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Supporting user participation design using a fuzzy analytic hierarchy process approach

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ABSTRACT

There are three fundamental problems that may occur in the process of user participation design: first, the participants/users may not be able to express their requirements clearly; second, they have little knowledge about design; and third, they are generally unfamiliar with the software that designers use. Based on this understanding, a method that considers design rationale is proposed in this work to support the process of user participation design. In addressing the user participation process, a fuzzy analytic hierarchy process (AHP) approach is applied to grasp people's ideas, in the initial design phase. A case study on creating house layout design is employed to illustrate the proposed approach. In this regard, to help participants/users create layout designs, it is proposed that a 3D generative system is used, which integrates navigational concepts, direct manipulation, and the design rationale theory. In a nutshell, this research proposes a system to implement a design rational model and improve design communication in the user participation process. To demonstrate the effectiveness of the proposed prototype system, a user test is performed and we put forward some findings and research questions for further research and industry practices.

1. Introduction

In many Asian countries, standardized housing units with few opportunities for adaptation, which offer very few choices for a variety of customers with specific needs and preferences, are the typical circumstance (Cheng and Lee, 2005). According to Juan et al. (2006), it is common that a house buyer wants to remodel the housing unit even if it is just newly built (Ozaki, 2003; Cheng and Lee, 2005). To solve this problem, searching for ways to reengineer the process and product to better conform to the demands of customers is necessary (Juan et al., 2006). Up to date, several researches suggest that customizable products that fulfill customers' current specific needs and preferences can be the best answer for the current direction in the housing market (Ozaki, 2003; Barlow et al., 2003; Dikmen et al., 2005; Juan et al., 2006). Hippel (2005) also emphasized the crucial role of users in innovation in different industries and types of products (Heiskanen and Lovio, 2010). It is generally acknowledged that user participation in the design process increases the likelihood of a successful outcome (Carroll and Rosson, 2007). User participation is a process through which design professionals can communicate their design ideas to the client. It involves users in key design decisions, thus helping them anticipate and address needs in their building design (Tweed and Woolley, 1992). For this reason, customer involvements or solutions associated with product conceptualization can be regarded as a pervasion on product innovation and are likely to result in more user satisfaction (Yan et al., 2009; Terry and Standing, 2004). Granath (2002) has developed a participatory process in which

- user participation can result in an acceptable design solution and
- users can gain knowledge that will enable them to take an active part in the redesign of a building and in the design management.

However, there are still unresolved issues with a formal participation process.

- Users are often poorly prepared for participation during the process of change and they may have problems conceptualizing their wishes, articulating them to themselves and even more so, communicating them to others (Granath, 2002; Cheng and Lee, 2005).
- Designing has become an increasingly complicated process. One of the main problems for effective participation is the complexity of the design process and the difficulty for the lay person to understand jargon, methods, and processes that are familiar to design professionals (Tweed and Woolley, 1992;

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Heiskanen and Lovio, 2010). In other words, users lack relevant knowledge.

- Building designs are typically beautifully packaged as rendered perspectives, elaborate layout drawings either hand drawn or produced by CAD. However, as users are generally novices when it comes to operating such tools, it compounds their difficulty in conceptualizing, articulating, and communicating their needs (Granath, 2002).

This paper attempts to address these issues, that is, capturing users' vague needs and preferences, providing proper knowledge and intuitive interfaces to users, by using notions derived from Lee and Lai (1996) on design rationale (DR). Accordingly, we propose to develop an example that could be applied to design rationale in a real design participation process. An intelligent interior design system was developed, a knowledge-based model with a 3D direct manipulation interface, based on a fuzzy AHP computation. DR is important for a number of reasons, principally, because it includes both the reasons underlying design decisions as well as justifications. DR can assist in understanding design and, more particularly, in explaining why certain design alternatives are rejected. Concurrent with DR is the commonly accepted notion that, in any design process, the information space may be vast and users need to navigate it. Apart from navigation being essential, it is desirable that it should also be intuitive and interactive. To search and visualize the information space, knowledge tree are extremely effective. Direct manipulation can further help inexperienced designers; by interacting with design elements intuitively and iteratively, it may help in easily understanding design decisions.

