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A Novel Intellectual Decision Support Model of Careers based on Semantic Spaces

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Abstract: This paper presents a new intellectual support model to evaluate the conditions of career choice for university graduates. This model is based on academic progress, intelligence and personal characteristics of university graduates. The proposed model is based on expert (employers) opinions about the importance of each characteristic for successful career. The Scientific novelty of this model is that the authors do not handle numeric values of the characteristics, but formalize them with the help of semantic spaces COSS because according to the properties of COSS each term has at least one typical representative and each point of universal set has at least one term. COSS allows handling characteristics correctly and getting sustainable final result. The efficiency of the proposed new model has been tested with numerical example to demonstrate that the developed model can be used successfully.

Keywords: decision making, intellectual model, semantic spaces, COSS, career, university graduates characteristics, linguistic values of characteristics, fuzzy opinion

1 Introduction

Nowadays a specialist should have a wide experience about his profession and be qualified enough at least in adjacent to his main profession spheres. Besides, he should combine special knowledge, creativity and personal qualities. Modern society requires specialists that are capable of making decisions independently and that are ready to take the responsibility in any professional situation to enable him to make the best decision and take the best solution. However, university graduates are very often not ready to solve tasks in their professional sphere due to various reasons. Some of these reasons can be summarized in the insufficiency or even the absence of certain psychological, physiological, and personal characteristics. Other reasons can be ascribed to the lack of specific knowledge in business areas and awareness of employers requirements for candidates. As a result, graduates can not show their potential and nor can they successfully implement their professional tasks. Consequently, some of the graduates have to change the professional sphere and to continue their education wasting a lot of time and money. To identify the optimal career perspective, we have developed a model that will consider two types of information. For one input of the model, we supply information about a university graduate a set of characteristics of their professional education, intellectual skills and personal qualities. For another input, we supply information from experts (employers) about the importance of this or that characteristic for their successful career in the chosen business area. This information is shown in expressions in natural language, that is why it is fuzzy and requires formalization. Information from both inputs arrives in a grid block where the degree of conformity between graduates characteristics and fuzzy employers requirements have been identified. As a result, we got a typical representative or some typical representatives for each business area (enterprise, companies, etc). Then, optimal career perspective for each university graduate is determined according to employers requirements. Optimal career for university graduate is measured according to the fact that this career opportunity corresponds to largely the grade of membership of his characteristics to the fuzzy set, determined by experts (employers) opinions. All graduates characteristics are divided into three groups, (i) professional education, (ii) intelligence, (iii) personal qualities. Professional

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education assessment can be done according to the students academic progress analysis for the whole period of education. Intelligence evaluation lets us determine the level of development of such components as logic reasoning, accuracy of perception, literacy, space imagination, mental process speed, etc. The level of personal characteristics development is assessed by tutors according, for example, to the qualities; social activities, discipline, diligence, emotional stability, self-control, leadership, authority in the group, motivation, etc. The rest of this paper is organized as follows: In section 2 mathematical and logical backgrounds and the formalization of graduates are presented and discussed in more details in order to identify the optimal business fields for the graduate. In section 3, the fuzzy experts opinions regarding corresponding characteristics for successful career in a certain business area are presented. Section 4 presents the proposed intellectual decision making model with proposed numerical example to test the developed model to prove that it can be used with success. Section 5 concludes the findings of this paper.

