Neutrosophic Sets and Systems
{Special Issue: Impact of Neutrosophy in solving the Latin American's social problems}, Vol. 37, 2020
University of New Mexico

Knowledge-based Hiring Recommender Model for Occasional Services in the Public Sector

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Abstract. Public employees often provide their services under contract for occasional services. This form of employment relationship may undergo the consequences of job instability. Classifying occasional job profiles allows us recommending new jobs for those who suffer from job instability. This research proposes a solution to the posed problem by using a Neutrosophic method to determine job profiles of people for the occasional service contract recommendation in the public sector. Ordered Weighted Averaging Distance (OWAD) operator is proposed for aggregation of similarities measures.

Keywords: Single-valued neutrosophic sets, job stability; hiring of public services, OWAD

1. Introduction

In the workplace, workers deal with different forms of hiring. The contract represents the legal support that guarantees the main rights of the people [1, 2]. Among the contractual relationships that can be contracted are services through indeterminate contracts and occasional contracts [3, 4]. The contracts favor labor relations where consequences of labor instability may be experienced [5, 6].

When starting an employment relationship, a set of public order and legal regulations are established. Relationships are caused by self-employment and under the dependence of others in order to guarantee to those who carry out their full development as a human person and to the community the effective integration of the individual in the social body and the regulation of conflicts between the subjects of those relationships [7-9].

Many people live on occasional contracts. Sometimes people spend part of their time looking for new job offers [10]. Knowing the profiles of skills associated with people would guarantee the hiring recommendation for occasional services [11, 12].

Paradoxism is an international movement in science and literature, created by Florentin Smarandache in the 1980s. It is based on disproportionate use of antitheses, oxymoron, contradictions, and paradoxes [13]. During three decades (1980-2020) authors from tens of countries around the globe contributed papers to international anthologies [14].

In 1995, Smarandache extended the Paradoxism to a new branch of philosophy called Neutrosophy that originated many scientific concepts and theories, such as: neutrosophic logic, neutrosophic set, neutrosophic probability and statistics, neutrosophic statistics, neutrosophic sociology and so on, with multiple applications in engineering, computer science, administrative work, medical research etc. [15].

This research aims to develop a neutrosophic method to determine job profiles of people for the recommendation of the occasional services contract in the public sector.

The paper is divided into the following sections: Section 2 is dedicated to the preliminaries concepts of neutrosophic sets, and OWAD operators. In section 3, we propose a method to hire people in occasional services for the public sector. Section 4 contains the results applied to an example. We finish the paper with the conclusions.

2. Preliminaries

This section introduces the main elements that facilitate the analysis and understanding of the proposed solution. We present the main theoretical references used for the development of the proposed method and characterize the elements associated with job stability and occasional services contracts.

2.1 Job stability and occasional service contract.

Contracts for Occasional Services in the Public Sector (COSPS), it is the modality that covers the occasional work granted to public servants temporarily, contained in article 17 of the COSPS, that classifies appointments, in permanent and provisional. Regarding provisional appointments, COSPS makes a sub classification: "Art. 17.- Appointment Classes for the exercise of the public function, the appointments may be: Permanent, provisional, those that are issued to occupy"[16-18].

Likewise, provisional appointment will be granted to those who were promoted, which will be evaluated within a maximum period of six months, through a technical and objective evaluation of their services and if it is determined after this evaluation that who does not qualify for the performance of the position, he/she will be reinstated to the previous position with his/her previous remuneration [19-21].

2.1 OWA operator

First of all we describe the main concepts of neutrosophic set theory.

Definition 1 ([22-24]): The neutrosophic set N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A and falsehood-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq \,]^-0, 1^+[$ and $^-0 \leq inf\ T_A(x) + inf\ I_A(x) + inf\ F_A(x) \leq sup\ T_A(x) + sup\ I_A(x) + sup\ F_A(x) \leq 3^+$.

Note that, according to the definition, $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x)$, $I_A(x)$ and $F_A(x)$ can be subintervals of $[0, 1]$. $^-0$ and 1^+ belong to the set of hyper-real numbers.

Definition 2 ([20]): The Single Valued Neutrosophic Set (SVNS) N over U is $A = \{< x, T_A(x), I_A(x), F_A(x) > : x \in U\}$, where $T_A: U \to [0, 1]$, $I_A: U \to [0, 1]$ and $F_A: U \to [0, 1]$. $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The Single Valued Neutrosophic number (SVNN) is represented by

N = (t, i, f), such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Aggregation operations are mathematical functions used in decision-making processes and information fusion process [25, 26] for aggregating values (x, y) in a domain D and to return a single value.

Among the main operators for information aggregation we have the arithmetic mean and weighted arithmetic mean operator [27, 28]:

Definition 3. The WA operator has an associated vector of weights w, with $w_i \in [0,1]$ and $\sum_1^n w_i = 1$, which are expressed as follows:

$$WA(a_1, .., a_n) = \sum_{i=1}^{n} w_i a_i \tag{1}$$

Where w_i represents the importance of the source a_i

An information aggregation operator Ordered Weighted Averaging [29], allows us to unify the classic criteria of uncertainty decision in an expression [30].

