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Моделі рольового складу команди для комплектації ІТ-компанії на платформі нечітких множин

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Анотація. Нині у глобальній Світовій економічній кризі й пандемії Covid/SARS-19, питання розвитку та функціонування компаній на дистанційній роботі і навчанні студентів, є актуальними як ніколи. Криза COVID-19, окрім Світової пандемії, завдала нищівного удару по економіці держави та організацій. Недостатній рівень забезпечення проведення досліджень, недосконаліть організаційної структури та організації управління науково-технічною діяльністю у ІТ-проектах обумовлюють необхідність перегляду та удосконалення наявної системи управління такими проектами. Метою дослідження є розробка комплексних моделей підвищення об'єктивності рольової оцінки компетенцій претендентів під час комплектації складу фахівців для ІТ-компанії в умовах невизначеності на платформі нечітких множин. У процессі дослідження були використані такі теоретичні методи наукового пізнання: метод синтезу та анлізу інформації, статистичний метод, метод максимізації та метод Мах-диз'юнкції. У дослідженні розглянуто розроблену модель оцінки компетенцій претендентів при комплектації рольового складу фахівців ІТ-компанії із використанням платформи нечітких множин. Проведено аналіз наявних проблем підбору персоналу, людських чи трудових ресурсів у корпораціях, діяльність яких пов'язана з розробкою програмного забезпечення різного спрямування. Наведено приблизний склад ролей у сучасних ІТ-компаніях із рекомендованими соціонічними типами інформаційного метаболізму для кожного конкретного виконавця ІТ-проекту. Механізм стимулювання в умовах специфічних обмежень дозволяє вдосконалити систему преміювання ІТ-персоналу та диференціювати такий персонал із використанням засобів проектного менеджменту. Авторами статті розроблено нечітку модель оцінки компетенцій претендента на будь-яку посаду в ІТ-корпорацію. Наведено лінгвістичні змінні, базис правил нечітких продукцій і укладення залежностей вихідної змінної від вхідних даних розробленої нечіткої моделі

Ключові слова: рольова оцінка персоналу, компетенції, команда, ІТ-компанія, нечітка логіка, нечітка модель

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Models of Team Composition for the Staffing of an IT Company on a Fuzzy Set Platform

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Abstract. Nowadays, in the conditions of global economic crisis and the Covid/SARS-19 pandemic, the issues of development and operation of companies in remote work and student education are more relevant than ever. The COVID-19 crisis, aside from the global pandemic, has dealt a crushing blow to the economy of states and organisations. Insufficient level of research funding, imperfection of the organisational structure and management of research activities in IT necessitate the revision and improvement of the existing management system for such projects. The purpose of the study is to develop comprehensive models for improving the objectivity of role assessment of applicants' competencies when completing a list of specialists for an IT company in conditions of uncertainty on the fuzzy set platform. The following theoretical methods were used in the study: information synthesis and analysis, statistical method, the maximisation method, and the Max-disjunctive method. The study considers the developed model for evaluating the competencies of applicants when selecting specialists for IT company using the fuzzy set platform. The analysis of existing problems of recruitment of personnel, human or labour resources in corporations whose activities are related to the development of software is carried out. The approximate composition of roles in modern IT companies with recommended socionic types of information metabolism for each specific performer of an IT project is given. The incentive mechanism under specific restrictions allows improving the bonus system for IT personnel and differentiate such personnel using project management tools. The authors of the paper have developed a fuzzy model for assessing the competencies of an applicant for any position in an IT Corporation. Linguistic variables, the basis of the rules of fuzzy products, and the conclusion of dependencies of the output variable on the input data of the developed fuzzy model are presented

Keywords: role assessment of personnel, competencies, team, IT company, fuzzy logic, fuzzy model

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Introduction

The construction of fuzzy economic models for the operation of the human-machine system and the use of computer systems is one of the most important problems of science in a context of uncertainty. The modern global labour market in the IT sector is developing very dynamically, small outsourcing companies and large corporations that are aimed at developing multi-vector application software are being created. Given the high degree of competition, the methods used for forming executive personnel in IT corporations are constantly being improved and unified.

