

Using Shape Grammar to design ready-made housing for humanized living

Towards a parametric-typological design tool

BrunaLinhares

*ISCTE-University Institute of Lisbon, School of Technology and Architecture, Portugal
anurblue@hotmail.com*

Helena Alarcão

*ISCTE-University Institute of Lisbon, School of Technology and Architecture, Portugal
helenalarcao@hotmail.com*

LuísCarvão

*ISCTE-University Institute of Lisbon, School of Technology and Architecture, Portugal
ark.luiscarvao@hotmail.com*

PedroToste

*ISCTE-University Institute of Lisbon, School of Technology and Architecture, Portugal
ck_jones_oo7@hotmail.com*

Alexandra Paio

*ISCTE-University Institute of Lisbon, School of Technology and Architecture and ADETTI-IUL, Portugal
alexandra.paio@iscte.pt*

Abstract: *The research described in this paper is part of a larger on-going project called “Emerg.cities4all” that proposes a generative computer-aided planning system for housing for low-income populations using shape grammars. This paper presents the preliminary research results of a group of four master students who proposed to develop a grammar of ready-made housing for humanized living based in three informal settlements case studies. The results of this research are based on the assumption that it is possible to generate modular, adaptable and affordable ready-made housing for humanized living solutions design, supported by a computational generation tool.*

Palabras clave: Shape grammars; emergent housing; housing design; CPLP

Introduction

Nowadays, the necessity to eradicate slums in the world is a crucial need. Over the last decades, the Portuguese-speaking countries in Africa and Latin America, observe the increase of informal cities: favelas, musseques and caniços. The current situation in these cities does not allow the achievement of adequate shelter for all (UN-Habitat II, 1997). Generally, the existing housing solutions produced to reformulate the informal cities, are inadequate to the cultural, social and economical conditions of their inhabitants (Coelho, 2010; Paoiet al, 2011). The improvement of current low-income housing models is essential to rise to this challenge. Fortunately, as Jacques (2001, pp.34) put it, “the issue that’s being

discussed today is no longer related to the removal and relocation of the favela populations to the furthest areas of the city”. The question is: Why is the “European” housing pattern always the example to be followed, to the detriment of the culturally/socially/economically and formally inventive and rich informal housing patterns? Along with these assertions, there are reasons to consider that diversity and adaptability yield a better match between the building environment and the life it shelters (Habraken, 1987).

This work began with the assumption that informal self-built housing has humanized logics that should be analysed and considered in the design process (Turner& Fichter,1972). It is important that housing patterns and

the social and cultural genesis of their structure and configuration are revealed. In the community of Portuguese-speaking countries (CPLP) the self-built process has been the predominant mode of housing built by low-income populations. According to Kowaltowski (1998, pp. 299) 60% of the housing in Brazil is self-built. Despite the dreadful living conditions offered in informal cities, the adaptability and evolutiveness of their houses as well as the social relations of their inhabitants have to be introduced in the proposed ready-made housing grammar. This way, the shape grammar proposed by this research starts to be an analytical grammar because it seeks to analyze how existing informal housing is self-built and what cultural, social and spatial dynamics are involved in their evolution. But in the end there is an original grammar. The results of this research is based on the assumption that it is possible to generate modular, scalable, adaptable and affordable ready-made housing for humanized living solutions design if supported by a computational generation tool based on shape grammars (Paio et al, 2011). Shape grammars have, over the past decades, been shown to be a powerful means of analyzing and generating housing designs (Duarte, 2001). Using shape grammars (Stiny & Gips, 1972), our primary goal has been to create a house that grows with the tenant family and adapts to its needs without compromising local lifestyle and culture. This system will therefore lead us to the generation of multiple solutions for dwellings able to simulate the diversity and complexity of real urban cluster. Creation, evolution and control will return to the emerging cities just the same as freedom of choice for cultural, social, aesthetical and functional matters to the new inhabitants.

This paper has three sections. The first section describes the preliminary conclusion of the analysis of the three case studies. The second section introduces a ready-made housing for humanized living grammar. The final section discusses the partial results of the research.

Case Study Analysis

In order to analyze the rules of the informal housing, three case studies were defined: (1) Complexo Alemão, Rio de Janeiro, Brazil; (2) Airport neighbourhood, Maputo, Mozambique; and (3) Marçal, Luanda, Angola. The main objective of this study has been to expose the humanized logics of self-built housing.

These analyses allow us to define some preliminary con-

clusions at two scales: urban and architectonic. With a first approach to favelas in Rio de Janeiro, Brazil, we found that inhabitants build their own homes in hills, meaning that the built morphology is dictated by the geometry of its specific topography, a characteristic that is not found in any other urbanization we analyzed. For example, looking at caniços in Maputo, Mozambique, the implantation strategy is the imposition of a square grid on a plain site. So, the street follows a straight line, sometimes interrupted by an unexpected construction, a public space or an improvised ephemeral structure, suggesting a kind of emergence, proper of the outskirts. Finally, musseques in Luanda, Angola, are defined by major orthogonal arteries, unoriginal from the city of Luanda then, a fractal composition of secondary roads starts deriving from those arteries.

