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A method based on shape-similarity for detecting similar opinions in group decision-making

A. Tapia-Rosero [a,b,*], A. Bronselaer [b], G. De Tré [b]

[a] Department of Electrical and Computer Engineering, Escuela Superior Politécnica del Litoral, Campus Gustavo Galindo V., Guayaquil, Ecuador
[b] Department of Telecommunications and Information Processing, Ghent University, St-Pietersnieuwstraat 41, B-9000 Ghent, Belgium

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ABSTRACT

In this paper, we propose a method to identify groups of similarly shaped membership functions representing criterion preferences provided by a large group of experts in the context of group decision-making. Our hypothesis hereby is that similarly shaped membership functions reflect similar expert opinions. The proposed method uses a symbolic notation to depict each membership function taking into account its shape characteristics (i.e., slopes and preference levels) and the relative length approximations on its X-axis segments (i.e., core segments, left and right spreads). The symbolic notation significantly reduces the complexity to handle a large group of expert opinions expressed by membership functions, and facilitates their comparison for grouping purposes through a shape-similarity measure.

The main goal of the method is to detect all membership functions that are relevant to represent trends or suitable concepts among a large group of people considered as experts. An illustrative example, demonstrating the applicability of the method, is included in the paper.

1. Introduction

Solving a decision-making problem often requires dealing with several expert opinions which offer different points of view over multiple criteria (technical, economic, administrative, etc.). In our time, collaborative and social tools are part of the strategies to involve a large number of people to give their opinions. When there are numerous opinions, each of them from a different perspective of the problem, this could be a hard task to pursue. However, it is possible to suggest a solution based on a combination of these opinions. The suggested solution should take into account the relevance of some points of view while trying to moderate the discordance among opinions. Besides, it is possible to summarize the expert opinions in order to reduce the complexity of the problem.

Nowadays, using soft computing techniques, a person could express his/her expertise or preferences with respect to a criterion specification through membership functions setting his/her preference levels. It is not necessary that all of the experts have foreknowledge of soft computing techniques to represent their preferences $P(x)$ as a matter of degree (i.e., $0 \leqslant P(x) \leqslant 1$, where 0 denotes a complete disagreement on the value x and 1 denotes the highest level of agreement) as long as they assign some preference degrees [8]. These preference degrees will be used for defining the attribute criterion in a membership function [40].

* Corresponding author at: Department of Telecommunications and Information Processing, Ghent University, St-Pietersnieuwstraat 41, B-9000 Ghent, Belgium. Tel.: +32 9 264 4222.
E-mail addresses: Ana.Tapia@Ugent.be (A. Tapia-Rosero), Antoon.Bronselaer@Ugent.be (A. Bronselaer), Guy.DeTre@UGent.be (G. De Tré).

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For illustration purposes we will consider a company with a horizontal hierarchy which promotes the participation of all its members. The company has to decide about the development of a new product based on its ''usefulness level'' (criterion) in a social network environment. One strategy to solve this decision-making problem is that each expert uses a membership function to express what he/she understands to be the level of usefulness. Under this scenario, if the usefulness level is represented by a percentage, it is possible to obtain answers interpreted as: ''the usefulness level is below 30%'', ''it is between 40% and 60%'' or ''it is above 70%'' [9,26, p. 37]. Nevertheless, we will have a number of membership functions that equals the number of experts involved. If there is a large number of people considered as experts, the decision maker could be overwhelmed with all of their opinions, and taking a final decision will become a complex task. But, if there are several opinions referring to a similar representation, then it is possible to group them to allow the decision maker to make a choice within a representative set of opinions. Furthermore, it is possible to detect and moderate conflicts among groups. Fig. 1, illustrates this example.

The presence of a large number of membership functions, representing expert opinions in a group decision-making context, could increase the complexity of a given problem. However, in some situations this number could be reduced by clustering similar opinions and obtaining a single representation that reflects the opinion of each cluster. In case that conflicting opinions occur or that a minority trend is present, this will be represented within a cluster for further consideration.

We found extensive literature [5,17,21,24,27,36,37] that deals with group decision-making, but only a few consider the presence of large groups of experts [1,25,31]. Furthermore, most of the approaches assume the existence of alternatives and use pairwise comparisons. However, when alternatives are present, other possibilities could be unnoticed. Let us return to our example. What happens if a reliable minority agrees that the usefulness level is not acceptable? It is possible that the product will be launched to the market because of the majority's opinion. But, a marketing study emphasizing the perception of usefulness over a specific user group or market segment, represented by a reliable minority, could be ignored.

Bearing in mind that all experts contribute to some extent to the final decision and that each expert usually has access to different profiles of information [27], this proposal considers that we are looking for a relevant collection of membership functions that better represents the experts' opinions in a given context. Our approach preserves each opinion by means of a membership function and detects the existence of distinct groups of experts with similar representations.

In this paper, we propose a method to identify similar expert opinions represented by membership functions. The similarity is based on the shape characteristics of membership functions used to represent the preference degrees on criterion specification in a group decision-making context. The proposed method is feasible in the presence of a large amount of membership functions and includes the symbolic notation as a novel component. The symbolic notation, used to depict shape characteristics of membership functions, reduces the clustering complexity while facilitating the function comparisons for those that are similarly shaped from a human's perspective (e.g., a triangular membership function and a trapezoidal membership function with a tiny core). Furthermore, it is possible in a graphical representation of membership functions to relate some segments' lengths to the expert profile. For example, smaller horizontal segments representing the highest level of preference (i.e., smaller cores) on the criterion could represent a more progressive or confident opinion of an expert, while bigger horizontal segments (i.e., bigger cores) could represent a more conservative or flexible opinion.

The remainder of this paper is structured as follows. The next section defines preliminary concepts. Section 3 provides an overview of related work. Section 4 is the core of our proposal, it provides details of the symbolic notation for membership functions, describes how the similarity measure is obtained and how it is used during the clustering step. Section 5 includes

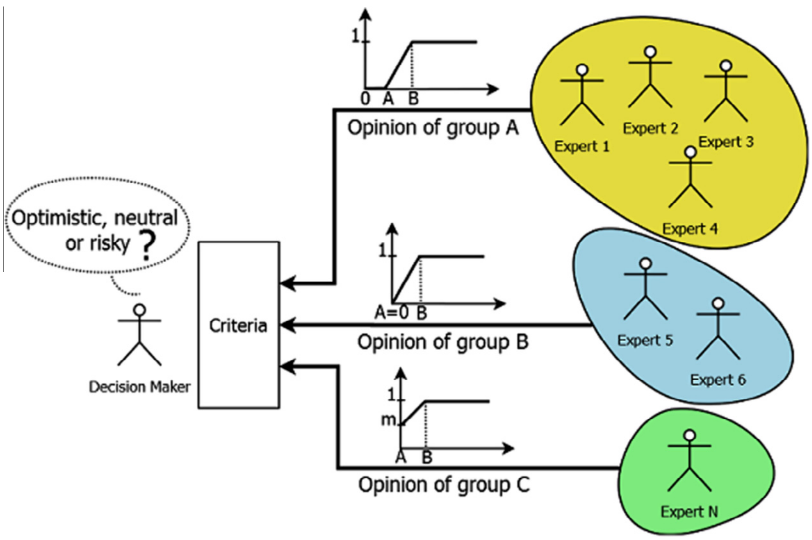

Fig. 1. Representation of several expert opinions grouped by shape-similarity.