24th International Symposium on Automation & Robotics in Construction (ISARC 2007)
Construction Automation Group, I.I.T. Madras

USER-IN-THE-LOOP: BUILDING TEMPLATES FOR CUSTOMIZED SOCIAL HOUSING *

S. Martinez, S. Montoiro, J. Nuñez, C. Balaguer
RoboticsLab
University Carlos III of Madrid, Spain
{scasa@ing.uc3m.es}

J. M. Navarro, C. Bosch, C. Barcena
Dragados, Spain
{navarros@dragados.com}

ABSTRACT

The objective of this paper is to show how the end user can be involved into the whole building process, specifically in social housing. Therefore, the end users preferences are taken into account in order to increase their satisfaction on the product. The first step consists on obtaining the user preferences by means of an enquiry file (*http://mbserver.uc3m.es/encuesta.htm*). There are about 2.000 surveys fulfilled up today. The results are analyzed in order to classify users into groups with similar features and family composition. Due to the social housing promotion laws, several building templates are produced as a parallel development. The obtained groups are matched with the pre-existing building templates that fit as best as possible with the users' preferences. After this matching, each final user is awarded with the correspondent social dwelling. This is the starting point for the process of the detailed design and configuration of the dwelling by the user. One common web portal enables the use of the design and configuration tools.

KEYWORDS

User Oriented, Social Housing, Building Templates.

1. INTRODUCTION

A long process starts at the very moment any person takes the important decision of buying a dwelling. Usually, purchaser's level of involvement in the process is very low. The user can only take decisions on definite periods and, also, many questions of the process are out of his/her control. Other issue is the degree of relationship between the different stakeholders involved in the process and the end user.

The main goal of this work is to change the actual role played by the user in the construction market. Nowadays, the end user is involved in the process at the beginning, selecting his/here future dwelling and paying it at the end. There are other minor issues, not so important, in which the user is involved. This paper shows one way to change the final user role, placing him into the centre of the process.

The first step is to know the user preferences. The results of an enquiry, which was made between users involved in the buying of social houses in Madrid, are presented here (*http://mbserver.uc3m.es/encuesta.htm*). The results were studied and grouped according to different preference criteria. The aim of the enquiry is to let us know the end user preferences of dwelling. The obtained results can help the developer to offer the user a set of possibilities, buildings and dwellings, according to these groups of preferences.

As it was said previously, this research will be applied in the development and sales process of social houses. Due to the social housing promotion laws, the buildings must be designed previously to the awarding process. The design of the buildings will agree with the results of the enquiry in order to satisfy the highest number of end users. For this

purpose, the features of the buildings are extracted to generate a set of building templates that will aid the matching between user and dwelling.

There is an awarding procedure to select the group of end users among all the possible candidates to obtain a social house. Each selected user must be included in one of the groups obtained in the enquiry. After that, a sub-set of building templates will be presented to each user for choosing among the available options. This sub-set of building templates has to do with the group in which the user was previously included. In this way, there is a higher probability of user's satisfaction.

When the final user has chosen a specific dwelling, the configuration and tuning process begins. Through a web based software tool, the virtual reality visualization of the dwelling is presented to the user who can make some permitted architectural changes and house equipment selection.

2. SCOPE OF THE WORK

2.1. User-in-the-loop

The significant change that this work wants to introduce is the user-in-the-loop philosophy in building construction, from design to the final cycle of life of the building [1]. In this way, the user can take part in all the stages of the process to get a final product according to his/here preferences. Within the actual building market, the user is out of important stages of the construction process and he/she cannot decide about many aspects of his/here future dwelling. This fact implies that the final user's degree of satisfaction about a dwelling depends on the joining between the user desires and the market offer.

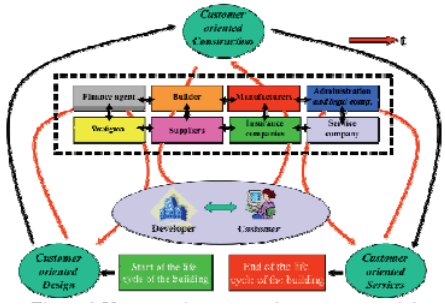

Figure 1 User Centric Construction Process Model

The aim of the research is to find a way of getting the end user involved in the whole process as an active actor. Furthermore, the user must not only be part of the building process but the centre of it (Figure 1). The end user must be able to participate taking decisions and showing some control during the building process. The main purpose is to increase the level of final satisfaction [2].

