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Decision support based on single valued neutrosophic number for information system project selection

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Abstract. Neutrosophic sets and its application to decision support have become a topic of great importance for researchers and practitioners alike. In this paper, a new model for decision making in the selection of information system projects is presented based on single valued neutrosophic number (SVN-numbers) allowing the use of linguistic variables with multiples points of view from experts. The proposed framework is composed of four activities, framework, gathering information, rating alternatives and information system project selection. Project alternatives are rated based on the Euclidean distance to the ideal alternative. A case study is developed in information system, showing the applicability of the proposal. Further works will concentrate in extending the model for dealing with heterogeneous information and in developing a software tool.

Keywords: Decision Analysis, SVN Numbers, Ideal Alternative, Information Systems, project selection.
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1 Introduction

Decision analysis is a discipline, belonging to decision theory, with the goal of computing an overall assessment that summarizes the information gathered and providing useful information about each evaluated element (Macarena Espinilla, Palomares, Martinez, & Ruan, 2012). Uncertainty is present in real world decision making problems in such cases the use of linguistic information to model and manage such an uncertainty has given good results (Estrella, Espinilla, Herrera, & Martínez, 2014). Experts feel more comfortable providing their knowledge by using terms close to human beings cognitive model (Rodríguez & Martínez, 2013) that is the rationale for using linguistic variables.

The conventional techniques have been not much effective for solving decision problems because of imprecise nature of the linguistic assessments. It is more reasonable to consider the values of alternatives according to the criteria as single valued neutrosophic sets (SVNS) (Wang, Smarandache, Zhang, & Sunderraman, 2010) for handling indeterminate and inconsistent information, while fuzzy sets and intuitionistic fuzzy sets cannot describe it properly . In this paper a new model of information system project selection is developed based on single valued neutrosophic number (SVN-number) allowing the use of linguistic variables (Biswas, Pramanik, & Giri, 2016).

This paper is structured as follows: Section 2 reviews some preliminaries concepts about decision analysis framework and SVN numbers is presented. In Section 3, a decision analysis framework based on SVN numbers for project selection. Section 4 shows a case study of the proposed model. The paper ends with conclusions and further work recommendations.

2 Preliminaries

In this section, we first provide a brief revision of a general decision scheme and the use of linguistic information using SVN numbers for information system Project selection.

2.1 Decision Scheme and Information Systems Project Selection

Decision analysis is a discipline with the main purpose of helping decision maker to reach a reliable decision (M. Espinilla, Ruan, Liu, & Martínez, 2010).

A common decision resolution scheme consists of following eight phases (Clemen, 1996; Estrella et al., 2014):

1. Identify decision and objectives.
2. Identify alternatives.
3. Framework:
4. Gathering information.
5. Rating alternatives.
6. Choosing the alternative/s:

7. Sensitive analysis
8. Make a decision

In the framework phase, the structures and elements of the decision problem are defined such as experts, criteria, options. The information provided by experts is collected, according to the defined framework.

The gathered information provided by experts is then aggregated to obtain a collective value of alternatives in the rating phase. Therefore, in rating phase, it is necessary to carry out a solving process to compute the collective assessments for the set of alternatives, using appropriate aggregation operators (Calvo, Kolesárová, Komorníková, & Mesiar, 2002).

A way to compute a rating of alternatives is by using the ideal alternative concept. A comparison between an ideal alternative and available options in order to find the optimal choice is used for the ratting of alternatives (Zeng, Baležentis, & Zhang, 2012). Normally, the closer the alternative to the ideal the better the alternative is.

Information systems project selection could be defined as a multicriteria decision problem (Lee & Kim, 2001) . This fact makes the process of selecting information systems projects suitable for decision analysis scheme model.

2.2 SVN-numbers

Neutrosophy (Smarandache, 1999) is mathematical theory developed by Florentín Smarandache for dealing with indeterminacy Neutrosophy have been the base for developing of new methods to handle indeterminate and inconsistent information like neutrosophic sets an neutrosophic logic (Smarandache, 2005; Vera, José, Menéndez Delgado, Gónzalez, & Vázquez, 2016) . It is used specially in decision making problems.

