Integrating soft computing in group decision support systems: a taste of the challenges and opportunities

Bartel Van De Walle*, Murray Turoff, Michael Bieber, Ajaz Rana

New Jersey Institute of Technology,
University Heights, Newark, NJ 07102, USA
bvdwalle@sckcen.be,
murray,rana,bieber\@cis.njit.edu
*On leave from Nuclear Research Center SCK.CEN, Boeretang 200, B-2400 Mol, Belgium

Abstract

Group decision support systems (GDSS) are designed to support and enhance the problem solving process of a group of decision makers. The various effects supporting or hindering the commensalism of GDSS and decision making groups have been explored in numerous controlled experiments over the last decade. We present a small yet flavorful selection of the many pertinent observations formulated within this body of literature on GDSS that point at clear opportunities or challenges to the integration of soft computing within GDSS.

Introduction

A group decision support system (GDSS) has been defined as an interactive computer-based system that facilitates the solution of problems by a group of decision makers (DeSanctis and Gallupe 1985). It combines communication, computer, and decision support processes or structures to support problem formulation and solution. The objective is to improve the process of group decision making by removing communication barriers, structuring or regulating the group interaction, and providing analytical tools such as decision aids for data-oriented, preference or resource allocation tasks (Dickson 1970; Hiltz, Dufner, Holmes and Poole 1991).

Controlled experiments on GDSS made their first appearance in literature in 1982 (Turoff and Hiltz 1982), and have since then known an exponential growth. In a recent overview paper, Fjermestad and Hiltz (Fjermestad and Hiltz 1997) identified 140 different experimental studies published in refereed journals or conference proceedings. Based upon their extensive analysis, Fjermestad and Hiltz provide a comprehensive framework in which four fundamental categories of variables are considered: contextual or independent variables, intervening variables, group adaptation processes, and outcomes.

In the next section, we introduce the category of contextual variables, and identify opportunities and challenges for the development and application of soft computing techniques. In particular, we examine the contextual factors of technology and task. Both factors are connected in the third section through the theory of Task-Technology Interaction. The various contingencies described in this theory lend themselves to the application of soft computing techniques. The fourth section then describes opportunities and challenges to soft computing within the area of collaborative hypertext. We conclude this working paper in section 5.

Contextual Factors in GDSS Experiments

Contextual factors are defined in (Fjermestad and Hiltz 1997) as "all external or driving factors that comprise the environment or conditions for the decision making task." It is from these variables that the independent variables manipulated in any given experiment are generally selected. Within the set of contextual factors, four basic factors are distinguished technological factors, group factors, task factors and environmental or organizational factors. In the following, we discuss shortly the technology and task factors.

Technology

In general, technology refers to the medium that supports group interaction within the GDSS. Obviously, the technology will vary according to the spatial or temporal distribution of the group. Among the technological factors, we may distinguish task support tools and process structuring tools.

Task support tools are intended for supporting the group in performing its decision making task. Examples of such tools are a meeting agenda, electronic brain storming, voting, cognitive feedback, etc. It would be challenging to enrich these tools by soft computing techniques. One could for instance view the work of Bandler and Kohout (Bandler and Kohout 1980) as highly relevant in this respect. Indeed, as Bandler and Kohout state: "Increasingly complex interaction between man and nature, increasingly complex interaction between man and man-made artificial systems, make it increasingly difficult to comprehend the consequences of changes in all these systems, to analyze them, to understand their dynamics, to influence their behavior. (...) Imprecision inherent in the real world, which cannot always be described probabilisticly, necessitates the introduction of the methodology of fuzzy systems." It has been shown by De Baets and Van de Walle (De Baets and Van de Walle 1994; Van de Walle and De Baets 1994) that the application of the work of Bandler and Kohout to multi-criteria decision analysis provides a rich analysis tool for such problems. The inclusion of such a decision analysis tool as a task support tool may be an important contribution to the introduction of soft computing in GDSS.

The first classification coding the sophistication of GDSS in term of its features stems from the work of DeSanctis and Gallupe (DeSanctis and Gallupe 1987). They framed three basic levels of intervention in group processes. Level 1 GDSS provide basic technological support aiming to remove communications barriers, to facilitate information exchange among participants, and to improve the decision making process. Level 2 GDSS provide decision modeling and group decision techniques aimed at reducing uncertainty. Finally, Level 3 GDSS are characterized by advanced communication patterns. Fjermestad and Hiltz found that the majority of the systems used are Level 1 GDSS, while the inclusion of soft computing techniques would be situated at Level 2 or Level 3.

Tasks

The task usually is the primary reason for the group to exist. A well-known and widely-used task typology has been developed by McGrath (McGrath 1984) in which eight different task types are distinguished within four categories. The graphical representation of this typology identifies tasks on two dimensions: an outcome-based dimension and a behavioral dimension. The most frequently used task type is the preference or decision making task, for which there is no 'best' decision and for which usually the decision of the majority is taken as the correct answer.

The limitations of the McGrath typology have been recognized. A more elaborate approach would be to consider the typical characteristics of a task, as was done in (Fjermestad and Hiltz 1997). Fjermestad and Hiltz distinguished the following characteristics: equivocality, complexity, analyzability, importance, enjoyability, and predictability. It would be challenging to construct a task classification scheme based upon these characteristics using fuzzy set theoretical models, for instance a fuzzy multi-criteria model.