Despite the implementation by existing IT corporations (NetCracker, Lohika system, Luxoft, SoftServe, etc.) of a flexible Agile policy of material and non-material incentives (free training, internships under the guidance of experienced mentors, moderators, tutors, provision of comfortable working conditions and flexible work schedules, financing entertainment events for the development of corporate spirit, payment for internships and advanced training courses), the current problems today are high staff turnover, reduced quality of work, unprofessionalism among both novice and already experienced IT employees [1-2]. This problem is caused by the imperfection of existing methods for assessing the professional abilities of candidates for senior and production positions in IT corporations. The exiting methods fail to fully take into account the specifics of the interaction of a number of psychological and professional factors [3-4].

In recent decades, computer programmes have gained popularity in predicting the overall results of complex operations and the sequence of possible variable events in human-machine systems. For example, Ukrainian scientists S.D. Bushuev, V.V. Morozov, use a socionic approach that is popular in the West to assess the competence of managers (technical, behavioural, contextual, and additional) [5-6]. V.V. Avdeev suggests a different approach, which also (but from a different perspective) uses socionics [7]. V.A. Rach, A.V. Biryukov propose an approach to the contextual assessment of the competence of IT project management teams based on the ICB and NCB UA [8]. G.S. Cherepakha uses a product and environmental approach, which is based on determining the requirements for the management system of the IT project team based on such factors of project uniqueness as the implementation environment, the personality of each member of the team, the professional activity of the team and the product of the IT project [9]. The advantage of this approach is its focus not on making generalised recommendations for managing average IT teams, but on making decisions on the problem of effective planning and development of each team for the real conditions of a particular IT project. A.V. Shakhov offers a role-based approach – an individual style, which should be understood as the entire system of distinctive features of a given person's activity, due to the characteristics of their personality, taking into account the risks of complementary (pyramid) IT teams [10].

Most foreign and Ukrainian specialists, experts in the field of management and team building use the model by R.M. Belbin [11-12]. When forming a long-term project team, the personality types of team members are taken into account, according to the Myers-Briggs typology. The involvement of various personality types in the use of the brainstorming method is considered. The interaction of different personality types during the use of the generalised method of activating creativeness is studied in detail. In particular, using the testing tool for selecting candidates, it is possible to determine the applicant's qualifications for any position in an IT company. The role assessment test by R. M. Belbin is quite universal. It is simple and straightforward, which is a tool for diagnosing the role composition of the group and the quality of performance of roles by participants in the IT team. Advantages: prevention of conflicts during interaction. Highlighting the role structure of an efficient team, understanding the need to distribute roles in a group. Disadvantages: strict distribution of roles hinders the development of the group [12].

It is difficult to select people according to the specified criteria and at the same time maintain the requirements for personal professionalism. There are other types of tests and role questionnaires for potential latent applicants, but their content is similar. Modern methods of selecting employees in the field of IT, as a rule, are not focused on obtaining a comprehensive assessment of the applicant's abilities. This assessment should include not only professional qualities, technical skills, personal characteristics, work experience, but also psychological characteristics, type of information metabolism, compatibility of a potential employee with the work team. As a result, the conclusion about the correspondence of the candidate's role to a certain position in an IT company should be based on the results of testing, questionnaires, and interviews, without formalising uncertainties and reasoned consideration of the personal makings and potential of the applicant for any position [13].

Purpose of the study. Development of comprehensive models for improving the objectivity of role assessment of applicants' competencies when hiring specialists for an IT company in conditions of uncertainty on the fuzzy set platform.

Methodology

The methodological basis of this study is theoretical and mathematical methods of scientific cognition. In the

process of research, the following theoretical methods were used: synthesis and analysis of information, statistical method, and a theoretical review of scientific literature on the subject matter was also carried out. The maximisation and the Max-disjunction methods were also used.

The method of information analysis and synthesis was used to consider questions about the specifics of the software development in modern IT companies. Using the methods of synthesis and analysis, it was determined that this process is characterised by a high mental and logical load on workers. In addition, using the method of synthesis and analysis, the composition of roles in modern IT corporations was considered and analysed. The statistical method was also used to consider these roles.