The truth value in neutrosophic set is as follows (Rivieccio, 2008):

Let N be a set defined as: $N = \{(T, I, F) : T, I, F \subseteq [0, 1]\}$, a neutrosophic valuation n is a mapping from the set of propositional formulas to N , that is for each sentence p we have $v\,(\mathrm{p}) = (T, I, F)$.

Single valued neutrosophic set (SVNS) (Wang et al., 2010) was developed with the goal of facilitate the real applications of neutrosophic set and set-theoretic operators.

A single valued neutrosophic set (SVNS) has been defined (Definition 1) (Wang et al., 2010):

Definition 1: Let X be a universe of discourse. A single valued neutrosophic set A over X is an object having the form of :

$$A = \{\langle x, uA(x), rA(x), vA(x)\rangle : x \in X\} \qquad (1)$$

where $u_A(x): X \to [0,1]$, $r_A(x), : X \to [0,1]$ and $v_A(x): X \to [0,1]$ with $0 \le u_A(x) + r_A(x) + v_A(x) :\le 3$ for all $x \in X$. The intervals $u_A(x)$, $r_A(x)$ y $v_A(x)$ denote the truth- membership degree, the indeterminacy-membership degree and the falsity membership degree of x to A respectively.

Single valued neutrosophic numbers (SVN number) are denoted by $A = (a,b,c)$, where $a,b,c \in [0,1]$ and $a+b+c \le 3$.

In decision analysis schema aggregation operating are important for rating options. Some aggregation operators have been proposed for SVN numbers (Ye, 2014a). Single valued neutrosophic weighted averaging (SVNWA) operator was proposed by Ye (Ye, 2014a) for SVNSs as follows(Biswas et al., 2016):

$$F_w(A_1, A_2, \dots, A_n) = \langle 1 - \prod_{j=1}^{n}\left(1 - T_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(I_{A_j}(x)\right)^{w_j}, \prod_{j=1}^{n}\left(F_{A_j}(x)\right)^{w_j} \rangle \qquad (2)$$

Alternatives could be rated according Euclidean distance in SVN (Şahin & Yiğider, 2014; Ye, 2014b).

Definition 2: Let $A^* = (A_1^*, A_2^*, \dots, A_n^*)$ be a vector of n SVN numbers such that $A_j^* = (a_j^*, b_j^*, c_j^*)$ j=(1,2, … , n) and $B_i = (B_{i1}, B_{i2}, \dots, B_{im})$ $(i = 1,2, \dots, m)$ be m vectors of n SVN numbers such that $B_{ij} = (a_{ij}, b_{ij}, c_{ij})$ $(i = 1,2, \dots, m)$, $(j = 1,2, \dots, n)$. Then the separation measure between $B_i's$ y A^* is defined as follows:

$$s_i = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(\left|a_{ij}-a_j^*\right|\right)^2 + \left(\left|b_{ij}-b_j^*\right|\right)^2 + \left(\left|c_{ij}-c_j^*\right|\right)^2\right\}\right)^{\frac{1}{2}} \qquad (3)$$

$(i = 1,2, \dots, m)$

In this paper the concept of linguistic variables (Leyva-Vázquez, Santos-Baquerizo, Peña-González, Cevallos-Torres, & Guijarro-Rodríguez, 2016) are represented using single valued neutrosophic numbers (Şahin & Yiğider, 2014)for developing a framework to decision support.

The gathering information phase is developed using SVN numbers (Deli & Şubaş, 2016) due to the fact that provides adequate computational models to deal with linguistic information (Leyva-Vázquez et al., 2016) in decision. It allow to include handling of indeterminate and inconsistent in information system project selection.

3 Proposed framework.

Our aim is to develop a framework for information system project selection based on SVN numbers. The model consists of the following phases (figure 1).

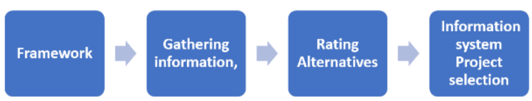

Figure 1: A framework for using SVN numbers in information system project selection

The proposed framework is composed of four activities, framework, gathering information, rating alternatives and information system project selection.

