Information systems modeling

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MATHEMATICAL MODEL FOR CALCULATING THE EXPERT'S COMPETENCY LEVEL

Abstract. In the context of the rapid development of information technologies, software quality is becoming critical for the successful operation of organizations in various industries. The growing complexity of modern software solutions requires the involvement of highly qualified specialists in software testing and quality assessment, capable of effectively identifying shortcomings and ensuring that the product meets established standards. At the same time, assessing the level of competence of such experts remains a difficult task, which is often based on subjective criteria and methods. The relevance of the study is due to the acute need of the modern IT market for objective tools for assessing the professional level of specialists, especially in the field of software quality assurance. Traditional approaches to qualification assessment, such as interviews, test tasks or resume analysis, often do not provide a complete and objective picture of the expert's competence. This problem becomes especially acute in the conditions of the global labor market, when companies are forced to evaluate specialists remotely, relying only on a limited set of data on their experience and skills. Today, software has become an integral part of many areas of our everyday life - from automation and optimization of production processes to creating comfort for an individual. **The object of the study** is the process of determining the level of competence of experts in software quality assessment. **The subject of the study** is a mathematical model for calculating the level of competence of an expert. The practical value of the results of the work is determined by the possibility of using the developed system by HR managers for effective selection of specialists, by heads of QA departments for the formation of balanced testing teams, by certification centers for objective assessment of competence, as well as by the experts themselves for planning their own professional development**. Conclusion** the developed mathematical model for calculating the level of competence of an expert allows you to reduce the time for assessing the competence of specialists, minimize the influence of subjective factors when making personnel decisions, and optimize the distribution of human resources in software development and testing projects.

Keywords: expert evaluation; testing; software quality; mathematical evaluation methods; model.

Introduction

Software quality assessment is a complex process that includes the analysis of functional compliance, performance, security, usability, maintainability and other characteristics [1]. The results of such an assessment significantly depend on the qualifications of the experts involved. However, traditional methods for determining the level of expertise of specialists are often based on subjective criteria or formal indicators that do not always reflect the real level of competence [2–4]. The research problem is the need to develop an objective, mathematically based system for assessing experts, which would allow formalizing the process of analyzing professional qualities and minimizing the influence of subjective factors. Modern research on this topic often focuses on individual aspects of assessment, ignoring the complex nature of the examination and the relationship between various professional indicators [5].

The publication [6] considers methods and means of expert assessment of software systems, and also provides their comparative characteristics. Special attention is paid to the modified method of expert assessment of software systems based on interval data analysis. The proposed method allows obtaining an interval assessment of a software product by experts, which is guaranteed to satisfy the requirements of software developers.

The study [7] considers the task of constructing a criterion for the compatibility of expert assessments in a group. The feasibility of using interval data analysis methods to construct the specified criterion is shown. The example demonstrates the effectiveness of using this criterion for selecting experts for their further involvement in the project assessment process. The work focuses on the compatibility of opinions between experts, which is an important aspect in the formation of expert groups. The use of interval data is effective for taking into account uncertainty in expert assessments, which is relevant for increasing the reliability of the results.

The article [8] investigates the problem of assessing the level of objectivity and qualification of experts in project assessments presented by them according to specified criteria. The feasibility of constructing quality assessment criteria for each expert based on a modified interval method of expert assessment is determined. The formulated criterion is based on the consistency of the interval assessment of the expert with two important indicators: the initial specified interval assessment of the customer and the interval assessment of the end user. The use of interval assessments allows to take into account uncertainty, but can complicate the comparison and aggregation of assessments.

In the study [9], the assessment is considered as a procedure for fixing quantitative and qualitative characteristics, which plays a significant role in the analysis of the final result of any activity. Studies of software systems assessment have shown that none of the methods and approaches to the expert assessment procedure is ideal. The quality of the final assessments is significantly affected by such criteria as the subjectivity of the expert or group of experts, as well as their competence and qualifications. The article shows how the proposed criterion for assessing the level of expert competence can minimize the influence of the subjectivity of opinions on the quality of assessments. In practice, the effectiveness of using the modified interval method of expert assessment when selecting experts who will carry out the procedure of expert assessment of software.