In the process of analysis, it was determined that TIMs (types of human information metabolism) with a highly developed function – the logic of fuzzy sets – are better suited for analytical and complex mental tasks; and employees with developed ethics and extraversion are better suited for performing tasks related to communication with people, establishing interpersonal contacts and learning. During the theoretical analysis of scientific literature, research papers by Ukrainian scientists were considered. It was found that the majority of foreign and Ukrainian specialists, experts in the field of management and team building use the model by R.M. Belbin [12] in their studies. The psychotypes of team members were considered in accordance with the Myers-Briggs typology.

In general, the study analysed the existing problems of recruitment of personnel, human or labour resources in corporations whose activities are related to the development of software in various areas. An approximate composition of roles in modern IT companies with recommended socionic types of information metabolism for each specific performer of an IT project is provided. The incentive mechanism under specific restrictions allows improving the bonus system for IT personnel and differentiate such personnel using project management tools. At the final stage, a fuzzy model for evaluating the competencies of an applicant for any position in an IT corporation was developed, including linguistic variables, the basis of fuzzy product rules, and the conclusion of dependencies of the output variable on the input data of the developed fuzzy model.

The development of the fuzzy model was carried out using the platform of the Fuzzy Logic Toolbox application package of the Matlab system, by sequentially performing the following stages: introduction of production rules that reflect the relationship between input and output data; formation of linguistic variables; setting functions for belonging variables; fuzzification of estimates of input variables; aggregation; activation and accumulation of conclusions and defuzzification of output variables of the fuzzy model [14-15]. The implementation of the aggregation operation was based on the maximisation method implemented in Matlab as Max. When the results were activated, the weight values for all input variables of the fuzzy model were assumed to be equal units. When accumulating, the Max-disjunction method was used to combine all the degrees of truth of the conclusions of the rules.

Results and Discussion

The specifics of software development in modern IT companies are characterised by a high mental and logical load on employees. The variability and dynamism of the IT market and tight deadlines for developing IT projects are the reasons for the need to decompose all functional stages of software creation between employees. This allows reducing the time required for software development and significantly increase the cost of an IT project. An example of the composition of an IT team in modern IT companies with a description of functional responsibilities and recommended types of information metabolism [14-16]. Since the type of human information metabolism (hereinafter referred to as TIM) is a sociotype, type of personality, that is, an innate type of human thinking structure that has a priority influence on its internal abilities, external implementation, it must be taken into account when evaluating the competencies of specialists in any field. The TIMs of employees of an IT corporation are shown in Table 1.

Table 1. Composition of roles in modern IT corporations

Role	Functional responsibilities	Results of work	TIM
Sales manager	Representative work. Search for clients, create and use personal connections to receive tenders and orders	Attracted customers	EIE, ESE, SEE
Project manager	Creation of the technical task structure, taking into account the customer's requirements. Calculation of the price and deadlines for completing tasks. Coordination of the production process	Technical and economic plan of the project	LSE, LIE, ILI
Software architect	Development of the project part of the order, decomposition of tasks and implementation of abstraction models and design templates	Project abstraction model	LII, ILI

Table 1, Continued

Role	Functional responsibilities	Results of work	TIM
Team lead	Distribution of priorities of tasks and responsibilities between the development team, monitoring the implementation of the project	Command execution of the work schedule	SEE, LSI
Business analyst	Coordination with the customer of all details, wishes, and requirements regarding the software being developed	Detailed list of requirements in general form	ESE, EII, ESI
Systems analyst	Formalisation of the list of agreed software requirements, taking into account the specifics of the subject area	Clear terms of reference	LSI, LSE
Technical writer	Draws up instructions and software specifications based on the generated terms of reference	List of specifications	ILI, SLI
UI designer	Development of a prototype graphical interface for a software product	Prototype interface	IEE, IEI
UE specialist	Development of a model of user interaction with the technical characteristics of the programme and the application	User interaction model	EII, ILE
Junior developer	Writing, modifying, and unit testing low-complexity code	Functional programme code for individual modules	LII, ILE, LIE
Middle developer	Writing, modifying, and unit testing medium-complexity code	Functional programme code for individual modules	LII, ILE, ILI
Senior developer	Writing the most responsible code, correcting mistakes made by less experienced software developers	Debugged programme code for the entire project	ILI, LII
Tester	Performing various types of testing in manual mode (White, Black, Grey-box)	Bug reports	SLI, ILI
Automation tester	Development of software scripts for automating the software testing process	Software testing automation scripts	ILE, SEE
QA engineer	Search and implement methods to improve the quality and speed of the software development process	Reduce software development time	SEI, ESE, EIE
Integration engineer	Integration of the developed software product into the customer's infrastructure, advising software maintenance personnel	Implemented software product	ESI, LSE, ESE
Support manager	Conducting training consultations and providing feedback from the customer with the development team	Trained employees on the customer's side	LSE, EIE, EII

