

Data Science based Recommendation System -An Application of Computer Science

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Abstract— Recommender system (RS) has emanated as the most popular application of e-commerce websites. In the e-commerce business, collaborative filtering based RS systems suggest products to the customers and find the interesting things for the users which they may wish to purchase. The success rate of any recommendation system depends upon, information reliability as well as expression of daily life behavior in the consolidated format. The main task is to produce the best ranked list of ‘n-number’ of items for the user’s need. Due to the natural structure, Z-Numbers are more consistent to producing a recommendation list. To solve real life problem, Z-Numbers should be incorporated into decision-making models. However, Online shopping involved multicriteria group decision-making (MCGDM). Z-information persisting some difficulties with MCGDM. Therefore, to enhancing the ability of Z-numbers Complex Fuzzy Sets (CFSs), are employed. Besides this entropy, distance measure, and aggregation operator are combined to produced MCGDM based ranking of customer preference.

Index Terms— Fuzzy Set, Linguistic Variables, Z-Numbers, Recommendation System.

I. INTRODUCTION

Data Science is one of the fastest growing fields under the umbrella of Computer Science. Moreover, Recommendation System is a co-domain of Data Science that is used by various e-commerce websites like Amazon, Flipkart, Netflix, and so on. It helps in presenting relevant products in front of user to increase the sale and customer base. However, it is not so easy to plot precise mapping of products and priority or choice of customer. The main reasons include the limited knowledge of decision-makers, lack of evaluation time, and insufficient understanding of alternatives. The success rate of any recommendation system depends upon, information reliability as well as expression of daily life behavior in the consolidated format. Z-numbers have been proven to be advantageous in revealing uncertain information. In 2011 Zadeh [1] proposed the concept of Z-numbers. In this article improved Z-numbers are applied to harness the Recommendation System. Considering that various uncertain data are inevitable in the process of addressing actual problems, uncertain Z-numbers are to express information and measure information reliability.

Generally accepted, linguistic description is more consistent with the daily expression [1]. However, there are still some difficulties limiting the applications. Like the calculation process in Z-Numbers is a typical nonlinear programming problem, which will inevitably lead to the problem of complicated calculation. Therefore, to enhancing the ability of Z-numbers Complex Fuzzy Sets (CFSs), are employed. Besides this entropy, distance

measure, and aggregation operator are combined to produced MCGDM based ranking of customer preference. Collaborative filtering systems help in automatically locating relevant opinions and aggregating them to provide recommendations. The main task is to present the best ranked list of 'n' number of items for the user's need. Clustering the preferred item's set and recommend the prioritized list are two major tasks of Collaborative filtering based Recommendation System. A preference expressed by a user for an item can be represented by a triplet (User, Item, Rating). Due to the difficult-to-quantify nature of evaluation, experts intend to describe the evaluation information with natural language like slightly good, good, very good, extremely good.

Z-Number is more suitable demonstrated more support to express mundane task [2], [3]. Besides this interval valued fuzzy sets and intuitionistic linguistic numbers are applied in [4], [5], [6] to express information with more reliability. Therefore "Z-Numbers" attract the attention of researchers in the domain of multifold group decisions [7], [8], control theory [9], [10], and cluster [11].

However, the calculation process is a typical nonlinear programming problem, which will inevitably lead to the problem of complicated calculation Aliev et al. [13], [14] defined the operations of discrete and continuous Z-numbers. Liu et al. [15] suggested the negation of discrete Z-numbers. To further enrich the related research, Z-numbers have also been tried to combine with other mature theories. In [16] and [17], Z-triplet is utilized to express the normal cloud model and the trapezium cloud model with linguistic terms.

Z-numbers employed to update the Bayesian network, VIKOR model, and TOPSIS model in [12],[18] and [19] respectively. In previous study a gap is found to express decision making problem which are based on two or more criteria. Hence there is requirement of harnessing the improved version of existing Z-Numbers.

The rest of this article is organized as follows. In Section II, some fundamental concepts are introduced along with transformation method between Z-numbers and CFSs. In Section III, IVZCFS method validated using proposed algorithm. Finally, Section VII concludes this paper.

II. FUNDAMENTALS

A. Z-numbers

Z-numbers are improved to uncertain Z-numbers. By utilizing an interval concept instead of a specific concept to characterize the fuzzy constraint and reliability. Typically, a Z-number is composed of A and B, recorded as $Z = (A, B)$. The parameters A and B represent the fuzzy constraint and reliability, respectively. The two components are connected by the underlying possibility distribution (UPD). For example User e1 is very certain, that product a1 is good based on a criteria c1" can be transformed into $Z = ("good," "very certain")$.