Statement for the task

Existing approaches to assessing the level of experts in the field of software engineering are often based on qualitative indicators, such as reputation, peer recommendations, past projects. Although these factors are important, they are difficult to formalize and quantify. At the same time, the growth of the popularity of professional networks, in particular LinkedIn, has created a unique source of quantitative data on the professional path and achievements of specialists [10–12]. Key problems that exist in the subject area include:

- The subjectivity of traditional methods of assessing experts, which leads to inconsistency and potential bias in determining their qualifications;
- The lack of a standardized methodology for determining the weight of different professional indicators in assessing the overall level of expertise.
- The difficulty of establishing a correlation between formal indicators (experience, education, certificates) and the real ability of the expert to provide substantiated assessments of software quality.
- The dynamic nature of the industry, which requires constant updating of evaluation criteria and their relative importance.
- The need for a balance between the simplicity of data collection for evaluation and the complexity of analysis to ensure its accuracy.

An important aspect of the study is to establish a connection between the level of expertise of a specialist and the reliability of his judgments about the quality of software. Qualitative software evaluation requires not only technical knowledge, but also analytical skills, critical thinking and the ability to take into account various factors [13].

The developed mathematical model should take into account these nuances, providing a multidimensional assessment of expertise, which correlates with the ability of a specialist to provide informed judgments about the quality of software products [14–17].

Thus, the development of methods for objectively assessing the level of experts in the field of software engineering is a necessary step to improve the quality and reliability of software evaluation processes [18–20].

The creation of a mathematical model that allows you to quantitatively determine the level of trust in expert assessments is essential for improving software quality assurance practices and making informed decisions about the development and implementation of software products [21-27].

Main part

To build any mathematical model, the first step is to identify key indicators, the formalization of which most accurately affects the final result. To build a mathematical model for calculating the level of expert competence, a set of quantitative parameters was obtained from professional LinkedIn profiles (Fig. 1), each of which represented a separate aspect in the field of software engineering.

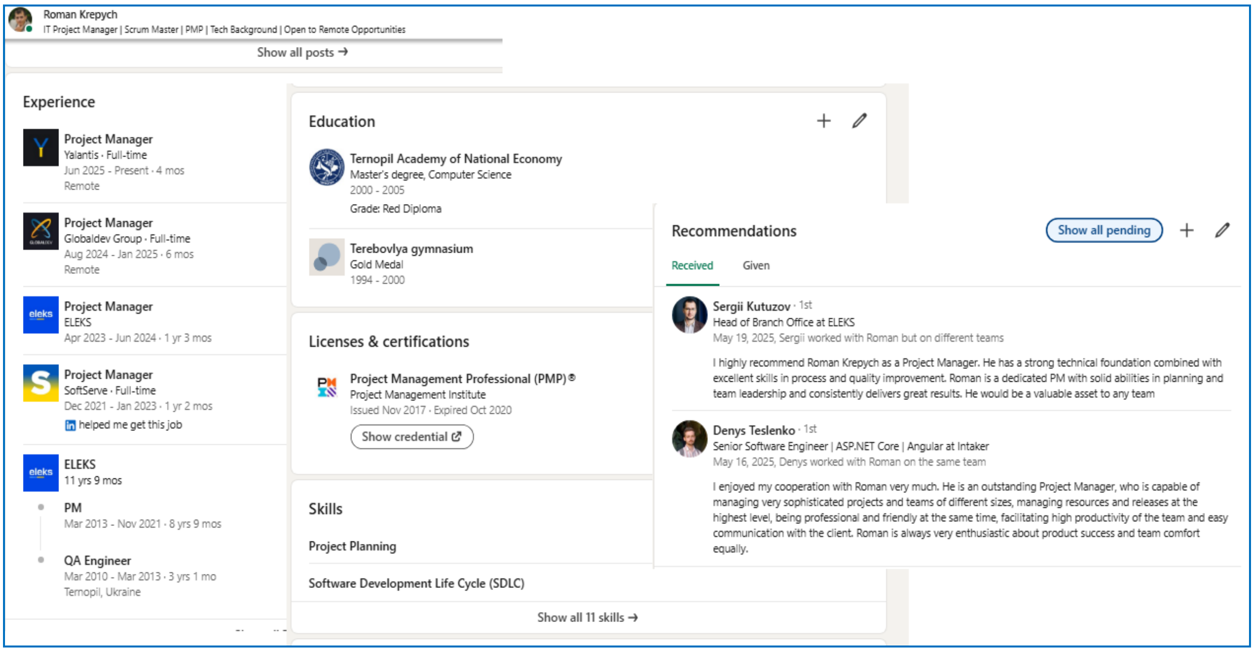

Fig. 1. LinkedIn forms

These criteria were carefully selected to cover both technical competence and professional recognition within the industry ecosystem. The measurable nature of these parameters ensures objectivity in the assessment process, and their diversity creates a multidimensional assessment model. Each criterion serves as an indicator of different aspects of professional development - from formal education to practical experience and recognition by colleagues. So, the following indicators will serve as input data for the mathematical model:

E – experience (calculated as the sum of working months);

C – number of companies where the expert worked (on the one hand, the higher this number, the higher the probability that the expert may be unstable and unprofessional, but on the other hand, a large number of companies means multifaceted experience);

Ed – (although nowadays in most cases for software developers, education may not be relevant to their competence, however, completed higher education is still an important criterion that shows at least the ability to complete long-term processes);

P – projects (the higher this number, the wider the range of projects with which the expert worked, which may indicate higher competence, at the same time, a small number of projects, but their long-term duration, may indicate the level of the expert in terms of ideology, high technical expertise, sustainability, etc.);

S – services offered (the scope of the expert's skills and their relevance to specific domains of software evaluation);

CL – number of certificates, licenses, and courses completed;

L – number of languages (specified (this criterion only takes into account languages that are foreign to the expert);

RR – recommendations received (an indicator of the recognition of the expert's competence by other LinkedIn members and, at the same time, communication and reputational assessments from colleagues in the industry);

GR – recommendations given (a reflection of the expert's ability to evaluate and support others in their professional network);

Sk – skills (the total number of skills listed in the LinkedIn profile. This criterion indicates the breadth of the person's expertise, demonstrating their versatility and knowledge in various fields);

SkE – confirmed skills (the number of confirmed skills reflects the recognition of specific professional skills by other members of the person's network of contacts, emphasizing their reliability and competence in these areas);

Ec – number of endorsements (the total number of endorsements (skills) demonstrates the degree of recognition of the person's skills by colleagues, highlighting their influence and authority within their professional community);

R – assessment (expert level assessment. It is based on personal knowledge and professional interaction with each expert in the sample. The assessment reflects a reasoned judgment about the experts' competence, reliability, and overall level of expertise in the field of software evaluation).

Table 1 presents the summary indicators of the expert sample.

Table 1 – **Meaning of expert selection indicators**

Експерт	*E*	*C*	*Ed*	*P*	*S*	*CL*	*L*	*RR*	*GR*	*Sk*	*SkE*	*Ec*	*R*
1	70	2	1	0	1	1	0	0	2	29	27	238	7
2	173	6	3	0	1	2	5	0	1	50	33	213	10
3	196	6	3	0	26	1	0	1	4	13	13	94	9
4	119	3	3	0	2	2	0	0	0	21	21	87	8
5	166	3	3	10	0	1	0	0	0	9	9	241	10
6	78	1	0	3	0	1	0	0	0	10	10	30	6
7	64	1	0	0	0	0	0	0	0	17	11	14	4
8	71	2	1	0	0	0	0	0	0	18	13	37	5
9	124	5	3	0	1	1	0	1	0	19	15	40	8
10	151	7	1	5	12	1	0	0	1	53	39	140	9
11	188	4	1	10	2	1	0	1	1	12	12	250	10
12	129	5	2	0	3	1	0	0	0	21	21	47	9
13	113	3	0	0	0	1	0	0	2	13	9	35	5
14	206	4	1	13	0	1	0	10	6	31	31	582	10
15	154	4	1	0	4	1	0	3	1	59	20	53	9
16	121	6	1	0	0	1	0	2	1	7	7	321	8
17	230	4	2	0	1	1	0	1	2	9	9	19	9
18	179	3	1	2	7	2	0	12	9	77	18	527	5
19	153	3	2	0	1	1	0	0	0	23	9	24	7
20	130	1	5	0	2	0	0	0	0	15	9	35	6
21	118	4	1	0	1	0	0	1	3	5	5	43	5
22	190	9	3	10	2	2	0	5	12	18	18	210	6
23	209	12	1	0	3	1	0	3	4	25	25	529	7
24	143	4	1	0	0	0	0	0	1	8	8	16	6