2.2. Building Templates

So far, the concept of template applied on building was related to 2D drawings or 3D modules. The 2D/3D templates are mainly fixed entities that can be joined in order to obtain a whole building design [3]. Another issue is the level of abstraction of the template. It can be from an empty sketch of a shape to a completely designed module.

For instance, the 2D templates are used to see the dwelling distribution. The layout can be modified by means of different preset options (Figure 2). These kind of templates only give information about one particular dwelling or storey but not about the whole building.

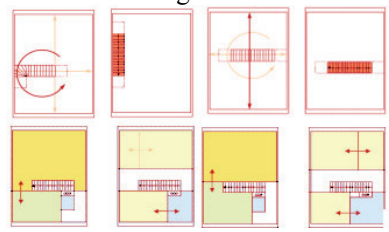

Figure 2 2D Templates

On the other hand, 3D templates can be used to have a scaled final design idea of the building. An example of that is the Bar-Code System where 3D modules are combined to develop an entire building. Housing units are the result of the aggregation of two kinds of space-bars: serving bars (kitchen and bathrooms) and served bars (other functions).

The addition of bars gives rise to a multiplicity of flexible housing layouts, generated by the computer system. Linear blocks are a result of the assemblage of housing units [4].

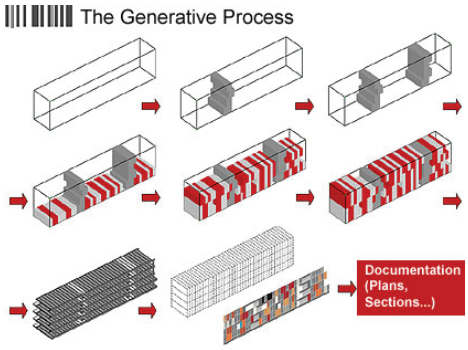

Figure 3 Bar-Code System

The concept used in this research doesn't start from 2D/3D predefined layouts or modules. Building templates are not only a set of designs (3D drawings). At the end of the templates generation process we find the joint of designs with a set of characteristics that make possible the match between building design and user desires.

2.3. Integrated Web Based Tool

Different software tools must be developed to enable and facilitate the use of the system. However, all the tools and the whole system must be usable and user oriented. For this reason, it will be created a common web portal from which all the tools can be accessed in an easy way.

But not only benefits to the end user are pursued. The use of a common platform presents advantages for the ICT development and information sharing among stakeholders. Some of these advantages are:

- All stakeholders have a common tool that enables intercommunication.
- Each stakeholder can have access to a different set of tools, depending on the role in the process.
- Information would be available in whole building life-cycle through access to open tools.
- The use of new standards enables the usability of the information and improves the development phase.
- The tool can be accessed in any place because is web based.
- This feature enables new collaboration business models and services.

3. USER'S PREFERENCES RESEARCH

3.1. Enquiry Development

In this enquiry, it is intended to show not only end user's preferences about social houses developments, in terms of the aspect and location of their dwellings, but to define general groups of personal and familiar profiles. This information will be very valuable in a near future when new developments will be promoted. The enquiry was designed by experts from different work fields in order to ask for the most important and valuable aspects for the user; for example, sociologists, architects, engineers, etc. The enquiry is divided into three main blocks:

1) General Questions

In this block, as described before, questions such as personal and familiar situation are gathered. Examples might be: age, family members, any disabled person in the family, intention to rent or buy…

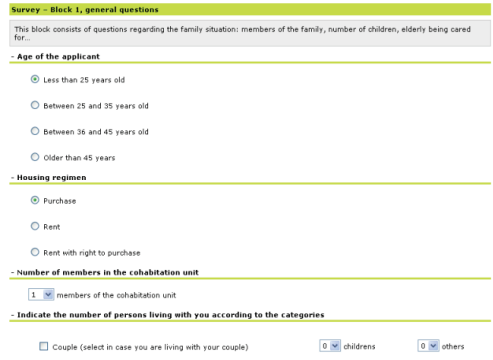

Figure 4 Enquiry's General Questions

2) How would you like your house to look like?