To do this, the methodology was divided into four parts. First, the thinking-aloud method was employed via a questionnaire to determine what a normal person's design needs could be, as well as the kinds of design preferences available. Second, the relationship between design needs and a vocabulary of used designs was established. This was important in interpreting how to apply the fuzzy AHP algorithm. Third, domain expert knowledge was collected for specifying inference rules, and to build the knowledge base. Fourth, an interface was developed, which used both direct manipulation and a knowledge tree to guide users to integrate into DR and to operate the system efficiently.

After we describe a framework for DR, we demonstrate its use in a design process, and conclude with a description of the potential benefit of the paper. There are a number of factors to be considered in the actual client participation process; for house design these include elevation, material strength, even funding, etc. Such factors are beyond the scope of this paper. Instead, we concentrate on client participation, especially customization at the floor plan level in the conceptual design. More narrowly in this paper, we focus on kitchen layout.

2. Related work

2.1. Reasoning with design rationale

Design rationale (DR) provides invaluable support for revising, maintaining, documenting, evaluating, annotating, and learning design. With DR, another designer can examine the original design intent as well as determine what alternatives have been considered and why they were rejected (Burge and Brown, 2000). DR can be seen as a form of "corporate memory", providing a valuable insight into a design that might otherwise be lost (Peña-Mora and Vadhavkar, 1997). Design rationale provides invaluable support for the design process by way of providing possible and pre-designed alternatives, reasons behind design decisions, justifications, trade-off evaluations, and argumentation. A DR system is a tool for capturing and creating information for dependency management, collaboration, reuse, maintenance, learning, and documentation (Lee, 1997).

Early works highlighting the approaches of design rationale in software design have been found in Kunz and Rittel's (1970) Issue-Based Information Systems (IBIS), McCall's (1987) Procedural Hierarchy of Issue-Based information System (PHIBIS), Maclean et al.'s (1996) Questions, Options, and Criteria (QOC), and Lee and Lai's (1996) Design Rationale Language (DRL). More recently, the ways of documenting and maintaining rationale for architectural decisions have resulted in some efforts to capture and use design rationale such as the IEEE standard 1471–2000 (IEEE, 2000) and the View and Beyond (V&B) approach (Clements et al., 2002). Bass et al. (2003) and Bosch (2004) have also focused on the need for documenting design rationale to maintain and evolve architectural artifacts, but they did not provide a new model for design rationale. Moreover, there is lack of proper supporting applications on how to document and reason with design rationale in making architectural design decisions (Tang et al., 2006).

After investigation of design rationale models, we adopt two design rationale methods, which are DRL (Lee and Lai, 1996) and QOC (Maclean et al., 1996). We employ DRL that supports

- argument space (body of reasons);
- issue space (decisions and their relationship);
- alternative space (multiple alternatives and their relationship);
- evaluation space (evaluation states that are made explicit and interrelated); and
- criteria space (criteria and their relations).

DRL provided the framework in which one could give context to three different meanings of DR (Lee, 1997; Lee and Lai, 1996). These are shown in Fig. 1.

For QOC, we make an adoption from Dutoit and Paech (2002) to provide a knowledge evaluation mechanism, which includes the following elements:

- questions (design issues);
- options (explored alternatives); and
- criteria (desirable qualities).

This decision is based on investigations into methods of implementing design rationale in software engineering. We specify a dynamic hierarchy structure, which is essentially a

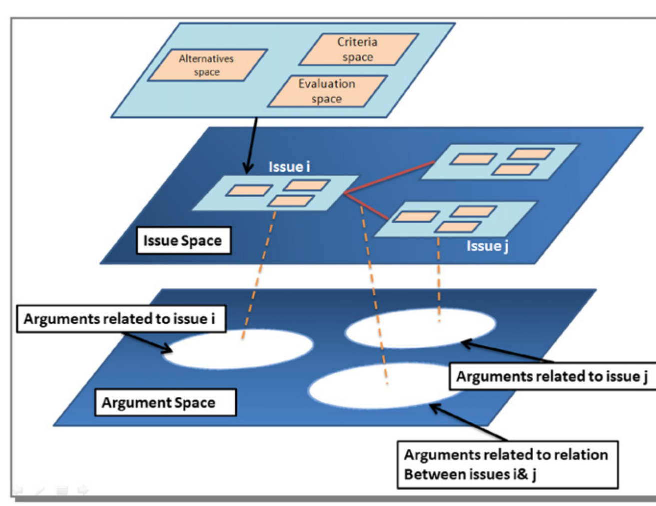

Fig. 1. Model of design rationale (redrawn from Lee and Lai (1996)).