

Chapter 17

Extension of the TOPSIS for Multi-Attribute Group Decision Making under Atanassov IFS Environments

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ABSTRACT

This paper extends the technique for order preference by similarity to ideal solution (TOPSIS) for solving multi-attribute group decision making (MAGDM) problems under Atanassov intuitionistic fuzzy set (IFS) environments. In this methodology, weights of attributes and ratings of alternatives on attributes are extracted from fuzziness inherent in decision data and making process and described using Atanassov IFSs. An Euclidean distance measure is developed to calculate the differences between alternatives for each decision maker and an Atanassov IFS positive ideal solution (IFSPIS) as well as an Atanassov IFS negative ideal-solution (IFSNIS). Degrees of relative closeness to the Atanassov IFSPIS for all alternatives with respect to each decision maker in the group are calculated. Then all decision makers in the group may be regarded as “attributes” and a corresponding classical MADM problem is generated and hereby solved by the TOPSIS. The proposed methodology is validated and compared with other similar methods. A numerical example is examined to demonstrate the implementation process of the methodology proposed in this paper.

INTRODUCTION

Multi-attribute group decision making (MAGDM) problems are of importance in most kinds of fields such as engineering, economics and management. It is obvious that much knowledge in the real

world is fuzzy rather than precise. Imprecision comes from a variety of sources such as unquantifiable information (Chen & Hwang, 1992; Triantaphyllou & Lin, 1996; Chen, 2000; Chu, 2002a, 2002b; Braglia et al., 2003; Chu & Lin, 2003; Li, 2003; Chen & Tzeng, 2004; Zhao et al., 2006).

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In many situations decision makers have imprecise/vague information about alternatives with respect to attributes. One of the methods which describe imprecise cases is the fuzzy set (FS) introduced by Zadeh (1965). The main characteristic of an FS \tilde{A} is that a membership degree $\mu_{\tilde{A}}(u) \in [0, 1]$ is assigned to each element u in a universe of discourse and a non-membership degree automatically is equal to $1 - \mu_{\tilde{A}}(u)$, i.e., this membership degree combines the evidence for u and the evidence against u . However, a human being who expresses the degree of membership of a given element in an FS very often does not express the corresponding degree of non-membership as the complement to 1. This reflects a well-known psychological fact that the linguistic negation is not always identified with the logical negation. Thus in 1983 Atanassov (1986, 1999) introduced the concept of an intuitionistic fuzzy set (IFS), which is called the Atanassov IFS for short in this paper. The Atanassov IFS is characterized by two functions expressing the degree of belongingness and the degree of non-belongingness, respectively. This idea is useful in decision making processes. Especially, the Atanassov IFS may give us a very natural tool for modeling preferences. Sometimes it seems to be more natural to describe imprecise and uncertain opinions not only by membership functions due to the fact that in some situations it is easier to describe our negative feeling than positive attitude. Even more, quite often one can easily specify alternatives (or objects) one dislikes, but simultaneously cannot specify clearly what are really wanted. Let us consider a situation observed in a real estate agency. Very often an interested customer looking for an apartment is not completely convinced on the location and considers several variants. It is obvious that some districts are more preferable than others whereas there are some districts that the customer dislikes. It seems to be much suitable for modeling such situations using the Atanassov IFSs. For example, it may happen

that the customer asked about his/her favorite district in Warsaw cannot definitely determine whether it is Ochota, Mokotów or Żoliborz, but he/she feels sure that he/she hates Wola. Thus the preferences of the customer may be modeled using the Atanassov IFS, where the membership function expresses the degree of a given district being preferred by the customer while the non-membership function indicates the degree of the given district which is not preferred (Grzegorzewski & Mrówka, 2005). People maybe meet a similar situation when comparing preferences expressed by means of orderings which admit uncertainty due to imprecision, vagueness and hesitance. In this case the Atanassov IFS may give us a natural tool for modeling such improper orderings (Grzegorzewski & Mrówka, 2005; Deschrijver & Kerre, 2007).

Obviously, the Atanassov IFS is a natural generalization of the FS. Gau and Buehrer (1993) introduced the concept of a vague set characterized by a truth-membership function and a false-membership function. But Bustince and Burillo (1996) showed that the vague set is the Atanassov IFS. Over the last decades, Atanassov's IFS has been applied to many different fields such as decision making (Chen & Tan, 1994; Szmidt & Kacprzyk, 2002, 2004; Gabriella et al., 2004; Atanassov et al., 2005; Herrera et al., 2005; Li, 2005, 2010a, 2010b; Pankowska & Wygralak, 2006; Lin et al., 2007; Liu & Wang, 2007; Li et al., 2010; Xu, 2007) and logic programming (Atanassov & Georgiev, 1993) as well as pattern recognition (Li & Cheng, 2002; Mitchell, 2005). Chen and Tan (1994) presented a technique for handling multi-criteria fuzzy decision making problems based on vague sets. They provided a score function to measure the degree of suitability of each alternative with respect to a set of criteria presented by vague values. Lin et al. (2007) and Liu and Wang (2007) discussed similar decision making problems using the Atanassov IFSs. Szmidt and Kacprzyk (2002, 2004) considered the use of the Atanassov IFSs for building soft decision making models with

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