Towards Effective City Rejuvenation with ICT: web-based shape grammar supported refurbishment design

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Abstract

In this paper we consider the architectural task of the rejuvenation of cities consisting of the large scale renovation of regular apartment buildings. It is argued that ICT, and specifically shape grammar systems, provide the means to take up this task by refurbishing the apartments in these buildings in an individualized way, thus avoiding large scale demolishment in cities. We give this argument for the specific case of Rabo-de-bacalhau apartment buildings in the city of Lisbon by sketching a shape grammar system for the refurbishment of these apartments that can be made available as a web tool directly to the apartment inhabitants.

Keywords

City rejuvenation, shape grammar system, refurbishment, apartment building, web-tool.

Introduction: the task of the large scale rejuvenation of European cities

A central focus in architecture is on designing new buildings, yet given the large stocks of existing buildings, another focus is on managing the buildings that have already been constructed. The management of the architectural highlights in these stocks has receiving ample attention and defines the discipline of conservation in architecture. In this paper the focus is on the renovation of the stocks of more regular apartment buildings that come in larger numbers and that can be categorized in architectural types. Specifically cities that have had large scale, planned extensions in the 19th and 20th centuries contain such stocks, and by their aging they are confronting cities with equally large scale rejuvenation tasks consisting of either demolishing the buildings or refurbishing them to meet the technical and functional needs of the 21st century.

In this paper we argue that ICT is increasingly providing the means to take up this rejuvenation task by refurbishment thus avoiding the socially and environmentally more destructive demolishing of larger building stocks in cities. Our case is the city of Lisbon. As other European cities Lisbon has had several periods in which larger quantities of regular apartment buildings were constructed, which are now recognized as types: the Pombalino type, constructed after the 1755 earthquake until the first half of the 19th century; the Gaioleiro type, built between the end of the 19th century to the 30s of the 20th century; and the Rabo-de-bacalhau type, constructed in the period of 1930s to 1960s of the 20th century (see Figure 1). These types constitute regular apartment buildings, done in a large scale in Lisbon, and not necessarily constituting exceptional architectural examples associated with particular architects or with architectural styles [1]. Other European cities have their own types of regular apartment buildings creating similar large stocks of similar buildings dominating and characterizing the cities concerned. To name just a few: Victorian mansion blocks in London; Berlage apartment buildings in Amsterdam and Rotterdam; Haussmann apartment buildings in Paris; Casa de renta in the Eixample by Cerdá in Barcelona [2].

By their aging and by the changing requirements set in the current century, the buildings of these types are increasingly in need of renovation, which by their large numbers translates to the architectural task of rejuvenating whole neighborhoods in cities. We argue that ICT, and specifically shape grammar systems made available to apartment inhabitants through web tools, provide the means to take up this task by refurbishing large quantities of buildings on an individual basis. ICT can in that sense innovate city rejuvenation while avoiding large scale demolishments. We start by arguing for this opportunity, using our case of Lisbon. Then we spell out how the opportunity can be realized, and we end by discussing the advantages and disadvantages.

Figure 1 – Examples of Lisbon's common apartment building types: from left to right Pombalino, Gaioleiro and Rabo-de-bacalhau.

An ICT response: individualized refurbishment by shape grammar systems

For renovating large quantities of apartment buildings of a specific type there seem to be three main options available: their demolishment and the new construction of up-to-date housing; centralized refurbishment to make the existing buildings fit current standards; and the individualized refurbishment of the apartments in the buildings. These three options are not attractive for various reasons from the perspective of the city and of the inhabitants of the apartments concerned.

Demolishing a large quantity of apartment buildings and replacing them by new housing would mean a major disruption of the social fabric of the city. It would imply the relocation of the current inhabitants, the disappearance of the social fabric in the neighborhoods concerned and a loss of the identity of the city by the vanishing of the types of buildings concerned. These implications define reasons against such a large scale demolishment. Inhabitants may resist their relocation and the loss of their neighborhoods, thus creating opposition to this option of renovation. In architecture one can support this opposition by arguing for the preservation of these apartment buildings not only for their historical significance but also because they belong to places still alive and valued by people [3]. In Lisbon, for instance, the Pombalino, Gaioleiro and Rabo-de-bacalhau types are considered in architecture to be characteristic to the city. Finally, replacing building stock may not be attractive from the point of view of ecological sustainability [3] [4]. The latest conservation ethics emphasizes environmentally sustainable construction and the revitalization of urban cores attributing cultural value to all urban fabric regardless of style. In fact, the city of Lisbon adopted recently a policy to actively aim at refurbishment [5].

