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A fuzzy group-preferences analysis method for new-product development

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Abstract

This paper reports a new idea-screening method for new product development (NPD) with a group of decision makers having imprecise, inconsistent and uncertain preferences. The traditional NPD analysis method determines the solution using the membership function of fuzzy sets which cannot treat negative evidence. The advantage of vague sets, with the capability of representing negative evidence, is that they support the decision makers with the ability of modeling uncertain opinions. In this paper, we present a new method for new-product screening in the NPD process by relaxing a number of assumptions so that imprecise, inconsistent and uncertain ratings can be considered. In addition, a new similarity measure for vague sets is introduced to produce a ratings aggregation for a group of decision makers. Numerical illustrations show that the proposed model can outperform conventional fuzzy methods. It is able to provide decision makers (DMs) with consistent information and to model situations where vague and ill-defined information exist in the decision process.

Keywords: New product development; Idea screening; Vague sets; Similarity measure; Group decision making

1. Introduction

New-product development is one of the most critical tasks in the business process. Every company develops new products to increase sales, profits, and competitiveness; however NPD is a complex process and is linked to substantial risks. The objective of NPD is to search for possible products for the target markets. In Copper (1998), the process for NPD is divided into eight phases as follows: (1) idea generation phase; (2) idea screening phase; (3) concept development and testing phase; (4) marketing strategy development phase (5) business analysis phase (6) product development phase; (7) market testing phase; (8) commercialization phase. In the NPD process, decision makers have to screen new-product ideas according to a number of criteria. Subsequently, they recommend the ideas to R&D engineers, marketers, and sales managers in every stage of development. Idea screening is a concept-level evaluation process that begins when the collection of new product ideas is complete. It uses technical, commercial, and financial information to weed out impractical ideas, so that only appropriate ideas can be selected into development and testing (Hart & Hultink, 2002). Idea screening can avoid both the ‘drop-error’ and the ‘go-error’. The former occurs when the company dismisses a viable idea; the latter takes place when the company permits an inferior idea to move into product development and market testing. A wrong decision in idea screening will lose resources, time to market, business opportunity etc. Hence idea screening is perhaps the most critical phase in NPD process. During the idea screening process, the decision makers’ preferences have a significant impact on the selection of new products and the result of the decision making. The method of obtaining the group preference of the decision makers on each new-product in a committee is an important issue which causes many difficulties. In most cases, NPD is risky

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due to the lack of sufficient information about imprecise, inconsistent and uncertain customer preferences. Recent studies (Kim & Kim, 1991; Kotler, 2003) report the failure rate of new consumer products at 95% in the United States and 90% in Europe. The failures lead to substantial monetary and non-monetary losses. For example, Ford lost $250 million on its Edsel; RCA lost $500 million on its videodisk player etc. There are many reasons for the failure of a new product. Some of the important factors in high technology NPD can be summarized as follows:

(1) In an idea-screening phase, it is impossible to acquire precise and consistent information regarding customers' preferences, but it is possible to obtain imprecise, inconsistent and uncertain information.
(2) In a concept development and testing phase, the criteria for new-product screening are not always quantifiable or comparable.
(3) In a product development phase, the choice of enabling technologies for developing new products is a challenging issue as the technologies evolve rapidly. In addition, it is often the case that development costs are higher than expected.
(4) In a commercialization phase, participating competitors will use a variety of means to contend.

This research sets out to provide more human-consistency by including the assumptions (i.e., "I am not sure") often prohibited by other existing approaches (Kao & Liu, 1999; Kessler & Chakrabarti, 1997; Lin & Chen, 2004). In this paper, we propose a new method, which extends the traditional NPD methods to the early product development and evaluation, uses the similarity measures of vague sets (Gau & Buehrer, 1993; Hong & Kim, 1999; Li & Cheng, 2002) to aggregate the ratings of all decision makers including the negative evidence. It supports decisions on the priority among alternatives through the use of a fuzzy synthetic evaluation method (Chen & Hwang, 1992) for phase.

The rest of the paper is structured as follows. Section 2 reviews important NPD literature. Section 3 introduces basic concepts and definitions in vague sets and their operations. Section 4 formulates the problem of new-product screening and describes the proposed algorithms and associated methods. Proofs for four resulting properties from the proposed algorithms are also included. In Section 5, an example of evaluating new ideas is shown, to illustrate the proposed method. Section 6 compares the outcomes with other approaches. Section 7 offers the conclusion on this work.

2. Literature review

Many methods (Calantone, Benedetto, & Schmidt, 1999; Copper, 1981, 1993, 1998; Copper & Kleinschmidit, 1986; Kessler & Chakrabarti, 1997; Lin & Chen, 2004) and tools (Henriksen & Traynor, 1999; Rangaswamy & Lilien, 1997) are used to control NPD process in an attempt to assist product managers in making better screening decisions. For example, 3M, Hewlett-Packard, Lego, and other companies use the stage-gate system to manage the innovation process (Kotler, 2003). Rangaswamy and Lilien (1997) comprehensively classified these methods into three main classes: (1) factor-weighting techniques (Kao & Liu, 1999); (2) eigenvector method, e.g., analytic hierarchy process (AHP) for NPD (Calantone et al., 1999); (3) screening regression methods. The factor-weighting method decides the importance of critical successful factors (CSF) of NPD using the weighted distance function (Kao & Liu, 1999). The AHP method (Satty, 1980) determines the weights of CSF of NPD by solving for the eigenvalues of a rating matrix (Liberatore, 1987; Calantone et al., 1999; Zimmermann & Zysno, 1983). Screening regression methods use a set of variables to analyze the importance weight of factors and to predict the success or failure of a NPD project using regression and statistics techniques (Copper, 1993). Other well-known techniques for NPD include beta-testing, conjoint analysis, quality function deployment (QFD), break-even analysis (Hart & Hultink, 2002).

However, the traditional technique (Calantone et al., 1999; Copper, 1981; Hart & Hultink, 2002; Kao & Liu, 1999; Kessler & Chakrabarti, 1997; Liberatore, 1987; Satty, 1980) is likely to use quantitative methods, such as optimal techniques, mathematical programming, AHP, and multiple regression models etc., which can only be applied to the case of performance evaluation of the product development phase when the required data are in numeric format.

Since the early phase of new-product screening most often operates in an uncertain situation with incomplete information, it must involve the judgements of decision makers. The expression of human judgment often lacks precision and the confidence levels on the judgment contribute to various degrees of uncertainty. A human-consistent approach is likely to adopt imprecise linguistic terms instead of numerical values in the expression of preference. The issue is compounded when a decision-making process involves a group of decision-makers who have inconsistent preferences.

In the next section, we use vague sets to represent the imprecise linguistic ratings of the group, and define three similarity measures based on mean value of vague sets. These allow the accumulation of the ratings of all the decision makers in order to make an appropriate decision on the priority among alternatives.

3. Preliminary description of vague set theory

The vague set (VS), which is a generalization of the concept of a fuzzy set, has been introduced by Gau and Buehrer (1993) as follows:

A vague set $A'(x)$ in X, $X = \{x_1, x_2, \ldots, x_n\}$, is characterized by a truth-membership function, t_A, and a false-membership function, f_A, for the elements $x_k \in X$ to $A'(x) \in X$, $(k = 1, 2, \ldots, n)$; $t_A : X \to [0,1]$ and $f_A : X \to [0,1]$, where the functions $t_A(x_k)$ and $f_A(x_k)$ are constrained by the