2 Graduates characteristics formalization

Qualitative characteristics formalization (academic progress, psychological physiological and personal characteristics) is important factors in this process. Because of the sustainability of the final conclusions and adequacy of recommendations highly are depending on the process of characteristics formalization. Conclusions received after processing the characteristics could be realistic if and only if they do not depend on the unit of measurement used for these characteristics. In other words, these conclusions must be invariable regarding permissible transformation of characteristic value measured in this or that scale. When experts use ordinal scales to evaluate qualitative characteristics, they often use average value of experts scores to find aggregating indexes. There are some ways for how to calculate average values: arithmetical average, geometrical average, harmonic average, mean square value, mode and median. Let us consider the usage of arithmetical average in ordinal scale as the most widely-used one. Suppose that 2 students got 4 - good and 3 - satisfactory marks for one discipline correspondingly and 4 - good and 5 - excellent marks for another discipline. It is well-known that marks are elements of ordinal scale. Total score and arithmetical average for both students are the same and equal to 8 and 4 correspondingly. Therefore, we can make a conclusion that both students have the same ranking score. As their knowledge is evaluated with ordinal scale, let us use strictly increasing transformation of this scale: $\Phi : \Phi(3) = 3, \phi(4) = 4, \phi(5) = 7$. According to the transformation done (that is permissible) total score and arithmetical average for the first student is absolutely the same, while for the second student now they equal to 10 and 5 correspondingly. So, ranking score of the second student has become higher than the first one. Sustainability of the results after permissible transformation is disrupted which shows that arithmetical operations with ordinal and nominal scales are incorrect and that we should find the way to avoid it. To evaluate qualitative and quantitative characteristics, experts use verbal scales often enough. Values in verbal scales are words expressing characteristic appearance intensity degree. These words are referred to as levels or gradations. Let us consider only those verbal scales with which it is possible to define a linear order, i.e. less more ratio [4]. Problems of determination of sets of verbal scale levels and quantitative values of qualitative characteristics within the limits of these levels are main ones in expert evaluations. For the purpose of application of known mathematical models of information processing, numerical points are put in correspondence to levels of verbal scales. The result of this approach is that the verbal scale is mapped to a verbally-numerical scale. Determination of values of the points put in correspondence to levels of verbal scales is a separate problem, the solution of which influences the stability of the results obtained within the limits of a mathematical model, so the justification of use of these values is needed. For example, marks 2, 3, 4, 5, which are put in correspondence to verbal values ”unsatisfactory, ”satisfactory, good, excellent, compose a verbally-numerical scale in their aggregate. Certainly, it is a must to remember that the numbers put in correspondence to verbal levels of qualitative characteristics are elements of an ordinal scale and all restrictions mentioned above are applicable to them. However, if within the scope of a specific problem the use of a certain verbally-numerical scale is justified, in actual practice experts face essential difficulties caused by intermittent transitions between levels, not allowing to catch and estimate intermediate conditions of the characteristic under evaluation. To evaluate intermediate conditions, process of artificial fuzzification of numerical points corresponding to levels of verbal scales is applied. For example, in educational process when evaluating the pupils knowledge without any limitations imposed on generality of ”good” knowledge, not only mark ”4, but also the whole range of marks [3.5; 4.5] is quite often used. Such process of points fuzzification simulates smoothness of estimating activity of experts, but does not facilitate process of exposing real objects with evaluations arranged near the boundaries of fuzzy areas. Verbal scales are used often enough to describe physical values of quantitative characteristics. With a range of definition (universal set) of quantitative characteristic and levels of a verbal scale known, an expert divides this area into non-overlapping sets which correspond to verbal levels. However, such approach is featuring with essential shortage which lies in the fact that while describing objects with boundary values of an indicator, an expert experiences difficulties caused by intermittent transitions between values. This shortage can be remedied with the fuzzy set theory in which not precise intervals of values are put in correspondence to verbal levels of quantitative property, but fuzzy sets.

According to [1], the set of pairs of the following form is referred to as a fuzzy set $\widetilde{A}$

$$(\{(x,\mu_{\widetilde{A}}(x)) : x \in X\}. \quad (1)$$

The resultant verbal-fuzzy scale is referred to as a linguistic scale (linguistic variable). A linguistic variable is a set of five

$$\{(X,T(X),U,V,S\}. \quad (2)$$

where X - is a name of a variable; $T(X) = \{X_i, i = \overline{1,m}\}$ - a term-set of variable X, i.e. a set of terms or names of linguistic values of variable X (each of these values is a fuzzy variable with a value from a universal set U); V - is a syntactical rule that gives names of the values of a linguistic variable X ; S - is a semantic rule that gives to every fuzzy variable with a name from T(X) a corresponding fuzzy subset of a universal set U [2]. A semantic space is a linguistic variable with a fixed term-set. The theoretical research of semantic spaces properties aims at producing adequacy improvement of the expert evaluation models and their utility for practical tasks solution has made it possible to formulate the valid requirements to the membership functions $\mu_l(X) = \{X_i, l = \overline{1,m}\}$ of their term-sets [3,4].