Source: [15]

The TIM column contains abbreviations of the corresponding recommended socionic types of specialists, consisting of combinations of three letters. The first letter defines the most significant, four-dimensional "basic" function (L – logic, S – sensorics, E – ethics, I – intuition), the second – identifies a three-dimensional "creative" function (L – logic, S – sensorics, E – ethics, I – intuition), the third-determines the attitude of perception of the world (I – introversion, E – extraversion).

As can be seen from Table 1, for analytical and complex mental tasks, TIMs with a highly developed function – the logic of fuzzy sets – are better suited for analytical and complex mental tasks; and employees with developed ethics and extraversion are better suited for performing tasks related to communication with people, establishing interpersonal contacts and learning. However, the proposed TIMs for the corresponding positions in the table are not categorical, but only recommended, since any person is able to work in the above roles by gaining experience and relying on their strong skills and functions [15]. The problem, in this case, may be the specifics of further career development. Since the position may require more time and effort, which is not always justified in a real IT company.

The human factor is crucial at the stage of evaluating the competencies and knowledge of the applicant for

the applied role and position. The company's focus on managing "human resources" and "staff of IT employees", without taking into account organisational and professional cultures, individual characteristics of team members and other poorly identified and measurable characteristics of IT teams, often leads to conflicts, difficulties "out of the blue" and failure of the entire IT company [17]. In IT projects, the role of the human factor increases, the presence of a person as a component of the product of an IT project [18-19]. The stage of forming an IT team involves "lapping" its members with each other professionally, creating community and compatibility within the team itself in the IT corporation. At the stage of development of an IT project team, disagreements and conflict situations often arise in its environment, it lacks unity, cohesion and responsibility in the orientation of the mission, goals and objectives of the IT company. The stage of normalisation of the IT project team involves finding mutual understanding between team members in the IT company regarding their functions and responsibilities. As a result, disagreements stop, and the team stabilises [20-22]. This stage consists of the following elements:

- assessment of theoretical knowledge of the subject area;
- assessment of practical skills in working with software and software development tools;
- evaluation of completed cases in the portfolio of the applicant for a particular position.

Assessment of theoretical knowledge of the applicant's subject area consists in conducting testing on priority topics and areas of the IT corporation. Such testing can be carried out based on the use of both free web resources of electronic testing (Let's test, Opentest) and paid analogues of local orientation (VegaTest). The test results are formalised and the level of competence is evaluated by the company's experts [14; 23]. Assessment of the applicant's practical skills consists of completing a test task with a clear technical task, specifications, and using specified technologies and tools. The duration of such a task, depending on the role or position, varies from 3 to 14 days. The result obtained is evaluated by an expert, which may be a Senior developer or Team lead [24-25]. Algorithm for evaluating the applicant's technical knowledge and competencies:

1) analysis of the applicant's resume (places and work experience, completed cases, positions held, functional responsibilities);
2) professional 360-degree testing [26];
3) organisation of an assessment center with imitation of typical business tasks at the training [27];
4) target orientation assessment;
5) formalisation of the obtained results for each candidate [28].

Therefore, it is possible to develop a fuzzy model of role assessment of the competencies of applicants for vacancies in an IT company. Based on the results obtained: assessments of the psychological, technical and organisational potentials of the applicant, a fuzzy model for assessing the final competence of a candidate for a certain position in an IT company is constructed. The use of fuzzy sets for solving such problems brings the mathematical model of evaluating the effectiveness of an IT project as close as possible to the logical reasoning of qualified specialists. This, for its part, allows the study to define the assessment of competencies as a product of the result of a particular project [29].