Questions in this block intend to define a framework based on the user preferences for the later design process of the dwelling. We can find here questions related to the house orientation, number of bedrooms, floor selection…

3) The background

Besides obtaining information about the dwellings and the building itself, the end users are able to express their opinion about where they want their

future house to be located; also, they will be able to classify, following a priority order, services surrounding the building: hospitals, schools, church, and so on. All this information can be useful when choosing potential locations for future developments, which will have higher level of acceptance.

The enquiry is available on the following URL: *http://mbserver.uc3m.es/encuesta.htm.* It has a Spanish version and an English one. Due to this, the answers and the results are not restricted to Spain.

3.2. Analysis of Results

There are about 7.500 current visits up to the enquiry web page. A total of 1.925 users have answered the enquiry and the results have been grouped in order to extract the main characteristics to classify future users.

The first important characteristic for considering is to regard the number of components of the user's family. This will define the needed space of the dwelling. It is related to the first block of questions mentioned before. The results show that the most of the users are only one member (36%) or two members (43%).

The second valuable result is derived from the previous one. It is important to know the necessity of space for each number of family members, that is, the number of rooms desired and other living spaces. For the numbers of rooms by number of components some results are:

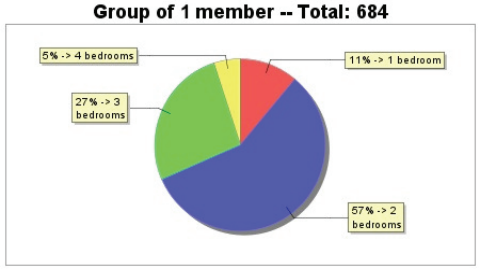

Figure 5 Number of Rooms for One Member Group

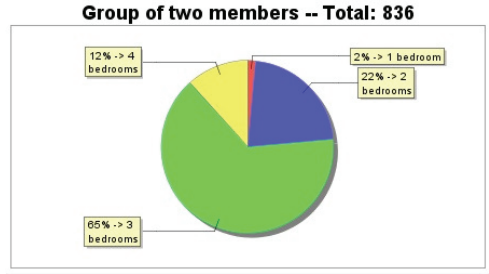

Figure 6 Number of Rooms for Two Members Group

In the two previous graphics, it can be observed that there are two and three rooms dwelling designs are preferred. The families with more than five members are a special case because of the necessity of more rooms, but have not been included in this paper.

Another interesting result is the number of bathrooms and toilets desired. The 91% of the users that answered the enquiry want more than one bathroom or toilet in the dwelling.

Summing up, Figure shows the number of bedrooms independently of the number of family members. The 80% of the users want two or three rooms.

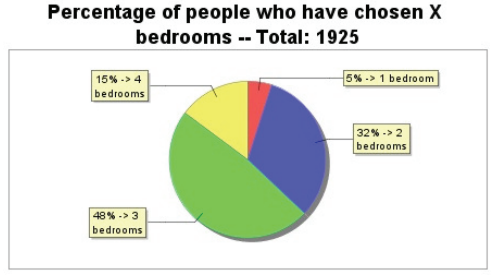

Figure 7 Number of Rooms

With the results of the enquiry showed before some interesting conclusions arise:

- For one and two family components, the ideal dwelling has one more room. That is, two for one member and three for two members.
- For three components, the ideal dwelling has three rooms.
- Selecting more rooms is quite limited by the cost of the dwelling.

- The user that has answered the enquiry is looking for his/here first dwelling. Due to this, the family is formed by one or two members.
- There are two main reasons to want one more room than the number of family members:
  1. The use of the extra space for other necessities.
  2. The future expectative of increasing the family members (i.e. children).
- The preferred number of bathrooms or toilets combinations is two.
- The cost of the dwelling is the most important for the user (social housing).

Other results extracted are related with the surroundings of the dwelling. This information can be useful for developers and urban planners in order to know which services are more important for the users. The answer given by the user must be classified in a 1 to 5 scale.

The results show that people want to live near sanitary services and the living area must have good communication by public transport. On the opposite, people don't give much importance to religious services near their dwelling. One example of these results can be seen on the Figure 8 Public Transport Services.

4. BUILDING TEMPLATES FOR CUSTOMIZED SOCIAL HOUSING

4.1. Dwelling Choice Assisted by Building Templates

As said before, the concept of building templates used in this work differs from a simple 2D or 3D design. The best way to understand what building templates mean here is describing the process showed in the Figure 9.