We build a mathematical model that includes all twelve indicators of the "quality" of an expert and for this we choose a linear structure of the model of the following form:

$$R_i = k_1 \cdot E_i + k_2 \cdot C_i + k_3 \cdot Ed_i + k_4 \cdot P_i + k_5 \cdot S_i + \\ + k_6 \cdot CL_i + k_7 \cdot L_i + k_8 \cdot RR_i + k_9 \cdot GR_i + \\ + k_{10} \cdot SK_i + k_{11} \cdot SkE_i + k_{12} \cdot Ec_i + k_{13}, \quad (1)$$

where k_j, $j = 1, 2, ..., 13 -$ unknown coefficients, the values of which must be calculated based on the analysis of the collected data by a group of experts; i – the variable in the model, depends on the amount of experimental data.

Let us compose a system of linear algebraic equations of the form (2).

$$\begin{cases} R_1 = k_1 \cdot E_1 + k_2 \cdot C_1 + k_3 \cdot Ed_1 + k_4 \cdot P_1 + k_5 \cdot S_1 + \\ \quad + k_6 \cdot CL_1 + k_7 \cdot L_1 + k_8 \cdot RR_1 + k_9 \cdot GR_1 + \\ \quad + k_{10} \cdot SK_1 + k_{11} \cdot SkE_1 + k_{12} \cdot Ec_1 + k_{13}; \\ \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ R_i = k_1 \cdot E_i + k_2 \cdot C_i + k_3 \cdot Ed_i + k_4 \cdot P_i + k_5 \times \\ \quad \times S_i + k_6 \cdot CL_i + k_7 \cdot L_i + k_8 \cdot RR_i + k_9 \cdot GR_i + \\ \quad + k_{10} \cdot SK_i + k_{11} \cdot SkE_i + k_{12} \cdot Ec_i + k_{13}; \\ \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ R_{24} = k_1 \cdot E_{24} + k_2 \cdot C_{24} + k_3 \cdot Ed_{24} + k_4 \cdot P_{24} + k_5 \times \\ \quad \times S_{24} + k_6 \cdot CL_{24} + k_7 \cdot L_{24} + k_8 \cdot RR_{24} + k_9 \times \\ \quad \times GR_{24} + k_{10} \cdot SK_{24} + k_{11} \cdot SkE_{24} + k_{12} \cdot Ec_{24} + k_{13}. \end{cases} \quad (2)$$

The solution of system (2) is the domain of model coefficients. We use the least squares method to find estimates of the coefficients of the SLAR (2) model, and we obtain, accordingly, the following model (3): the variable in the model depends on the amount of experimental data.

We compose a system of linear algebraic equations of the form (2).

$$R_i = 0.019 \cdot E_i + 0.057 \cdot C_i + 0.09 \cdot Ed_i + 0.163 \times \\ \times P_i + 0.068 \cdot S_i + 0.984 \cdot CL_i + 0.147 \cdot L_i + \\ + 0.219 \cdot RR_i - 0.6 \cdot GR_i - 0.029 \cdot SK_i + \\ + 0.066 \cdot SkE_i - 0.001 \cdot Ec_i + 3.289. \quad (3)$$

Fig. 2 presents the results of checking the adequacy of the mathematical model (3) taking into account a 15% deviation corridor of the expert ratings, so that the element of subjectivity of the assessment is taken into account.

As we can see, the mathematical model for calculating the expert's competence level demonstrates high performance when applied to a calibration sample. It also successfully determines the assessment of the competence level of an individual representative from the LinkedIn system. Additionally, experimental studies were conducted to reduce the number of input parameters from 12 to a smaller number, but all potential simplified models showed significantly worse predictive results. Models built using only seven or fewer criteria demonstrated significant deviations from the initially defined ones, with errors often exceeding 30-40% of the estimates obtained from real data.

This rapid decrease in accuracy shows that there is a critical threshold below which the assessment structure cannot adequately reflect the multidimensional nature of the indicators of the "quality" of an expert in the field of software development. This study is only an initial stage in the study of expert competence levels, and further work will only develop and improve the results obtained.