Usually, the determination of UPD is a problem. In 2002, the concept of complex fuzzy sets (CFSs) was defined by Ramot et al. [20]. It is an extension of type-1 fuzzy sets, in which the codomain of the membership function is the unit disc. A brief description of CFS is given in next subsection.

B. Complex Fuzzy Sets

Assumed that S is CFS in an universe of discourse U, then $S = \{(x, \mu_s(x)) | x \in U\}$

where $\mu_s(x) = r_s(x) \cdot e^{j\omega_s(x)}$, $r_s(x) \in [0, 1]$, $\omega_s(x) \in [0, 2\pi]$, $j = \sqrt{-1}$.

C. Uncertain Z-Numbers

In [17] Z-numbers were combined with Atanassov's interval-valued intuitionistic linguistic fuzzy sets to formalized "uncertain Z-numbers".

$$IVZ = ((\text{very good}, [0.6, 0.8]), (\text{uncertain}, [0.7, 0.8])).$$

Expression can be represented by pair of bounded interval $IVZ = ([Sa^-, Sa^+], [Hb^-, Hb^+])$, where Sa^- and Sa^+ represent the upper and lower bounds of linguistic constraint, respectively. Hb^- and Hb^+ indicate the upper and lower bounds of reliability, respectively.

The aim of IVZ is to better represent the fuzzy constraint and reliability. IVCFSs

$I_s = [r_s^-(x), r_s^+(x)] \cdot e^{j[\omega_s^-(x), \omega_s^+(x)]}$ can also achieve the aim. $r_s^-(x)$ and $r_s^+(x)$ represent the upper and lower bounds of amplitude term, respectively. $\omega_s^-(x)$ and $\omega_s^+(x)$ indicate the upper and lower bounds of phase term, respectively.

The theme of 'IVZ', state that "interval concept is more appropriate than a specific concept to characterize the fuzzy constraint and reliability, e.g. {anticipated budget deficit, between 1.8 and 2.2 million dollars, likely, very likely}

D. Transformation From Uncertain Z-Numbers to IVCFSs:

Z- numbers are expressed by triplet (Z,A,B) [1] to make information more expressive and reliable A and B were projected into interval rather than specific in uncertain Z-numbers. To express IVZ in IVCFSs, the membership variables of $[S_{a-}, S_{a+}]$ and the probabilistic variables of $[H_{b-}, H_{b+}]$ are represented by $r_s^-(x)$ and $r_s^+(x)$ and $\omega_s^-(x)$, and $\omega_s^+(x)$ respectively by using definition (1).

Definition 1: Given two Linguistic Term Set S and H,

where $S = \{S_0, S_1, \dots, S_E | E \in \mathbb{N}\}$ and $H = \{H_0, H_1, \dots, H_F | F \in \mathbb{N}\}$,

for $([S_{a-}, S_{a+}], [H_{b-}, H_{b+}])$, and for $J_s = [r_s^-(x), r_s^+(x)] * e^{j[\omega_s^-(x), \omega_s^+(x)]}$

using $r_s^-(x), r_s^+(x) \in [0,1]$ and $\omega_s^-(x), \omega_s^+(x) \in [0, 2\pi]$

E. Generalized Entropy

Entropy, an essential concept in thermodynamics and information theory, is usually adopted to measure the chaos of a system. Scholars have proposed many entropy calculation methods for classical fuzzy sets [21]. As far as we know, however, there is no approach to calculate the entropy of Z-numbers from the perspective of CFSs. generalized entropy $E_g(J)$ is defined as equation (2).

$$E_g(J) = 1 - \left[\frac{1}{2} (|r_s^-(x) + r_s^+(x) - 1|^p + \frac{1}{2\pi} |\omega_s^-(x) + \omega_s^+(x) - 2\pi|^p) \right]^{1/p} \quad (2)$$

In literature various ordered weighted operators are reported, among them the entropy weight method (EWM) preserved the objective. Moreover, EWM is high reliability and convenience [22]. Therefore a weight calculation method is employed based on generalized entropy based equation (2). Equation (1) $J_s = [r_s^-(x), r_s^+(x)] * e^{j[\omega_s^-(x), \omega_s^+(x)]}$ is adopted to derive the weight of each criterion. The weight vector $\{w_1, w_2, \dots, w_n\}$ is derived as ,

$$w_i = \frac{1 - E_g(J_i)}{\sum_{k=1}^n [1 - E_g(J_k)]} \quad (3)$$

where $\{i = 1, 2, \dots, n\}$,

F. Aggregation Operator

Interval-valued complex fuzzy sets power weighted average (IVCFSsPWA)) is used in the process of information fusion is proposed.

