Expert Systems with Applications 39 (2012) 3037–3047

Contents lists available at SciVerse ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

A fuzzy decision support system for digital camera selection based on user preferences

S. Emre Alptekin *

Galatasaray University, Department of Industrial Engineering, Çırağan Cad. No. 36, Ortaköy 34357, Istanbul, Turkey

ARTICLE INFO

Keywords:
Fuzzy analytic hierarchy process (FAHP)
Fuzzy compromise programming
Multi criteria decision making
Decision support tool
User preferences

ABSTRACT

Mobile phones have been the most rapidly spreading development in the field of communication and information technologies over the past decades. Nowadays, digital cameras have taken their place. The wide product range in the market, each with numerous heterogeneous technical attributes, complicates the selection of the most convenient camera for end-users. The aim of this work is to provide end-users with a decision support framework for selecting the best digital camera according to their preferences. End-users and photography experts use subjective assessments when determining their requirements and making their evaluations. The proposed decision support tool is built on the basis of fuzzy set theory. The imprecision of the subjective assessments are transformed to fuzzy triangular numbers. The fuzzy analytic hierarchy process (FAHP) and fuzzy compromise programming methodologies are applied in order to determine the relative weights of sub-criteria and criteria and to rank the digital camera alternatives, respectively.

1. Introduction

Digital photography has taken the world by storm in recent years. Everyone, even children, knows how to operate these technologically advanced cameras. From cell phone cameras to the more advanced models with professional options, the world of photography has leaped off the small screen into the gigantic world of possibilities. Each alternative is able to provide a different level of satisfaction for every objective. Therefore, an end-user needs some assistance in order to choose the most satisfying option. Multiple criteria decision making includes a body of methods to support a decision in such an environment. Fuzzy multiple criteria decision making methods are built to find better ways for handling risk and uncertainty.

In this paper, we aim at establishing a decision support system in the highly competitive digital camera market for selecting the best camera. As the end-users use digital cameras for different occasions and with different goals, the best camera for each user differs. Hence, we have first differentiated the end-users into three groups: dabblers, students, and news, sports and action photographers. These three groups were the most convenient ones for our interviewers, however it is possible to determine more groups, especially more groups for professional photographers. Then, we have determined the most convenient criteria and their sub-criteria in order to differentiate the digital camera alternatives in the market. The fuzzy analytic hierarchy process and fuzzy compromise programming techniques enable us to find the priority weights of these criteria and sub-criteria and then to rank the decision alternatives. We have chosen the 'technique for order preference by similarity to ideal solution' (TOPSIS) methodology, which is one of the most common multi criteria decision making methodologies, as the benchmark model. TOPSIS defines an index called 'similarity to the ideal solution' and the remoteness from the anti-ideal solution. Then, the method chooses an alternative with the maximum similarity to the ideal solution (Hwang & Yoon, 1981). We have compared the rankings obtained with the proposed framework and the ones obtained with fuzzy TOPSIS methodology.

The remainder of the paper is organized as follows: Section 2 summarizes related research. Section 3 presents the mathematical background and the theoretical background of the methodologies. In the next section, we have presented the elements of the hierarchy of our proposed framework with the decision alternatives, criteria, sub-criteria and the user profiles. In Section 5, we give the main lines and the process flow of our proposed decision support framework. Section 6 is the application part where we present all the results. The paper is concluded in Section 7.

2. Related work

The AHP methodology was first introduced by Thomas L. Saaty in the 1970s and afterward it gained wide acceptance among researchers and practitioners (Saaty, 1980). The AHP method is

* Tel.: +90 212 227 4480; fax: +90 212 259 5557.
E-mail address: ealptekin@gsu.edu.tr

0957-4174/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2011.08.166

accepted as a suitable tool to be used in selection problems as it has the ability to simultaneously take into account numerous heterogeneous criteria. Işıklar and Büyüközkan (2007) have proposed a framework which is based on the AHP and TOPSIS methodologies in order to evaluate mobile phone options. Duran and Aguilo (2008) have proposed an AHP based on a fuzzy numbers multi-attribute method for the evaluation and justification of an advanced manufacturing system. Wang and Yang (2009) have used the AHP method and fuzzy compromise programming for supplier selection. At the same time, their selection model allocates order quantities among suppliers with their quantity discount rates. Naghadehi, Mikaeil, and Ataei (2009) have used a fuzzy model to select the optimum mining method by using effective and major criteria and at the same time taking subjective judgments of decision makers into consideration. Their approach is based on the combination of a fuzzy AHP method with an advanced type of AHP. İç and Yurdakul (2009) have used fuzzy AHP and fuzzy TOPSIS to propose a decision support system to help decision makers in their machining center selection decisions. Kahraman and Kaya (2010) have used a fuzzy AHP-based methodology for the selection among energy policies and they have determined the best energy policy for Turkey. Lin, Chen, and Tzeng (2010) have combined AHP and fuzzy integral method with multi criteria decision making techniques to construct a value-created evaluation model for planning new era mobile phones. Önüt, Efendigil, and Kara (2010) have modeled shopping center site selection problem with a number of conflicting qualitative and quantitative criteria for real world application in Istanbul. They have used a fuzzy AHP for assigning weights to the criteria for site selection and fuzzy TOPSIS for determining the most suitable alternative using these criteria weights.

