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O. I. MOROZOVA*National Aerospace University named after N. E. Zhukovsky "KhAI", Kharkiv, Ukraine***SUPPORT FOR THE DECISION TO SELECT THE FUTURE PROFESSION WITH USE OF FUZZY RELATIONS**

The article suggests one of the ways to solve the problem of vocational guidance for applicants in choosing a future profession through the use of artificial intelligence systems, namely, fuzzy relations. On the basis of fuzzy relations, a number of additional concepts are defined that are used to construct fuzzy models of complex systems. An example of the use of fuzzy relations is provided to support the decision-making on the choice of the future profession. To clarify the result, since the Applicant can choose several professions with the same rating, was proposed to apply an alternative operation of composing two binary fuzzy relations – (max-prod)-composition.

Keywords: *decision support, professional orientation, artificial intelligence systems, fuzzy sets, composition of fuzzy relations.*

Introduction

At present, the difficulties encountered by applicants for admission to a higher educational institution when solving the multicriteria task of choosing a university, as well as the specialty of education for obtaining a future profession, are increasingly encountered [1, 2].

The paper suggests the use of fuzzy relations for the purpose of vocational guidance of students in choosing the future profession on the basis of their competencies. The apparatus of the theory of fuzzy relations is used for qualitative analysis of the interrelations between the objects of the system under study. Having assessed the main competences for the future profession and the competency of the applicant, he (or she) will be asked to choose the profession in which the obtained values of the composition of fuzzy relations are of the greatest importance.

The research of this problem was conducted with the aim of increasing the efficiency of professional orientation of applicants, namely the solution of the problem related to the choice of a specialty for future education.

1. Features of the theory of fuzzy sets use

The theory of fuzzy sets allows us to describe inaccurate concepts and knowledge about the world around us, and also to operate with this knowledge in order to obtain new information [3, 4]. A fuzzy set is a collection of elements of an arbitrary nature, with respect to which it is impossible to state with complete certainty whether an element of the considered

population belongs to a given set or not.

The concept of fuzzy relations, along with the notion of the fuzzy set itself, should be attributed to the fundamental backbone of the whole theory of fuzzy sets [5, 6]. On the basis of fuzzy relations, a number of additional concepts are defined that are used to construct fuzzy models of complex systems. A meaningful fuzzy relation is defined as any fuzzy subset of ordered tuples constructed from elements of certain basic sets [7].

In the general case, a fuzzy relation defined on the sets (universes) X_1, X_2, \dots, X_m , is a certain fixed fuzzy subset of the Cartesian product of these universes. In other words, if we denote an arbitrary fuzzy relation N , then by definition

$$N = \{ \langle x_1, x_2, \dots, x_m \rangle, \mu_N(\langle x_1, x_2, \dots, x_m \rangle) \},$$

where $\mu_N(\langle x_1, x_2, \dots, x_m \rangle)$ is the membership function of a given fuzzy relation, which is defined as the map $\mu_N: X_1 \times X_2 \times \dots \times X_m \rightarrow [0,1]$. A fuzzy relation between elements of two universal sets is called binary.

Since each fuzzy relation is a fuzzy set, then with respect to fuzzy relations, all operations that apply to fuzzy sets are valid.

Let S and T be finite or infinite binary fuzzy relations. And the fuzzy relation

$$S = \{ \langle x_i, x_j \rangle, \mu_S(\langle x_i, x_j \rangle) \},$$

where $i = 1..6, j = 1..7$, is given on the Cartesian product of universes $X_1 \times X_2$, and the fuzzy relation

$$T = \{ \langle x_j, x_k \rangle, \mu_T(\langle x_j, x_k \rangle) \},$$

where $j=1..7, k=1..6$, is given on the Cartesian product of the universes $X_2 \times X_3$.

The fuzzy binary relation given on the Cartesian product $X_1 \times X_3$ and denoted by $S \times T$ is called the

composition of the binary fuzzy relations S and T, and its membership function is defined by the expression:

$$\mu_{S \otimes T}(\langle x_i, x_k \rangle) = \bigcup_{x_j} \mu_S(\langle x_i, x_j \rangle) \cap \mu_T(\langle x_j, x_k \rangle). \quad (1)$$

Defined in this way composition of binary fuzzy relationships is called (max-min)-composition or maximin convolution of fuzzy relations.

