On a concept of a consensus reaching process support system based on the use of soft computing and Web techniques

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An idea of a new model of a Web-based system to support a group of decision makers in reaching consensus is proposed. The core of the system is a flexible human consistent representation of preferences. However many means, notably Web-based, are conceived to help a group member to form and express his or her preferences. Moreover the model integrates the mechanisms for the discussion guidance so as to smoothly and effectively run the session.

Keywords: consensus; group decision making; fuzzy logic; preferences; ontology.

1. Basic concepts

Choosing a restaurant for a dinner by a group of friends or selecting an investment project most beneficial for the local community – however different in scale and consequences – these two tasks do share some important features. What matters here is taking into account and respecting the opinions of all participants, developing a joint solution, making arguments and convincing, identifying various aspects of the problem under consideration, exchanging the knowledge, seeking for a new information. These features characterize briefly what is known in the literature as the *consensus decision making*.

In the paper we propose a concept of a Web-based system combining human-consistency of the assumed representation of the decision problem, intelligent and knowledge-based support for the information search and decision process monitoring and guidance with the user-friendliness and intuitiveness of the user interface.

A very important aspect of the proposed system is its support for the discussion in the group. A longterm goal is here to "understand" the dis-

cussion and to automatically build the profiles of the experts, notably with respect to their preferences concerning the options. The first step in this direction is via imposing some structure on the discussion. The idea of documenting and supporting discussion using some automatic means has a long history.[1] An interesting line of research concerns here the automatic generation of arguments on the basis of an agent preferences. For example, Carenini and Moore[2] consider a problem of generating argumentation assuming user's preferences modelled in the framework of the multi-attribute utility theory. Their work, belonging to the natural language generation (NLG) domain, is readily applicable for our purposes. Each participant of the group is provided with a template of the argument – based on his or her profile. At the early stages of the discussion such a profile is usually coarse and suggested templates are abstract. Interaction with the system helps to build up the profile and at the later stages suggested templates are getting more precise and complete.

Closely related concept of the *recommendation systems*, notably of the collaborative filtering[3] plays an important role in our approach. First of all this paradigm is applied in its "native mode" to enhance the search experience of the group members when looking for some additional sources of information. Furthermore the same paradigm may be used when suggesting the changes in the preferences of the group members.

2. The big picture of the system

We assume the following setting of the decision making problem: a set of individuals (*experts*) $E = \{e_i\}$, and a set of *options* $O = \{o_j\}$, possibly characterised with a set of attributes. There is also the *moderator* responsible for the whole process. The experts engage in a discussion and express their preferences until the consensus is reached. The practical inappropriateness of the definition of consensus as a total agreement of all experts as to their preferences concerning all pairs of options was a starting point of our research (cf. paper by Kacprzyk[4] and later[4–7]) and of many other researchers (cf., papers by Herrera-Viedma et al., e.g.,[8]). A more flexible definition of consensus proposed in[4] as "the agreement of *most* of the experts as to the *most* pairs of the options" is more realistic and useful.

Now we are especially interested in how:

- the support for the information seeking may be integrated with the rest of the system,
- the discussion may be formalized in order to make it automatically in-

terpretable and at the same time convenient for the users to engage in,
- the knowledge concerning the domain of the decision problem under consideration and decision making as such may be accounted for,
- the consensus may be evaluated and the session guided in such an information rich environment.

The information environment. One of the main aims of the proposed concept of the system is the integration of the "raw" decision making process with the information seeking activities. The moderator arranges for the access of the experts to the information sources such as relevant textual documents and databases. The experts access them using flexible querying interfaces to databases, automatic categorization of the documents, the ontologies and the recommender systems. The user profiles are used and build throughout these information seeking activities. Their important part are the preferences concerning the options under consideration.

The ontologies. Two types of ontologies are employed: a domain ontology domOnt and a consensus reaching specific ontology consOnt. The latter is constructed following the work on the argumentation theory and abstract modelling.[9,10] Its main classes are: Option, Expert, Preference and Argument. This ontology covers the basic concepts regarding the group decision making. The domOnt ontology is a formal conceptualization of the domain related to the decision problem in question. Additionally it:

- supports the argumentation and expression of the preferences by the experts; both ontologies combined serve as a source of templates for the generation of arguments during the discussion,
- supports the search for additional information,
- provides an opportunity to analyse the consensus on several levels of abstraction; for instance it may be the case that there is no consensus as to the choice of a particular wine but there is consensus that French wines are preferred (assuming the choice of the wine is the decision problem),
- provides an opportunity to formalize the knowledge of the group regarding the domain of the decision problem and to alleviate the cognitive barriers for reaching the consensus (assuming it is jointly constructed/extended by group members).

The consOnt ontology is a part of the system but the domOnt ontology is problem-dependent. If it is not available then the moderator prepares a basic domain ontology which may be further extended during the session.

A way to obtain such an extension is via going from a *folksonomy* to an ontology. The experts are encouraged to tag both the arguments and opinions (see later) as well as consulted text documents with the keywords of their choice. Thus created folksonomy is the starting point to the construction of a basic ontology.[11]

Preferences representation and expression. The preferences are internally represented by the system in the form of (intuitionistic) fuzzy preference relations. They are expressed by giving some arguments in the natural language. The arguments express opinions of the experts and provide their justifications. Depending on the availability of ontologies the arguments may be generated quasi-automatically (NLG!) Then the "surface" text of the arguments is accompanied by metadata (referring to the concepts from the ontology) securing machine-interpretable semantics of the arguments.