Definition 2: Assume that $J_s = [r_s^-(x), r_s^+(x)] * e^{j[\omega_s^-(x), \omega_s^+(x)]}$ $\{i=1,2, 3, \dots, n\}$.

The integrated J is given by equation (4).

$$J = IVCFSsPWA(J_1, J_2, \dots, J_n) = J_1 \oplus J_2 \oplus \dots \oplus J_n \quad (4)$$

Where Integration Operation is given by equation (5)

$$J_1 \oplus J_2 = [1 - \prod_{i=1}^n (1 - r_i^-)^{w_i}, 1 - \prod_{i=1}^n (1 - r_i^+)^{w_i}] \cdot e^{j[2\pi(1 - \prod_{i=1}^n (1 - (\omega_i^- / 2\pi))^{\omega_i}), 2\pi(1 - \prod_{i=1}^n (1 - (\omega_i^+ / 2\pi))^{\omega_i})]} \quad (5)$$

G. Distance Measure and Similarity Measure

The distance and similarity measure between J_1 and J_2 is calculated by equation (6) and (7) respectively.

$$D(J_1, J_2) = \frac{1}{4} (|r_2^-(x) - r_1^-(x)| + |r_2^+(x) - r_1^+(x)| + \left| \frac{\omega_2^-(x) - \omega_1^-(x)}{2\pi} \right| + \left| \frac{\omega_2^+(x) - \omega_1^+(x)}{2\pi} \right|) \quad (6)$$

$$S(J_1, J_2) = 1 - \frac{1}{\sqrt{2}} \left(\left(\frac{r_1^-(x) + r_1^+(x)}{2} - \frac{r_2^-(x) + r_2^+(x)}{2} \right)^2 + \left(\frac{\omega_1^-(x) + \omega_1^+(x)}{4\pi} - \frac{\omega_2^-(x) + \omega_2^+(x)}{2\pi} \right)^2 \right)^{1/2} \quad (7)$$

III. PROPOSED SYSTEM

In the real-time online users may either drop the idea of shopping or divert to another e-shopping cart due to following reasons . Limited knowledge of decision-makers, lack of evaluation time, and insufficient understanding of other products. That triggered pop up best products in millisecond based on Z-information.

Therefore to satisfy multicriteria decision making in collaborative filtering based recommendation uncertain Z-numbers are with improved version in proposed algorithm.

Steps

- (i) : Attain the IVCFSs of evaluation information as shown in Table1.
- (ii) : Estimate weight vector.
- (iii) : Obtain collective evaluation information.
- (iv) Calculate the positive and negative distances (D_p) and (D_n) between alternatives and ideal solutions.
- (v) : Generate a non- decreasing order of list of products based on matching of customer query.

The evaluation information is displayed in Table I, II, and III for attributes c_1, c_2, c_3 , and c_4 .

TABLE I EVALUATION INFORMATION FOR E1

	c4(lips and chin)	c3(eyes)	c2(nose)	c1(forehead)
f1	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }
f2	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, very large, extremely uncertain, very certain }
f3	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }
f4	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }

TABLE II EVALUATION INFORMATION FOR E2

	c4(lips and chin)	c3(eyes)	c2(nose)	c1(forehead)
f1	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }
f2	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, very large, extremely uncertain, very certain }
f3	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }
f4	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }

TABLE III EVALUATION INFORMATION FOR E3

	c4(lips and chin)	c3(eyes)	c2(nose)	c1(forehead)
f1	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }
f2	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, very large, extremely uncertain, very certain }
f3	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }
f4	{ slightly-large, large, certain, extremely certain }	{ small, slightly small, uncertain slightly uncertain }	{ extremely small, very large, slightly certain, certain }	{ slightly small, slightly large, extremely uncertain, certain }

VI. EXPERIMENTS

During the online shopping displaying specific set of products in first few seconds play extremely important role to attract customer attention. Recommendation of best suited products are based on profile building features of Collaboration filtering. Besides this, produce a list of products with decreasing order of taste, may be helpful in printing good impression in customer memory. Customer, always want to choose the most suitable brand of the product based on their needs. Suppose that customer wants to select one from four brands a_1, a_2, a_3 , and a_4 . For the sake of prudence, a group of three online users e_1, e_2 , and e_3 evaluate the options from four aspects, including the physical appearance (c_1), color combination (c_2), performance (c_3), and price (c_4) among the brands a_1, a_2, a_3 , and a_4 . Assuming that the Linguistic Term Sets (LTSs) are $H = \{h_0 = \text{extremely terrible}, h_1 = \text{very terrible}, h_2 = \text{terrible}, h_3 = \text{slightly terrible}, h_4 = \text{slightly good}, h_5 = \text{good}, h_6 = \text{very good}, h_7 = \text{extremely good}\}$ and $S = \{s_0 = \text{extremely uncertain}, s_1 = \text{very uncertain}, s_2 = \text{uncertain}, s_3 = \text{slightly uncertain}, s_4 = \text{slightly certain}, s_5 = \text{certain}, s_6 = \text{very certain}, s_7 = \text{extremely certain}\}$.