Bardossy, Bogardi, and Duckstein (1985) contributed to the compromise programming framework by incorporating a multi-level hierarchical structure in the objectives. This new implementation, also known as 'composite programming', allows the decision maker to use different metrics of distance (p values) individually for groups of objectives. Bardossy and Duckstein (1992) further extended compromise programming to deal with the vagueness, fuzziness inherited in information, developing *fuzzy composite programming*. Some recent applications of compromise programming include: Merino, Jones, Clements, and Miller (2003) solved a multiobjective decision-making problem of assessing six management alternatives for the karstic aquifer management problem just indicating a preference order in objectives followed by the application of fuzzy composite programming. Ehrgott and Podehl (2003) used the compromise programming approach to find ideal and anti-ideal solutions for multicriteria optimization problems. Wu and Chang (2004) developed an optimal production planning strategy with varying environmental costs. Terol, Gladish, Parra, and Uria (2006) have used fuzzy compromise programming in order to solve the portfolio selection problem. For this task, they have introduced the fuzzy ideal solution concept based on soft preference and indifference relationships and on the canonical representation of fuzzy numbers by means of their α-cuts. In one of our recent works, we used the compromise programming as one of the methodologies of an integrated framework for the selection of third-party logistics outsourcing (Işıklar, Alptekin, & Büyüközkan, 2007). Allouche, Aouni, Martel, Loukil, and Rebai (2009) have proposed an aggregation procedure that integrates three different criteria to find the best sequence in a flow shop production environment. Abdelaziz and Masri (2010) have proposed a compromise programming approach together with the chance constrained approach to transform the multiobjective stochastic linear partial information on probability distribution.

3. Mathematical background

3.1. Fuzzy sets, triangular fuzzy numbers and linguistic terms

The subjective and ambiguous information obtained during the evaluation of criteria by different user profiles and digital cameras are to be given great care. Thus, we have implemented fuzzy set theory, first proposed by Zadeh (1965), to deal with the vagueness of human thought. The major contribution of fuzzy set theory is its capability of representing vague data. In this work, we used a 9-point scale represented by triangular fuzzy numbers, as suggested by Saaty (1988). A triangular fuzzy number $\tilde{A}$ can be defined using the elements (a, b, c) (Fig. 1). A fuzzy set is characterized by a membership function, which assigns to each object a grade of membership ranging between zero and one. Such a membership function is represented as:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < a, \\ \frac{x-a}{b-a} & a \leqslant x \leqslant b, \\ \frac{c-x}{c-b} & b \leqslant x \leqslant c, \\ 1, & x > c. \end{cases} \tag{1}$$

The 9-point scale consists of a 5-point sub-scale $\tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}$ (Table 1). During the competitive analysis, the 5-point scale values correspond to *very poor*, *poor*, *neutral*, *good*, and *very good*. On the other hand, the fuzzy numbers used in the AHP process primarily represent the relative importance of one criterion over another. These values are labeled as *equally important*, *moderately more important*, *strongly more important*, *very strongly important* and *extremely more important,* respectively.

The membership function representation of the 9-point scale is shown in Fig. 2.

3.2. Fuzzy AHP methodology

Fuzzy AHP methodology extends conventional AHP by combining it with fuzzy set theory. In this methodology, all elements in the decision matrix and weight vectors are represented by

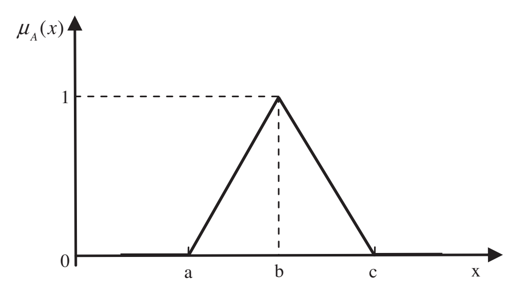

Fig. 1. The triangular fuzzy number *A*.

Table 1
Membership functions of the fuzzy numbers.

Fuzzy Number	Membership function	Meaning in pairwise comparisons	Meaning in performance evaluations
$\tilde{1}$	(0,1,2)	Equally important	Very poor
$\tilde{3}$	(2, 3, 4)	Moderately more important	Poor
$\tilde{5}$	(4, 5, 6)	Strongly more important	Neutral
$\tilde{7}$	(6,1, 8)	Very strongly more important	Good
$\tilde{9}$	(8, 9, 9)	Extremely more important	Very good