Using Principal component analysis to resolve interactive criteria decision making problems

Olfa Meddeb*and Fouad Ben Abdelaziz†

The basic data of a multi-criteria decision making (MCDM) problem are: a set of m alternatives, a set of n conflicting criteria, and criterion outcomes of each alternative.

The aim of MCDM is to help the decision-maker (DM) in the process of making the choice between alternatives. For this purpose, different aggregation procedures can be applied, including the preferences of the DM like criterion importance and priorities (see e.g. [4]). In fact, the choice of the aggregation procedure depends on the nature of available information and the behavior of DM.

For example, when the additivity and independence assumptions are not verified, Sugeno and Choquet integrals can be applied for the ordinal and the cardinal framework respectively (e.g. [4]). In such models, the interaction among criteria can be modeled by considering a weight of each group of the criteria. The function assigning a weight of each subset of the criteria is known as a fuzzy measure or capacity. A review on modeling interactions among criteria in MCDM methods can found in [3]. However, the main difficulty in the practical use of fuzzy measures, is the necessity of defining 2^n coefficients for the n criteria problem.

This paper avoids the problem of fuzzy measure identification when dealing with interactive criteria by utilizing the method of principal component analysis (PCA). PCA is a technique for the compression and classification of data in factor analysis [2]. It is applied for quantitative data where a set of statistical individuals is assigned to a set of observation vectors according to a set of correlated variables. The process consists in reducing the dimensionality of the data set by finding a new set of variables, smaller than the original

*Faculty of Economics and Management of Nabeul, University of Carthage, Compus Universitaire Mrezga, Route Hammamet, 8000, Nabeul.

†NEOMA Business school, Rouen Campus, 1 Rue Marechal Juin, Mont Saint Aignan, 76825 France. Email: Fouad.ben.abdelaziz@neama-bs.fr

set of variables. An orthogonal transformation is used to convert a set of observations of original variables into a set of values of uncorrelated variables called principal components. This transformation is defined in such a way that the largest possible variance is assigned to the first principal component. Each succeeding component has the highest variance possible under the constraint that it is orthogonal to the preceding components. To the best of our knowledge, PCA is connected to MCDM problems with interactive criteria in a few number of papers (e.g. [1]).

In this paper, the basic ideas can be intuitively introduced as follows:

- The alternatives and the criteria can be viewed as statistical individuals and variables respectively.
- The interaction among the criteria is the principal cause of the correlation of the observed values of individuals.
- The determination of fuzzy measure coefficients is not necessary if the criteria are transformed in non interactive ones or an ideal alternative having the maximum value on each criteria, exists.
- The best alternative is the one that looks the most like the ideal alternative.

Based on the above ideas, this paper proposes a decision-aid method to select the best alternative using PCA. First, an ideal alternative is added to the basic data of the problem. Second, the method of PCA is adopted by considering the ideal alternative as an illustrative individual. Finally, the best decision is the alternative with the shortest distance to the ideal alternative in the graphs of the individuals. To conclude, the method is illustrated by an example via R package language.

Keywords:
Multi-Criteria Decision Analysis, Decision Support Systems.

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