The generated linguistic variables and their belonging functions are shown in Table 2. The developed fuzzy model contains 64 logical rules (Table 3). Conclusions of the surface estimate of the fuzzy model of the dependence of the competence level assessment on input variables were obtained in the course of modelling (Fig. 1-3). Fuzzy output surface data allows the study to establish the dependence of the values of the output variables on the values of the input variables of the fuzzy model when fixing other variables at the main level [16; 21]. This dependency can serve as the basis for software implementation of the corresponding fuzzy algorithm for automated assessment of competencies of applicants for the role. The developed fuzzy model allows obtaining the value of the applicant's competence assessment for each point belonging to a three-dimensional surface and reflects qualitative transitions between parameter values like "depressions" and "bursts".

Table 2. Linguistic variables and their belonging functions

Name of a linguistic variable	Terms of variable (symbolic view)	Branch definition of the affiliation function
Assessment of the applicant's psychological skills (APS)	Low (l)	X, 0, 20
	Minimum (m)	X, 10, 60
	Sufficient (s)	X, 50, 85
	Perfect (p)	X, 85, 100
Assessment of the applicant's technical skills (ATS)	Low (l)	X, 0, 20
	Minimum (m)	X, 10, 55
	Sufficient (s)	X, 50, 90
	Perfect (p)	X, 85, 100

Table 2, Continued

Name of a linguistic variable	Terms of variable (symbolic view)	Branch definition of the affiliation function
Assessment of the applicant's organisational skills (AOS)	Low (l)	X, 0, 30
	Minimum (m)	X, 15, 45
	Sufficient (s)	X, 40, 80
	Perfect (p)	X, 70, 100
Competence level (CL)	Low (l)	Y, 0, 0.33
	Average (a)	Y, 0.16, 0.7
	High (h)	Y, 0.55, 1

Table 3. Fuzzy product rule base for an IT project model

Variable name	Rule number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
APS	l	m	s	p	l	m	s	p	l	m	s	p	l	m	s	p
ATS	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l
AOS	l	l	l	l	m	m	m	m	s	s	s	s	p	p	p	p
CL	l	l	l	l	l	l	l	a	l	l	l	a	l	l	a	a
Variable name	**Rule number**															
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
APS	l	m	s	p	l	m	s	p	l	m	s	p	l	m	s	p
ATS	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
AOS	l	l	l	l	m	m	m	m	s	s	s	s	p	p	p	p
CL	l	l	l	a	l	l	a	a	l	l	a	a	l	l	a	h
Variable name	**Rule number**															
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
APS	l	m	s	p	l	m	s	p	l	m	s	p	l	m	s	p
ATS	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
AOS	l	l	l	l	m	m	m	m	s	s	s	s	p	p	p	p
CL	l	l	l	a	l	l	a	a	l	a	a	a	l	a	a	h
Variable name	**Rule number**															
	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
APS	l	m	s	p	l	m	s	p	l	m	s	p	l	m	s	p
ATS	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p	p
AOS	l	l	l	l	m	m	m	m	s	s	s	s	p	p	p	p
CL	l	l	a	a	l	a	a	h	a	a	h	h	a	h	h	h