1. For every $X_l, l = \overline{1,m}$ there is $U\hat{(l)} \neq \varnothing$, where $U\hat{(l)} = \{X \in U : \mu_l(x) = 1\}$ is a point or an interval.

2. Let $U\hat{(l)} = \{X \in U : \mu_l(x) = 1\}$, then $\mu_l(x), l = \overline{1,m}$ does not decrease to the left of $U\hat{(l)}$ and does not increase to the right of $U\hat{(l)}$.

3. $\mu_l(x), l = \overline{1,m}$ have maximum two points of discontinuity of the first type.

4. For every $x \in U \sum_{i=1}^{m} \mu_l(x) = 1$ The semantic spaces, whose membership functions meet the mentioned requirements, are named complete orthogonal semantic spaces (COSS) [3]. This paper deals with expert evaluations of characteristics in the form of COSS. It is quite logical, as according to the properties of COSS each term has at least one typical representative and each point of universal set has at least one term which describes this point with a non-zero membership value. The membership functions only of the two adjacent terms can cross each other at 0.5 level point. The sum of all the membership functions at the fixed point of universal set equals 1. This allows to separate the used notions and to avoid semantically close terms or synonyms. All these properties correspond to the thinking activity of the experts that is why COSS are chosen for modeling. Theoretical and practical studies of some researchers have shown that these COSS describe expert evaluations most adequately, and as a result they were often included in more sophisticated models of intellectual systems for decision making and data analysis. As a result of using verbal scale in the form of COSS, a quantitative characteristic is corresponded with physical values measured by a technical instrument and. On the other hand, linguistic values are "measured" by an expert. Each physical value belongs to some linguistic one with certain degree of expert confidence. Creating of a linguistic scale for qualitative characteristics is much more complicated. If a verbal-numerical scale for qualitative characteristics represents a set of verbal levels with the corresponded set of numbers (elements of an ordinal scale), then a linguistic scale is a set of verbal levels with a set of the corresponded fuzzy sets specified at some universe. As qualitative characteristics cannot be measured objectively (by instrument), the universal sets applicable for them cannot be unambiguously defined, as they do for quantitative characteristics. Definition of universal set is made within the scope of each qualitative characteristic and requirements of each specific task. Thus, expedient values of linguistic scales for qualitative characteristics are fuzzy sets. In the mathematical statistics, a set of numerical data and a corresponded set of random variables are referred to as a sample; similarly, in the fuzzy set theory verbal levels and corresponded fuzzy sets are referred to as linguistic values. Definition of linguistic values of characteristics (based on the fuzzy set theory) makes it possible to operate not with values of the characteristics which are non-comparable among themselves by substance and content (as they are estimated in different scales and having different dimensions), but also with dimensionless values of membership functions. There are many papers on the use of fuzzy sets in data processing of the educational process [3] - [13]. This paper expands the field of practical applications of fuzzy sets in educational sphere. To formalize graduates characteristics within the framework of professional education, intelligence and personal qualities we offer to use methods worked out in [3,14]. Suppose that all students characteristics are formalized on universal set [0,1]. Professional education characteristics values are students marks and grades for corresponding disciplines. Academic progress is evaluated within the framework of the scale unsatisfactory, satisfactory, good, excellent. Subjects are chosen according to the graduates major. Intelligence characteristics without restricting the generality could be such components as logic reasoning, accuracy of perception, literacy, space imagination and mental process speed. All intelligence characteristics are evaluated within the framework of the scale low 2, medium 3, high 4, very high 5. Personal qualities without restricting the generality can include social activities, discipline, diligence, emotional stability, self-control, leadership, authority in the group, motivation. All personal characteristics are evaluated within the framework of the scale low 2, medium 3, high 4, very high 5. Consider the academic progress of graduates in disciplines with the names . It is obvious that there are no unsatisfactory marks in the considered data, that is why it is logical to study a three-level scale

