The Software Support for Multiple-Criteria Evaluation – Various Types of Partial Evaluations Aggregation

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Abstract

This paper presents the software product FuzzME that was developed as a tool for creating fuzzy models of multiple-criteria evaluation and decision making. The partial evaluations with respect to criteria express the (fuzzy) degrees of fulfillment of corresponding goals. FuzzME allows the utilization of several aggregation methods – fuzzy weighted average, fuzzy OWA operator, fuzzified WOWA operator, fuzzified discrete Choquet integral, and fuzzy expert system. In this paper, all these methods will be described and the conditions for their use will be studied. The paper also describes an example from area of banking. In this example, it is shown how different types of criteria interactions can be modeled by the FuzzME.

Keywords: Multiple-Criteria Evaluation, Fuzzy Methods, Criteria Interactions, Software.

1. Introduction

The software product FuzzME was developed as a tool for creating fuzzy models of multiple-criteria evaluation and decision making. The type of evaluation employed in the fuzzy models fully agrees with the paradigm of the fuzzy set theory; the evaluations express the (fuzzy) degrees of fulfillment of corresponding goals (Bellman and Zadeh, 1970; Talašová, 2003).

2. Linguistic fuzzy modelling applied in FuzzME

The software makes it possible to work with expertly set data and knowledge. The evaluations of alternatives with respect to qualitative criteria may be set verbally. Expert estimations of quantitative criteria values can be handled. As an important feature, this software allows for modelling uncertain expertly set weights of criteria (Pavlačka and Talašová, 2007). Rather complex evaluating functions may be set verbally by means of fuzzy rule bases. The FuzzME software takes the fullest advantage of linguistic fuzzy modelling.

3. Structure of evaluation models, various modes of aggregation of partial evaluations

In FuzzME, a goals tree is the basic structure of evaluation (Talašová, 2003). Within the goals tree, the aggregation of partial fuzzy evaluations is done either by one of fuzzified aggregation
operators or by a fuzzy expert system. The choice of the appropriate mode of aggregation depends on the relationships among evaluation criteria.

In case of independent evaluation criteria, the evaluator can choose from three types of aggregation operators – fuzzy weighted average (FuzzyWA, see Pavlačka and Talašová, 2007), ordered fuzzy weighted average (FuzzyOWA, see Talašová and Bebčáková, 2008), and fuzzified WOWA operator (Yager, 1988). The latter operator uses two sets of weights: the first set is connected to individual criteria; the second one is related to the decreasing order of partial evaluations (Torra and Narukawa, 2007). In case of independent criteria, the expert can use any of those three aggregation operators in FuzzME, according to the problem to be solved.

If relationships of redundancy or complementarity are present among criteria, a fuzzified discrete Choquet integral is used for aggregating partial evaluations in FuzzME (Bebčáková et al., 2010). In this case, the weights of the sets of partial goals are defined by a fuzzified fuzzy measure. The fuzzy measure itself generalizes a classical measure, with additivity being replaced by monotonicity; in case of the fuzzified fuzzy measure, the values of the fuzzy measure are modelled by fuzzy numbers. The Choquet integral cannot be used for all types of interactions among criteria; the interactions are required to have global character, i.e. to be valid within the whole domain of criteria. If the interactions among criteria differ with respect to particular values of criteria, the aggregation must be performed as described below.

The FuzzME software offers aggregation for all cases. Generally, it holds that any continuous (even any Borel-measurable) function can be approximated with arbitrary accuracy by a fuzzy rule base and a suitable inference algorithm (e.g. Kosko, 1993). For that reason a fuzzy expert system with several approximate reasoning algorithms (Mamdani, Sugeno) was implemented in the FuzzME, which makes it possible to utilize expert knowledge for modelling complex evaluation functions. Some new inference algorithms (Sugeno-WA, Sugeno-WOWA) were also included in this software.

![FuzzME interface](image)

4. Application in banking
The software was tested on a company credibility-rating problem. The problem was solved with cooperation of the Technical University in Vienna and one of the Austrian banks.
At that time, two different rating systems were used for the company evaluation in the bank – the quick test of Kralicek and the POD (Probability of Default) rating system (Fürst, 2010). The quick test of Kralicek is solely hard-fact rating test. Various ratios are calculated by the test. These ratios give a good overview of the company’s financial situation and rigidity. The POD rating system of the bank works with self-organizing maps and neural networks. Fuzzy expert systems are applied to calculate the company's probability of default. The POD rating system works mainly with hard-fact data, but it also allows taking in account soft-fact (qualitative) data. Because there is usually a lot of uncertainty in such data, the fuzzy approach was tested. For this testing, suitable software was necessary. The FuzzME turned out to be the perfect software for this problem.

The company evaluation in FuzzME was based on a questionnaire with 27 qualitative criteria. They were grouped into 10 categories. The partial evaluations were aggregated with the fuzzy weighted average method on the both levels – first to calculate partial evaluations of the categories and then to obtain the final evaluation. Two alternative models were compared. In the first one, crisp weights were used whereas fuzzy weights were employed in the later one. As a result of this aggregation, average rating of the company was obtained.

The advantage of the fuzzy weights is that the dispersion of the partial evaluations is reflected into uncertainty of the final evaluation. Let us consider a company that is fully satisfying according to the half of the criteria and fully unsatisfying according to the rest of criteria. Let us consider another company that is average according to all the criteria. The weighted average with crisp weights would give the same evaluation for both of the companies. The fuzzy weighted average (which uses fuzzy weights) does not have this significant disadvantage. The evaluations of both the companies would be expressed by fuzzy numbers with the same centers of gravity. The evaluation of the first one would be, however, much more uncertain.

The subsequent discussion showed that the average rating does not describe the risk rate of the companies sufficiently. The criteria used for the evaluation are not independent - there exist combinations of the criteria values which signalize a substantial danger of the default. The companies with these combinations of criteria values should be rejected by the bank, no matter how good they are according to the rest of criteria, because the risk that they will go bankrupt is very high. That is why besides the evaluation based on the fuzzy weighted average (average rating), another evaluation (risk rate) was calculated. A fuzzy expert system was applied to compute the risk rate. Ten dangerous combinations of the criteria values were identified. For each of them, a corresponding rule was added to the rule base. The solely use of the original fuzzy model (based on fuzzy weighted average) without the fuzzy expert system would have lead to a rating score, which may have underestimated the risk inherent to this company.

Finally, the average rating and the risk rate were integrated into a single model. For the aggregation, the fuzzy MINIMAX method was applied. The fuzzy MINIMAX operator is a special case of the fuzzy OWA operator. The resulting evaluation calculated this way is the infimum of the fuzzy numbers representing the partial evaluations.
After the model was created, we proceeded to the evaluation of the companies. The list of companies together with their criteria values was imported from Excel to the FuzzME. The overall evaluations of the companies were calculated and the results were analyzed. In this test, a relatively small sample was used – 62 companies. The results were studied and the alternative models were compared in detail in (Fürst, 2010). The author of that paper concludes that in this case the use of the fuzzy models is a step in the right direction.

5. Conclusion

The FuzzME is the result of many years of research in the area of the theory and methods of multiple-criteria fuzzy evaluation. The new theoretical approach to multiple-criteria fuzzy evaluation, new fuzzy methods, and new algorithms were implemented in the software. In the paper, an example from the area of banking was described. In this example, the FuzzME was applied to a real problem and tested on real data.

6. References


