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A Knowledge-based Recommendation Framework using SVN Numbers

Roddy Cabezas Padilla[1], José González Ruiz[2], Milton Villegas Alava[3], Maikel Leyva Vázquez[4]

[1]Universidad de Guayaquil, Facultad de Ciencias Administrativas, Guayaquil Ecuador. E-mail: roddy.cabezasp@ug.edu.ec
[2]Universidad de Guayaquil, Facultad de Ciencias Matemáticas y Físicas, Guayaquil Ecuador. E-mail: jose.gonzalezr@ug.edu.ec
[3]Universidad de Guayaquil, Facultad de Ciencias Administrativas, Guayaquil Ecuador. E-mail: milton.villegasa@ug.edu.ec
[4]Universidad de Guayaquil, Facultad de Ciencias Matemáticas y Físicas, Guayaquil Ecuador. E-mail: mleyvaz@gmail.com

Abstract:

Current knowledge based recommender systems, despite proven useful and having a high impact, persist with some shortcomings. Among its limitations are the lack of more flexible models and the inclusion of indeterminacy of the factors involved for computing a global similarity. In this paper, a new knowledge based recommendation models based SVN number is presented. It includes database construction, client profiling, products filtering and generation of recommendation. Its implementation makes possible to improve reliability and include indeterminacy in product and user profile. An illustrative example is shown to demonstrate the model applicability.

Keywords: recommendation systems, neutrosophy, SVN numbers.

1 Introduction

Recommendation systems are useful in decision making process providing the user with a group of options that meet expectations [1]. Based on the information and the algorithms used to generate the recommendations,, various techniques can be distinguish [2, 3]:

Knowledge Based Recommender Systems use the knowledge about users' necessities to infer recommendations not requiring a great amount of data like another approaches [4]. They use cased based reasoning techniques frequently. In this paper, a new framework for including neutrosophic in knowledge based recommender system is presented.

This paper is structured as follows: Section 2 reviews some important preliminary concepts about Single valued neutrosophic numbers (SVN number). In Section 3, is presented a knowledge based recommendation model framework based on SVN numbers. Section 4 shows a case study of the proposed model. The paper ends with conclusions and further work recommendations.

2.2 SVN-numbers

Neutrosophy [5] is a mathematical theory developed for dealing with indeterminacy. Neutrosophy has been the base for developing new methods to handle indeterminate and inconsistent information like neutrosophic sets an neutrosophic logic [6, 7] .

The truth value in neutrosophic set is as follows [8]:

Definition 1. 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 (p) $= (T, I, F)$.

Single valued neutrosophic set (SVNS) [9] were developed with the goal of facilitate the real world applications of neutrosophic set and set-theoretic operators.

A single valued neutrosophic set (SVNS) has been defined as follows [9]:

Definition 2. Let X be a universe of discourse. A single valued neutrosophic set A over X is an object having the form:

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

where $u_A(x): X \rightarrow [0,1]$, $r_A(x) : X \rightarrow [0,1]$ and $v_A(x): X \rightarrow [0,1]$ with $0 \leq u_A(x) + r_A(x) + v_A(x): \leq 3$ 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) is denoted by $A= (a, b, c)$, where $a, b, c \in [0,1]$ and $a+b+c \leq 3$.

Euclidean distance in SVN is defined as follows[12, 13]:

Definition 3. 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, … , m) be m vectors of n SVN numbers such that $B_{ij} = (a_{ij}, b_{ij}, c_{ij})$ (i = 1,2,

… , m), (j = 1,2, … , n). Then the separation measure between B_i's y A^* is defined as follows:

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

(i = 1,2, … , m)

In this paper linguistic variables[14] are represented using single valued neutrosophic numbers [13] for developing knowledge based recommender system.

3 Proposed framework

The proposed framework is presented in Figure 1. It is based mainly on the proposal made by Cordon [15] for recommendation systems based on content/knowledge adapted to SVN numbers.