For (max-min) - of the compositions of the relations S and T, the operation \cap can be replaced by any other for which the same restrictions are fulfilled as for \cap : associativity and monotonicity with respect to each argument.

In particular, the operation \cap can be replaced by algebraic multiplication, then we speak of a (max-prod)-composition (formula (2)):

$$\mu_{S \otimes T}(\langle x_i, x_k \rangle) = \bigcup_{x_j} \mu_S(\langle x_i, x_j \rangle) \cdot \mu_T(\langle x_j, x_k \rangle). \quad (2)$$

Let us pass directly to the consideration of the proposed method of supporting decision-making in choosing a future profession.

2. Using fuzzy relationships to support decision making

To select a future profession, the applicant has built a fuzzy model based on two binary fuzzy relationships S and T. The first of these fuzzy relations is built on two basic sets X and Y, and the second on two basic sets Y and Z.

Here, X describes the set of professions, Y is the set of core competencies, and Z is the set of applicants. The fuzzy relation S describes the relationship of the

profession with competences in a meaningful way, and T describes the assessment of competencies for each of the applicants. For concreteness:

$$X = \{x_1, x_2, x_3, x_4, x_5, x_6\},$$

$$Y = \{y_1, y_2, y_3, y_4, y_5, y_6, y_7\},$$

$$Z = \{z_1, z_2, z_3, z_4, z_5, z_6, z_7\}.$$

Elements of universums X, Y, Z have the following conceptual meaning:

- x_1 – "IT developer",
- x_2 – "Engineer",
- x_3 – "Sales manager",
- x_4 – "HR specialist",
- x_5 – "Architect",
- x_6 – "Logistics specialist";
- y_1 – "Logical thinking",
- y_2 – "Creativity",
- y_3 – "Communication skills",
- y_4 – "Technical skills",
- y_5 – "Flexibility of thinking",
- y_6 – "Organizational skills",
- y_7 – "Observation";
- z_1 – "Applicant 1",
- z_2 – "Applicant 2",
- z_3 – "Applicant 3",
- z_4 – "Applicant 4",
- z_5 – "Applicant 5",
- z_6 – "Applicant 6",
- z_7 – "Applicant 7".

The concrete values of the membership functions $\mu_S(\langle x_i, y_j \rangle)$ and $\mu_T(\langle y_j, z_k \rangle)$ of the fuzzy relations under consideration are presented in the following tables (Tables 1, 2).

Table 1

Fuzzy relation S

Professions	Core competencies						
	Logical thinking	Creativity	Communication skills	Technical skills	Flexibility of thinking	Organizational skills	Observation
IT developer	0.8	1	0.7	0.8	1	0.7	0.8
Engineer	0.8	0.8	0.7	1	0.9	0.7	0.8
Sales manager	0.7	0.7	0.9	0.6	0.8	0.6	0.8
HR specialist	0.7	0.8	0.8	0.6	0.8	0.8	0.9
Architect	0.8	0.9	0.7	0.9	0.8	0.9	0.8
Logistics specialist	0.9	0.7	0.8	0.8	0.8	0.8	0.7

Table 2

Fuzzy relation T

Core competencies	Applicants						
	Applicant 1	Applicant 2	Applicant 3	Applicant 4	Applicant 5	Applicant 6	Applicant 7
Logical thinking	0.7	0.8	0.6	0.3	0.9	0.4	0.5
Creativity	0.5	0.7	0.5	0.5	0.5	0.5	0.7
Communication skills	0.5	0.8	0.7	0.3	0.5	0.7	0.9
Technical skills	0.8	0.6	0.5	0.7	0.7	0.3	0.6
Flexibility of thinking	0.6	0.8	0.7	0.5	0.8	0.5	0.5
Organizational skills	0.8	0.5	0.5	1	0.6	0.7	0.3
Observation	0.4	0.7	0.9	0.8	0.7	0.9	0.3

