HOW EXPLICIT ARE WE IN A DESIGN MEETING: INVESTIGATION ON MEETING KNOWLEDGE STRUCTURING WITH DESIGN RATIONALE

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Abstract

Knowledge management can improve a company's competitiveness by managing organisational knowledge as a company's capital. However, the knowledge produced in a meeting is hard to be captured due to its collective and volatile nature. In this paper, we want to zoom into the issue of knowledge management for design meetings. Since it is impossible for an individual to reconstruct the group decision making process without any personal bias, and designers are incapable or reluctant to document collectively their reasoning process during a meeting, we want to investigate the feasibility to reconstruct the design rationale of a naturalistic small group meeting, based on a collection of meeting recordings. We want to examine how much explicit knowledge can be extracted from our meeting data. A semantic network based design rationale model is proposed to classify the meeting data, and we will demonstrate the result of using design rationale as a knowledge representation for naturalistic design meeting, as well as the limit of this representation.

Keywords: Conceptual design, Decision making, Knowledge management, Investigation

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1 INTRODUCTION

Due to the economy shift from material dependent economy to knowledge economy (Stewart, 2007), knowledge has become one of the important assets for companies. Creating and sharing knowledge can foster innovation (Kim and Mauborgne, 2003) increase the organization's competitive advantage (Foss and Pedersen, 2002), facilitate novice employee training (Hinds et al., 2001). Knowledge management is a concept that embodies various issues, its goal is to manage knowledge in an organization to promote knowledge sharing, in order to enhance organizational learning (Alavi and Leidner, 2011). Two types of knowledge management strategies have been identified: personalization and codification (McMahon et al., 2004; Hansen et al., 1999). Codification strategy is focused on how to codify organizational knowledge with information technology, in order to make it accessible for a larger amount of people, while personalization strategy promotes person-to-person communication. In this paper, we want to focus on the codification strategy for design meeting knowledge management.

Design is a knowledge intensive activity, with the emergence of concurrent design, people with different knowledge backgrounds have to collaborate together in a design project (Ma et al., 2008; Prasad, 1996). For these project-based organizations, the knowledge produced during the project is usually lost in the end of the project, along with the decomposition of the project team (Dieng-Kuntz and Matta, 2002). It is important to preserve the project knowledge, which can be shared within a certain community to enhance organizational learning (Vera and Crossan, 2003), and more importantly, to shed light on the design rationale. Design rationale refers to the reasons behind design decisions. It has several benefits: a traceability of design evolution is available for all project members (Klein, 1997), new design projects can benefit from similar past project experiences (Prabhakar and Goel, 1998).

Several design rationale models exist to help designers to clarify their design, and these models have also proved useful to capture design decision making. However, among the few empirical studies of the application of design rationale, it is discovered that, if not specially trained with design rationale (Shum and Hammond, 1994), designers are experiencing difficulties or are simply reluctant to consciously document their reasoning during a meeting (Bekhti and Matta, 2009). Moreover, the collective dimension of a meeting makes the meeting knowledge impossible for an individual to reconstruct without any person bias, hence the meeting report, usually edited by the manager, can not fully represent the collaborative decision making process (DAI et al., 2014).

In this paper, we want to zoom into the issue of knowledge management for design meetings. Since it is impossible for an individual to reconstruct the group decision making process, and designers are incapable or reluctant to document collectively their reasoning process during a meeting, we want to investigate the feasibility to reconstruct the design rationale of a naturalistic small group meeting, based on a collection of meeting recordings. One of the future trends of design rationale capturing systems involves the implementation of new technologies to ease the access of information, provide a natural user interface (Chandrasegaran et al., 2012). In this study, the meeting samples are collected from master students' design projects from the university of twente with lavaliere microphones and cameras, and a NLP engine was used to transcribe automatically the meeting recordings. We want to examine how explicit are we when we are making a collaborative design decision, how much explicit knowledge can be extracted from our meeting data. A semantic network based design rationale model will be proposed to classify the meeting data, and we will demonstrate the result of using design rationale as a knowledge representation for naturalistic design meeting, as well as the limit of this representation.

2 DESIGN RATIONALE AS A COLLABORATIVE DECISION MAKING KNOWLEDGE STRUCTURE

One of the reasons that design rationale techniques are developed is to document the reasons behind design decisions. From this perspective, it can be used as a knowledge capturing structure for the decision making process. According to the source and goal, design rationale can come in various forms. The ISAL model aims to extract design rationales from design documents (Liu et al., 2010), which consist of three layers, namely issue, solution and artifact. The decision rationale language (DRL) model is a descriptive language that represents the elements related to design decisions (Moran and Carroll, 1996). The argumentation-based design rationale model adapts argumentation as the knowledge

representation of the design reasoning, and argumentation is considered as the most common form of reasoning (Toulmin, 2003), hence closest to natural communication.

