Application of Bipolar Intuitionistic Fuzzy Soft Sets in Decision Making Problem

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ABSTRACT
This article describes how recently, a paper by D. Ezhilmaran and K. Sankar called Morphism of bipolar intuitionistic fuzzy graphs, has introduced bipolar intuitionistic fuzzy sets and morphism of bipolar intuitionistic fuzzy graphs. By using this concept, the authors of this article have combined a bipolar intuitionistic fuzzy set and a soft set. They introduce the notion of bipolar intuitionistic fuzzy soft set and study their basic properties. Also, presented in this article are the basic operations on bipolar intuitionistic fuzzy soft sets, extended unions, and the intersection of two bipolar intuitionistic fuzzy soft sets. An application of bipolar intuitionistic fuzzy soft set provides into a decision-making problem and a general algorithm to solve this decision making problem.

KEYWORDS
Bipolar Fuzzy Set, Bipolar Intuitionistic Fuzzy Set, Bipolar Intuitionistic Fuzzy Soft Set, Fuzzy Soft Set, Soft Set

1. INTRODUCTION
Decision making is one of the most significant and useful thing in our day-to-day life. But with the growing complexities of the systems, it is difficult to the decision maker for making a correct decision under these environments. For handling it, the fuzzy set theory (Zadeh 1965)) and intuitionistic fuzzy set theory (Atanassov (1986)) have been defined for making a decision smoother. After their development, researchers have work on it and present several algorithms for solving the decision-making problems by Garg (2016a, 2016b, 2016c, 2016d, 2016e).

The classical methods unable to modeling uncertain data in economics, engineering, environmental science, sociology and information sciences successfully, because they have inherent difficulties and that have troubled the usual theoretical approaches. To overcome these difficulties, (Molodtsov (1999)) introduced the concept of soft set theory as a new mathematical tool for dealing with uncertainties which is free from difficulties. In theoretical aspects, soft set theory has a rich application in different direction. Now, works on the soft set theory are progressing rapidly. Maji et al. (2002, 2003) described the application of soft set theory in a decision-making problem and studied several operations on the theory of soft sets. Then many researcher find tremendous works using soft set theory as they have foundation. Ali et al. (2009) studied some new operations on soft set theory, Acar et al. (2010) introduced soft set and soft ring, Aktas and Çağman (2007) introduced

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the definition of soft groups and derived some basic properties of it, Sezgin et al. (2012) introduced soft near ring. Jana and Pal (2016) provided new soft intersection set on groups, Feng et al. (2008) initiated the concept of soft semiring, soft ideals on semiring and soft idealistic semiring.

It is well known that soft set theory as a tool for applications in both theoretical areas as well as a technique for laying the foundations. Nowadays and upcoming days, it has been stimulated a breadth of the disciplines of Information Sciences with intelligent systems, expert and decision support systems, approximate reasoning, self-adaptation and self-organizational systems, information and knowledge, modeling and computing as seen in the following studies like decision making (Çağman and Enginoğlu, 2010; Zhan, Liu and Herawan, 2017).

The characterization of various problems in system identification are essentially non-probabilistic in nature (by Zadeh (1962)). In response to this situation, (Zadeh (1965)) introduced fuzzy set theory as an alternative to probability theory in 1965. Classical soft sets are not appropriate to deal with imprecise and fuzzy parameters. In order to overcome this situation, Maji et al. (2001) introduced the concept of fuzzy soft sets as a generalization of the standard soft sets and presented an application of fuzzy soft sets in a decision-making problem. Çağman and Enginoğlu (2010) analyzed Soft set theory and uni-int decision making. Majumder and Samanta (2010) studied generalized fuzzy soft set. By using this notion, Roy and Maji (2007) studied some applications in decision making problem. Fuzzy sets and its extension have a momentum of growth in different application of fuzzy sets and proposed by authors such as intuitionistic fuzzy sets by (Atanassov (1999)) interval-valued fuzzy sets, type-2 fuzzy sets, fuzzy multi sets. In 1998, Zhang (1998) introduced Bipolar fuzzy sets. In a bipolar fuzzy set, positive information represents what is guaranteed to be possible, while negative information represents what is impossible or forbidden, or surely false. Bipolar valued fuzzy set by Lee (2000) introduced another generalization of fuzzy sets in which membership degree is enlarge from interval [0,1] to [-1,1]. In bipolar fuzzy sets, membership degree 0 means that elements are irrelevant to corresponding property, membership degree belong to (0,1] indicate that somewhat elements are satisfy the corresponding property and membership degree belong to [-1,0) indicate that somewhat elements are satisfy implicit counter property. Recent development by Mahmood and Hayat (2015), Hayat et al. (2016) studied bipolar fuzzy and bipolar anti-fuzzy h-ideals on hemi-rings, Aslam et al. (2013), Abdullah et al. (2014) and, Naz and Shabirb (2014) provided bipolar fuzzy soft set and its application in decision making problem. Garg (2016) studied fuzzy Number Intuitionistic fuzzy soft sets and its properties. Also, Ezhilmaran and Sankar (2015) introduced the notion of bipolar intuitionistic fuzzy set $B = \{(x, \mu^p(x), \mu^n(x), \gamma^p(x), \gamma^n(x)) : x \in X\}$, where $\mu^p : X \rightarrow [0,1]$, $\mu^n : X \rightarrow [-1,0]$, $\gamma^p : X \rightarrow [0,1]$ and $\gamma^n : X \rightarrow [-1,0]$ are the functions such that $0 \leq \mu^p(x) + \gamma^p(x) \leq 1$ and $-1 \leq \mu^n(x) + \gamma^n(x) \leq 0$, and $\mu^p(x)$, $\mu^n(x)$, $\gamma^p(x)$ and $\gamma^n(x)$ are respectively denote positive membership degree, negative membership degree, positive non-membership degree and negative non-membership degree. Motivated enough above these results and best of our knowledge there is no work available on bipolar intuitionistic fuzzy soft set and its application in decision making. For this reason, based on soft set theory, we developed bipolar intuitionistic fuzzy soft set and applied it into socialistic decision-making problem. The results of this paper can be applied in different soft algebraic structures and decision-making problems.

In this paper, we introduced a combination of bipolar intuitionistic fuzzy set with soft set. We introduced the notion of bipolar intuitionistic fuzzy soft set and proved some basic properties. We presented basic operations on bipolar intuitionistic fuzzy soft set. Also, we presented extended union and intersection of two bipolar intuitionistic fuzzy soft sets. We give an application of bipolar intuitionistic fuzzy soft set into a decision-making problem and a general algorithm is given to solve this decision-making problem.
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