The matrices of these fuzzy relations have the form (formula (3), (4)):

$$M_S = \begin{bmatrix} 0.8 & 1 & 0.7 & 0.8 & 1 & 0.7 & 0.8 \\ 0.8 & 0.8 & 0.7 & 1 & 0.9 & 0.7 & 0.8 \\ 0.7 & 0.7 & 0.9 & 0.6 & 0.8 & 0.6 & 0.8 \\ 0.7 & 0.8 & 0.8 & 0.6 & 0.8 & 0.8 & 0.9 \\ 0.8 & 0.9 & 0.7 & 0.9 & 0.8 & 0.9 & 0.8 \\ 0.9 & 0.7 & 0.8 & 0.8 & 0.8 & 0.8 & 0.7 \end{bmatrix}, \quad (3)$$

$$M_T = \begin{bmatrix} 0.7 & 0.8 & 0.6 & 0.3 & 0.9 & 0.4 & 0.5 \\ 0.5 & 0.7 & 0.5 & 0.5 & 0.5 & 0.5 & 0.7 \\ 0.5 & 0.8 & 0.7 & 0.3 & 0.5 & 0.7 & 0.9 \\ 0.8 & 0.6 & 0.5 & 0.7 & 0.7 & 0.3 & 0.6 \\ 0.6 & 0.8 & 0.7 & 0.5 & 0.8 & 0.5 & 0.5 \\ 0.8 & 0.5 & 0.5 & 1 & 0.6 & 0.7 & 0.3 \\ 0.4 & 0.7 & 0.9 & 0.8 & 0.7 & 0.9 & 0.3 \end{bmatrix}. \quad (4)$$

Since the fuzzy relations under consideration satisfy the formal requirements necessary for performing their fuzzy composition according to (1), the result of the fuzzy composition operation of these relations can be represented as a resulting fuzzy relation matrix (5):

$$M_{S \otimes T} = \begin{bmatrix} 0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.7 \\ 0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.7 \\ 0.7 & 0.8 & 0.8 & 0.8 & 0.8 & 0.8 & 0.9 \\ 0.8 & 0.8 & 0.9 & 0.8 & 0.8 & 0.9 & 0.8 \\ 0.8 & 0.8 & 0.8 & 0.9 & 0.8 & 0.8 & 0.7 \\ 0.8 & 0.8 & 0.7 & 0.8 & 0.9 & 0.7 & 0.8 \end{bmatrix}. \quad (5)$$

Let us present a fuzzy composition of the two initial relations in the form of Table 3.

Let us Consider how one of the values of the membership function of the composition is obtained, for example, the value $(\langle x_1, z_1 \rangle) = 0.8$.

First, let us find the minimum values of the membership function of all pairs of elements of the first row of Table 1 and the first column of Table 2. Namely: $\min\{0.8 \ 0.7\} = 0.7$; $\min\{1 \ 0.5\} = 0.5$; $\min\{0.7 \ 0.5\} = 0.5$; $\min\{0.8 \ 0.8\} = 0.8$; $\min\{1 \ 0.6\} = 0.6$; $\min\{0.7 \ 0.8\} = 0.7$; $\min\{0.8 \ 0.4\} = 0.4$. After this, let us find the maximum of 7 obtained values, which will be the target value of the membership function: $\mu_{S \otimes T}(\langle x_1, z_1 \rangle) = \max\{0.7 \ 0.5 \ 0.5 \ 0.8 \ 0.6 \ 0.7 \ 0.4\} = 0.8$. The remaining values of the membership function can be found similarly.

To clarify the result, since the Applicant can choose several professions with the same rating, let us apply an alternative operation of composing two binary fuzzy relations – (max-prod)-composition (formula (2)). The result of the operation of the fuzzy composition of these relations can be represented as a matrix of the resulting fuzzy relation (6):

$$M_{S \otimes T} = \begin{bmatrix} 0.64 & 0.8 & 0.72 & 0.7 & 0.8 & 0.72 & 0.7 \\ 0.8 & 0.72 & 0.72 & 0.7 & 0.72 & 0.72 & 0.63 \\ 0.49 & 0.72 & 0.72 & 0.64 & 0.64 & 0.72 & 0.81 \\ 0.64 & 0.64 & 0.81 & 0.8 & 0.64 & 0.81 & 0.72 \\ 0.72 & 0.64 & 0.72 & 0.9 & 0.72 & 0.72 & 0.63 \\ 0.64 & 0.72 & 0.63 & 0.8 & 0.81 & 0.63 & 0.72 \end{bmatrix}. \quad (6)$$

Let's present a fuzzy (max-prod)-composition of two initial relations in the form of a table 4.