Framework

In this phase, the evaluation framework, the decision problem of information system project selection is defined. The framework is established as follows:

- C=$\{c_1, c_2, \dots, c_n\}$ with $n \geq 2$, a set of criteria.
- E=$\{e_1, e_2, \dots, e_k\}$ with $k \geq 2$, a set of experts.
- $X = \{x_1, x_2, \dots, x_m\}$ with $m \geq 2$, a finite set of information systems projects alternatives. The set of experts will provide the assessments of the decision problem.

Gathering information

In this phase, each expert, e_k provides the assessments by means of assessment vectors:

$$U^K = (v^k{}_{ij}, i = 1, . . , n, j = 1, . . , m) \quad (5)$$

The assessment v_{ij}^k, provided by each expert e_k, for each criterion c_i of each project alternative x_j, is expressed using an SVN number.

Rating alternatives

Initial aggregation process is developed for rating alternatives. The aggregated SVN decision matrix obtained by aggregating of opinions of decision makers. In our proposal the SVNWA aggregation operator used Eq. (2).

For rating alternatives an ideal project option is constructed (Leyva-Vázquez, Pérez-Teruel, & John, 2014; Şahin & Yiğider, 2014). The evaluation criteria can be categorized into two categories, benefit and cost. Let C^+ be a collection of benefit criteria and C^- be a collection of cost criteria. The ideal alternative is defined as:

$$I = \left\{\left(max_{i=1}^k T_{U_j} | j \in C^+, min_{i=1}^k T_{U_j} | j \in C^-\right), \left(min_{i=1}^k I_{U_j} | j \in C^+, max_{i=1}^k I_{U_j} | j \in C^-\right), \left(min_{i=1}^k F_{U_j} | j \in C^+, max_{i=1}^k F_{U_j} | j \in C^-\right)\right\} = [v_1, v_2, \dots, v_n] \quad (6)$$

Alternatives are rated according Euclidean distance I:

$$s_i = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(\left|T(v_{ij}) - T(v_i^I)\right|\right)^2 + \left(\left|I(v_{ij}) - I(v_i^I)\right|\right)^2 + \left(\left|F(v_{ij}) - F(v_i^I)\right|\right)^2\right\}\right)^{\frac{1}{2}}$$

$(i = 1,2, \dots, n)$ (7)

Information System Project Selection

Ranking is based in the global distance to the ideal. If alternative project x_i is closer to I the distance measure (s_i closer) better is the project alternative (Leyva-Vázquez, Pérez-Teruel, Febles-Estrada, & Gulín-González, 2013).

4 Case study

In this section, we present an illustrative example in order to show the applicability of the proposed framework for information system project selection.

In this case study the evaluation framework is compose by 2 experts E=$\{e_1, e_2\}$ who evaluate 3 alternatives(information system projects) .

x_1: CRM

x_2: ERP

x_3: SCM

These projects are described in Table #1.

TABLE I. PROJECTS OPTIONS

id	Name	Description
1	CRM.	Custumer Relation Management Software
2	ERP	Enterprise Relationship Managemet Software
3	SCM	Supply Chain Managemet Software

3 criteria are involved, which are shown below:

c_1: Benefits

c_2: Factibility

c_3: Cost

In Table 2, we give the set of linguistic terms used for experts to provide the assessments.

TABLE II. LINGUISTIC TERMS USED TO PROVIDE THE ASSESSMENTS (ŞAHIN & YIĞIDER, 2014)

Linguistic terms	SVNSs
Extremely good (EG)	(1,0,0)
Very very good (VVG)	(0.9, 0.1, 0.1)
Very good (VG)	(0.8,0,15,0.20)
Good (G)	(0.70,0.25,0.30)
Medium good (MG)	(0.60,0.35,0.40)
Medium (M)	(0.50,0.50,0.50)
Medium bad (MB)	(0.40,0.65,0.60)
Bad (B)	(0.30,0.75,0.70)
Very bad (VB)	(0.20,0.85,0.80)
Very very bad (VVB)	(0.10,0.90,0.90)
Extremely bad (EB)	(0,1,1)

Once the evaluation framework has been determined the information about the projects is gathered (see Table 3).

