and symmetrical system. This stage is composed of eight rules (Figure 1.). From the initial shape, a geometric center, the user has to define the direction, the geometric axis (x, y) to symmetry and proportion; the limit, a circle, which will be dived in equal parts defining the generative shape (Figure 2.). The equilateral triangle, the square and the pentagon are the three primary plane shape shapes which have it owns archetypal behaviour in terms of itself and in the final structure of the planimetric systems.

Stage 2: Proportion and symmetry

In the second stage of the urban grammar, the user operates rules to create a symmetric and proportionate structure, based on a generative shape selected in the stage 1. The sequential steps emulate the similitude to the operation with the compass and the straightedge. In order to clarify the following steps, (Figure 1.) is

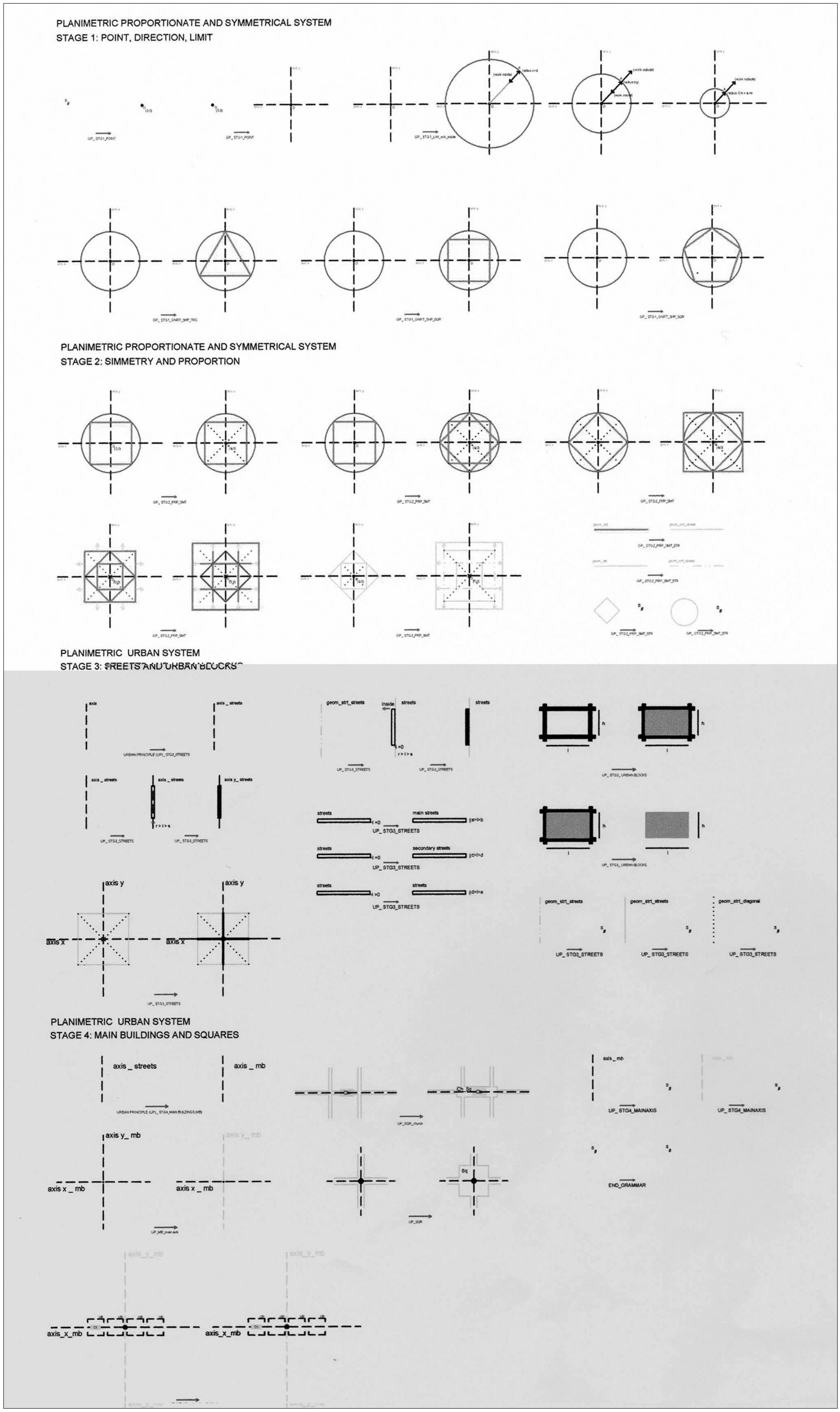

Figure 1. Shape-rules for generating planimetric urban

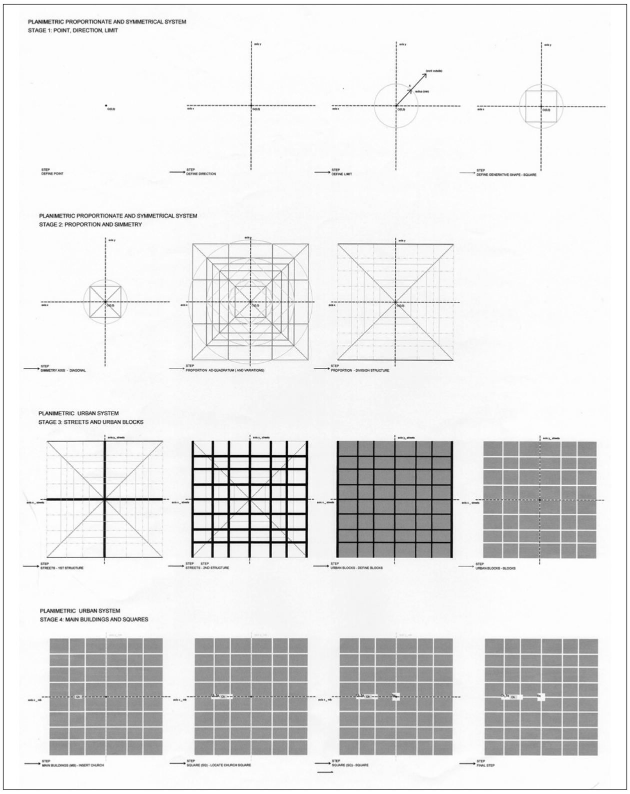

Figure 2. The derivation of the urban design Sample.

showed an example of a set operations (steps) that can be manipulated by the user: Step 1. Define the four axis of symmetry; Step 2. Decide the square-based proportions needed to work. The example has shown that the user rotated squares based on geometric progressions or arithmetic division in a nine-unit grid. Define the limit of application of the progression or the repetition of the squares (Figure 1.); Step 3. The regulating square is defined by lines originated from the square-based proportion and results in a particular grid whereby (Figure 1.) streets, blocks and buildings will emerge in the following stage. The result is a consistent geometric structure which regulates the planning of the Portuguese urban plans at many scales (Figure 2.).

Stage 3: Streets and urban blocks

In the third stage, urban generative elements emerge according to set-rules as follows: Step 1. Define first structure streets; Step 2. Define the final structure of streets, dimensions and hierarchy; Step 3. Define urban blocks; Step 4. Erase the streets structure and geometric structure no longer necessary. This final step will highlight the urban blocks grid and the main axis, a fundamental step towards the final stage of the grammar (Figure 2.).

Stage 4: Main buildings and squares