Besides these urban scale first impressions, we were also able to retain major conclusions from their lifestyle and architectural processes for the development of a grammar: (1) Rooms inside dwellings are contiguous, leaving no space for circulation areas; (2) Rooms have minimum areas and as a consequence, maximum segmentation, leaving no surplus space; (3) Dwellings grow by the means of their family necessities, for example, household changing number; (4) Inhabitants value the exterior space, spending more time outside than inside their homes, generating greater experiences of community living, exploring the soil for subsistent farming or even washing and drying their clothes; (5) In urban scale, the overcrowding of these complexes require a nearly complete occupation of the exterior space inside blocks, leading to disputes and resulting, in most cases, in constant narrowing of the pedestrian accesses; and (6) Only spaces with specific exterior functions, as referred to in point 4, are left open inside these blocks. (7) It should be highlighted that the void, despite being a space resulting from the construction, is very important as it assumes the cultural and social patterns of the analyzed study cases.

From the analysis of the case study, the question emerges of cultural patterns and inhabitation forms that result from the daily living of a specific family or in a bigger scale of a specific community. As Habraken (1988, pp.10) refers, "the culture, the social patterns, and shared preferences of a people are expressed in the house form itself". Having in account the size and the type of the family group, this becomes the main element that defines the house. Once the elements that constitute the house were defined, the relationship between them was

established (Table 1). We propose a creation of dwellings that may be adapted to their needs. In other words, an emergence of a new dwelling is intended, that will grow in harmony with the habitant family.

This way, and according to the analysis done of the case study, these dwellings were thought for general situations, where household consists, of at least, 1 element, to 12 elements (maximum).

Table 1 synthesizes a set of situations that could occur. For example, a family with 5 elements will have a dwelling corresponding to their household. But if, they want more rooms nothing prevents the housing to evolve into a corresponding number of rooms, for example, 7 or 8 persons. But the opposite also happens. If another family evolves to 1 or 2 persons, and for financial reasons cannot evolve the house, they can profit from some of their rooms, like the bedroom (Table 1). To make the most out of the bedrooms, these were thought to be able to take more than one person/bed.

Through the analytical decoding of the case studies, it was possible to progressively depict the attributes and to establish the shape rules of the grammar.

N° Personas/ dwellings	Exterior		Interior				N° of rooms
	N° floor	N° of	Common		Services		
			Kitchen	Bathroom	Living Area Laundry	Bedroom	
1	1	1	1	1	1	1	5
2	1	1	1	1	1	1	5
3	1	1	1	1	2	1	6
4	1	1	1	1	2	1	6
5	1	1	1	1	3	1	8
6	1	1	1	1	3	1	8
7	2	1	1	1	4	2	11
8	2	1	1	1	4	2	11
9	2	1	1	1	5	2	12
10	2	1	1	1	5	2	12
11	2	1	1	1	6	3	13
12	2	1	1	1	6	3	13

* No common exterior area. Dimensioned red, 4. In the rest of the remaining space of dwelling, height can vary, subject to maximum 4.5 meters height.

Number of persons	GENERAL		EXCEPTIONS	
	General	EXCEPTIONS	General	EXCEPTIONS
01 - 02	Couple (parents) / Widower		Parent + son	
03 - 04	Couple (parents) + 1-2 children		Widower + central children	
05 - 06	Couple (parents) + 3-4 children		Parent + son + grandparent	
07 - 08	Couple (parents) + 3-4 children + couple (parents)		Couple (parents) + 2 children + 1 child + grandparent	
09 - 10	Couple (parents) + 3-4 children + couple (parents) + grandparent		Couple (parents) + couple (parents) + 1 child + 1 grandparent	
11 - 12	Couple (parents) + 3-4 children + 2 couple (parents)		Couple (parents) + 2 children + 2 couple (parents) + 4 children + uncle	

Table 1 - Number of dwelling elements and number of persons per household

Preliminary Grammar

The proposed ready-made housing for humanized living grammar is a bi-dimensional parametric shape grammar with fixed rules and adaptive rules (Fig. 1). The rules shape the relations between the created spaces using a description grammar (Stiny, 1981).

In the first phase, the parameterization of the minimum unity was executed, which corresponds to the maximum limit of construction per household (6 x 14 meters). The first element to emerge in the house is the dining area characterized for being the space where the family meets

for their daily meals. Related to this space, emerges the bedroom (3 x 3 meters) where one or two people can fit, according to a generic distribution, although it could in exceptional cases, take three to four people (Table 1). The bathroom is the space that follows. After, comes the Multifunctional space that could assume one of the following functions: office, commercial space, living room or storage space or according to an adaptive rule, the space could be changed into a bedroom.