satisfactory, good, excellent. Let us call a relative number of graduates with the satisfactory mark for the discipline , - a relative number of graduates with the good mark for the discipline , - a relative number of graduates with the excellent mark for the discipline , where . Based on these data and the method [11] we can construct linguistic variables with the names and a term-set satisfactory, good, excellent. Consider the academic progress of N graduates in disciplines with the names $X_j, j=\overline{1,k}$. It is obvious that there are no unsatisfactory marks in the considered data, that is why it is logical to study a three-level scale satisfactory, good, excellent. Let us call a_1^j a relative number of graduates with the satisfactory mark for the discipline X_j, a_2^j - a relative number of graduates with the good mark for the discipline X_j, a_3^j - a relative number of graduates with the excellent mark for the discipline X_j, where $j=\overline{1,k}$. Based on these data and the method [11] we can construct linguistic variables with the names and a term-set satisfactory, good, excellent. Let us call $\mu_{1,j}(x)$ membership functions of fuzzy numbers $\widetilde{X_{1,j}}$ corresponding to the term satisfactory for the each discipline $X_j, j=\overline{1,k}$, $\mu_{2,j}(x)$ membership functions of fuzzy numbers $\widetilde{X_{2,j}}$ corresponding to the term good for the each discipline $X_j, j=\overline{1,k}$ and $\mu_{3,j}(x)$ membership functions of fuzzy numbers $\widetilde{X_{3j}}$ corresponding to the term excellent for the each discipline $X_{3j}, j=\overline{1,k}$. The membership functions of fuzzy numbers $X_{1j}, X_{2j}, X_{3j}, j=\overline{1,k}$ are constructed so that the areas of the figures restricted by their graphs accordingly equal to $a_3^j, a_2^j, a_3^j, j=\overline{1,k}$ (analogue geometric probabilities). Then

$$\mu_{1j}(x)=\left(0,a_1^j-\frac{b_1^j}{2},0,b_1^j\right), \tag{3}$$

$$\mu_{2j}(x)=\left(a_1^j+\frac{b_1^j}{2},a_1^j+a_2^j-\frac{b_2^j}{2},b_1^j,b_2^j\right), \tag{4}$$

$$\mu_{3j}(x)=\left(1-a_3^j+\frac{b_2^j}{2},1,b_2^j,0\right), \tag{5}$$

where min $\left(a_1^j,a_2^j\right)$ were designated by b_1^j , min $\left(a_2^j,a_3^j\right)$ by $b_2^j, j=\overline{1,k}$. The first two parameters are abscissas of the apexes of the trapezium upper bases that is a graph of the corresponding membership function, while the last two parameters are the lengths of the left and right trapezium wings correspondingly. If we have not got enough statistical information to construct COSS, we offer to construct membership functions of COSS on the basis of direct inquiry of a single expert. This approach can be applied to formalize both quantitative and qualitative characteristics [15,16]. It is worth mentioning that a COSS based on inquiry of experts will always possess some property of uniqueness, i.e. it reflects judgments of the experts who often use the information known to few people who are in gathering. Actually, if one wants to construct COSS ”height” = low, average, high, very high from point of view of Moscow and Tokyo experts, then, obviously, there will be two spaces with a different collection of membership functions. If one wants to build COSS ”profit” = very low, low, average, high, very high, the money equivalent which is considered as high profit, will dramatically differ for different firms. It is just the case when defining similar categories experts use the information known to few people only, on the one hand, and unique for a certain firm, on the other hand. Together with the marks satisfactory, good and excellent we will consider marks formalizations as graduates marks satisfactory, good and excellent, in other words its fuzzy numbers $\widetilde{X_{l,j}}, l=\overline{1,3} j=\overline{1,k}$ or its membership functions $\mu_{l,j}(x), l=\overline{1,3} j=\overline{1,k}$ We can call $\widetilde{X_j^n}$ and $\mu_j^n(x)\equiv(a_{j1}^n,a_{j2}^n,a_{jL}^n,a_{jR}^n), n=\overline{1,N}, j=\overline{1,k}$ a mark of n-graduate for the discipline X_j. It is obvious that the fuzzy number $\widetilde{X_j}^N$ with the membership function $\mu_j^n(x)$ equals to one of the fuzzy numbers $\widetilde{X_{l,j}}, l=\overline{1,3} j=\overline{1,k}$. Call weight coefficients of the disciplines studied as

$$\omega_j, j=\overline{1,k}, \sum_{j=1}^{k}\omega_j=1 \tag{6}$$

Fuzzy rating point of n-graduate, $n=\overline{1,N}$ within the framework of his professional education $X_j, j=\overline{1,k}$ is determined [14] as a fuzzy number

