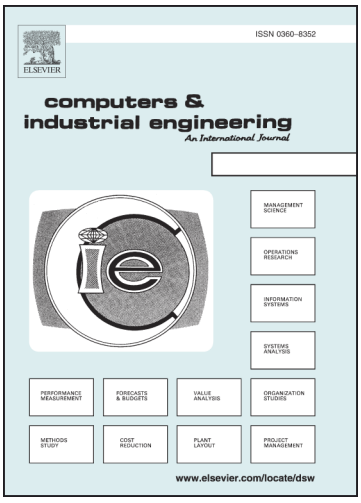

New evidential reasoning rule with both weight and reliability for evidence combination

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New evidential reasoning rule with both weight and reliability for evidence combination

Abstract

Two aspects of problems such as weight over-bounding and reliability-dependence cannot be well solved in the evidential reasoning (ER) approach with both weight and reliability. In order to solve the above problems, the characteristics of the weight and the reliability are investigated and summarized, i.e., the reliability of evidence is objective and absolute to reflect information quality, while the weight of evidence is subjective and relative to reflect information importance. Then a new discounting method is defined to generate the probability masses for the evidence by assigning the residual support of weight to the empty set and that of reliability to the power set. A new ER rule is established for recursively combining the evidence with both reliability and weight by the orthogonal sum operation and a series of theorems and corollaries are introduced and proved. Finally numerical comparison and illustrative example are provided to demonstrate the performances and the applicabilities of the proposed rule and algorithm.

Keywords: Evidential reasoning, Evidence combination rule, Evidence discounting, Evidence weight, Evidence reliability

1. Introduction

The evidential reasoning (ER) approach is a general approach for analyzing multiple criteria decision making (MCDM) problems under uncertainties (Yang and Singh (1994)). In the ER approach, the belief structure and the belief decision matrix are introduced to model uncertainties of various types of nature, and a generic conjunctive probabilistic reasoning process satisfying a generalized bayesian inference process is established to combine multiple pieces of evidence generated from criteria or experts. The ER approach has been widely applied to solve some practical problems in different fields such as medical quality assessment (Kong et al. (2015)), technical analysis in forex trading expert system (Dymova et al. (2016)), trauma outcome prediction (Kong et al. (2016)), smart home subcontractor selection (Polat et al. (2016)), environmentally-friendly designs selection (NG (2016)), navigational risk assessment (Zhang et al. (2016)), data classification (Xu et al. (2017)), and so on.

In the published literature, three versions of the ER approach are successively developed during the past decades. The first version of the ER approach is introduced to discover the link between the MCDM and the Dempster-Shafer theory of evidence (DST) (Yang and Singh (1994)) by using the original concept of ER for criteria aggregation. It employs the Dempster's combination rule and the Shafer's discounting method for criteria aggregation with the introduction of criteria weights in the probability mass assignment. Since it is incapable of separating an unassigned probability mass into the part caused by incompleteness and that caused by criterion weight, the reasoning process is approximate and the ignorance may be exaggerated in the fusion result. Meanwhile, this version approach has other drawbacks such as the compensation among criteria is unable to be reflected, random numbers or interval uncertainty are not to be handled, and etc. In order to overcome the drawbacks existing in the first version, the second version of ER approach is proposed to hold a more rigorous and rational reasoning process. The second version approach is equipped with a new ER rule and information transformation techniques (Yang (2006)). It is capable of properly handling both qualitative and quantitative information, probabilistic uncertainty, incomplete information and complete/global ignorance in some assessments. It is important to note that the residual support (for weight) generalized by Shafer's discounting method is distinguished from the degree of global ignorance denoted by frame of discernment in the new ER rule. The global ignorance in a piece of evidence is considered as an intrinsic property and has no relevance to other evidence, while the residual support is considered as an extrinsic property of the evidence and it may be incurred when applying weights to discount evidence. Accordingly, if the residual support and global