The flexibility of some spaces in the house, allows it to evolve and it adapts to the usual family needs. A 3 x 3 meter room is the best example. This room can assume multiple occupations, from the most basic function, the bedroom, to a multifunctional space. The latter may be, among others, an office, a living room, a storage room, or a commercial space. It is still necessary to refer the public purpose of this space, and consequently its location restrictions, having always to be located as close to the main street as possible, because of cases where, for example, the office or commercial space function exists. In all cases where the contact with the main street is impossible because of the house evolution, the adaptive rule will be applied (Fig.1).

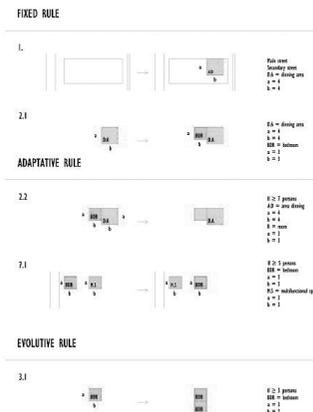


Fig. 1. Shape Rules

Derivation

Established the parameters and the set rules of the grammar, two examples of derivations were generated to show different types of dwellings: (1) Variation of a dwelling for a household with 3-4 people; (2) Variation of a dwelling for a household with 9-10 people (Fig.2). Figure 3 has the configuration of a tree in which the lines represent the applied rules. The tree illustrates some of the many possible solutions for the house, where the elements that constitute the space are the consequence

of the application of fixed rules, adaptive and evolving, according to the logic of number of inhabitants per services and bedrooms – it evolves according to the number of inhabitants and the number of floors. From 7 to 8 people onwards, a new floor is created, and together with this, space for the stairs, which appear in the limits of the construction extremities. In the two floor house even more combinations appear, with the 1st floor keeping its shape and the 2nd floor possibly changing.

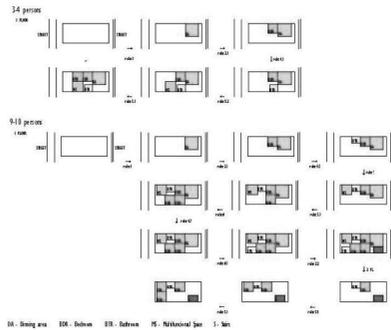


Fig. 2. Ready-made housing for a household for 3-4 people (left); and a household for 9-10 people (right)

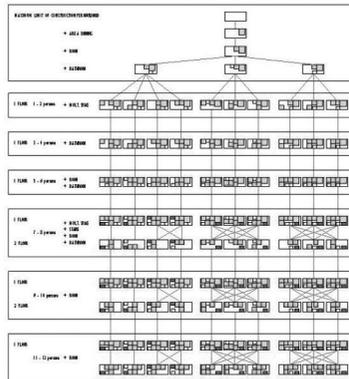


Fig. 3. Tree diagram to illustrate the derivation of some modular, adaptable and evolutive ready-made housing for humanized living

Discussion and Conclusion

One of the most important conclusions for this project is that we cannot impose our own habits and processes to these communities. They have their own quotidian life styles and habits, meaning that for creating this specific architecture we needed to learn with them. Such as Habraken (1988, pp.5) said “This makes the house a cultural artefact: the collective product of what a people is all about”. On the other hand, a new tool has appeared to help us to deal with complex issues such as self-evolution, self-adaptation and formal diversity on

architecture. A new way of facing the greatest problem of contemporary emergent cities is being explored. Our work will continue, studying the way these dwellings interact, creating spatial relationships, patios, squares, streets, blocks and even new city tissue. The multiple possibilities of room dispositions will help to generate formal diversity and plural behaviour among these populations. A new kind of ready-made architecture will rise from this computational process and also better and cheaper constructive methods and materials experimenting CAD-CAM precision equipment.

References

- Coelho, A. 2010. Apresentação do 1º CIHEL. Actas do 1º CIHEL Lisboa. Argumentum, 14-15
- Duarte, J. 2001. Customizing Mass Housing: a discursive grammar for Siza’s houses at Malagueira. Ph.D. MIT
- Jacques, P. 2001. The Aesthetics of the favela: the case of an extreme. Transforming cities, design in the favelas of Rio de Janeiro. AA Publications.
- Habraken, N. 1987. The Control of Complexity. Places, (4), 3-15
- Habraken, N. 1988. Type as a social agreement. Asian Congress of Architects, 3-18.
- Kowaltowski, D. 1998. Aesthetics and Self-Built Houses: an Analysis of a Brazilian Setting. Habitat Intl, (22), 299-312
- Paio, A., Eloy, S, Reis, J., Santos, F, Rato, V, Lopes, P. 2011. Emerg.cities4all: Towards a sustainable and integrated urban design. UIA 2011
- United Nations. 1997. Human Settlements Program - Habitat II,
- Turner, J. & Fichter, R. 1972. Freedom to build. Macmillan Company
- Stiny, G. & Gips, J. 1972. Algorithmic Aesthetics: Computer Models for Criticism and Design in the Arts. University of California Press.
- Stiny G. 1981. A note on the description of designs. Environment and Planning B: Planning and Design(8), 257-267