The process starts when a potential end user wants to buy a dwelling and makes a request for a social house. Then the user must fulfil a questionnaire in order to be classified. This classification helps the developer to offer a set of possible dwelling that can fit into the user preferences.

In the building development process it is necessary to make the 3D design of the building. Moreover, one file must be linked to the 3D model containing a set of rules and dwelling characteristics that enables the user-dwelling matching process in an automatic way.

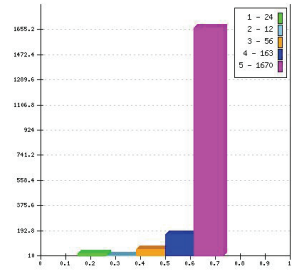

Figure 8 Public Transport Services

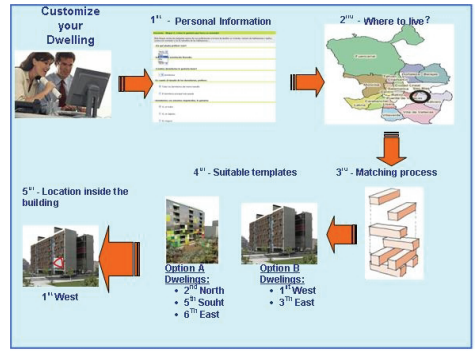

Figure 9 Dwelling Choice Assisted by Building Templates

Supposing that several areas with several developments are available, the user must choose in which one wants to live. The system gives the user some previous information, such as average cost for the square metre of the dwelling in every selected area. If some aspect of the presented information is an impediment for the user, he/she can go back and make another selection.

When the area is selected, a set of possibilities are displayed to the user for making the choice. This set is the building templates. Automatically, the system makes a matching process between user preferences and building characteristics. The result of that operation is a 3D representation of the buildings with the different available dwellings on each one. The user can easily view the future

dwelling and the surroundings. This facilitates the selection.

The virtual representation is very useful for the end user because of two issues. The first is that if the building is already built is not necessary to go to its place to take a look. And the second one is that if the building is in the design stage the user can view the future dwelling before the construction and start a customization process.

4.2. Customization Process

When the user has selected the dwelling, the customization process can start. The user will have a list with the possible allowed modifications (architectural, furniture, decoration, etc.) and he/she will be able to do them according to constraints that the designer put on the 3D building model. For example, the user can move a wall but it cannot be situated a position where there is a window [2].

The customization is an iterative process within a virtual reality based tool. The user can view the result of any modification in real time. Move walls, choose colours, move or change objects… rapid and easily. The tool is connected to the catalogues from suppliers of materials, furniture, etc., offering other possibilities to change to. This will be possible due to the connection of the system with a data base containing the different constructive elements and their suppliers. This data base is called 'intelligent component catalogue'. The cost of changes will be visible at all time in order to enable the end user to make a decision to maintain the configuration or discard the change.

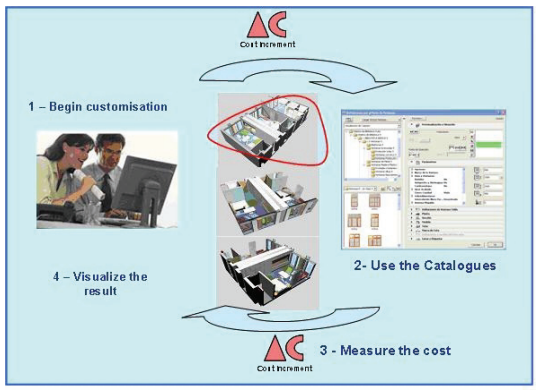

Figure 10 Dwelling Customization Process

5. INTEGRATED WEB PORTAL

The user of the integrated web portal will perceive a single platform, where the different tools are seamlessly integrated, i.e. there is a single common working environment which manages the invocations to different tools/modules.

In general the system should be accessible by all kind of users, regardless their origin, technological skills (the final user of the system must not mandatory be and ICT expert) or language. As a consequence, the platform should provide easy-to-use interfaces. The system must have four main features:

a) Adapted to different user profiles

The platform is not conceived for a specific type of user (e.g. architect). On the contrary, it can be targeted to a wide range of user profiles from the whole AEC/FM industry as manufacturers or builders as the end user. This range of user will be grouped and classified in several user profiles.