Definition 4. An OWA operator is a function $F: \mathbb{R}^n \to \mathbb{R}$, of dimension n if it has an associated vector *W* of dimension n with $w_j \in [0, 1]$ and $\sum_{j=1}^{n} w_j = 1$, so that:

$$F(a_1, a_2, \dots, a_n) = \sum_{j=1}^{n} w_j b_j \tag{2}$$

Where b_j is the greatest j-th of the a_j.

Each family of operators is used in different contexts. There are several aggregation operator formulations that unify the WA and OWA operators combining the advantages of both [31, 32].

Another extension is the OWA operator based on distance (OWAD)[33].

Definition 5: An OWAD operator of dimension n is a mapping OWAD: $\mathbb{R}^n \times \mathbb{R}^n \to \mathbb{R}$ that has an associated weighting vector W with $\sum_{j=1}^{n} w_j = 1$ and it is defined as follows:

$$\mathrm{OWAD}(\langle x_1, y_1\rangle, \ldots, \langle x_n, y_n\rangle) = \sum_{j=1}^{n} w_j d_j \quad (3)$$

where d_j is the jth largest distance between x_i and y_i are the ith argument of the sets X and Y, respectively. In this case the Euclidean distance between single-valued neutrosophic numbers (SVNNs) are used:

$$d(X,Y) = \sqrt{(T_x - T_y)^2 + (I_x - I_y)^2 + (F_x - F_y)^2} \quad (4)$$

The OWAD operator can provide a parameterized family of distance aggregation operators between the minimum and the maximum giving greater flexibility to the process.

3. Design of the method for hiring people in occasional services for the public sector

The proposed method consists of three stages: input, inference, and output. The inference process is guided by management in three components: selection of profiles, evaluation of alternatives and selection of the knowledge base of the similarity profile.

Figure 1 shows a diagram with the general operation of the proposed method.

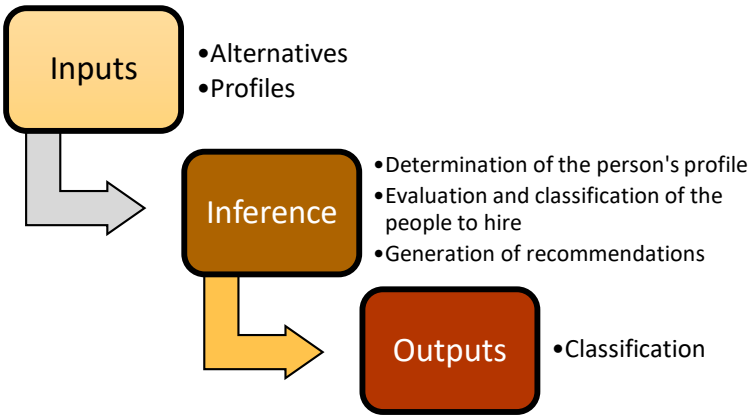

Figure 1. General diagram of the method's operation.

The proposed method bases its operation on the knowledge management proposal for knowledge-based recommendation systems of Cordón in [34-36]. The proposal allows to represent through linguistic terms and model uncertainty from Single Value Neutrosophic Numbers [37-40].

Figure 2 shows a diagram with the workflow of the inference process.

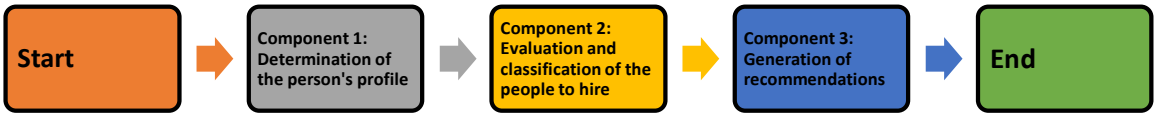

Figure 2. Diagram of the inference process workflow**.**

Figure 2 summarizes the workflow of the inference process of the proposed method. Below is a detailed description of the components of the method.

Component 1: Creation of the database with the profiles of the people

For the creation of people's profiles, a description of personal characteristics is made. Each person a_i is described through the finite set of details about each person, forming the personal profile.

$C = \{c_1, \dots, c_k, \dots, c_l\}$

Profiles form a characterization of people. They can be obtained through structured interviews with people or in a direct automated way with the use of computational algorithms used to capture people's data: $F_{a_j} = \{v_1^j, anv_k^j, \dots v_l^j\},\ j = 1, \dots, n.$

The evaluations of the characteristics of the people a_j, will be expressed using the linguistic scale S, $v_k^j \in S$ where $S = \{s_1, \dots, s_g\}$ is the set of linguistic terms defined to evaluate the characteristic c_k using the SVN numbers [41-43]. The linguistic terms to be used are defined [44].

The alternatives of the process are associated with the set of characteristics that describe people.

$A = \{A_1, = eA_j, = eA_m\}$

Personal profiles are stored in a database that contains knowledge about the different alternatives of the process. This information is subsequently retrieved.