$$\widetilde{A_n}=\omega_1\otimes\widetilde{X_1}^n\oplus\ldots\oplus\omega_k\otimes\widetilde{X_k}^n \tag{7}$$

with the membership function

$$\mu_n(x)\equiv\left(\sum_{j=1}^{k}\omega_j a_{j1}^n,\sum_{j=1}^{k}\omega_j a_{j2}^n,\sum_{j=1}^{k}\omega_j a_{jL}^n,\sum_{j=1}^{k}\omega_j a_{jR}^n\right), \tag{8}$$

$$n=\overline{1,N} \tag{9}$$

Consider graduates intelligence characteristics with the names $Y_i, i=\overline{1,m}$. Let us call c_1^i a relative number of graduates with the low mark for the characteristic $Y_i, i=\overline{1,m}$, c_2^i - a relative number of graduates with the medium mark for the characteristic $Y_i, i=\overline{1,m}$, c_3^i - a relative number of graduates with the high mark for the characteristic , c_4^i - a relative number of graduates with the very high mark for the characteristic $Y_i, i=\overline{1,m}$. Let us call $\eta_{1i}(x)$ membership functions of fuzzy numbers $\widetilde{Y_{1i}}$ corresponding to the term low for the each characteristic $Y_i, i=\overline{1,m}$, $\eta_{2i}(x)$ membership functions of fuzzy numbers $\widetilde{Y_{2i}}$corresponding to the term medium for the each characteristic $Y_i, i=\overline{1,m}$,$\eta_{3i}(x)$ membership functions of fuzzy numbers $\widetilde{Y_{3i}}$ corresponding to the term high for the each characteristic $Y_i, i=\overline{1,m}$ and $\eta_{4i}(x)$ membership functions of fuzzy numbers $\widetilde{Y_{4i}}$

corresponding to the term very high for the each characteristic $Y_i, i=\overline{1,m}$. Then

$$\eta_{1j}(x) \equiv \left(0, c_1^i - \frac{d_1^i}{2}, 0, d_1^i\right), \tag{10}$$

$$\eta_{2j}(x) \equiv \left(c_1^i + \frac{d_1^i}{2}, c_1^i + c_2^i - \frac{d_2^i}{2}, d_1^i, d_2^i\right), \tag{11}$$

$$\eta_{3j}(x) \equiv \left(c_1^i + c_2^i + \frac{d_2^i}{2}, c_1^i + c_2^i + c_3^i - \frac{d_3^i}{2}, b_2^i, d_2^i, d_3^i\right), \tag{12}$$

$$\eta_{4j}(x) \equiv \left(1 - c_4^i + \frac{d_3^i}{2}, 1, d_3^i, 0\right) \tag{13}$$

where $\min\left(c_{v-1}^i, c_v^i\right)$ were designated by $d_{v-1}^i, v=\overline{1,3}, i=\overline{1,m}$ Together with the marks low, medium, high and very high we will consider marks formalizations as graduates marks low, medium, high and very high, that is fuzzy numbers $\widetilde{Y_{li}}, l=\overline{1,4} i=\overline{1,m}$ or its membership functions $v_{li}(x), l=\overline{1,4} i=\overline{1,m}$. We can call $\widetilde{Y_i}^n$ and $v_i^n(x) \equiv (b_{i1}^n, b_{i2}^n, b_{i3}^n, b_{i4}^n), n=\overline{1,N}, i=\overline{1,m}$, a mark of n-graduate within the framework of his intelligence characteristic Y_i . It is obvious that a fuzzy number $\widetilde{Y_i}^n$ with a membership function $v_i^n(x)$ equals to one of the fuzzy numbers $\widetilde{Y_{li}} l=\overline{1,4}, i=\overline{1,m}$. Suppose that the set of weight coefficients of the characteristics studied as

$$\omega_i, i=\overline{1,m}, \sum_{i=1}^{m} \omega_i = 1 \tag{14}$$

Fuzzy rating point of an n-graduate within the framework of his intelligence is determined as a fuzzy number

$$\widetilde{B_n} = \omega_1 \otimes \widetilde{Y_1}^n \oplus \ldots \oplus \omega_m \otimes \widetilde{Y_m}^n \tag{15}$$