Table 3

Fuzzy composition of two fuzzy relations

Professions	Applicants						
	Applicant 1	Applicant 2	Applicant 3	Applicant 4	Applicant 5	Applicant 6	Applicant 7
IT developer	0.8	0.8	0.8	0.8	0.8	0.8	0.7
Engineer	0.8	0.8	0.8	0.8	0.8	0.8	0.7
Sales manager	0.7	0.8	0.8	0.8	0.8	0.8	0.9
HR specialist	0.8	0.8	0.9	0.8	0.8	0.9	0.8
Architect	0.8	0.8	0.8	0.9	0.8	0.8	0.7
Logistics specialist	0.8	0.8	0.7	0.8	0.9	0.7	0.8

Table 4

Fuzzy (max-prod)-composition of two fuzzy relations

Professions	Applicants						
	Applicant 1	Applicant 2	Applicant 3	Applicant 4	Applicant 5	Applicant 6	Applicant 7
IT developer	0.64	0.8	0.72	0.7	0.8	0.72	0.7
Engineer	0.8	0.72	0.72	0.7	0.72	0.72	0.63
Sales manager	0.49	0.72	0.72	0.64	0.64	0.72	0.81
HR specialist	0.64	0.64	0.81	0.8	0.64	0.81	0.72
Architect	0.72	0.64	0.72	0.9	0.72	0.72	0.63
Logistics specialist	0.64	0.72	0.63	0.8	0.81	0.63	0.72

Table 3 shows the assessment of the choice of the future profession by the applicant. Analyzing an obtained result, it can be seen that there are situations that make it difficult to choose a suitable profession according to competencies, for example, for the Applicant 1 the most suitable are several professions, since their membership functions are equal to each other. Having analyzed the obtained refined result (Table 4), we can conclude that a suitable profession for Applicant 1 is the "Engineer", since its membership function is $(\langle x_2, z_1 \rangle) = 0.8$. Using different models, the same results are obtained, this fact indicates the existence of a stable connection or regularity between the individual elements of the models. Thus, having received a composition of fuzzy relations, it is possible to recommend applicants the choice of a future profession on the basis of their competences.

Conclusion

In this article, it is proposed to use the apparatus of the theory of artificial intelligence systems to support the decision-making on the choice of the future profession on the basis of their competences.

In the future, it is necessary to implement informatisation of the learning processes, namely, to

organize systems for supporting educational processes in schools on the basis of web technologies and to give them a professional orientation.

References (GOST 7.1:2006)

1. *Integration of higher and secondary education: problems and ways of their solution on the basis of information technologies [Electronic resource] / Kostiantyn Meteshkin, Oleksandr Sokolov, Olga Morozova, Nataliya Teplova // Journal of Education, Health and Sport. – 2016. – Vol. 6(7). – P. 375-390. – Available at: <http://ojs.ukw.edu.pl/index.php/johs/article/view/3703> (accessed 04.05.2016).*
2. *The Change of Attitude to the Profession of University Graduates and Young Specialist [Text] / A. B. Sarsenova, M. S. Sadyrova, A. B. Montayev, B. I. Imanbekova, // International Journal of Environmental & Science Educatio. – 2016. – Vol. 11(18). – P. 12486–12499.*
3. *Lu, J. Solving nonlinear optimization problems with fuzzy relation equation constraints [Text] / J. Lu, S. C. Fang // Fuzzy Sets and Systems. – 2001. – Vol. 119(1). – P. 1-20.*
4. *Gottwald, S. Fuzzy sets and fuzzy logic: The foundations of application-from a mathematical point of view [Text] / S. Gottwald. – Springer-Verlag, 2013. – 216 p.*

5. Lootsma, F. A. *Fuzzy logic for planning and decision making [Text]* / F. A. Lootsma. – Springer Science & Business Media, 2013. – 198 p.