The second option of a large-scale, centralized refurbishment of existing types of apartment buildings is environmentally more sustainable but shares much of the other disadvantages of the first option. One could envisage a grand master plan for the refurbishment of each type of apartment building: consisting of one uniform refurbishment design for Pombalino buildings, one for Gaioleiro buildings and one for Rabo-de-bacalhau buildings, and a systematic effort to refurbish all the buildings of these types one by one. Neighborhoods can then be renovated in a piece-meal manner, leaving the social fabric in place, and inhabitants could return to their original apartments. Such an approach is however not feasible by two reasons. First, types of regular buildings may not be fully standardized since the characteristics defining types may be more abstract and merely establish a family resemblance in the Wittgensteinian [6] sense. For instance, Rabo-de-bacalhau buildings form a type by sharing topological characteristics of their floor layouts, yet there is still a

considerable variety in their actual floor layouts (see Figure 2); different Rabo-de-bacalhau buildings may therefore require different refurbishing designs. Moreover, when inhabitants are to return to their original apartments, one refurbishment design per building may not work since the inhabitants of the building can have different demands for making their apartments fit the standards of their current life. Hence, for avoiding that this second option again evolves into large scale relocations of inhabitants and the loss of the social fabric of neighborhoods, centralized refurbishment will have to involve giving refurbishments for each apartment individually. This means that the second option is in fact similar to the third, to which we turn now.

The final option of refurbishing each apartment individually would mean creating refurbishment designs for each apartment, and by the large number of apartments involved (an estimate of the number of Rabo-de-bacalhau apartments is 30.000) [7] this option seems not feasible or desired. Forcing inhabitants to hire architects to redesign their apartments seems politically unrealistic by the costs involved for inhabitants. Letting inhabitants do their designs themselves or arrange them otherwise will compromise the architectural quality of the refurbishment; an unfortunate removal of a wall in one apartment may compromise the structural integrity of the building containing the apartment; and given the large number of apartments involved, accidents are then bound to happen.

This survey suggests that renovating regular apartment building types in European cities will be a matter of choosing between only disadvantageous options. If however contemporary developments in ICT tools for architecture are included, this conclusion can be avoided. Specifically research on shape grammar systems in architecture has created tools that can create refurbishment designs that meet regular standards of architectural design [8] [9] as well as grammar-based systems that enable the generation of an existing housing type but altered in order to conform to the contemporary context [10] [11]. Making these grammar systems available to inhabitants as, say, web tools would enable them to create refurbishment designs for their own apartments that meet their own demands as well as construction standards concerning, say, structural integrity of buildings. Hence, when including ICT tools, the third option of large scale but individualized refurbishment of outdated building stocks in cities becomes favorable, thus realizing the rejuvenation of cities without large scale social and environmental disruptions. In the remainder of this paper we spell out a scenario for this option focusing on Lisbon's Rabo-de-bacalhau apartments.

Description of the grammar system

For refurbishing Rabo-de-bacalhau apartments (see Figure 2) a shape grammar called Rabo-de-Bacalhau Transformation Grammar (RdB-TG) was developed [8]. The grammar is a computational generative system that uses shape rules to adapt the layout of the apartments to contemporary requirements in a very precise and systematic way, taking in account functional, technical and constructional requirements.

