Acta Cybernetica **19** (2009) 61–92.

Clouds, *p*-boxes, Fuzzy Sets, and Other Uncertainty Representations in Higher Dimensions

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Abstract

Uncertainty modeling in real-life applications comprises some serious problems such as the curse of dimensionality and a lack of sufficient amount of statistical data.

In this paper we give a survey of methods for uncertainty handling and elaborate the latest progress towards real-life applications with respect to the problems that come with it. We compare different methods and highlight their relationships. We introduce intuitively the concept of potential clouds, our latest approach which successfully copes with both higher dimensions and incomplete information.

Keywords: uncertainty models, potential clouds, confidence regions, higher dimensions, incomplete information, reliability methods, *p*-boxes, Dempster-Shafer theory, fuzzy sets

1 Introduction

Among the major problems in real-life applications of uncertainty representations we have identified two particularly complicated ones. One concerns the dimensionality issue. High-dimensionality can cause computations to become very expensive, with an effort growing exponentially with the dimension in many cases. This phenomenon is famous as the curse of dimensionality [45]. Even given the full knowledge about a joint distribution the numerical computation of error probabilities may be very time consuming, if not impossible. Moreover, rigorous computation or (preferably tight) bounding of failure probabilities can only be done in very few cases because the space of possible scenarios is too large. In higher dimensions full probabilistic models need to estimate high-dimensional distributions for which rarely sufficient data are available. Frequently it is just the other way around, i.e., statistical data are scarce. This leads to the second issue which is incomplete, imprecise, or subjective information. Thus we can formulate our ultimate question for discussing an uncertainty method: How does the quality of the method respond

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