with the membership function

$$v_n(x) \equiv \left(\sum_{i=1}^{m} \omega_i b_{i1}^n, \sum_{i=1}^{k} \omega_i b_{j2}^n, \sum_{i=1}^{n} \omega_i b_{iL}^n, \sum_{i=1}^{n} \omega_i b_{iR}^n\right), \tag{16}$$

$$n=\overline{1,N} \tag{17}$$

If we consider personal characteristics of N graduates that are called $Z_j, j=\overline{1,p}$ we will find that these qualities are evaluated within the scale: low 2, medium 3, high 4, very high 5. Suppose that a set a_1^j as an average number of graduated with the low mark for the characteristic Z_j , a_2^j as an average number of graduated with the medium mark for the characteristic Z_j , a_3^j as an average number of graduated with the high mark for the characteristic Z_j , a_4^j as an average number of graduated with the very high mark for the characteristic $Z_j, j=\overline{1,p}$. We can call $\xi_{1j}(x)$ membership functions of fuzzy numbers $\widetilde{Z_{1j}}$, corresponding to the term low for the each characteristic $Z_j, j=\overline{1,p}$, $\xi_{2j}(x)$ membership functions of fuzzy numbers $\widetilde{Z_{1j}}$. These functions are corresponding to the term medium for the each characteristic $Z_j, j=\overline{1,p}$, $\xi_{3j}(x)$ membership functions of fuzzy numbers $\widetilde{Z_{1j}}$. As will as it is corresponding to the term high for the each characteristic $Z_j, j=\overline{1,p}$, $\xi_{4j}(x)$ membership functions of fuzzy numbers $\widetilde{Z_{4j}}$, corresponding to the term very high for the each characteristic $Z_j, j=\overline{1,p}$.
Then

$$\xi_{1j}(x) \equiv \left(0, \alpha_1^j - \frac{\beta_1^j}{2}, 0, \beta_1^j\right), \tag{18}$$

$$\xi_{2j}(x) \equiv \left(\alpha_1^j + \frac{\beta_1^j}{2}, \alpha_1^j + \alpha_2^j - \frac{\beta_2^j}{2}, \beta_1^j, \beta_2^j\right), \tag{19}$$

$$\xi_{3j}(x) \equiv \left(\alpha_1^j + \beta_2^j + \frac{\beta_2^j}{2}, \alpha_1^j + \alpha_2^j + \alpha_3^j - \frac{\beta_3^j}{2}, \beta_2^j, d_2^j, \beta_3^j\right), \tag{20}$$

$$\xi_{4j}(x) \equiv \left(1 - \alpha_4^j + \frac{\beta_3^j}{2}, 1, \beta_3^j, 0\right) \tag{21}$$

where $\min\left(\alpha_{v-1}^i, \alpha_v^i\right)$ were designated by $\beta_{v-1}^i, v=\overline{1,3}, j=\overline{1,p}$
Together with the marks low, medium, high, very high we will consider marks formalizations as graduates marks low, medium, high and very high, that is fuzzy numbers $\widetilde{Z_{lj}}, l=\overline{1,4}, j=\overline{1,p}$ or its membership functions $\xi_{lj}(x), l=\overline{1,4}, j=\overline{1,p}$. We can call $\widetilde{Z_j}^n$ and $\xi_j^n(x) \equiv (c_{j1}^n, c_{j2}^n, c_{jL}^n, c_{jR}^n), n=\overline{1,N}, j=\overline{1,p}$ a mark of an n-graduate within his personal qualities characteristics Z_j . It is obvious that a fuzzy number $\widetilde{Z_j}^n$ with a membership function $\xi_j^n(x)$ equal to one of the fuzzy numbers $\widetilde{Z_{lj}}, l=\overline{1,4}, j=\overline{1,p}$.
Suppose that the set of weight coefficients of the characteristics studied as

$$\omega_j, j=\overline{1,p}, \sum_{j=1}^{p} \omega_j = 1 \tag{22}$$

Fuzzy rating point of an n-graduate $n=\overline{1,N}$, within the framework of his personal qualities is determined as a fuzzy number