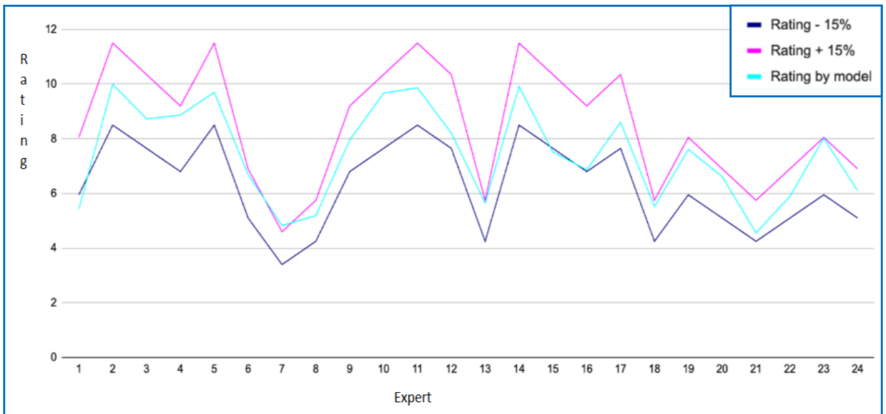

Fig. 2. Diagram of expert evaluation based on a mathematical model for calculating the level of expert competence

Conclusions

As a result of the analysis of existing methods for assessing the professional competence of software evaluation specialists, it was found that most of them are characterized by a high level of subjectivity and insufficient formalization, which complicates their application in the conditions of the global labor market. It was found that professional social networks, in particular LinkedIn, contain a significant amount of quantitative data that can be used to objectively assess the level of competence of specialists, but existing solutions do not provide the proper level of their integration and analysis. A mathematical model for assessing the level of competence of software quality assessment experts has been developed, which takes into account a set of quantitative indicators from professional profiles, including work experience, implemented projects, technical skills, education, certifications and professional connections. Each indicator has an individual weight, which is determined on the basis of an expert analysis of its significance for a specific specialization in the field of software evaluation. The proposed model provides a multifactorial assessment of a specialist's competence, which allows you to obtain an objective idea of his professional level.

The practical value of the developed mathematical model is confirmed by the possibility of its use for solving various tasks in the field of human resources management in the field of software development. The model allows you to reduce the time for assessing the competence of specialists, minimize the influence of subjective factors when making personnel decisions, and optimize the distribution of human resources in software development and testing projects.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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Математична модель розрахунку рівня компетентності експерта

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Анотація. В умовах стрімкого розвитку інформаційних технологій якість програмного забезпечення набуває критичного значення для успішної діяльності організацій різних галузей. Зростаюча складність сучасних програмних рішень вимагає залучення висококваліфікованих фахівців з тестування та оцінки якості програмного забезпечення, здатних ефективно виявляти недоліки та забезпечувати відповідність продукту встановленим стандартам. Водночас оцінювання рівня компетентності таких експертів залишається складним завданням, яке часто ґрунтується на суб'єктивних критеріях та методах. Актуальність дослідження зумовлена гострою потребою сучасного ІТ-ринку в об'єктивних інструментах оцінювання професійного рівня фахівців, особливо у сфері забезпечення якості програмного забезпечення. Традиційні підходи до оцінки кваліфікації, як-от співбесіди, тестові завдання чи аналіз резюме, часто не дають повного та об'єктивного уявлення про компетентність експерта. Особливої гостроти ця проблема набуває в умовах глобального ринку праці, коли компанії змушені оцінювати фахівців дистанційно, спираючись лише на обмежений набір даних про їхній досвід та навички. На сьогодні програмне забезпечення перетворилося на невід’ємну складову багатьох сфер нашого повсякденного життя – від автоматизації і оптимізації процесів на виробництві до створення комфорту окремої людини. **Об’єктом дослідження** виступає процес визначення рівня компетентності експертів з оцінки якості програмного забезпечення. **Предметом дослідження** є математична модель розрахунку рівня компетентності експерта. Практична цінність результатів роботи визначається можливістю використання розробленої системи HR-менеджерами для ефективного підбору фахівців, керівниками QA-відділів для формування збалансованих команд тестування, сертифікаційними центрами для об'єктивної оцінки компетентності, а також самими експертами для планування власного професійного розвитку. **Висновок** розроблена математична модель розрахунку рівня компетентності експерта дозволяє скоротити час на оцінку компетентності фахівців, мінімізувати вплив суб'єктивних факторів при прийнятті кадрових рішень та оптимізувати розподіл людських ресурсів у проектах з розробки та тестування ПЗ.

Ключові слова: експертне оцінювання; тестування; якість програмного забезпечення; математичні методи оцінювання; модель.