Q-Neutrosophic Soft Expert Set and its Application in Decision Making

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ABSTRACT
This article describes how Smarandache defined neutrosophic sets to handle problems involving incomplete, indeterminacy and awareness of inconsistency knowledge, and is further developed to neutrosophic soft expert sets by Sahin et al. Adam and Hassan defined multi Q-fuzzy soft sets as an extension to fuzzy soft sets and gave its applications. This article will extend this further by presenting a novel concept of Q-neutrosophic soft expert sets, and define the associated related concepts and basic operations of complement, subset, union, intersection, AND and OR. This novel concept enables the single dimensionality of soft expert sets to be extended to two dimensions. Then, this article constructs an algorithm based on this concept. The following will illustrate the feasibility of the new method by an example. Finally, a comparison of the proposed method to existing methods is furnished to verify the effectiveness of the novel concept.

KEYWORDS
Algorithm, Decision Making, Neutrosophic Soft Sets, Q-Fuzzy Set, Soft Expert Set

INTRODUCTION
The theory of probability, fuzzy set (Zadeh, 1965), intuitionistic fuzzy set (Atanassov, 1986), rough set (Pawlak, 1982), and soft set (Molodtsov, 1999) are utilized as tools to deal with diverse types of uncertainties and imprecision. It was further extended to vague sets (Gau & Buehrer, 1993) which were shown to be intuitionistic fuzzy sets (Bustince & Burillo, 1996). The vague sets were extended to the interval-valued form, generalized form and later to its multisets by Alhazaymeh and Hassan (2012, 2013a, 2014a). However, the above theories are inadequate to deal with information of indeterminate and inconsistent nature. Smarandache (1998) developed neutrosophic set (NS) generalizing probability, fuzzy and intuitionistic fuzzy sets. NS can be described by membership degrees of truth, indeterminacy and and non-membership (Smarandache, 2005). This theory and its variants has been applied to varied areas of topology (Lupianez, 2008), control theory (Aggarwal et al., 2010), databases (Arora & Biswas, 2010; Arora et al., 2011), diagnosis (Ansari et al., 2011), decision making (Broumi et al., 2014; Deli, 2015; Deli & Broumi, 2015; Kharal, 2014), and multiple attribute decision-making

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(Chi & Liu, 2013; Liu & Shi, 2015; Liu & Wang, 2014; Sahin & Liu, 2016; Ye, 2015). Maji (2013) introduced neutrosophic soft set, followed by fuzzy soft expert set (Alkhazaleh & Salleh, 2014) which were later extended to generalized fuzzy soft expert set (Hazaymeh et al., 2012), vague soft expert set (Hassan & Alhazaymeh, 2013), generalized vague soft expert set by Alhazaymeh and Hassan (2013b, 2014b, 2014c) and multi \( Q \)-fuzzy soft expert set (Adam & Hassan, 2016). Sahin et al. (2015) introduced neutrosophic soft expert sets, while Al-Quran and Hassan (2016a, 2016b) extended it further to neutrosophic vague soft expert set and fuzzy parameterised single valued neutrosophic soft expert set, which were later enlarged to possibility neutrosophic vague soft expert set (Hassan & Al-Quran, 2017). \( Q \)-fuzzy soft sets were on the other hand, proposed by Adam and Hassan (2014a, 2014b, 2014c), followed by multi \( Q \)-fuzzy soft sets (2014d, 2014e, 2015).

Sahin et al. (2015) introduced neutrosophic soft expert sets using a single universe \( U \). This can be seen from the example provided by Sahin et al. (2015) in their article with a single universe \( U \) regarding a set of products. In some real-life problems, we need to deal with two dimensional universal set \( X \times Q \), hence the need for \( Q \)-neutrosophic soft expert sets. Most decisions are not simply based on the products, but also to suppliers of these products or their manufacturers too. We therefore extend the single dimension neutrosophic soft expert sets to \( Q \)-neutrosophic soft expert sets by adding an extra dimension. This can be seen by our illustrated examples where we take the consideration of suppliers besides the products that they supply.

In this paper we will extend these works by proposing the concept of a multi \( Q \)-neutrosophic soft expert set and its operations along with illustrative examples. We constructed an algorithm for its use in decision making. Finally, we apply this new concept to solve a decision-making problem and compare it with other existing methods to show its feasibility and effectiveness. Thus, decision making are shown not to be only confined to deterministic concepts such as goal programming (Hassan & Halim, 2012; Hassan & Loon, 2012; Hassan et al., 2012).

**PRELIMINARIES**

Smarandache (2005) proposed the definition of neutrosophic set below.

**Definition 1:** Let \( V \) be a universe of discourse, with a generic element in \( V \) denoted by \( v \), then a neutrosophic (NS) set \( A \) is an object having the form

\[
A = \{ (v : \mu_A(v), \theta_A(v), w_A(v)), v \in V \}
\]

where the functions \( \mu, \theta, w : V \to [0, 1] \) define respectively the degree of membership (or Truth), the degree of indeterminacy, and the degree of non-membership (or Falsehood) of the element \( v \in V \) to the set \( A \) with the condition

\[
0 \leq \mu_A(v) + \theta_A(v) + w_A(v) \leq 3
\]

The following two definitions on soft neutrosophic set and power set of neutrosophic set are given by Maji (2013).

**Definition 2:** Let \( V \) be an initial universe set and \( E \) be a set of parameters. Consider \( AE \). Let \( P(V) \) denotes the set of all neutrosophic sets of \( V \). The collection \( (F, A) \) is termed to be the soft neutrosophic set over \( V \), where \( F \) is a mapping given by \( F : A \to P(V) \).
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