A specific transformation grammar applied to a particular type of apartments was firstly created and ongoing work is being done to develop a general structure to the transformation grammar capable of encoding the principles and rules behind the adaptation of other types of existing houses so that a larger scope of buildings can be refurbished [12].
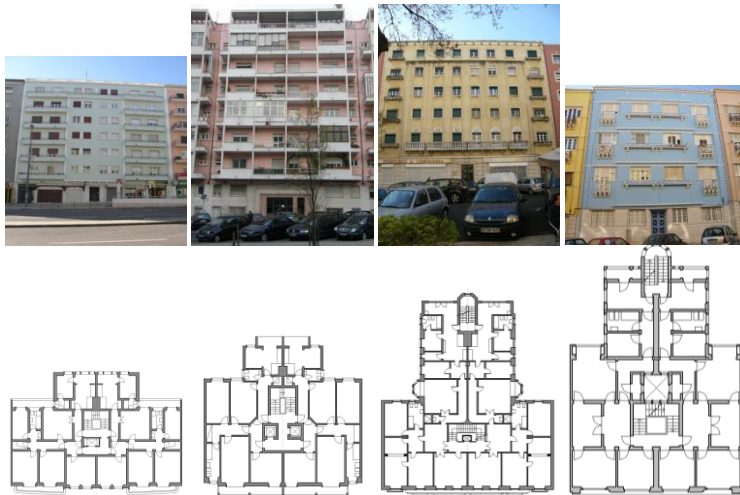

Av. de Roma, 47 (type A) Av. de Roma, 82 (type B) Av. Guerra Junqueiro, 7 (type C) Av. Actor Isidoro 11 (type D)
Figure 2 – Examples of Rabo-de-bacalhau apartment buildings, photo of the façade and typical floor plan.

As any shape grammar the RdB-TG system enables to generate multiple viable designs in response to different client choices (see Figure 3), yet based on a single architectural language. The RdB-TG system uses a complex set of data that is cross-referenced in rules that encode knowledge about the aspects that are related to this type of architecture assignment. With this knowledge and a set of algorithms and rules that determine how to act on the information, a particular apartment can be redesigned for a particular client meeting specific functional and constructional requirements. The grammar addresses the functional

requirements by first identifying the habitable characteristics of the apartment (available area, natural light conditions, room length and width) and then intervening in the position of walls (eliminating and adding) and in the connections between rooms (identifying connection potentials by adjacencies and opening or closing doors and passages). Making circulation more fluid by removing doors in hallways or enlarging social areas by connecting adjacent rooms are actions that the grammar operates. To address the constructional requirements the RdB-TG system includes conditions on the demolishment and construction of walls and on the relocation of bathrooms and kitchen, such that the structural integrity of the building containing the apartment to be refurbished is maintained. Constructional constraints were introduced in the grammar rules so that, in the light of current concepts of rehabilitation work, the proposed layouts would follow the original language and be not too intrusive. Thus, major interventions to the apartments are avoided, such as preventing the removal of concrete columns or other structural elements, since they are irreversible and would risk the integrity of the building.

The RdB-TG system also defines the needed Information, Communication and Automation Technologies (ICAT), usually called Domotic, and establishes how to locate the devices.

The shape rules have a shapes part and a conditions part which covers knowledge in terms of the dimensions and the functionality of the apartment areas. Parallel representations were used in the shape rules to address different properties of space, namely, topology, dimensional aspects or geometrical properties, the constructed elements and their characteristics and the void space. The conditions part was developed by using a mathematical language that forms a descriptive grammar which reveals certain characteristics that cannot be described in shapes and include all the conditions to restrain the transformation rules' application. Descriptions of the shape rules and further information about the RdB-TG system can be found in [8].
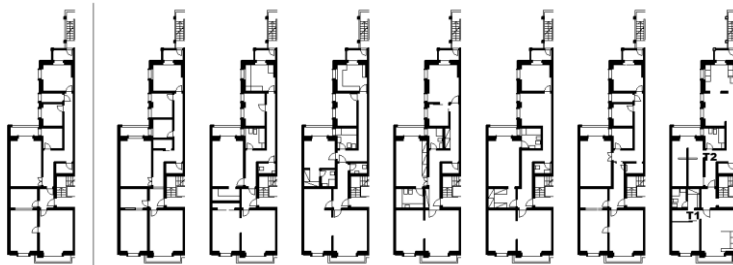
Figure 3 – On the left a sample of an original Rabo-de-bacalhau apartment; on the right seven possibilities of transformation generated by the RdB-TG system.