Several knowledge representation models exist that can be used to capture the design rationale, most of these models are extensions of two fundamental models, namely IBIS (Conklin and Yakemovic, 1991) and QOC (MacLean et al., 1991). These models generally involve three major concepts: issue, position, and argument. They are represented in graphs, consisting of nodes as concepts and links as relationships. The QOC model has proved to be useful for each individual designer to clarify their design intentions, but is unable to represent the collaborative decision making (Lewkowicz and Zacklad, 2000). Therefore, we choose to use the issue based structure IBIS, since it is a flexible structure that describes the communications of the design progress (Regli et al., 2000). In order to better represent the dynamic negotiation process, the IBIS model is further elaborated into a semantic network as illustrated in Figure 1:
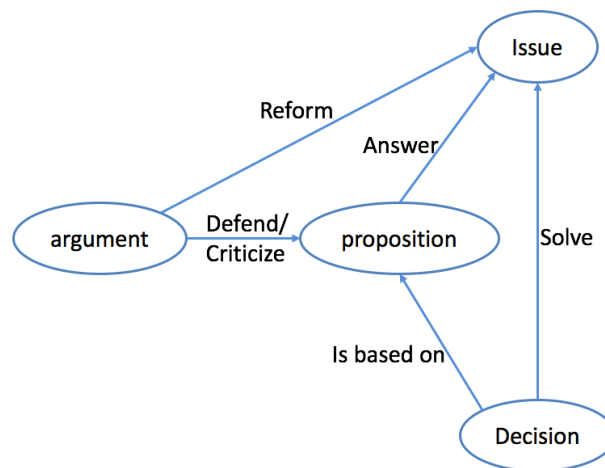

Figure 1. The semantic network of decision making process (DAI et al., 2014)

The semantic network of decision making includes the classic IBIS model concepts issue, proposition (position), and argument. In order to represent the evolving nature of issue, the relationship "reform" is introduced between argument and issue to indicate that issue may be modified according to the arguments, and a new issue may be established if the group decides to accept the modification. Compared to the IBIS model, the concept "decision" is added to indicate the outcome of the problem-solving. This semantic network will be used as the knowledge structure for design meetings.

3   DESIGN MEETING DATA COLLECTION AND STRUCTURING

As the goal of this study was to investigate the feasibility to reconstruct design rationale from a naturalistic meeting, the participants were not specially trained with design rationale, and no specific problem-solving methods were imposed on them. The participants in our study were all master students. The master students were supposed to collaboratively work on the conceptual design of a product or software in a project. Each project group consisted of 4 master students.

So far, 11 master student design project meetings with a total duration of approximately 600 minutes were recorded. These meetings were held in the context of a design project. The design project is required in the course "intelligent system" they followed. The project specification was given to the students beforehand, they were supposed to answer three general questions in their meetings: 1. What is the function of the product? 2. How your product is qualified as an intelligent product? 3. Is your product privacy friendly? They were required to hand in a list of their decisions about their design right after the meeting. Lavaliere microphones were used to record each participant's speech, and two cameras were also used to record the video of meetings.

The speech data of the meetings were transcribed into texts with a speech recognition engine[1], and each utterance was further annotated by a trained design rationale expert with design rationale concepts

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[1] https://github.com/laurensw75/SpeechAPIDemo

mentioned in Figure 1. Firstly, issues realated to product design are identified. Secondly, discussions following the identified issues will be annotated as propostisions or arguments. Finally, decisions are annotated repectively to issues. Note that issues may evolve in a discussion, arguments may be directed towards the current issue to reform it, in this case, a new issue will be identified. These annotated texts were segmented into issue-based decision making cases, structured under the semantic network of decision making (Figure 1.).

Two problem solving case samples are presented in Table 1 and Table 2. The first one illustrates the process in which the design team explored the breadth of alternatives to define the general functions of a navigational watch for visually impaired people, and the second one shows the process of a relatively in-depth reasoning to determine the interface design of a collaborative learning platform for students.