TABLE III. RESULT OF GATHERING INFORMATION

	e_1			e_1		
	x_1	x_2	x_3	x_1	x_2	x_3
c_1	MG	EG	MB	M	VVG	M
c_2	G	MG	M	B	MB	M
c_3	MG	MG	G	MB	MG	B

For rating project alternatives, an initial aggregation process is developed. Then the aggregated SVN decision matrix obtained by aggregating of opinions of decision makers is constructed by Eq. (2). The result is given in Table 4. The importance of each expert is expressed in the weighting vector $W = [0.7,0.3]$.

TABLE IV. AGGREGATED SVN DECISION MATRIX

	x_1	x_2	x_3
c_1	(0.57,0.39,0.43)	(1,0,0)	(0.4, 0.60,0.57)
c_2	(0.65,0.31,0.35)	(0.55,0.42,0.45)	(0.50,0.50,0.50)
c_3	(0.63,0.32, 0.37)	(0.60,0.35,0.40)	(0.61,0.35,0.47)

Calculation SVN positive-ideal solution is made as Table 5.

TABLE V. SVN POSITIVE-IDEAL VALUES

	Positive-ideal
c_1	(1,0,0)
c_2	(0.65,0.31,0.35)
c_3	(0.63,0.32, 0.37)

Separation measure of each alternative from the positive-ideal solution are calculated using Eq. (4) and are given by Table 6.

TABLE VI. DISTANCE TO THE IDEAL SOLUTION

	SVN positive-ideal	Ranking
x_1	0.42	2
x_2	0.11	1
x_3	0.61 0.37)	3

According to descending order of relative closeness coefficients values, four alternatives are ranked as: $x_2 \succ x_1 \succ x_3$.

5 Conclusions.

In recent years, neutrosophic sets and its application to multiple attribute decision making have become a topic of great importance for researchers and practitioners. In this paper a new model information system project selection based on SVN-number applied allowing the use of linguistic variables for application in in complex decisions that require multiples points of view. To demonstrate the applicability of the proposal a case study. Our approach has many application information system project selection that include indeterminacy.

Further works will concentrate extending the model for dealing with heterogeneous information (Pérez-Teruel, Leyva-Vázquez, & Espinilla-Estevez, 2013). Another area of future work is the developing of new aggregation models based on SVN numbers specially compensatory operators (Espin-Andrade, González Caballero, Pedrycz, & Fernández González, 2015) and the developing of a software tool.

References

Biswas, P., Pramanik, S., & Giri, B. C. (2016). TOPSIS method for multi-attribute group decision-making under single-valued neutrosophic environment. *Neural Computing and Applications, 27*(3), 727-737.

Calvo, T., Kolesárová, A., Komorníková, M., & Mesiar, R. (2002). Aggregation operators: properties, classes and construction methods *Aggregation Operators* (pp. 3-104): Springer.

Clemen, R. T. (1996). *Making Hard Decisions: An Introduction to Decision Analysis*: Duxbury Press.

Deli, I., & Şubaş, Y. (2016). A ranking method of single valued neutrosophic numbers and its applications to multi-attribute decision making problems. *International Journal of Machine Learning and Cybernetics*, 1-14.

Espin-Andrade, R. A., González Caballero, E., Pedrycz, W., & Fernández González, E. R. (2015). Archimedean-Compensatory Fuzzy Logic Systems. *International Journal of Computational Intelligence Systems, 8*(sup2), 54-62.

Espinilla, M., Palomares, I., Martinez, L., & Ruan, D. (2012). A comparative study of heterogeneous decision analysis approaches applied to sustainable energy evaluation. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 20*(supp01), 159-174.

Espinilla, M., Ruan, D., Liu, J., & Martínez, L. (2010). *A heterogeneous evaluation model for assessing sustainable energy: A Belgian case study.* Paper presented at the Fuzzy Systems (FUZZ), 2010 IEEE International Conference on.