Amongst the existing grammar interpreters, the following recent ones should be highlighted since they are closest to the focus of the presented RdB-TG system: MALAG for the Malagueira grammar by Duarte [13]; the interpreter for the Yingzao fashi grammar by Li [14]; and other general interpreters such as those produced by Trescak et al. [15]. Although, according to Chase [16] in order to make an impact on industry methods using grammar based approaches a great deal of ground still needs to be covered by computerized grammar interpreters.

Description of the web tool

There are two scenarios in which the RdB-TG system could be made available as a web tool through the internet to the potential clients aiming at creating refurbishment designs for specific Rabo-de-bacalhau apartments:

i) as an open-access web tool available to everyone without costs;

ii) through a specific agent who owns the tool and makes it commercially available for clients after paying a fee or as part of a refurbishment assignment.

In the first scenario the tool could be made available by, e.g., the City Council of Lisbon, through its public website. And because the RdB-TG system creates refurbishment designs that comply to all regulations, the system could be incorporated in the licensing of building and after getting the license the client could select a constructor with a well-defined building assignment. In the second scenario property constructors that want to use the software for their clients could buy it or the use of it. Constructors could than obtain refurbishment solutions for property developers or families living in Rabo-de-bacalhau apartments, and immediately offer the construction work.

On both scenarios clients could use the RdB-TG system as a stand-alone system that delivers without a supervising role by architects a design solution based on the data the clients introduce.

In the web tool's portal the client would need to input the following information in order to generate a design solution (see Figure 4):

- Input 1: Get a CAD drawing from the apartment and upload it to the RdB-TG system (see Figure 4a);
- Input 2: Fill in in the characterization of the household (see Figure 4b);
- Input 3: Add additional requirements on the functional program (see Figure 4d); Add additional requirements to the pack of ICAT functions.

Input 1 of the process presupposes that the family uploads to the web tool a CAD floor plan of the Rabo-de-bacalhau apartment or that the web tool has a direct link to the City Council archive services such that a file could be imported to the system. The CAD file would have to follow certain design rules that would be stated by the web tool in the first case or that would already be followed by the City Council archive services in the second case.

The second input implies giving information about the household: number, age, gender, kinship, special needs and period of occupation. In this step the client also makes a distinction in the RdB-TG system between "minimum" and "recommended" requirements for the functional program, and between "basic", "medium" and "optimal" for ICAT functions.

With the data from input 2 the RdB-TG system creates a household profile and generates with that a preliminary functional program, consisting in a description of an ideal housing solution for the client (see Figure 4c), and a pack of ICAT functions, consisting in a list of all the useful domotic technologies for the clients' profile.
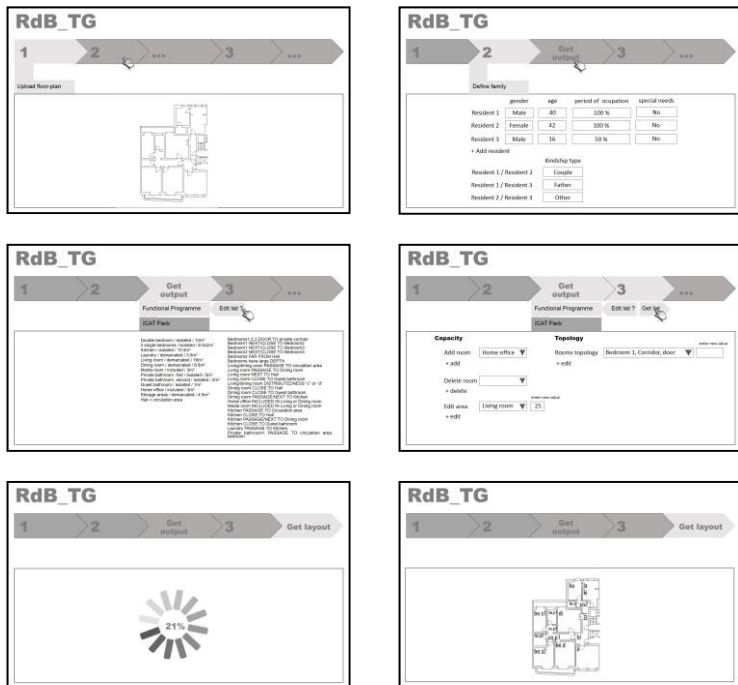

Figure 4 - Sequence of screens in a simulated interface for the RdB-TG system web tool (from top left to bottom right): a), b), c), d), e), f).