The design of the interfaces will also take into account this diversity, being adaptable to the particular requirements for each user profile.

Thus, the following requirements should be met by the system:

- Inclusion of the different actors of the construction process, i.e. architect, builder, manufacturer, etc, with distinction of the functionalities that each of them could access to. This authentication will be controlled with username and password.
- As a result of the above, it is very important that the system is customer-driven, considering the customer as another user profile.

b) Adapted to spatial dispersion

In every construction project the spatial dispersion of actors is very common. Firstly, the number of actors can be big (administration, builders, manufacturers, logistics managers). Secondly the process itself can take place in several scattered locations.

This poses some requirements regarding the integrated portal:

- It should be based on a collaborative environment in such a way that disperse working groups can collaborate efficiently.
- The access to the different tools considered will be remotely accessible, through a web interface.

c) Adapted to geographical diversity

Another quite common characteristic of construction project and also related to the previous one, is the geographical diversity of the projects. The scope of many projects exceeds regional or even national scope. Furthermore, it is more and more common that in the same work site people from multiple origins coincide.

Therefore, the platform should be open take into these particularities of the Construction Sector, especially regarding the following issues:

- It should consider different countries' specificities by providing information or links to common practices and normative documents of the country/region to support the process.
- Iconic interfaces based on standard, international symbols.
- Adaptation of the individual modules (integrated tools) considered will depend on the internal configuration of such modules.

d) Adapted to cultural diversity

Other characteristic of the construction projects is the multiculturalism of people involved in the whole process (customer, architect...). Furthermore, it is more and more common that in the same work site people from multiple origins meet. Due to this, the platform should have:

- Multilingual interfaces should be very convenient. In particular it should be open enough to include in the future any desired new language in the interface, without interfering the functionality
- Iconic interfaces based on standard, international symbols which replace or support textual information would provide openness to the interface.

6. CONCLUSIONS AND FUTURE WORKS

The aim of this work is to increase the customer satisfaction and the participation into the construction business process.

User's preferences have been taken into account by mean of the analysis of the results of an enquiry. Almost 2.000 fulfilled questionnaires have been used from social housing applicants.

On the other hand, the concept of building templates assists to the process of dwelling selection and customization. The fact of designing a specific set of templates goes right against the philosophy of maintaining and open and adaptable system that can be modified according to the changes in the users' wishes or society needs.

The definition of these templates must take into account factors such as architectural, geographical, legal, financial aspects, etc. Templates must accomplish all these issues in different percentages depending on the significance of each one. Moreover, the templates and the user's groups must be established together and not separately.

Another important issue is the fact that user's wishes are something variable, something temporary that evolves with time and with society's alterations. For this reason, a way to capture this continuously changing wishes had to be found in order not to be left behind in the process of fulfilling society's needs.

Furthermore, a process was described so that adaptable, flexible and cost effective designs can be achieved in different parts of the continent. These designs will indeed cover a wide scope of countries and will be able to fulfil end user's requirements as well as presenting the smallest difficulties for installation, operation, maintenance and reparation.

The web portal and its architecture will be developed more in detail and tested. It will be applied to one demonstration scenario to face all possible issues and develop the functionalities.

7. REFERENCES

[1] C. Balaguer, "Open issues and future possibilities in the EU construction automation", IAARC International Symposium on Robotics and Automation (ISARC'00), Taipei (Taiwan), 2000.

[2] S. Martínez and C. Balaguer. "User-oriented interactive building design", IAARC International Symposium on Automation and Robotics in Construction (ISARC 2006), Tokyo (Japan), 2006; electronically available at http://www.iaarc.org/ external/isarc2006-cd/www/ISARC2006/ 00165_200605312357.pdf

[3] C. Balaguer. "EU FutureHome project results", IAARC International Symposium on Robotics and Automation in Construction (ISARC'03), Eindhoven, (The Netherlands), electronically available at http://www.iaarc.org/external/ isarc2003-cd/www/ISARC2003/INDEX.HTM

[4] L. Madrazo, "Bar code housing system", electronically available at http://www.architecture-page.com/go/projects/ bar-code-housing-system__2

* This works is part of the EU ManuBuild project