NOURAN M. RADWAN

Assistant Lecturer, Information Systems Dept., Sadat Academy, Egypt
PhD Student, Information Systems Dept., Mansoura university, Egypt
E-mail: radwannouran@yahoo.com

Neutrosophic Applications in E-learning: Outcomes, Challenges and Trends

Abstract

There has been a sudden increase in the usage of elearning to support learner's learning process in higher education. Educational institutions are working in an increasingly competitive environment as many studies in elearning are implemented under complete information, while in the real world many uncertainty aspects do exist. This has resulted in emerging various approaches to handle uncertainty. Neutrosophic logic has been used to overcome the uncertainty of concepts that are associated with human expert judgments. This paper presents current trends to enhance elearning process by using neutrosophic to extract useful knowledge for selecting, evaluating, personalizing, and adapting elearning process.

Keywords

E-learning, neutrosophic logic, neutrosophic logic based systems.

1. Introduction

The word uncertainty is dealing with vague data, incomplete information, and imprecise knowledge regardless of what is the reason [1]. One of the significant problems of artificial intelligence is modeling uncertainty for solving real life situations [2]. Previous researches presented various models that handle uncertainty by simulating the process of human thinking [3,4]. Managing uncertainties is a goal for decision makers including indefinite cases where it is not true or false [5]. This leads to emerging approaches such as fuzzy, intuitionistic fuzzy, vague and neutrosophic models to give better attribute interpretations. Fuzzy, intuitionistic fuzzy, and vague models are limited as they cannot represent contradiction which are a feature of human thinking [6].

Smarandache [7] proposed neutrosophic logic as an extension of fuzzy logic of which variable x is described by triple values x= (t, i, f) where t is the degree of truth, f is the degree of false and i is the level of indeterminacy. Neutrosophic logic is capable to deal with contradictions which are true and false as the sum of components any number between 0 and 3^+. An example of neutrosophic logic is as following; the argument "Tomorrow it will be sunny" does not mean a constant-valued components structure; this argument may be 60% true, 40% indeterminate and 35% false at a time; but at in a second time may change at 55% true, 40% indeterminate, and 45 % false according to new indications, provenances, etc. [8].

The usage of elearning has been increased in the last recent years in which learners have started using smart devices to access eLearning content. Also many elearning applications have been emerged to support universities in spreading educational resources to the learners [9]. Previous studies [10] in e-learning are implemented under complete information, while the real environment has uncertainty aspects. That is why traditional evaluation methods may not be virtuous. This leads us to suggest neutrosophic logic to give better attribute interpretations to enhance elearning.

Considering the above facts, this paper is organized as follows: Related work is described in Section 2. In Section 3, the need and outcome of using neutrosophic logic is discussed. Section 4 gives the trends and challenges of applying Neutrosophic to elearning.

2. Related Work

Neutrosophy is originated from "neuter" and "Sophia". Neuter means neutral in Latin and Sophia means wisdom in Greek. Neutrosophy means neutral thought knowledge [7]. Neutrosophic Logic was developed to represent mathematical model of uncertainty including vagueness, ambiguity, imprecision, and inconsistency. Expert systems, decision support system, belief system, and information fusion tend to depend not only on truth value, but also on false and indeterminacy values. So current systems which are dedicated to simulate human brain are constrained with strict conditions, whereas, Neutrosophic logic has its chance to simulate human thinking and to be utilized for real environment executions [8].

Aggarwal et al. in 2010 [11] propose block diagram of neutrosophic inference system to illustrate designing of neutrosophic classifier which is more flexible to get more accurate results. Aggarwal et al. in 2011 [12] suggest the possibility of extending the capabilities of the fuzzy systems by applying neutrosophic systems and incorporating neutrosophic logic in medical domain. Vagueness, imprecision, ambiguity, and inconsistency, should be presented in medical systems as medical diagnosis depends on available data and expert recognition, and avoiding uncertainty leads to misplaced accurate interpretation. Neutrosophic Cognitive Maps (NCM) for investigating the effect of critical factors of breast cancer is presented in [13]. A neutrosophic lung segmentation method was developed by [14] to improve the expectation-maximization analysis and morphological operations for our computer-aided detection segmentation. This method facilitates image analysis tasks and computer aided applications for lung abnormalities and improve the accuracy of lung segmentation, mostly for the cases affected by lung diseases.