If the preliminary functional program does not completely meet the client's needs or if the client wishes to emphasize certain characteristics, input 3 is available in which the RdB-TG system allows the client to introduce additional spaces and topology and to alter the ICAT pack (see Figure 4. d). After input 3 the client obtains an adjusted list of the functional program and an adjusted list of the ICAT functions.

When this procedure is concluded the client receive from the RdB-TG system the new design of the apartment layout, and in this step the shape rules are used (see Figure 4e). Since this tool is intend to serve the clients' needs the interface does not include a module for seeing the apartment being transformed by the shape rules. The output of this last step consists of: i) a layout of the adapted apartment (see Figure 4f); ii) a full description of the ICAT elements that are to be included, such as the layout of the wiring, sensors and appliances.

Discussion

When evaluating the possibility of an RdB-TG based web tool for the large scale individualized refurbishment of Rabo-de-Bacalhau apartment buildings, there are several advantages but also disadvantages to be noted. We start by advantages.

First inhabitants can generate their own design solution enabling a more participatory and bottom-up approach towards architectural design. Inhabitants could play with the web tool generating different solutions by changing variables and in this way become aware of the design possibilities and restrictions.

Second the architectural quality of the apartments is maintained. The RdB-TG system ensures that the existing building construction systems, materials and identity are kept as much as possible. Furthermore there is evidence that refurbishment designs generated by the RdB-TG system have the same architectural quality as designs done by human architects [7].

Third the RdB-TG designs of individual apartments do not compromise the structural integrity of the building containing the apartments, and thus prevent buildings from collapsing by the refurbishing of an individual apartment [8].

Fourth several strategies of rehabilitation may be combined in the same building with different layouts (see Figure 3) creating more lively neighborhoods populated by mixed generations and family types.

Finally, the web tool enables European cities to rejuvenate while avoiding large scale reallocations of its inhabitants and the demolishment of its existing characteristic social and architectural fabric.

A disadvantage of the tool is its inability to give detailed designs of, say, water, sewage, electricity and telecommunications. As long as the RdB-

TG system does not generate such designs, detailing and the coordination of the final design remains the responsibility of other agents, as, e.g., the constructor involved in the refurbishment.

A second disadvantage is that this approach to the refurbishment of apartment buildings excludes architects from the individual design assignments. This exclusion may alter current thinking about the role of architects in the renovation of regular apartment buildings, and put the initiative and responsibility for this renovation more with inhabitants and building constructors (as it may already be). Still the approach does not rule out that also architects take up refurbishment tasks; it rather enables inhabitants and constructors to join the large scale rejuvenation tasks facing many cities. As such the approach will actually relief architects from being endlessly engaged in the repetitive and less profitable tasks of refurbishing all individual apartments of the regular types of apartment buildings in European cities.

Conclusion

In this paper we sketched the structure and use of a web tool for generating refurbishment designs for regular apartments that come in large numbers, such as existing in the larger European cities. This web tool can create designs for individual apartments based on the particular needs of their current inhabitants, using a shape grammar generative system. The example we presented concerned the renovation of the stock of Rabo-de-bacalhau apartments in the city of Lisbon. For that task a shape grammar system exists, called the Rabo-de-bacalhau Transformation Grammar, which we described in some detail.

We argued that this web tool by being available directly to the inhabitants of apartments makes accessible the option to European cities to renovate large stocks of existing apartment buildings in an individualized manner. This option is an alternative to the demolishment or centralized refurbishment of these apartment buildings, and thus enables a rejuvenation of European cities that avoids the large scale destruction of the social and architectural fabric of cities, while assuring that the refurbishment is still meeting architectural and structural requirements.

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