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Chapter 1 : Computing with Words in Decision Making | Soft Computing and Intelligent Information System

The concept of fuzziness, inspired by Zadeh (), brings us fruitful results when it is applied to problems in decision making. Recently, problems in fuzzy decision making are getting more complex, and one of the most complex facÂ- tors is dynamics in systems.

In June of , he was promoted to Full Professor with tenure. His research interests include dynamic programming, fuzzy sets, decision making and control in a fuzzy environment, and operations research with applications to socio-technical systems such as health care, water resource management and disaster control planning. He is also the Director of the Intelligent Systems and Controls Laboratory which is currently investigating a hybrid approach to intelligent control via fuzzy sets, neural networks, and reinforcement learning theories as well as its application to various large-scale, nonlinear and uncertain dynamical systems. Consultant to various agencies and organizations. In addition to his research and professional activities, Dr. Esogbue teaches courses in dynamic programming, stochastic operations research, engineering design, and neuro-fuzzy control. Pergamon Press, Oxford-Elmsford, N. Decision criteria and optimal inventory processes. The mathematics of systems and computations. Pergamon Press, Oxford, Edited by Augustine O. Sixth International Workshop of the Bellman Continuum. Dynamical aspects in fuzzy decision making, , Stud. Applied mathematics reviews, Vol. Publishing, River Edge, NJ, The computational complexity of some fuzzy dynamic programs. Fuzzy sets in decision analysis, operations research and statistics, , Handb. Fuzzy Sets and Systems 98 , no. Fuzzy sets modeling and optimization for disaster control systems planning. Fuzzy Sets and Systems 81 , no. Kacprzyk, Janusz; Esogbue, Augustine O. Liu, Baoding; Esogbue, Augustine O. Fuzzy criterion set and fuzzy criterion dynamic programming. Advances in fuzzy adaptive control. Transformation of mass function and joint mass function for evidence theory in the continuous domain. Computational aspects and applications of a branch and bound algorithm for fuzzy multistage decision processes. Computational experiments with a class of dynamic programming algorithms of higher dimensions. Combining fuzzy imprecision with probabilistic uncertainty in decision making, , Lecture Notes in Econom. Systems, , Springer, Berlin, On the best main serial chain of nonserial loop networks in dynamic programming. Application of Lagrangian relaxation to computer network control. The mathematics of systems and computations Atlanta, GA, A high level dynamic programming algorithm for processing nonserial looped systems. Mathematics, computers and systems: Optimal procedures for dynamic programs with complex loop structures. A high-level computing algorithm for diverging and converging branch nonserial dynamic programming systems. A 12 , no. Aspects of a high level algorithm for processing diverging and converging branch nonserial dynamic programming systems. Transactions of the third Army conference on applied mathematics and computing Atlanta, Ga. Fuzzy Sets and Systems 18 , no. Fuzzy dynamic programming and its extensions. Fuzzy sets and decision analysis, , Stud. Opsearch 12 , no. The imbedded state space approach to reducing dimensionality in dynamic programs of higher dimensions. Two machine flow shop scheduling problems with sequence dependent setup times:

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The problem of linguistic approximation in clinical decision making. International Journal of Approximate Reasoning, 2: Therefore, it is necessary to apply an approximation function app1. On the problem of retranslation in computing with perceptions. International Journal of General Systems, 35 6: To solve the problem we need an approximation function app1. From the example, it is clear that the use of the approximation function to solve the retranslation problem introduces some loss of information which is a critical aspect to be taken into account in decision models. In this model the aggregation is carried out directly acting over the membership functions associated to the linguistic labels using classical fuzzy arithmetic and obtaining a fuzzy set that represent the aggregated value. These approaches usually use ranking functions to order the fuzzy numbers and to obtain a final numerical evaluation K. A linguistic multicriteria analysis system combining fuzzy sets theory, ideal and anti-ideal points for location site selection. Expert Systems with Applications, 35 4: A fuzzy optimization method for multicriteria decision making: An application to reservoir flood control operation. Expert Systems with Applications, 34 1: Linguistic Computational Model Based on Type-2 Fuzzy Sets This computational model makes use of type-2 fuzzy sets to model linguistic assessments: An architecture for making judgement using computing with words. Historical reflections on perceptual computing. Type 2 representation and reasoning for cww. Fuzzy Sets and Systems, Meta-linguistic axioms as a foundation for computing with words. Information Sciences, 2: Therefore, Type-1 representation does not provide good approximation to meaning representation of words and does not allow computing with words a richer platform. Computing with words and its relationships with fuzzistics. Information Sciences, 4: We therefore need a fuzzy set model for a word that has the potential to capture its uncertainties, and an interval type-2 fuzzy set should be used as a fuzzy set model of a word. Aggregation using the linguistic weighted average and interval type-2 fuzzy sets. It can be seen as an extension of the Fuzzy Weighted Aggregation operator where both weights and attributes are words modelled by interval type-2 fuzzy sets. It is worth to note that as the previous linguistic model, this type-2 fuzzy sets based model also suffers from the retranslation problem, that is, the resulting type-2 fuzzy set from an aggregation operation must be mapped into a linguistic assessment at the end of a decision process. Linguistic Symbolic Computational Models Based on Ordinal Scales In the literature, we can find 3 different linguistic symbolic computational models which are based on ordinal scales: A linguistic symbolic computational model based on ordinal scales and max-min operators A linguistic symbolic computational model based on indexes and A linguistic symbolic computational model based on continuous term sets. Linguistic symbolic computational model based on ordinal scales and max-min operators R. A new methodology for ordinal multiobjective decisions based on fuzzy sets. Decision Sciences, 12 4: To be able to aggregate information expressed as linguistic labels in that ordered linguistic scale the classical operators Max, Min and Neg are used, where: Non-numeric multi-criteria multi-person decision making. Group Decision and Negotiation, 2 1: Aggregation of ordinal information. Fuzzy Optimization and Decision Making, 6 3: The multiple judge, multiple criteria ranking problem: A fuzzy set approach. Fuzzy Sets and Systems, 13 1: Linguistic symbolic computational model based on convex combination M. On aggregation operations of linguistic labels. International Journal of Intelligent Systems, 8 3: Note that this model usually assumes that the cardinality of the linguistic term set is odd and that linguistic labels are symmetrically placed around a middle term. From the example we can conclude that this model for linguistic aggregation also suffers from loss of information. Herrera-Viedma , and J. Direct approach processes in group decision making using linguistic owa operators. Aggregation operators for linguistic weighted information. Systems and Humans, 27 5: A linguistic aggregation of majority additive operator. International Journal of Intelligent Systems, 18 7: Evaluating the information quality of web sites: A methodology based on fuzzy computing with words. Linguistic symbolic computational model based on virtual linguistic terms Z. A method based on linguistic aggregation operators for group decision making with linguistic preference relations. Information Sciences, With this extension we can preserve all given information in the problem thus avoiding one of the biggest problems for the classical linguistic symbolic computational models. It is important to note that this symbolic computational model uses a term set that changes during the decision process as new virtual terms are created in the aggregation processes. In addition, this model allows the use of arithmetic operators and the multiplication between a label and a real number which could lead to virtual terms being in a quite different range than the original ones. These facts limit the interpretability of the decision models that implement this computational model. Therefore, this model also presents a retranslation problem if the results of the operations are virtual linguistic terms and they will usually be virtual ones and the final results must be expressed in the original linguistic term set. However, as the linguistic symbolic computational model based on linguistic terms is simple, as it avoids loss of information and as virtual linguistic terms can be used to rank alternatives and thus, to select the best of them, its use can be convenient in particular situations. Several different operators have been defined in order to aggregate linguistic information using this model. For example, some extensions to the classical families of ordered weighted averaging and geometric operators have been presented in Z. Eowa and eowg operators for aggregating linguistic labels based on linguistic preference relations. Induced uncertain linguistic owa operators applied to group decision making. Information Fusion, 7 2: A 2-tuple fuzzy linguistic representation model for computing with words. The linguistic computational model based on linguistic 2-tuples carries out processes of CW easily and without loss of information. The linguistic domain can be treated as continuous, whilst in the classical models it is treated as discrete. The results of processes of CW are always expressed in the initial linguistic domain extended to a pair of values that include the label and additional information. In addition, the model defines a set of transformation functions between numeric values and linguistic 2-tuples: In addition we have: In the next figure we can see an example of a 2-tuple linguistic label that express the equivalent information of the result of a symbolic aggregation operation: Even being a quite recent model, the 2-tuple model has received a quite good acceptation in the specialized literature and some extensions to the 2-tuple linguistic model have been developed in which the underlying definitions of linguistic labels and linguistic variables are taken into account in the process of aggregating linguistic information by assigning canonical characteristic values of the corresponding linguistic labels J. A new version of 2-tuple fuzzy linguistic representation model for computing with words. An approach to computing with words based on canonical characteristic values of linguistic labels. A linguistic-valued weighted aggregation operator to multiple attribute group decision making with quantative and qualitative information. International Journal of Computational Intelligence Systems, 1 3: A linguistic approach to decisionmaking with fuzzy sets. They used the linguistic computational model presented in the previous section in which the computations are carried out directly acting over the membership functions associated to the linguistic labels. Another seminal paper in which CW is applied to multiobjective decision making was written by Yager, The values to be used for the evaluation of the ratings and importances will be drawn from a linguistic scale which makes it easier for the evaluator to provide the information. In fact, Yager uses the linguistic symbolic model based on ordinal scales and max-min operators presented in the previous section to solve multiobjective decision problems where not only the information about each alternative is given using linguistic terms but also where the importance of each objective is evaluated linguistically. It was later revisited and extended in R. Buckey also studied decision making problems in a linguistic context in which the best alternative from a feasible set has to be selected by an analyst according the the opinions of several judges which supply information about the alternatives for a set of different criteria: Buckley states several reasons for using the ordinal scale instead of other exact, ratio or interval scales, e. To resolve these problems the author discusses the three main issues that have to be faced to obtain the final ranking of the alternatives: In this work the linguistic symbolic computational model based on ordinal scales and max-min operators presented in the previous section is used with some variations of the median, max and min operators to aggregate the linguistic information. Finally, two short contributions published in dealt with multicriteria optimization problems and selection of models. Automatic Control and Computer Sciences, 19 6: In particular they use different linguistic term sets to evaluate the degree to which a decision maker is satisfied with a particular solution and to control the rate of change between different criteria. Both works use a linguistic computational model based on membership functions. Recent Applications of CW in Decision Making In this section we present some of the recent applications published in the specialized literature in and based on a CW approach: Resource management and transfer Papers Sustainable energy management H. Multi-criteria decision aid for the formulation of sustainable technological energy priorities using linguistic variables. European Journal of Operational Research 2 doi: Expert Systems with Applications 34 1 doi:

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