Neutrosophic is used in many multiple criteria decision-making problems in real life such as personal choice in academia, project assessment, supplier selection, industry systems, and others areas of management systems [15] [16] [17] to support taking a correct decision from the available alternatives in uncertain environment. Researchers tend to use neutrosophic sets in various decision making applications as traditional crisp multiple criteria decision-making methods are not enough to handle uncertainty in real world cases because of the ambiguity of people thinking, it is more reasonable to simulate human thinking with handling contradictions which are true and false at the same time [18]. In 2016, Ye [19] suggests computation of trust value by integrating a neutrosophic logic with the proposed fuzzy based trust model that considers all the factors affecting the trust in ecommerce. As traditional models of trust fall in representing the indeterminacy values involved while capturing the perception of human. As it is concluded that imprecision of systems could be due to the deficiency of knowledge that received from human in the real world.

A proposed social Learning Management System (LMS) that integrates social activities in e-learning, and utilize a new set theory called the neutrosophic set to analyze social networks data conducted through learning activities is presented in [20]. A new approach based on neutrosophy is presented to provide better interpretation of the assessment results of the e-learning systems that are described by uncertainty aspects [21].

Another study [22] concerns the importance of social networks in e-learning systems. Recommender system has a significant role in e-learning as it supports e-learners in choosing among different learning objects and activities using different algorithms: C4.5, K-Means, support vector machine, and Apriori algorithms.

Neutrosophic sets [23] is proposed in order to evaluate the quality of learning objects based on the multi-criteria approach. Neutrosophic way of thinking help experts to represent their opinion in degrees of truth, false, and indeterminacy.

3. Outcomes of using Neutrosophic Logic

Neutrosophic idea is based on indeterminacy set that can deal with vagueness, imprecision; ambiguity and inconsistent information existing in real world. An example of neutrosophic problems is as follows: a vote with three symbols which are A, B and D ballots is occurred, in which some votes are indistinct, and it can’t be determined if it is A, B or D. These indeterminate votes can be expressed with neutrosophic logic.

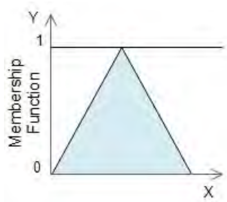
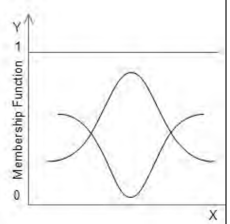
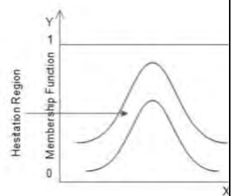
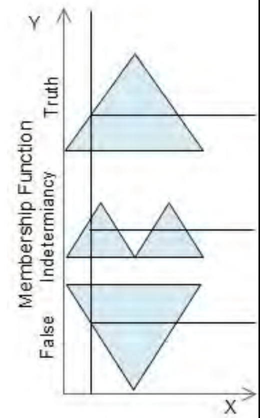
Therefore, indeterminacy can be handled by neutrosophic logic while other approaches neglect this point [7].

Fuzzy sets represent the membership without expressing the corresponding degree of non-membership so it provides an imperfect expression of uncertain information. The degree of non-membership in fuzzy sets is the complement of membership for fuzzy sets, Therefore the non-membership is not independent.

Intuitionistic fuzzy sets, as well as vague sets, are suitable in simulating the impreciseness of human understanding in decision making by representing degree of membership and non-membership, but it also cannot express indeterminacy degree which is the ignorance value between truth and false.

Indeterminate can be handled by neutrosophic logic which has the truth, indeterminacy and false membership functions as shown in Table 1[6].