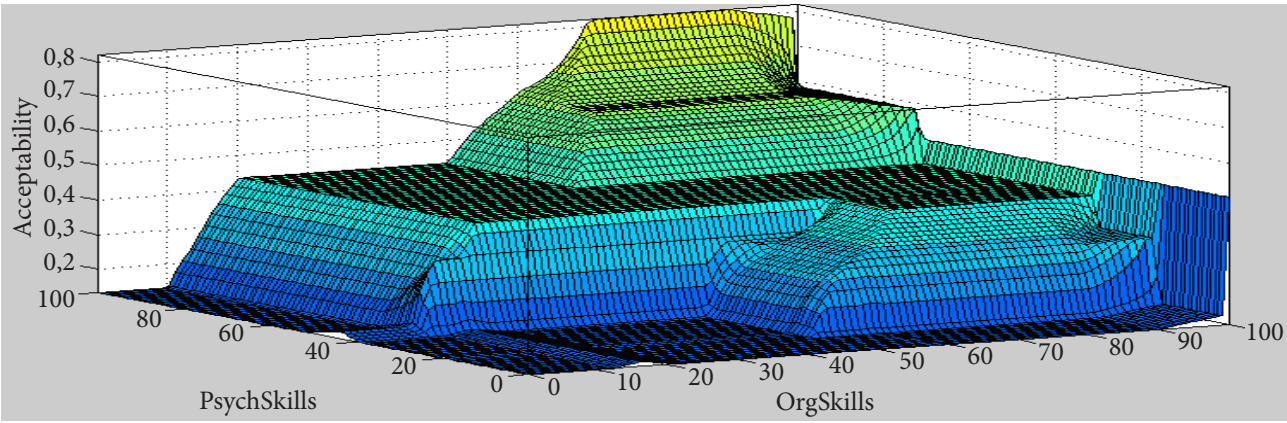

Figure 1. Three-dimensional visualisation of a fuzzy model for assessing the level of competence of an applicant based on their psychological and organisational skills

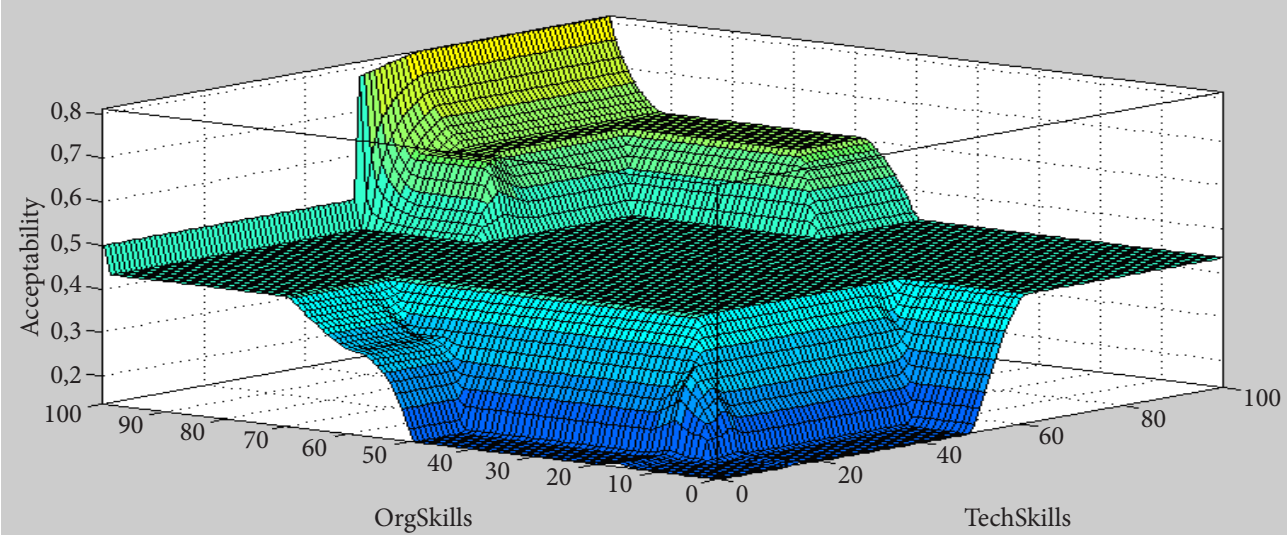

Figure 2. Three-dimensional visualisation of a fuzzy model for assessing the applicant's level of competence based on their technical and organisational skill**s**

