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Distributed Capture of System Requirements as Individual and Group Cognitive Maps

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Abstract

Cognitive mapping and group support systems have been used to capture requirements for information systems. However, cognitive mapping has been used to focus on the views of individuals and group support systems have been applied to identify group views in non-distributed environments. This paper describes a system that supports capturing requirements in a distributed environment.

Introduction

Requirements analysis is often considered essential to developing the “right” information system. However, gathering requirements has largely been limited to interviews with key users of the system. Both group support systems technology (GSS) and cognitive mapping techniques have been applied to address the limitations of these interviews. Both approaches have their own limitations. For example, cognitive mapping has been commonly used to identify individual perceptions and GSS have been used in non-distributed environments. GSS have recently been used to implement a cognitive mapping approach that reveals individual and group perceptions. In this paper, we describe a distributed group cognitive mapping system applied to support the requirements capture process. The system was implemented within a WWW browser environment using the Java language.

Requirements Capture

In information systems development, knowledge of many people with varied backgrounds is required to adequately capture system requirements. In recent years, workshop approaches for capturing systems requirements have been used instead of the more traditional approach of one-on-one interviews (Nunamaker and Sprague, 1993; Liou and Chen, 1993; Graham, 1995). Likewise, approaches such as joint application development (JAD) and rapid application development (RAD) reduce the length of the requirements capture process and produce a more integrated set of requirement specifications in less time.

Cognitive Mapping

Cognitive mapping is a research method for studying and recording people’s perceptions. An analysis of various cognitive mapping techniques (Axelrod, 1976; Bougon et al., 1977; Eden et al., 1992) shows that most of the techniques may be viewed as consisting of three major parts: (1) eliciting issues, (2) refining issues, and (3) identifying relationships between issues. A common characteristic of these approaches is a focus on obtaining the views of people in the problem environment.

Cognitive maps have been used to support requirements capture. Montazemi and Conrath (1986) explored the use of cognitive maps to elicit systems requirements from individuals.

This approach is consistent with the goals and approaches used for requirements analysis. These views are often obtained using broad questions with the intention that the participants will provide the details they feel are most important. However, the use of cognitive mapping based approaches have focused on identifying the perceptions at an individual level and not a group level (Langfield-Smith, 1992).

Obtaining the shared perceptions of group members requires researchers to implement a difficult process of identifying congregating labels. This involves evaluating individual cognitive maps and inferring that the individuals identified similar ideas. The group cognitive map is based on these inferences. Furthermore, the iterative interview process and volume of data required to identify individual cognitive maps, makes the creation of congregate maps impractical.

However, GSS technology has been applied to implement a cognitive mapping approach (Sheetz et. al., 1994). The advantage of this approach is the GSS allows capture of group perceptions and eliminates the difficult process of inferring that the individuals shared understandings are sufficient for defining congregating labels (Bougon, 1992).

Group Support Systems

Several studies suggest using a GSS as a research methodology as opposed to a decision making tool (Anson et al., 1992; Davis et al., 1992; Hoffer et al., 1990). Also, GSS utilizing various knowledge acquisition techniques have been shown to successfully elicit information from individuals in group settings (Liou and Nunamaker, 1993). Several studies have integrated a GSS and a CASE tool to support requirements specification (Chen and Nunamaker, 1991; Liou and Chen, 1993). Our use of GSS to support requirements capture is consistent with these applications of the technology.
Approach

The procedures used for data collection and analyses consist of multiple steps. First, data collection steps including identification of issues, identifying categories of similar issues, rating of the importance of these categories, and identifying relationships among categories are completed. This is similar to the interview stage common to many requirements analysis techniques. Second, common cognitive map analysis techniques are used to analyze the collected data. This augments the process used by analysts to understand and evaluate the requirements collected.

Issue Identification. The purpose of this step is to identify what the participants believe the requirements of the system should be. This is supported by a framing statement to provide a context for electronic brainstorming of issues the system is required to address.

Category Generation. The purpose of this step is to identify and define a set of categories in which to classify the issues identified in the previous step. Participants look for issues that address a similar idea. They then take turns suggesting category names and definitions that capture the similarities they observe. A chat room style interface is provided to facilitate distributed group discussion of the meanings of the categories.

Issue Categorization. In the issue categorization process, participants are provided with listings of the issues generated in the brainstorming process and the categories produced in the category generation process. They are asked to individually assign each of the issues to a category.

Rating of Categories. This activity is comprised of three ratings interspersed with two chat room discussions of the ratings. The three ratings are intended to be the equivalent of a Delphi panel process and are used to reach consensus on the relative importance of the categories of issues for the system being developed (Dalkey & Rourke, 1971). The ratings are performed individually by each group member and average group ratings are discussed.

Relationship Identification. Relationships among the categories exist from both process and data perspectives. Separate relationship identification steps are used to capture these data. The first step identifies relationships among the categories from a process perspective, i.e., how the categories of requirements combine to implement business rules. The second set of relationships identifies how the participants perceive that data is shared among the categories of requirements.

Derived a cognitive map representing shared perceptions from both the process and data individual maps involves determining the number of participants that identified each possible relationship between the categories. Capturing relationships among the categories from these perspectives facilitates use of either structured or object-oriented techniques for completing the system design and implementation.

Cognitive Map Analysis. The first approach to analyzing the group cognitive maps incorporates the idea of "levels of agreement." Levels of agreement refer to participants independently identify the relationships. Thus, all participants identify/agree on some relationships, while others are agreed on by a subset of individuals. The map that shows perfect agreement is referred to as a group consensus map. Beginning with this map and relaxing the level of agreement provides an approach to observe the "emergence" of the complexity of the process and data revealed by the group maps.

The cognitive maps also can be evaluated using givens means ends (GME) analysis (Bougon et al., 1977; Weick & Bougon, 1986). GME analysis is an analytical technique that interprets the direction of flow through a cognitive map. In this case, the flow of process and data among the categories of requirements is represented.

A third cognitive map analysis technique is "domain analysis" (Eden et al., 1992). Domain analysis produces a measure of cognitive centrality of a category in a cognitive map. Cognitive centrality is defined as the total number of relationships that the category has with other categories in the cognitive map. Thus, the approach reveals the most cognitively central requirements categories in terms of the process and data required for the system.

Cluster Analysis. The participants' perceptions can be represented as three levels of aggregation. The issues and the categories are the first two levels. The categories are an aggregation of the issues. The third level is derived using cluster analysis to identify constructs that are aggregations of the categories. Issue categorization and the process and data cognitive maps provide data for calculating the similarity of the categories. The highest level of aggregation results from cluster analyses applied to the similarity matrices calculated from these data. Defining this level of aggregation is an attempt to identify constructs underlying the shared representation of the participants provided at the issue and category levels. Similarity of the categories is calculated using the Jaccard similarity measure (Voyer, 1993). The levels provide a hierarchical knowledge representation of the group's understanding of the system requirements.

Summary

The approach described above supports multiple views of system requirements. The system allows the individuals to identify a set of underlying issues, categories of issues, and relationships between the categories that leads to identifying the underlying process and data required to design and implement the required system. Also, the approach supports the developers in identifying a set of clusters of the underlying elements. Through the analysis of the importance rankings and the cognitive maps, the developers can identify where resources should be applied to ensure that the most essential aspects of the system identified by the users are achieved.

References

References available upon request (sheetz@vt.edu; dtegarde@vt.edu).