The user has, again, set-rules options to locate the main buildings (church, town hall, governor's house, priest's house and military buildings) and set-rules to locate the squares with various formal shapes. All set of shape rules transmit the relation between the main axis and the main buildings and these with the squares. In this final stage the user has to define main axis to insert the main buildings (Figure 2.). The derivation shows one way to insert the church and after the associated square. This grammar allows the user to locate one, two or three squares, and one of them can be generated without being related to a main building, as we can see in the derivation. The final step of the stage and the grammar is the erase of the main axis.

Discussion and Conclusions

This paper showed the application of shape grammar techniques to urban design history. This structural and structured knowledge-based research was essential to develop a generative parametric urban grammar for Portuguese colonial new towns in the 18th century, because structures are rarely explicitly represented in Portuguese selected corpus. The fundamental motivation of this research was to recover the elements of genetic foundation and represent these as constituents of visual reasoning processes. Since the major part of pre-design stages in urban design are devoted to the study of precedents as strategy to produce new design the experience may offer a new incentive to improve the teaching of geometry and urban design precedents in the schools of architecture and urbanism.

The results showed that shape grammars can constitute a valuable basis for the understanding of the colonial Portuguese urban design process. The resulting planimetric system ends up by corresponding to a basic compositional procedure supporting the implementation of designs and working as a scale. Once established the planimetric system, the urban plan absorb proportions and symmetry with surprising balance.

From the results obtained, it can be said that is possible to create a usefully tool to be used in the learning process of historical urban design. The descriptive and generative character of this tool will allow the user simultaneously to both interpret and simulate new designs based on theoretical knowledge, as well as to manipulate and generate various Portuguese colonial parametric urban design solutions.

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