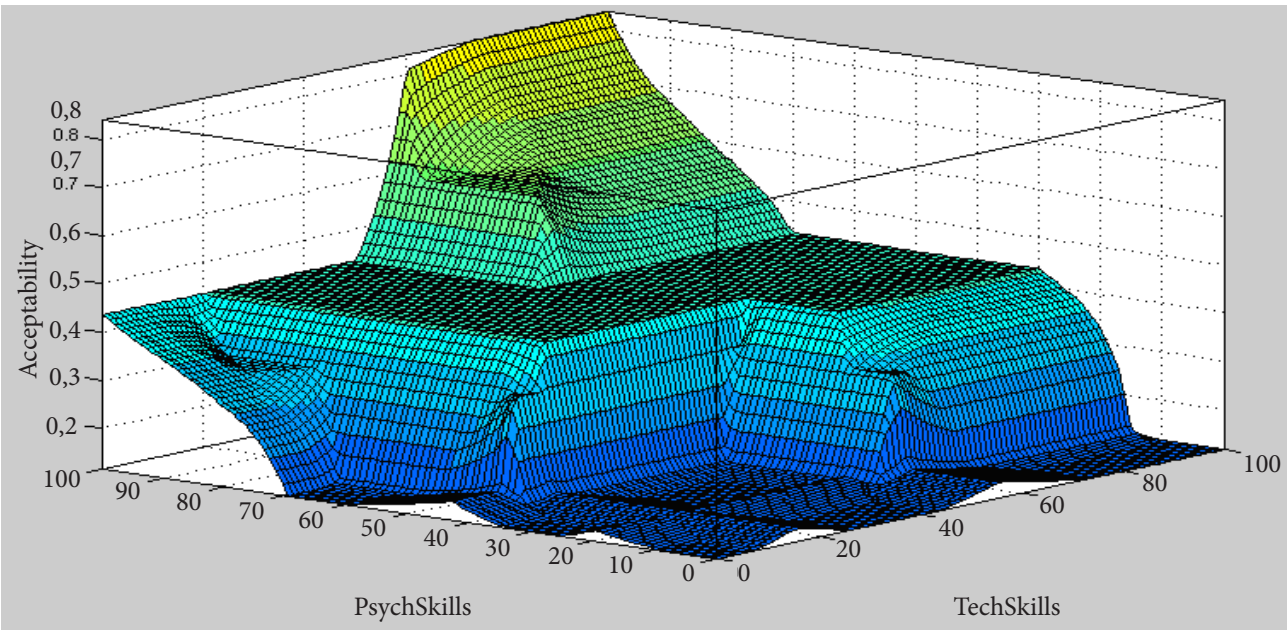

Figure 3. Three-dimensional visualisation of a fuzzy model for assessing the level of competence of an applicant based on their psychological and technical skills

Data on the fuzzy surface allows finding out whether the value of unreliable changes in the original fuzzy models is exhausted in the case of fixed changes at the main level. Such a contribution can become the basis for software implementation of a certain fuzzy algorithm for automatic assessment of the applicant's compliance with a certain position. The fuzzy model is constructed in such a way that it is possible to determine the value of the applicant's competence assessment for each point belonging to a three-dimensional surface, and display qualitative transitions between the parameter values in the form of "depressions" and "bursts".

Conclusions

Consequently, based on the fuzzy model developed by the authors of the study for assessing the competencies of an applicant for a role or position in an IT company, the time required to determine their labour potential is reduced. This is achieved due to the fuzzy rule mechanism embedded in the developed fuzzy model using the Matlab Rule Viewer module. Such a mechanism allows identifying and quantifying the degree of influence of specific values of assessments of the roles of the psychological, technical, and organisational potential of the client on existing roles (positions) in an IT corporation.

Combining and transforming the function of belonging of input variables reflects the specifics of the relationship between such role assessments and the final level of competence of the applicant. In particular, the results of the study of the developed fuzzy model allow the authors to establish that the level of technical and psychological potential of the applicant has a more significant impact on the level of competence. This is conditioned by the high degree of mental and logical load when working in the field of modern information technologies, and the need for the employee to develop such psychological qualities: perseverance, concentration and the ability to abstract from external stimuli (triggers). The proposed model of fuzzy sets, by its logic, allows optimising the speed of decision-making of the efficiency of an IT company and at the same time ensure maximum accuracy.

Comparison of the results of fuzzy output of various values of input variables obtained on the basis of calculations, using the developed fuzzy model in Matlab, shows good consistency of the model and confirms its adequacy when evaluating the competencies of applicants for positions in an IT company. The developed fuzzy model for assessing the competence of applicants allows studying and analysing numerous relationships of uncertainty mechanisms in the interrelationships of the psychological, technical, and organisational potential of a candidate for a certain position in an IT company.

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