The experts express their opinions placing messages on the Internet forum - the heart of the system. Two basic types of messages are assumed: a *position* explicitly expressing the preferences concerning a pair of options and an *argument* providing a rationale (pros and cons) to earlier expressed position. Thus experts either express their preferences directly or subscribe/oppose to earlier expressed preferences. A text document (or excerpt thereof) which is judged as justifying/invalidating the position may play the role of an argument. Moreover the experts may tag the arguments creating this way a folksonomy.

The internal representation of the preferences is recovered from opinions placed on the forum. The intuitionistic fuzzy preference relations well fit this scenario providing a proper account of the pro and con arguments.

Consensus measuring. The original consensus measure proposed by Kacprzyk[4] and some related measures[5,6] are used. They refer to the notion of the *importance* of options and experts. The importance of an option may be measured by the number of opinions concerning it. The importance of an expert may be measured by the number of opinions he or she placed on the forum (the activity component) which were confirmed by other experts (the authority component).

The consensus measures are interpreted as similarity measures and used whenever the comparison of two experts or two options is needed (e.g., in collaborative filtering).

Consensus reaching process guidance. Various mechanisms are conceived to help the group to reach consensus. A basic one consists in computing the consensus measures and checking if they grow or diminish.

The joint building of the domain ontology helps to clarify some cognitive differences between experts concerning the perception of the decision problem. The taxonomical part of the domain ontology may be used to look at the decision problem at some different granularity levels and discover the agreement there.

Collaborative filtering makes the information flow in the group more efficient. In fact it may be used in two "opposite" scenarios:

- at the early stages of the discussion the same documents will be suggested to experts of similar profiles, determined first of all by their so far expressed preferences,
- at some later stages of the discussion, when some conflicts of opinions emerge, the documents consulted by the experts expressing opposite opinions will be suggested to their adversaries in order to share the knowledge.

The recommendation system paradigm will be also used to direct the discussion in the group and/or the individual assessment processes. For example an expert e_i will be suggested to reconsider his or her preferences concerning a pair of options o_j and o_k if, e.g., "most of other experts having similar to e_i preferences on the remaining pairs of options agree among themselves and disagree with e_i on o_j versus o_k". More generally, the linguistic summaries are employed here to guide the discussion, as proposed in[7] with respect to both static and dynamic analysis of the consensus reaching process.

3. Concluding remarks

We have proposed a new concept of the consensus reaching process support system. Its characteristic features are the use of flexible preference representation, multi-level consensus evaluation, explicit knowledge representation component (ontology) used throughout the whole process, and combination of intelligent textual information and database retrieval support.

In the paper we present a work in progress. The ultimate goal of our research is the implementation of an advanced Web-based group decision support system with a special emphasis on supporting the consensus reaching process. Here we present some design assumptions which show the novelty of our approach, notably in comparison to earlier similar works, cf., e.g.[5,12,13]

Acknowledgment

This work was partially supported by the Ministry of Science and Higher Education under Grant N N519 404734

References

1. D. G. Lowe, Cooperative structuring of information: The representation of reasoning and debate, *Int. J. of Man-Machine Studies* **23**, 97–111 (1985).
2. G. Carenini and J. D. Moore, Generating and evaluating evaluative arguments, *Artif. Intell.* **170**, 925–952 (2006).
3. A. Jameson and B. Smyth, Recommendation to groups, in *The Adaptive Web*, eds. P. Brusilovsky, A. Kobsa and W. Nejdl, LNCS, Vol. 4321 (Springer, 2007).
4. J. Kacprzyk, On some fuzzy cores and "soft" consensus measures in group decision making, in *The analysis of fuzzy information*, ed. J. Bezdek (CRC Press, Boca Raton, 1987) pp. 119–130.
5. S. Zadrożny, An approach to the consensus reaching support in fuzzy environment, in *Consensus under fuzziness*, eds. J. Kacprzyk, H. Nurmi and M. Fedrizzi (Kluwer, Boston, 1997) pp. 83–109.
6. S. Zadrożny and J. Kacprzyk, An internet-based group decision and consensus reaching support system, in *Applied decision support with soft computing*, eds. X. Yu and J. Kacprzyk (Springer Verlag, Heidelberg, 2003) pp. 263–275.
7. J. Kacprzyk, S. Zadrożny and A. Wilbik, Linguistic summarization of some static and dynamic features of consensus reaching, in *Computational Intelligence, Theory and Applications*, ed. B. Reusch (Springer-Verlag, Berlin Heidelberg, 2006) pp. 19–28.
8. F. Herrera, E. Herrera-Viedma and J. Verdegay, A model of consensus in group decision making under linguistic assessments, *Fuzzy Sets and Systems* **78**, 73–88 (1996).
9. P. Rittgen, Negotiating models, in *CAiSE*, eds. J. Krogstie, A. L. Opdahl and G. Sindre, Lecture Notes in Computer Science, Vol. 4495 (Springer, 2007).
10. C. Tempich, H. S. Pinto, Y. Sure and S. Staab, An argumentation ontology for distributed, loosely-controlled and evolving engineering processes of ontologies (diligent), in *ESWC*, eds. A. Gómez-Pérez and J. Euzenat, Lecture Notes in Computer Science, Vol. 3532 (Springer, 2005).
11. P. Mika, Ontologies are us: A unified model of social networks and semantics, *J. Web Sem.* **5**, 5–15 (2007).
12. M. Fedrizzi, J. Kacprzyk and S. Zadrożny, An interactive multi-user decision support system for consensus reaching processes using fuzzy logic with linguistic quantifiers, *Decision Support Systems* **4**, 313–327 (1988).
13. E. Herrera-Viedma, L. Martinez, F. Mata and F. Chiclana, A consensus support system model for group decision-making problems with multi-granular linguistic preference relations, *IEEE Trans. on Fuzzy Systems* **13**, 644–658 (2005).