A Brief Review and Future Outline on Decision Making Using Fuzzy Soft Set

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ABSTRACT

Decision making using fuzzy soft set (FSS) and its extensions has become the most significant research area in the age of uncertainty. In this article, the authors survey the evolution of fuzzy soft sets (FSSs) during the last decade and a half (2001-2015) to analyze the impact of FSS and its extension in the decision-making paradigm. Based on some selected journals, conferences, and online databases, this article classifies the decision-making process mainly into ten different categories, which are based on different types of FSSs. This article briefly explores each individual category by mentioning the theoretical/algorithic approaches proposed by the respected authors. Furthermore, all papers are categorized with respect to publication year, published journal, application type, and decision-making criteria. This literature survey provides a platform to the researchers to find out the dimensions of future research works in FSSs by analyzing the present state and potential areas.

KEYWORDS

Decision Making, Fuzzy Soft Set, Hesitant Fuzzy Soft Set, Intuitionistic Fuzzy Soft Set, Literature Review

1. INTRODUCTION

Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker(s) (Harrison, 1981, Harris, 1998). Decision making can be performed by a single decision maker or a group of decision makers/experts. The second option is known as group decision making (GDM), where a group of decision makers interact with each other to reach a final conclusion for a particular problem. In GDM, each decision maker might have their own thought which differs from others’ but they should have a common goal to reach the ultimate destination or selecting the best option(s). Since the real-life problems are often uncertain, decision making in real life is always challenging. The need of proper decisions is everywhere like selection of house(s), selection of car(s), selection of suitable candidate(s) for a company, selection of investment sector(s), disease diagnosis of patient(s), finding proper location for installing a plant, etc. In the era of uncertainty, where the real-life problems are full of imprecise and incomplete information, use of fuzzy sets and soft sets are becoming more significant due to their specific capabilities to deal with uncertainty. In reality, human thinking and reasoning also frequently involve fuzzy information originating from inherently inexact human nature. Fuzzy system has been proved to be useful for decision making in uncertain environment. To cope with the complex real-life situations, a number of generalizations of fuzzy set have been evolved. But the theory of fuzzy sets has its own difficulties due to the inadequacy
of parameterization. As a result, soft set has been evolved. Soft set theory (Molodtsov, 1999) was introduced as a generic mathematical tool for dealing with uncertain problems which are difficult to handle with the traditional mathematical tools. A soft set can be used for approximate description of objects without any restriction. Due to this absence of restriction on the approximate description, soft set theory has been emerging as a convenient and easily applicable tool in practice. As soft set uses crisp logic, the applicability of it in real life problems is limited, because the real-life problems are full of imprecise and incomplete, i.e., uncertain information. Finding the necessity of incorporating fuzzy set with soft set, Maji et al. (2001) introduced FSS. Since its introduction, FSS theory has been successfully applied in many different fields such as decision making, data analysis, forecasting, simulation, optimization, texture classification, etc. This article reviews the development of FSS in decision making paradigm over the last one and half decade (2001-2015) based on the available literatures published online. The reason behind selecting this duration is that researchers started to use FSSs and other hybridizations of soft sets to handle different real-life problems and as a result many contributions in the literature are found in this period. This paper surveys and classifies FSS related papers mainly into ten different categories, which are based on FSS, multi-fuzzy soft set (MFSS), generalized fuzzy soft set (GFSS), fuzzy soft expert set (FSES), interval-valued fuzzy soft set (IVFSS), type-2 fuzzy soft set (T2FSS), intuitionistic fuzzy soft set (IFSS), generalized intuitionistic fuzzy soft set (GFSS), interval-valued intuitionistic fuzzy soft set (IVIFSS), and hesitant fuzzy soft set (HFSS).

The rest of the paper is organized as follows. Section 2 – Section 11 present the survey of different types of FSSs and their hybridizations. Section 12 presents a brief discussion on the existing FSS methodologies and their applications. Finally, in Section 13, we conclude and present a future outline on FSSs based articles.

2. DECISION MAKING USING FSS

This section presents the relevant definitions and a brief description of FSSs based articles followed by tabular representations of their key aspects.

2.1. Soft Set (Maji et al., 2001)

Let \( U \) be an initial universe and \( E \) be a set of parameters. Let \( P(U) \) denote the power set of \( U \) and \( A \subset E \). A pair \((F, A)\) is called a soft set over \( U \), where \( F \) is a mapping given by \( F : A \rightarrow P(U) \). In other words, a soft set over \( U \) is a parameterized family of subsets of the universe \( U \). For \( \epsilon \in A \), \( F(\epsilon) \) may be considered as the set of \( \epsilon \)-approximate elements of the soft set \((F, A)\).

2.2. Fuzzy Soft Set (Maji et al., 2001)

Let \( U \) be an initial universe and \( E \) be a set of parameters. Let \( P(U) \) denotes the set of all fuzzy sets of \( U \) and \( A \subset E \). A pair \((F, A)\) is called a FSS over \( U \), where \( F \) is a mapping given by \( F : A \rightarrow P(U) \).

2.3. Possibility Fuzzy Soft Set (Alkhazaleh et al., 2011)

Let \( U = \{x_1, x_2, \cdots, x_n\} \) be the universal set of elements and let \( E = \{e_1, e_2, \cdots, e_m\} \) be the set of parameters. The pair \((U, E)\) will be called a soft universe. Let \( F : E \rightarrow I^\mu \) and \( \mu \) be a fuzzy subset of \( E \), that is, \( \mu : E \rightarrow I^\mu \), where \( I^\mu \) is the collection of all fuzzy subsets of \( U \). Let \( F_\mu : E \rightarrow I^\mu \times I^\mu \) be a function defined as follows:

\[
F_\mu(e) = (F(e)(x), \mu(e)(x)), \forall x \in U
\]