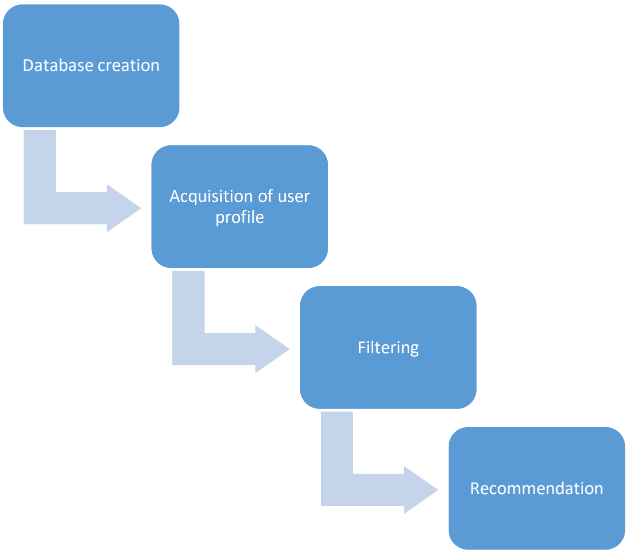

Figure. 1 Proposed framework

3.1 Database creation

A key for a recommendation model is the creation of the database. Each product a_i will be described by a set of characteristics that make up the profile:

$$C = \{c_1, \dots, c_k, \dots, c_l\} \quad (3)$$

Each product will be described by a vector of features:

$$F_{a_j} = \{v_1^j, \dots, v_k^j, \dots v_l^j\}, j = 1, \dots n \quad (4)$$

There are techniques for generating these profiles automatically or semi-automatically for recommendation systems [15]. In this case, an expert or group of experts is suggested.

Profiles of product a_j, is expressed using the linguistic scale expressed S, $v_k^j \in S$ where $S = \{s_1, \dots, s_g\}$ is the linguistic term set for evaluating the characteristic c_k using SVN. Having described the products:

$$A = \{a_1, \dots, a_j, \dots, a_n\} \quad (5)$$

Then, are stored in a database.

3.2 Acquisition of the user profile

The proposed framework presents a fundamental difference with previous proposals, it is focused in the fact that most of this information is collected using SVN numbers this information is stored in the database.

$$P_e = \{p_1^e, \dots, p_k^e, \dots, p_l^e\} \quad (6)$$

This profile will be composed of a set of attributes:

$$C^e = \{c_1^e, \dots, c_k^e, \dots, c_l^e\} \quad (7)$$

3.3 Filtering

In this activity, products according to the similarity with the user profile are filtered to find out which are the most appropriate for the student.

The similarity between user profile, P_e, product a_j is calculated. For the calculation of the overall similarity

The similarity measure can be obtained from a distance measurement, if $d(x,y)\epsilon[0, max]$ then[16] :

$$sim(p_k^e, v_k^j) = 1 - \frac{d(dp_k^e, v_k^j)}{max} \quad (8)$$

In this case similarity is calculated as follows:

$$S_i = 1 - \left(\left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(|a_{ij}-a_j^*|\right)^2+\left(|b_{ij}-b_j^*|\right)^2+\left(|c_{ij}-c_j^*|\right)^2\right\}\right)^{\frac{1}{2}}\right) \quad (9)$$

Where function S calculate similarity among user profile and products profiles [17].

3.4 Recommending

In this activity, a set of products that match with the user profiles is suggested. After calculating the similarity products are ordered and represented with the following similarity vector:

$$S = (s_1, \dots, s_n) \quad (10)$$

The best is that best meet the needs of the user profile (greater similarity).

4 Case study

To show the applicability of the model, a case study is developed.

Initially a database of products is created:

$$A = \{a_1, a_2, a_3, a_4, a_5\}$$

described with the following attributes:

$$C = \{c_1, c_2, c_3, c_{4,}, c_5\}$$

Attributes are evaluated in the linguistic scale show in Table 1 and stored in the database.

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)

Table 1. Linguistic terms used to provide the assessments [13].

Database used in this example is shown in Table 2.

	c_1	c_2	c_3	c_4
a_1	MDB	M	MMB	B
a_2	B	MD	MB	M
a_3	MMB	M	M	B
a_4	M	B	MMB	B

Table 2: Products database.