Estrella, F. J., Espinilla, M., Herrera, F., & Martínez, L. (2014). FLINTSTONES: A fuzzy linguistic decision tools enhancement suite based on the 2-tuple linguistic model and extensions. *Information Sciences, 280*, 152-170.

Lee, J. W., & Kim, S. H. (2001). An integrated approach for interdependent information system project selection. *International Journal of Project Management, 19*(2), 111-118.

Leyva-Vázquez, M., Pérez-Teruel, K., Febles-Estrada, A., & Gulín-González, J. (2013). Técnicas para la representación del conocimiento causal: un estudio de caso en Informática Médica. *Revista Cubana de información en ciencias de la salud, 24*(1), 73-83.

Leyva-Vázquez, M., Pérez-Teruel, K., & John, R. I. (2014). *A model for enterprise architecture scenario analysis based on fuzzy cognitive maps and OWA operators.* Paper presented at the Electronics, Communications and Computers (CONIELECOMP), 2014 International Conference on.

Leyva-Vázquez, M., Santos-Baquerizo, E., Peña-González, M., Cevallos-Torres, L., & Guijarro-Rodríguez, A. (2016). *The Extended Hierarchical Linguistic Model in Fuzzy Cognitive Maps.* Paper presented at the Technologies and Innovation: Second International Conference, CITI 2016, Guayaquil, Ecuador, November 23-25, 2016, Proceedings 2.

Pérez-Teruel, K., Leyva-Vázquez, M., & Espinilla-Estevez, M. (2013). *A linguistic software requirement prioritization model with heterogeneous information.* Paper presented at the 4th International Workshop on Knowledge Discovery, Knowledge Management and Decision Support (EUREKA 2013), Mazatlán (Mexico).

Rivieccio, U. (2008). Neutrosophic logics: Prospects and problems. *Fuzzy sets and systems, 159*(14), 1860-1868.

Rodríguez, R. M., & Martínez, L. (2013). An analysis of symbolic linguistic computing models in decision making. *International Journal of General Systems, 42*(1), 121-136.

Şahin, R., & Yiğider, M. (2014). A Multi-criteria neutrosophic group decision making metod based TOPSIS for supplier selection. *arXiv preprint arXiv:1412.5077*.

Smarandache, F. (1999). A Unifying Field in Logics: Neutrosophic Logic. *Philosophy*, 1-141.

Zeng, S., Baležentis, T., & Zhang, C. (2012). A method based on OWA operator and distance measures for multiple attribute decision making with 2-tuple linguistic information. *Informatica, 23*(4), 665-681.

Smarandache, F. (2005). *A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrsophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability*: Infinite Study.

Vera, M., José, P., Menéndez Delgado, C. F., Gónzalez, M. P., & Vázquez, M. L. (2016). Las habilidades del marketing como determinantes que sustentaran la competitividad de la Industria del arroz en el cantón Yaguachi. Aplicación de los números SVN a la priorización de estrategias. *Neutrosophic Sets & Systems, 13*.

Wang, H., Smarandache, F., Zhang, Y., & Sunderraman, R. (2010). Single valued neutrosophic sets. *Review of the Air Force Academy*(1), 10.

Ye, J. (2014a). A multicriteria decision-making method using aggregation operators for simplified neutrosophic sets. *Journal of Intelligent & Fuzzy Systems, 26*(5), 2459-2466.

Ye, J. (2014b). Single-valued neutrosophic minimum spanning tree and its clustering method. *Journal of intelligent Systems, 23*(3), 311-324.

F. Smarandache, M. Ali, *Neutrosophic Triplet as extension of Matter Plasma, Unmatter Plasma, and Antimatter Plasma*, 69th Annual Gaseous Electronics Conference, Bochum, Germany, October 10-14, 2016, http://meetings.aps.org/Meeting/GEC16/Session/HT6.112

F. Smarandache, *Neutrosophic Perspectives: Triplets, Duplets, Multisets, Hybrid Operators, Modal Logic, Hedge Algebras. And Applications*. Pons Editions, Bruxelles, 325 p., 2017.

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