Table 1. Decision making case on the issue function definition, for the design of a navigational watch for visually impaired people

Project: Design of a navigational watch for visually impaired people			
Issue: Function definition			
Proposition	**Argument**		**Decision**
Integrated microphone that allows speech commands	Defend	Spontaneous command	Integrated microphone that allows speech commands
	Criticize	The environment noise may cause disturbance	
		Voice command may make the visually impaired people socially inappropriate in public	
Vibration to give feedbacks	Criticize	People may not feel the vibration	Vibration to give feedbacks
		Vibration is not an accurate navigational feedbacks	
	Defend	This feedback is more discreet	
GPS system to determine the location	Null		GPS system to determine the location
Exterior sensors to detect the surroundings	Defend	More reactive in face of accidents	Exterior sensors to detect the surroundings
Connection to a smart phone to enable a personalized intelligent service	Criticize	May violate the user's privacy	Connection to a smart phone to enable a personalized intelligent service
Audio feedbacks with a loudspeaker	Criticize	The noise of the watch may make the user self-conscious in public	Null
Track the user's daily activity, change the real environment with the aggregated data	Criticize	The idea of arranging the public environment according to one particular user is unrealistic	Null
The user should be able to choose what kind of feedback as one prefers	Null		The user should be able to choose what kind of feedback as one prefers

Table 2. Decision making case on the how to present the learning subjects, for the design of collaborative learning platform

Project: Design of a collaborative learning platform for students			
Issue: How to present learning subjects			
Proposition	**Argument**		**Decision**
Present the subjects in a text-based categories	Defend	Easy for searching	Present the subjects in a text-based categories
		Corresponds to our mental concepts	
	Criticize	Not innovative, too traditional	
		We need a presentation that inspires people	
Feature certain special subjects and present them one by one	Defend	People can get inspired by our propositions	Null
Personalize the subjects according to each user's preferences	Null		Personalize the subjects according to each user's preferences
Present the subjects based on their locations	Defend	The user can join the learning session as quickly as possible	Null
		The presentation is more fun for students	
Present the subjects base on their schedule	Null		Null

For every question concerning the product design evoked in the meeting, a case table was built. The issues were generally restricted by the pre-defined specifications of the project, but new issues could also rise during the discussion. Irrelevant chitchat and questions about communication are not included in the analysis. During the meeting, some evoked issues may not have been addressed at all, some issues may have initiated an argumentation that not resulted in a decisions, and some propositions may have had no arguments. In these cases, respective parts of the table are indicated as "null".

4 RESULTS

After the classification of the meeting data of the 11 master student design project meetings, 27 product design related issues have been identified. 16 of them initiated an argumentation, among which 14 of them lead to decisions. 11 issues were ignored or rejected during group discussion, which did not initiate decision making. In other words, for 87.5% of the issues that have initiated decision making in the meeting, a complete issue based argumentation case can be represented, and each meeting entailed at least one complete case. The decision making process for these cases can be classified under the design rationale format. The overview of issues is presented in the Figure 2 below:
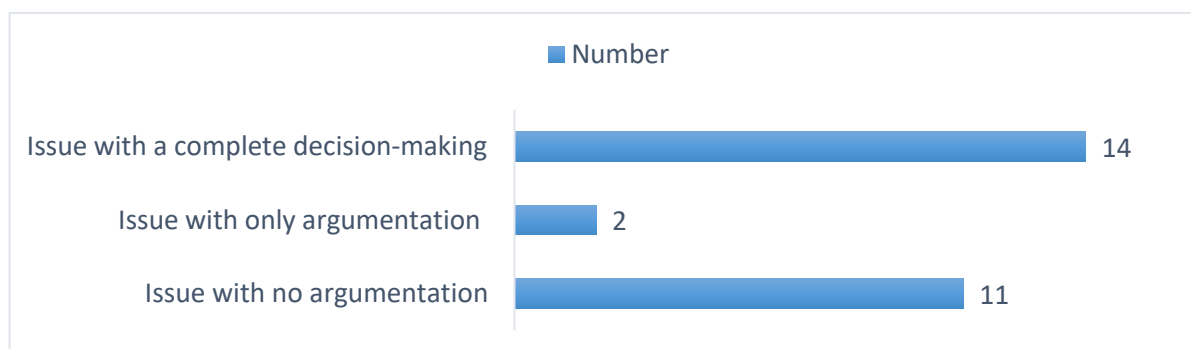