Table 1. *Multivalued Logic Membership Function*

	Fuzzy set	**Intuitionistic Fuzzy**	**Vague**	**Neutrosophic**
Membership Function	Degree of belonging	Degree of membership function and non-membership function	Degree of membership function and non-membership function	Degree of membership function, indeterminacy and non-membership function
	 Fig 1. Type1 fuzzy membership function [1]	 Figure 2. Intuitionistic Fuzzy Set [24]	 Figure 3. Vague Set [24]	 Figure 4. Neutrosophic Set [11]

A better understanding of the need and the outcome of using neutrosophic logic is presented in this section. The uncertainties types include vagueness, imprecision, ambiguity, and inconsistency. *Vagueness* when available information is normally having a degrees of attribute; for example: "This man is nearly tall". *Imprecision* when information is not a definite value; for example: "The student performance for a task is between 80-85% ".   when available information has more than one meaning or refer to more than one subject; for example: "The flower color may be yellow or red". *Inconsistency* when obtainable information is conflicted or contradicted; for example:"the chance of raining tomorrow is 80%", it does not mean that the chance of not raining is 20%, since there might be hidden weather factors that is not aware of.

Fuzzy set describes vagueness, Intuitionistic fuzzy set is an extension of fuzzy sets which describes vagueness and imprecision by a range of membership values. Neutrosophic set describes vagueness, imprecision; ambiguity and inconsistent information that exists in real environment. Therefore, Neutrosophic logic handles indeterminacy of information while other approaches neglect this point.

4. Challenges and Trends of Neutrosophic Applications in E-learning

In the recent years, there has been increasing demand in incorporating of new technologies into educational processes. Effectiveness of elearning becomes a big challenge as elearning process is currently conducted in highly controlled way. Elearning challenges can be categorized according to their focus into: individual, course, technology and contextual as shown in Figure 5[9]. It is expected that neutrosophic logic utilized for enhancing eLearning environment as following:

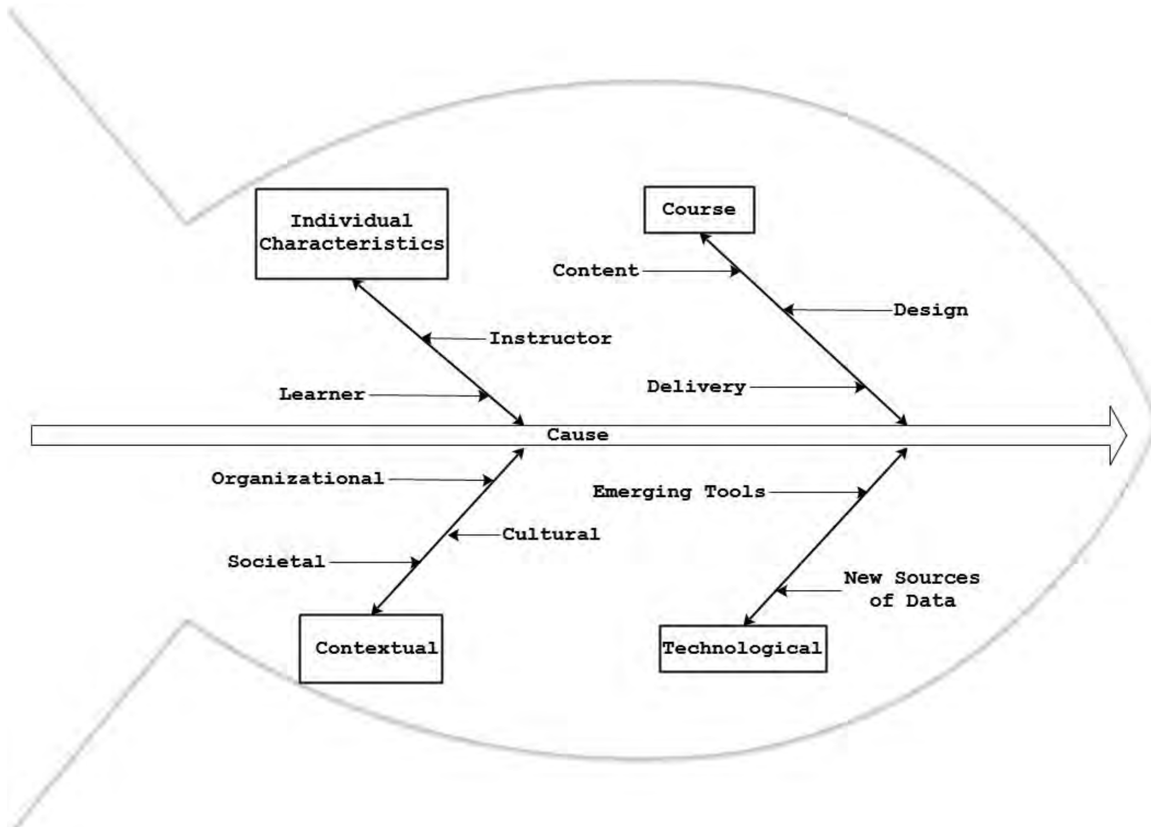


Figure 5. *E-Learning Challenges*

4.1 Neutrosophic Cognitive Map for E-learning Success Factors

According to the researchers' insights in the matter, elearning offer advantages over the traditional learning methods. The study of critical success factors helps decision makers to extract from the learning process the core activities that are essential for success. The investigation of the success factors from different perspectives such as learner's, instructor's and organization is needed [25]. Previous researches presented fuzzy cognitive maps and intuitionistic fuzzy logic by considering the expert's hesitancy in the determination of the relations between the concepts of a domain [26]. Further studies are needed to analyze and build a neutrosophic cognitive map for modelling critical success factors in elearning. Neutrosophic cognitive map extends the aggregation of the information from different resources under uncertain environment.

4.2 Neutrosophic Multi-Criteria Decision Making Methods for Elearning Software Selection

There are hundreds of elearning software available in the marketplace. Selecting the most suitable elearning that meets specific requirements is a problem of decision making. Many studies in elearning selection are implemented under complete information, while in the real world many uncertainty aspects do exist. As these systems were described by decision makers with vague, imprecise, ambiguous and inconsistent terms, it is understandable that traditional multi criteria decision making methods may not be effective [27] [28]. Further studies deal with presenting a hybrid neutrosophic multi criteria decision making method to handle indeterminacy of information.

4.3 Neutrosophic Expert System for Evaluating E-learning Applications

Expert system aims to represent the problem of uncertainty in knowledge to draw conclusion with the same level of accuracy as would a human expert do. Different evaluation models for e-learning quality attributes developed under the condition of the availability of complete information. Real environment is characterized by vagueness, imprecision, ambiguity, and inconsistency information, this problem leads researchers to use approaches that deals with uncertainty like fuzzy logic, intuitionistic fuzzy logic. This section suggests neutrosophic expert system for evaluation of elearning applications [6], [29].

4.4 Neutrosophic Logic Based System for E-learning Personalization

Generating the content according to learner's intellect is a current challenge in e-learning systems. Most of the e-learning systems evaluate the learner's intellect level according to tests crisp responses that are taken during the learning process. However, many factors lead to uncertainty about the evaluation process. Further work will present a novel approach using neutrosophic logic to build an intelligent system that handles imprecision, vagueness, ambiguity, and inconsistence information about the learner's assessment to personalize the learning material according to learner's level is needed [30].

4.5 Adaptive test sheet generation in e-learning

Successful test sheet refers to the ability of questions to check the learner's cognitive skills in the most efficient manner. Designing and developing a test assignment for an adaptive e-learning system depends on organization of questions, concept, activity and learner level. Test adaptation can be done by utilizing one of learning styles models like Myers Brigs Type Indicator, Bloom's Taxonomy, and David Kolb's Model e-test classify in an e-learning environment. Adaptive test works toward providing electronic test sheet generation according to learner's style in a customized surroundings. The incorporation of neutrosophic logic and learning style model provides a suitable way of assessment that has an important role in enhancing learner recognition, and performance. Traditional test includes questions with different difficulty levels to get the overall view about the learner's ability despite of adaptive test that designed to ensure that learner is above a special ability value as it includes questions with definite difficulty level [31].

5. Conclusion

With the major changes in e-learning technology, there is a need to take into considerations the current trends and challenges of neutrosophic logic in elearning to add benefits to learners.

The chapter presents recent challenges and trends in neutrosophic applications. The neutrosophic logic has many achievements in different applications such as medical, decision making, ecommerce, and elearning. The outcome of neutrosophic logic is handling different uncertainty types vagueness, imprecision; ambiguity and inconsistent information exist in real world. Therefore, human thinking indeterminacy can be handled by neutrosophic logic while other approaches neglect this point. Furthermore, the study provides insights of neutrosophic applications challenges and trends in elearning. Future work will deal with talent elearning system to recommend training courses suitable for learner's talent in which neutrosophic is needed to identify learner’s needs and skills. The integration of talent management and elearning system, improve the learner’s task related skills.

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