Task and Technology Interaction Theory

The Theory of Task and Technology Interaction (TTI), proposed by Rana (Rana, Turoff and Hiltz 1997), provides a sound foundation for determining the generic properties of technologies that can be brought to bear on the needs of the collaborating individuals. The propositions of the TTI are based on the premise that the technological support needs of collaborating individuals are tied to the nature of activities involved in the performance of a task (or project). At the heart of the TTI lie two classification schemes, one for distinguishing tasks and the other for defining generic properties of group support technologies.

The task classification scheme is based on the notion of functional requirements of tasks. By functional requirements it is meant that the successful performance of a task depends upon the performance of certain activities or fulfillment of certain functions. An activity by the group or its members may serve any of the three functions postulated by McGrath's TIP theory (McGrath 1991): production, member support, and group well being. In TTI, for the sake of simplicity, the three functions of TIP are called general functions. The TTI posits that since the successful performance of a task depends upon the fulfillment of certain general functions then the definitions of group tasks should facilitate the determination of the activities that could fulfill those functions. The task classification scheme of TTI attempts to meet this objective by defining the task distinctions along three ordinal dimensions (complexity, validation, and coordination). The positioning of a task along each of the three dimensions is based on the identification of a range of attributes. These distinguishing attributes are called critical task contingencies.

In TTI, a GDSS is defined as a combination of electronic or non-electronic features taken from three broad classes of generic support types: support for the individual; group process support; and meta-process support. Each class of support type constitutes features/tools of varying levels of sophistication that are intended to support certain types of activities a group or its members may undertake.

The TTI posits that the various sub-activities of a task may require different combinations of technologies (media combinations, electronic or non-electronic tools, procedures, etc.). The implication is, as the nature of activities vary over the life time of a project so should the technologies that can support those activities. Rana argues that the task classification (or the identification of a task's critical contingencies) obtained by a careful evaluation of a task's characteristics helps in the determination of the activities that could fulfill a task's general functions and hence facilitates the determination of technological features that could support/ enhance the performance of those activities. It should be noted that in TTI, face-to-face meetings or the non-face-to-face synchronous or asynchronous processes involved in a group task are treated as forms of coordination activities.

It would be challenging to extend the process of determining a task's contingencies to the context of a fuzzy multi-criteria decision problem.

Collaborative Hypertext

Hypertext is usually seen as a support tool to aid the collaborative processes of both composition and use of a collection of information. Indeed, the concepts of mail and conferences can be interpreted as dedicated, tailored versions of collaborative hypertext, since they are all specialized linking structures designed to support human communication in groups (Turoff 1990).

The research area of collaborative hypertext provides a rich source of opportunities for the application of soft computing. To illustrate this, it suffices to quote various pertinent observations from (Turoff, Rao and Hiltz 1991):

(i) Referring to the nature of links in Hypertext, Turoff et al. state that "It would be nice for designers if all real world problems could be mapped in 0 or 1 pointers in the internal structure of the software. However, this is far from the reality of the problems that users are trying to solve."
(ii) Continuing this line of thought, Turoff et al. observe that "In the planning and analysis of task, the nature of links may vary by their degree of necessity, sufficiency, desirability, feasibility, intensity, significance, etc. Trying to represent this for conceptual purposes by using objects with attributes that only have or do not have links to other objects results in a model which provides only limited cognitive insights."
(iii) Moreover, it is concluded that "Knowing the strength of a linkage would allow the introduction of prioritized search algorithms and the use of such methods as fuzzy logic." We believe that the work on fuzzy relational compositions by Bandler and Kohout (Bandler and Kohout 1980, Kohout and Bandler 1992), and the application of these compositions in multi-criteria decision making problems -- as in (Van de Walle and De Baets 1994) -- could be of particular interest. In fact, the whole area of fuzzy preference modeling (Van de Walle, De Baets and Kerre 1995-- 1997) may produce fascinating applications within the hypertext environment. Just imagine, the visual representation of trails of preference, indifference or incomparability among the set of alternatives as indicated by a group of decision makers.

The research area of collaborative hypertext may become a new break-through area for applications of fuzzy reasoning and soft computing. As we have important developments in the area of fuzzy information retrieval, hypertext may now foster the development of fuzzy information composition.

Conclusions

Freeing the individual decision maker from constraints by the group and allowing everyone to work on the cognitive tasks they feel best at is the key to collective intelligence in groups. Soft computing may provide some of the essential means to achieve that goal.

Short Curricula of the Authors

Bartel Van de Walle has a PhD in applied mathematics and computer science from Gent University (Belgium). He is a researcher at the Belgian nuclear research center SCK•CEN, conducting applied and fundamental research on preference modelling and multi-criteria decision analysis. He is currently a visiting researcher at the Computer and Information Science department at NJIT.

Murray Turoff is Distinguished Professor of Computer and Information Science at NJIT. He has received numerous awards and honors, among which the 1994 Pioneer Award by the Electronic Frontiers Foundation and the Award for Creativity from the Electronic Network Association. He has (co-)authored more than 200 publications, and is author together with Dr. Starr Roxanne Hiltz of the book "The Network Nation: Human Communication via Computer".

Michael Bieber is Assistant Professor at the Computer and Information Science Department at NJIT, and Director of the Hypermedia Research Laboratory.

Ajaz Rana is Assistant Professor and Director of the CIS Distance Instruction at NJIT. He has obtained his Ph.D. in Management Information Systems from Rutgers University in NJ. Dr. Rana has developed the theory of Task-Technology Interaction.

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