Figure 2. The overview of issues

One important element in design rationale is the argumentation, which reveals the design intention or reasoning behind decision making. When we take a look at these 14 cases, we discover that 82 different propositions have been made, and only 45 of them were argued about. Among the 45 propositions with argumentation, 39 of them were included in the final decision. 56 decisions were made in total, and 17 of them were based on propositions with no argumentation. The overview of decisions and argumentations is presented in the Figure 3 below:
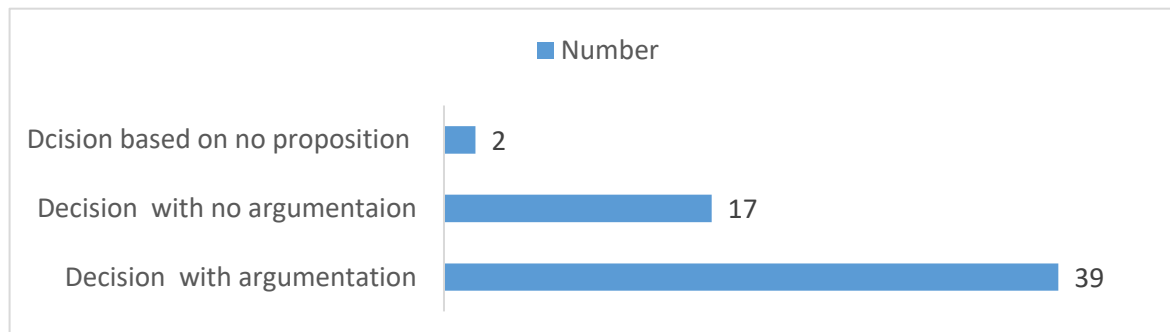

Figure 3. The overview of decisions and argumentations

For each design meeting, the issue "function definition" was required to be addressed by all groups. The decision making process concerning this issue generally follows the design rationale structure, at the same time, the overview of decisions and argumentations have shown that 34% of the decisions are based on propositions with no argumentations, in other words the design intention behind these decisions remains obscure.

5 ANALYSIS

The meetings studied in our research were conducted in the conceptual design phase, in which the design team focused on the breadth of design alternatives. Among 16 issues that have evoked decision making during these meetings, 87.5% of them can be classified into the argumentation-based decision-making process. The results of our research show that design rationale is a good knowledge representation model for problem-solving knowledge in a design meeting during the conceptual design phase. This is in line with the theory of "ill defined" design problems (Thomas and Carroll, 1979). Literature has generalized four elements of design problem-solving: goal, constraint, alternatives and solutions (Smith and Browne, 1993;Jonassen, 1997), and they are respectively represented in design rationale as issue, argument, proposition and decision.

Although most of the meeting information can be structured under the design rationale model, they cannot all be reused. People can't gain knowledge from a list of decisions made in face of a problem, they need to understand the reason behind these decisions. Therefore, argumentation behind design decisions is crucial for the purpose of knowledge management. The results of our study show that 34% of the decisions do not have any argumentation, which makes the reasons behind these decisions obscure, and nearly half of the issues are ignored or rejected in group discussion without explicit explanation. Two factors may contribute to this situation. On one hand, collaborative decision making is not only shaped by rational problem-solving, as not all design alternatives go through a logical evaluation process, but is also influenced by the group's social dynamics (Vinciarelli et al., 2008; Hogg and Terry, 2014) and emotion (Schwarz, 2000), which can be hardly captured by design rationale. For example, a decision can arbitrarily be made by a dominant leader without giving the group a chance to evaluate it. On the other hand, each individual's mental model and knowledge level evolve with the group interaction during the meeting, so a shared group mental model may lead to consensus, without explicit negotiation (Lim and Klein, 2006; Langan-Fox et al., 2004). In this case, the group reasoning behind its decision making becomes tacit knowledge. In the domain of social signal processing, several studies have been done to investigate how participant's social signals are related to their meeting behavior (Renals et al., 2007; Aran et al., 2010). The social aspect in design meetings can provide a complementary explanation on design decision making.

Note that apart from the complete decision making cases, there are two issues with argumentation that have lead to no decisions. They are interpreted as unresolved conflicts. In spite of the absence of

decisions in these cases, the argumentation still illustrates the pros and cons for each proposition, and it is valuable knowledge for other designers facing a similar issue.

6 CONCLUSION

In this paper we investigated the feasibility to reconstruct design rationale from design meeting recordings. Design rationale models have been developed to help the designers to clarify their reasoning, and they can be used as knowledge representation to structure design knowledge. However, past research has shown that it is very difficult if not impossible to ask the designers to consciously document their reasoning during a meeting. Microphones and cameras can be used to record naturalistic design meetings, and the meeting data were classified according to an issue based design rationale model. The findings of our research have shown that in conceptual design phase, most of the problem-solving process in meetings (87.5%) falls into the pattern of an argumentation-based design rationale model, although nearly one third of decisions are not explained by explicit argumentation. Hence we conclude that issue based design rationale is quite good as the knowledge representation structure of collaborative decision making in the phase of conceptual design. We believe that both the social aspect and a shared group mental model can result in tacit knowledge. How to make this tacit knowledge explicit, without any excessive cognitive effort still remains a challenge. Our future research will be be focused on how to combine human machine interation technology with knowledge capturing in the context of collaborative decision making in the domain of engineering design.

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