Chapter 9
Fuzzy–Probability: DSS Human Health Risk Assessment Under Uncertain Environment

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ABSTRACT

Human health risk assessment is an important and a popular aid in the decision-making process. The basic objective of risk assessment is to assess the severity and likelihood of impairment to human health from exposure to a substance or activity that under plausible circumstances can cause harm to human health. One of the most important aspects of risk assessment is to accumulate knowledge on the features of each and every available data, information and model parameters involved in risk assessment. It is observed that most frequently model parameters, data, and information are tainted with aleatory and epistemic uncertainty. In such situations, fuzzy set theory or probability theory or Dempster-Shafer theory (DSS) can be explored to represent uncertainty. If all the three types of uncertainty coexist how far computation of the risk is concern, two ways to deal with the situation either transform all the uncertainties to one type of format or need for joint propagation of uncertainties. Therefore, this article presents an effort to combine Probability distributions, fuzzy numbers (FNs) and DSS. Highlights of this study are: 1) The approaches presented here deal with the amalgamation of probability distributions where representations of parameters are of bell shaped fuzzy numbers (BFNs)/FNs; fuzzy numbers (FNs) of various types and shapes plus DSS with fuzzy focal elements of different types within the same framework; 2) Non-cancer human health risk assessment is carried out in this setting and 3) Risk values are obtained in the form of FNs at different fractiles. The techniques provided in this study are proficient to exploit in any mathematical models which represent real world problems, wherein model parameters are tainted with uncertainty where representations of uncertain model parameters are probability distributions with bell BFNs/FNs parameters; DSS with fuzzy focal elements of different types plus FNs with different shapes and types.

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INTRODUCTION

Human health risk assessment is a significant apparatus in decision making system and it is always most important to accrue knowledge on the features of each and every existing data, information and model parameters involved in risk assessment process. It is observed that most frequently existing data/information is construed in probabilistic intellect because it is an extremely well-built and well instituted mathematical apparatus to treat aleatory uncertainty that arises due to inherent variability, natural stochasticity, environmental or structural variation across space or time, due to heterogeneity or the random character of natural processes. Traditionally, probability distributions are used in risk analysis to represent the uncertainty associated to random (aleatory) phenomena. The parameters (e.g., their mean, variance etc.) of these distributions are usually affected by epistemic (state-of-knowledge) uncertainty, due to limited experience and incomplete knowledge about the phenomena that the distributions represent (Pedronia, Zioa, Ferrariob, Pasanisid, & Couplet, 2012). The uncertainty framework can be then characterized by a P-box. If representations of the parameters (e.g., mean and standard deviation) of probability distributions are BFNs or normal FNs, then families of P-boxes can be obtained from which fuzzy numbers are generated at different fractiles.

However, it is understandable that not each and every existing data, information and model parameters are influenced by the aleatory uncertainty and so can’t be handled by conventional probability theory. But, model parameters may be fouled with epistemic uncertainty that by reason of lack of precision, deficiency in data, diminutive sample sizes or data acquire from specialist opinion or subjective construal of existing data or information. In such situations, conventional probability theory is improper to characterize epistemic uncertainty. To overcome the drawback of probabilistic method, L.A Zadeh in 1965 commenced a new notion called fuzzy set theory while Dempster in 1967 developed an important theory called Dempster-Shafer theory (DST) of evidence. Fuzzy set theory is apposite to represent epistemic uncertainty, that is defined as a set in which every element has certain degree of membership i.e., precisely assigns a real value from [0,1] as an indication of their degree of truthfulness and it delineates the degree of involvement of a recognizable element in the set. Normally, triangular fuzzy numbers (TFNs) or trapezoidal fuzzy numbers (TrFNs) are extensively deliberated to embody epistemic uncertainty. However, in real world situations, there are some applications where bell-shaped fuzzy numbers may occur to characterize epistemic uncertainty. Again, the DST of evidence is based on two measures viz., belief measure and plausible measure. The primitive function in DST to define belief measure and plausible measure is branded as basic probability assignment (BPA). The focal elements and BPA of DST together called as DSS. The utilization of DST in health risk assessment has numerous benefits over the existing probabilistic approach. It presents expedient and ample technique to lever engineering problems incorporating inaccurately specified distributions, inadequately recognized and unfamiliar correlation between different variables. DST is especially supportive for modelling aleatory and epistemic uncertainty when lack of data or no data are available and need to depend on expert judgment. Experts’ judgments are desirable when stumbling upon uncertainty, ignorance and complexity. It is also required to cope with the condition where outlay of technical impenetrability involved, otherwise uniqueness of the condition beneath study make it complicated/impracticable to craft enough annotations to enumerate the models with exact data. Generally in DST, experts present BPA for interval focal elements (Dutta & Ali, 2011c). But, due to the presence of imprecise or incomplete or insufficient information or uncertainty data can be treated as TFNs or bell-shaped fuzzy numbers (BFNs).
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