Component 2: Evaluation and classification of the people to hire

The component starts from the determination of the information of people that is stored in a profile [45, 46], so that:

$P_e = \{p_1^e, \dots, p_k^e, \dots, p_l^e\}$

The profile is made up of a set of attributes that characterize people:

$C^e = \{c_1^e, \dots, c_k^e, \dots, c_l^e\}$

Where $c_k^e \in S$.

This can be obtained through a conversational approach, which can be adapted to increase the precision of the process [37, 47, 48].

Subsequently, people are filtered according to the stored profile to find which are the most appropriate according to their characteristics.

For this purpose, the similarity between the profiles of people is calculated, $P_e$and each available A_j profile registered in the database. We used OWA operator based on distance (OWAD).

The following expression is used to calculate the total similarity [49-51]:

$$S_j = 1 - OWAD(P_e, A_j) \tag{5}$$

The S function calculates the similarity between the values of the attributes of the people profile and those stored a_j [8, 38, 52].

Component 3: Generation of recommendations

This component is the part of the method that yields the result of the proposed inference. The similarity between the profile of the people and those stored in the database is calculated [40, 45]. Once the similarity determination process has been carried out, the resulting profiles are ordered. The similarity obtained is represented by a similarity vector [53, 54].

$$S = (s_1, \dots, s_n) \tag{6}$$

The recommendation component is designed to generate the best recommendation in response. The best recommendation is considered to be those that best fit the needs of the person's profile, mathematically the greatest similarity.

4. Application of the method for hiring people in occasional services for the public sector

This section describes the implementation of the proposed method to hire people in occasional services for the public sector. As a result of the present investigation, the proposed method was coded using a computational system that allows managers to control and process the method.

The tool allows obtaining reliable data. For the application of the proposal, we start with the set of data stored in several Human Resources departments of public institutions with different alternatives. Below there is a demonstrative example in which a manager starts from the database of his/her own:

$$A = \{A_1, A_2, A_3, A_4, A_5, A_6, A_7, A_8, A_9, A_{10}\}$$

Which is described by the attribute set as follows:

$$C = \{c_1, c_2, c_3, c_4, c_5, c_6, c_7\}$$

Attributes will be assessed on the following linguistic scale (Table 1). These ratings will be stored in the database.

Linguistic term	SVN numbers
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 (MDG)	(0.60,0.35,0.40)
Medium (M)	(0.50,0.50,0.50)
Medium bad (MDB)	(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 [55].

Table 2 shows a view with the data used in this example.

	c_1	c_2	c_3	c_4	c_5	c_6	c_7
A_1	VVG	MDG	VVG	M	VVG	VVG	G
A_2	VG	G	VG	MDG	VG	VVG	VG
A_3	G	VVG	M	M	G	VG	M
A_4	VVG	M	VVG	G	VVG	MDG	VVG
A_5	VG	G	VG	MDG	VG	MDG	VG
A_6	VG	G	VG	MDG	VG	VG	VG
A_7	G	VVG	B	B	G	G	B
A_8	VVG	B	VVG	G	VVG	M	VVG
A_9	VG	G	VG	MDG	VG	VG	VG
A_{10}	VVG	B	VVG	G	VVG	MDG	VVG

Table 2. Database of personal profiles.

If a person u_e, wishes to receive the recommendations of the system, they must provide information about his/her personal profile. In this case:

$$P_e = \{VG, VVG, MDG, VG, VG, VVG, MDG\}.$$

The next step in our example is to calculate the similarity between the personal profile and the profiles stored in the database. Table 3 shows similarity between the stored profiles and the personal profile using the OWAD operator with weighting vector to avoid extreme values [56],

W=[0.10, 0.10, 0.20, 0.20, 0.20, 0.10, 0.10]

A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
0.82	0.86	0.9	0.76	0.82	0.85	0.79	0.73	0.85	0.74

Table 3. Similarity between stored profiles and personal profile

In the recommendation phase, the profile closest to the personal profile would be recommended. An ordering of the profiles based on this comparison would be as follows.

$$A_3 \succ A_2 \succ A_6 \approx A_9 \succ A_1 \approx A_5 \succ A_7 \succ A_4 \succ A_{10} \succ A_8$$

If the system recommends the two best profiles, these would be the recommendations:

$$A_3, A_2$$

The application of the recommendations provides a neighborhood closest to the comparative profile for the example in question, the solution is A_3.

The demonstrative example allowed to run an example with 10 profiles of workers to process. It is important to note that the larger the knowledge base, the more accurate the recommendation will be. The knowledge base can be feed with more criteria and people that make up a proposal for greater dissemination and another linguistic scales based on SVN number could be defined [57].

Conclusions

The present investigation described the implementation of a method to hire people in occasional services for the public sector. The implemented method allows managers to obtain personal profiles that characterize people for subsequent hiring. The application of the proposal starts from the historical data set that several Human Resources departments of public institutions have for the successive hiring recommendation. The use of OWAD operator gives more flexibility to the process.

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Received: March 28, 2020. Accepted: July 30, 2020