6. *Fuzzy relation equations and their applications to knowledge engineering [Text]* / A. Di Nola, S. Sessa, W. Pedrycz, E. Sanche. – Springer Science & Business Media, 2013. – 280 p.

7. Leonenkov, A. V. *Fuzzy modelling in MATLAB and fuzzyTech [Text]* / A. V. Leonenkov. – St. Petersburg: BHV, 2005. – 756 p.

References (BSI)

1. Meteshkin, K., Sokolov, O., Morozova, O., Teplova, N. Integration of higher and secondary education: problems and ways of their solution on the basis of information technologies. *Journal of Education, Health and Sport*, 2016, vol. 6(7), pp. 375-390. Available at: <http://ojs.ukw.edu.pl/index.php/johs/article/view/3703> (accessed 04.05.2016).

2. Sarsenova, A. B., Sadyrova, M. S., Montayev, A. B., & Imanbekova, B. I. The Change of Attitude to the Profession of University Graduates and Young Specialists. *International Journal of Environmental & Science Education*, 2016, vol. 11(18), pp. 12486–12499.

3. Lu, J., & Fang, S. C. Solving nonlinear optimization problems with fuzzy relation equation constraints. *Fuzzy Sets and Systems*, 2001, vol. 119(1), pp. 1-20.

4. Gottwald, S. *Fuzzy sets and fuzzy logic: The foundations of application-from a mathematical point of view*. Springer-Verlag Publ., 2013. 216 p.

5. Lootsma, F. A. *Fuzzy logic for planning and decision making*. Springer Science & Business Media Publ., 2013. 198 p.

6. Di Nola, A., Sessa, S., Pedrycz, W., & Sanchez, E. *Fuzzy relation equations and their applications to knowledge engineering*. Springer Science & Business Media Publ., 2013. 280 p.

7. Leonenkov, A. V. *Fuzzy modelling in MATLAB and fuzzyTech*. St. Petersburg, BHV Publ., 2005. 756 p.

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ПІДТРИМКА ПРИЙНЯТТЯ РІШЕННЯ ЩОДО ВИБОРУ МАЙБУТНЬОЇ ПРОФЕСІЇ З ВИКОРИСТАННЯМ НЕЧІТКИХ ВІДНОСИН

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У статті запропоновано один із шляхів вирішення проблеми професійної орієнтації абітурієнтів щодо вибору майбутньої професії за рахунок використання систем штучного інтелекту, а саме нечітких відносин. На основі нечітких відносин визначається цілий ряд додаткових понять, що використовуються для побудови нечітких моделей складних систем. Наведено приклад використання нечітких відносин для підтримки прийняття рішень щодо вибору майбутньої професії. Для уточнення отриманого результату, так як абітурієнт може вибрати кілька професій з однаковою оцінкою, запропоновано застосувати альтернативну операцію композиції двох бінарних нечітких відносин – (max-prod)-композиції.

Ключові слова: підтримка прийняття рішення, професійна орієнтація, системи штучного інтелекту, нечіткі множини, композиція нечітких відносин.

ПОДДЕРЖКА ПРИНЯТИЯ РЕШЕНИЯ ПО ВЫБОРУ БУДУЩЕЙ ПРОФЕССИИ С ИСПОЛЬЗОВАНИЕМ НЕЧЕТКИХ ОТНОШЕНИЙ

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В статье предложен один из путей решения проблемы профессиональной ориентации абитуриентов по выбору будущей профессии за счет использования систем искусственного интеллекта, а именно нечетких отношений. На основе нечетких отношений определяется целый ряд дополнительных понятий, используемых для построения нечетких моделей сложных систем. Приведен пример использования нечетких отношений для поддержки принятия решений по выбору будущей профессии. Для уточнения полученного результата, так как абитуриент может выбрать несколько профессий с одинаковой оценкой, предложено применить альтернативную операцию композиции двух бинарных нечетких отношений – (max-prod)-композицию.

Ключевые слова: поддержка принятия решения, профессиональная ориентация, системы искусственного интеллекта, нечеткие множества, композиция нечетких отношений.

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