$$\widetilde{C_n} = \omega_1 \otimes \widetilde{Z_1}^n \oplus \ldots \oplus \omega_p \otimes \widetilde{Z_p}^n \tag{23}$$

with the membership function

$$\xi_n(x) \equiv \left(\sum_{j=1}^{p} \omega_j c_{j1}^n, \sum_{j=1}^{p} \omega_j c_{j2}^n, \sum_{j=1}^{p} \omega_j c_{iL}^n, \sum_{j=1}^{p} \omega_j c_{jR}^n\right), \tag{24}$$

$$n=\overline{1,N} \tag{25}$$

3 Experts opinions formalization regarding importance of characteristics for graduates successful career

Rating points worked out in section 2 are supposed to be used to identify the optimal business area for the graduates. Such rating points are supplied to one of the input of the model, whereas fuzzy experts opinions (employers) regarding corresponding characteristics or characteristics groups for successful career in a certain business area are supplied on the other input. As an example of experts opinions, the following can be mentioned: Academic progress is less important than intelligence characteristics, and personal qualities are of a high importance. Such statement could be used not only for the groups of characteristics, but also for single elements: Academic progress in fundamental disciplines is of no importance, while special knowledge progress and perception accuracy are important, and spatial perception, discipline, dutifulness and diligence are extremely important.

To formalize fuzzy experts opinions (due to natural language usage), it is necessary to formalize the following levels (linguistic terms): absolutely not important, fairly not important, not very important, rather important, important, very important. These levels are placed in an ascending order of intensity of importance. That is why fuzzy numbers $\widetilde{D}_1,...,\widetilde{D}_6$ are used without restricting the generality with the following membership functions [15, 16]:

$$\mu_1(x) \equiv (0,0,0.2), \mu_2(x) \equiv (0.2,0.2,0.2) \quad (26)$$
$$\mu_3(x) \equiv (0.4,0.2,0.2), \mu_4(x) \equiv (0.6,0.2,0.2) \quad (27)$$
$$\mu_5(x) \equiv (0.8,0.2,0.2), \mu_6(x) \equiv (1,0.2,0) \quad (28)$$

We can consider that fuzzy experts (employers) opinions are formulated within the r business areas of graduates careers. Fuzzy rating points of graduates professional education were called $\widetilde{A}_n, n = \overline{1,N}$, fuzzy rating points of graduates intelligence were called $\widetilde{B}_n, n = \overline{1,N}$, and fuzzy rating points of graduates personal qualities were called $\widetilde{C}_n, n = \overline{1,N}$. Then, according to the experts opinion regarding importance of characteristics, a number $\widetilde{R}_n^i$ could be a rating point of an n-graduate within the i-business area of his career and could be found without restricting the generality in the following way:

$$\widetilde{R}_n^i \equiv \widetilde{D}_{1i} \otimes \widetilde{A}_n \oplus \widetilde{D}_{2i} \otimes \widetilde{B}_n \oplus \widetilde{D}_{3i} \otimes \widetilde{C}_n \quad (29)$$
$$n = \overline{1,N}, i = \overline{1,r} \quad (30)$$

Fuzzy numbers $\widetilde{D}_{1i}, \widetilde{D}_{2i}, \widetilde{D}_{3i}$ equal to one of the fuzzy numbers $\widetilde{D}_1,...,\widetilde{D}_6$.

4 Finding out optimal business area for each graduate

We will call $\mu_n^i(x)$ a membership function for a rating point (fuzzy number) $\widetilde{R}_n^i$ of an n-graduate within the i-business area. Therefore, we could get rating points $\widetilde{R}_n^i, i = \overline{1,r}, n = \overline{1,N}$ for each graduate within the framework of each business area of his future career. As these business areas are determined in a fuzzy way based on experts opinions, we call $\mu_i(n), n = \overline{1,N}, i = \overline{1,r}$ membership functions of graduates to these business areas. If $\sup nx : \mu_n^i(x) = 1, n = \overline{1,N}$ belongs to $\widetilde{R_k^i(x)}$, then k-graduate is considered to be a typical representative of i - business area and that $\mu_i(k) = 1$. Levels of membership $\mu_i(n), n = \overline{1,N}, n \neq k$ of other graduates to this business area is found in the following way:

$$\mu_i(n) = \max_x \min\left(\mu_k^i(x), \mu_k^i(x)\right) \quad (31)$$

If there are several typical representatives of i - business area, for example, these are graduates $k_1, k_2, ..., k_p$, then we can find the levels of membership $\mu_i^l(n), l = \overline{1,p}, n = \overline{1,N}, n \neq k_l$ of other graduates to i-business area based on each of typical representatives:

$$\mu_i^l(n) = \max_x \min\left(\mu_n^i(x), \mu_{k_l}^i(x)\right) \quad (32)$$

Then choose the maximum of them:

$$\mu_i(n) = \max_l \mu_i^l(n), n = \overline{1,N}, n \neq k_l, l = \overline{1,p} \quad (33)$$

Summing up, the model worked out in this article allows to consider graduates characteristics and experts (employers) opinions about importance of these characteristics as well as to find out the optimal business area for each graduate. Numerical examples have assisted us to consider fuzzy rating points of five graduates on the basis of their academic progress, intelligence characteristics and personal qualities. These fuzzy rating points are presented accordingly in Tables 1-3. Fuzzy rating points are presented as trapezoidal fuzzy numbers with four parameters. The first two parameters are abscissas of the apexes of the trapezium upper bases that is a graph of the corresponding membership function, while the last two parameters are the lengths of the left and right trapezium wings correspondingly.

Selection of graduates is carried out of four formulated business areas of graduates careers. 1. Academic progress is very important, intelligence characteristics are very important and personal qualities are absolutely unimportant; 2. Academic progress is not so important, intelligence characteristics are important enough, and personal qualities are very important; 3. Academic progress is rather unimportant, intelligence characteristics are important, and personal qualities are

Table 1: Table 1. Fuzzy rating points of graduates on the basis of their academic progress

	Number of the graduate				
	1	2	3	4	5
Fuzzy rating points	0,709	0,416	0,519	0,674	0,396
	0,839	0,571	0,686	0,747	0,531
	0,132	0,103	0,106	0,088	0,118
	0,145	0,052	0,113	0,128	0,086

Table 2: Table 2. Fuzzy rating points of graduates on the basis of their intelligence characteristics

	Number of the graduate				
	1	2	3	4	5
Fuzzy rating points	0,613	0,271	0,341	0,498	0,312
	0,698	0,342	0,396	0,539	0,576
	0,115	0,094	0,029	0,126	0,114
	0,118	0,126	0,095	0,103	0,204

Table 3: Table 3. Fuzzy rating points of graduates on the basis of their personal qualities

	Number of the graduate				
	1	2	3	4	5
Fuzzy rating points	0,635	0,468	0,602	0,732	0,574
	0,687	0,488	0,625	0,768	0,598
	0,116	0,112	0,109	0,096	0,104
	0,211	0,142	0,134	0,094	0,036

Table 4: Table 4. Levels of membership of graduates to four business area

Number of the graduate	Levels of membership			
	1	2	3	4
1	1	1	0,98	1
2	0,45	0,76	0,68	0,66
3	0,73	0,85	0,82	0,83
4	0,96	1	1	1
5	0,53	0,61	0,77	0,79

rather unimportant; 4. Academic progress is absolutely unimportant, intelligence characteristics are important enough, and personal qualities are important, Levels of membership of graduates to four business area are presented in Table 4. Based on the analysis carried out, graduate 1 is recommended for business areas 1,2,4, graduate 2 business area 2, graduate 3 business area 2, graduate 4 - business areas 2,3,4, and graduate 5 is recommended for business area 4.

5 Conclusions

This paper presents an intellectual support model of career choice for university graduates. The input information for this model is the information about different characteristics values and information got from experts or employers regarding the importance of these characteristics for graduates successful careers. The formalization stage or presenting various characteristics in one unified abstract way allowing using them correctly is of an essential importance for sustainable results. This paper uses the the method of displaying qualitative characteristics values as linguistic variables values which provides sustainability of final outcome and adequacy of managing recommendations is used. Experts (employers) opinions are presented as fuzzy sets that are permissible due to natural (professional) language usage. The model allows not only recommend to each graduate one or several optimal business areas for future career, but also range all graduates within the framework of all majors. The numerical example has demonstrated that developed model can be used with success.

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