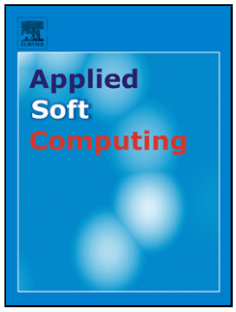

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Group decision making using distances between unbalanced linguistic assessments

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Abstract. Currently, societal and technological trends make decision-making environments more and more complex. Linguistic variables are used to enrich the assessment of decision makers. This fact leads to the computational techniques of unbalanced linguistic terms for group decision making in the literature. First, we redefine the concept of unbalanced linguistic term set. We use three vertices in a graph based on a uniformly distributed term set to represent the left, central, and right parts of an unbalanced linguistic term set. Our definition makes unbalanced linguistic terms more arbitrary compared with previous definitions. We combine the 2-tuple linguistic model to construct an approximation representation model, which pursues computational convenience and concision at the expense of accuracy. Second, we propose a distance measure between two vertices on the graph and prove its reasonability. We extend this measure to aggregate preference of unbalanced linguistic terms provided by decision makers. Finally, a numerical example is given to illustrate the feasibility and validity of the proposed model. Our methodology allows a decision maker to use diversified assessment spaces to construct his/her preference. Furthermore, by using the aggregated geodesic distance to measure the ranking of alternatives, the slight difference in assessments can be noticed and reflected in the ranking.

Keywords: Group decision making (GDM); Unbalanced linguistic term set (ULTS); Graph; Distance measure

1 Introduction

As society develops, we will see more and more uncertain information appearing in decision making. Zadeh [1] provided linguistic approach tools to model and manage such uncertainty. Zadeh [1-3] first introduced the concept of a linguistic variable as a model of words or labels that can represent vague concepts in a natural language. Several different linguistic computational models have been proposed: the linguistic computational model based on membership functions[4, 5]; the symbolic linguistic model based on ordinal scales[6]; the linguistic 2-tuple model and its extensions[7-10]; the linguistic model based on type-2 fuzzy sets representation[11-13]; the linguistic computational models based on discrete fuzzy numbers[14, 15]; and the linguistic computational model based on granular computing[16, 17].

Since determining membership functions or fuzzy sets associated with linguistic labels is difficult or impossible in some practical applications[18], symbolic models [7-10] were proposed to avoid the drawbacks. They have been widely used in Computing with Words (CWW) because of their simplicity and high interpretability. 2-tuples [7] and proportional 2-tuples[8] are two typical models. Even when membership functions are known,Vicente Riera and Torrens [15] noted that direct aggregation on fuzzy numbers may lead to information loss. Meanwhile, linguistic aggregation functions defined on membership functions require transformation and retransformation processes, which are complex. Thus, the linguistic computational models based on discrete fuzzy numbers and granular computing have attracted attention. Vicente Riera and Torrens [15] directly aggregated subjective information, which is expressed as discrete fuzzy numbers. Massanet, Riera, Torrens and Herrera-Viedma [14] proposed several aggregation operators defined on the set of all discrete fuzzy numbers. On the other hand, some studies[16, 17] have presented linguistic assessment as an information granulation to make it operational in decision-making problems. Pedrycz and Song [17] were concerned with information granulation in the problems of Analytic Hierarchy Process (AHP). Javier Cabrerizo, Herrera-Viedma and Pedrycz [16] formulated the granulation of linguistic terms as an optimization problem solved by using the particle swarm optimization.

Most of these models and their extensions are based on uniformly and symmetrically distributed linguistic term sets, which are called balanced linguistic term sets. There exist problems whose variables need to be assessed with linguistic term sets that are not uniformly and symmetrically distributed. These are called unbalanced linguistic