A. Results

Table IV, V, and VI consist of evaluation information in the form of IVCFSs. After calculating the weight vector of criteria for user e_1, e_2 , and e_3 , estimated collective evaluation information with aggregation operator is shown in Table VI. Besides these distances between alternatives and ideal solutions distances D_p and D_n are estimated. Besides this Table VII is displaying ranking of all alternatives in decreasing order of preference. Hence the order of displaying of face sketch can follow the estimated sequence to achieve better impression.

TABLE IV INPUTS ARE IN IVCFS FOR E1

	c1	c2	c3	c4
a1	(0.43,0.57,0.90,4.49)	(0.14,0.86,3.59,4.49)	(0.29,0.43,1.79,2.69)	(1.79,2.24,4.49,6.28)
a2	(0.14,0.29,1.79,2.69)	(0.71,1,3.59,5.38)	(0.29,0.57,1.79,4.49)	(0.43,0.71,3.59,6.28)
a3	(0.29,0.43,0.90,1.79)	(0.71,0.86,0.90,4.49)	(0.71,1,2.69,3.59)	(0.57,0.71,0.90,1.79)
a4	(0.43,0.57,2.69,4.49)	(0.14,0.71,0.90,1.79)	(0.86,1,1.79,2.69)	(0.43,0.57,2.69,3.59)

TABLE V INPUTS ARE IN IVCFS FOR E2

	c1	c2	c3	c4
a1	(0.28,1,2.690,6.28)	(0.42,0.57,0.89,4.48)	(0.14,0.85,1.79,3.49)	(1.39,0.854,3.58,3.58)
a2	(0.14,0.28,1.79,3.58)	(0.14,0.28,1.79,2.69)	(0.710,1,1.79,2.69)	(0.73,1,1.79, 2.62)
a3	(0.14,1,0.89,3.58)	(0.28, 0.42, 0.89, 1.79)	(0.714,0.85,2.69,1.79)	(0.71,0.89,0.90,1.79)
a4	(0.14,0.28, 3.58, 6.28)	(0.42,0.57,2.69,4.49)	(0.14,0.71,1.79,4.49)	(0.14,0.71,2.69,4.48)

TABLE VI INPUTS ARE IN IVCFS FOR E3

	c1	c2	c3	c4
a1	(0.43,0.57,0.90,4.49)	(0.14,0.86,3.59,4.49)	(0.29,0.43,1.79,2.69)	(1.79,2.24,4.49,6.28)
a2	(0.14,0.29,1.79,2.69)	(0.71,1,3.59,5.38)	(0.29,0.57,1.79,4.49)	(0.43,0.71,3.59,6.28)
a3	(0.29,0.43,0.90,1.79)	(0.71,0.86,0.90,4.49)	(0.71,1,2.69,3.59)	(0.57,0.71,0.90,1.79)
a4	(0.43,0.57,2.69,4.49)	(0.14,0.71,0.90,1.79)	(0.86,1,1.79,2.69)	(0.43,0.57,2.69,3.59)

TABLE VII RANKING OF ALL BRANDS

	a1	a2	a3	a4
e1	0.54	0.66	0.61	0.62
e2	0.65	0.57	0.58	0.44
e3	0.62	0.56	0.61	0.53
Ø	0.62	0.58	0.59	0.55
Ranking	a1> a3> a2> a4			

III. CONCLUSIONS

Even though Z-Numbers is a naive concept just introduced in 2011, and it is in preliminary stage. Besides this it's an effective tool to develop MCGDM. E-Commerce website using recommendation system to help online customers in purchasing daily life commodities. Therefore, an improved version of Z-Numbers i.e. IVZ is applied along with CFS. In this paper IVCFS TECHNIQUE is adopted to handle uncertain Z-numbers. The support of CFS is unrestricted and may include real numbers, daily households, accessories, moreover provides feasibility of interpreting information expression uncertainty and reliability. Therefore, CFS base IVZ is used to ranked and recommend certain set of preferred items.

Generalized entropy, distance measure, and aggregation operator are applied proposed recommendation system., which is ultimately producing a ranking of favorite products from high to low. The limitation of presented work is high degree of dependency of evaluation information from different sects of users.

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