If user u_e, wish to receive recommendation expressing his/her preferences in this case:

$$P_e = \{\text{MDB}, \text{MB}, \text{MMB}, \text{MB}\}$$

The next step in this case is the calculation of similarity between user profile and products profiles stored in database.

a_1	a_2	a_3	a_4
0.44	0.76	0.42	0.84

Table 3: Similarity calculation

A ranking of products based on similarity calculation is:

$$\{a_4, a_2, a_1, a_3\}$$

In case that the recommendation of two products was needed it is as follows:

$$a_4, a_2$$

This example shows the applicability of the proposal

5 Conclusions

In this paper, a product recommendation model was presented following the knowledge-based approach. It is based on the use of SVN numbers to express linguistic terms.

Future work will be related to the creation of the database from multiple experts, as well as obtaining the weights of the characteristics using group evaluations. In addition, we will work on the integration of more complex aggregation models, as well as hybridization with other models of recommendation.

References

1. Leiva, J.L., et al., *Realidad aumentada y sistemas de recomendación grupales: Una nueva perspectiva en sistemas de destinos turísticos.* Estudios y perspectivas en turismo, 2014. **23**(1): p. 40-59.
2. Dietmar Jannach, *Tutorial: Recommender Systems*, in *International Joint Conference on Artificial Intelligenc e Beijing, August 4, 2013*. 2013.
3. Cordón, L.G.P., *Modelos de recomendación con falta de información. Aplicaciones al sector turístico*. 2008, Universidad de Jaén.
4. Aggarwal, C.C., *Knowledge-based recommender systems*, in *Recommender Systems*. 2016, Springer. p. 167-197.
5. Smarandache, F., *A Unifying Field in Logics: Neutrosophic Logic.* Philosophy, 1999: p. 1-141.
6. Smarandache, F., *A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrsophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability*. 2005: Infinite Study.
7. Vera, M., et al., *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, 2016. **13**.
8. Rivieccio, U., *Neutrosophic logics: Prospects and problems.* Fuzzy sets and systems, 2008. **159**(14): p. 1860-1868.
9. Wang, H., et al., *Single valued neutrosophic sets.* Review of the Air Force Academy, 2010(1): p. 10.
10. Ye, J., *A multicriteria decision-making method using aggregation operators for simplified neutrosophic sets.* Journal of Intelligent & Fuzzy Systems, 2014. **26**(5): p. 2459-2466.
11. Biswas, P., S. Pramanik, and B.C. Giri, *TOPSIS method for multi-attribute group decision-making under single-valued neutrosophic environment.* Neural computing and Applications, 2016. **27**(3): p. 727-737.
12. Ye, J., *Single-valued neutrosophic minimum spanning tree and its clustering method.* Journal of intelligent Systems, 2014. **23**(3): p. 311-324.
13. Şahin, R. and M. Yiğider, *A Multi-criteria neutrosophic group decision making metod based TOPSIS for supplier selection.* arXiv preprint arXiv:1412.5077, 2014.
14. Leyva-Vázquez, M., et al. *The Extended Hierarchical Linguistic Model in Fuzzy Cognitive Maps*. in *Technologies and Innovation: Second International Conference, CITI 2016, Guayaquil, Ecuador, November 23-25, 2016, Proceedings 2*. 2016. Springer.

15. Nunes, M.A.S., S.A. Cerri, and N. Blanc. *Towards user psychological profile*. in *Proceedings of the VIII Brazilian Symposium on Human Factors in Computing Systems*. 2008. Sociedade Brasileira de Computação.

16. Bonillo, M.L., *Razonamiento Basado en Casos aplicado a Problemas de Clasificación*. 2003, Universidad de Granada.

17. Pérez-Teruel, K., M. Leyva-Vázquez, and V. Estrada-Sentí, *Mental Models Consensus Process Using Fuzzy Cognitive Maps and Computing with Words.* Ingenieria y Universidad, 2015. **19**(1): p. 7-22.

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