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A COMPREHENSIVE REVIEW OF INFORMATION SYSTEMS FOR SCIENTIFIC PROJECT ASSESSMENT

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Evaluation of scientific and scientific-technical projects is a multifaceted task that requires a balanced approach to the analysis of innovativeness, feasibility and potential impact of research initiatives. Traditional methods of expert evaluation are based on subjective conclusions of specialists, which create risks of inconsistency and limited reproducibility of solutions. In this regard, the importance of intelligent information systems that can improve the quality, transparency and efficiency of evaluation procedures is increasing. The article presents a comprehensive review of architectural solutions, network models and technologies used in information systems designed to support expert evaluation of scientific projects. Both classical knowledge-based approaches and modern solutions using artificial intelligence methods are considered: machine learning, natural language processing (NLP), fuzzy logic, and genetic algorithms. Particular attention is paid to the use of blockchain technologies to ensure the reliability, security and auditability of expert procedures. Key decision support methods are analyzed, including multi-criteria analysis methods, optimization algorithms, and automated distribution of applications between experts. Examples of successful implementation of cloud and distributed architectures in the scientific expertise system are presented.

Keywords: intelligent systems, expert assessment, scientific projects, information systems, systems architecture, machine learning (ML), fuzzy logic, blockchain, multi-criteria analysis, natural language processing (NLP).

ҒЫЛЫМИ ЖОБАНЫ БАҒАЛАУ ҮШІН АҚПАРАТТЫҚ ЖҮЙЕЛЕРДІ КЕШЕНДІ ШОЛУ

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Ғылыми және ғылыми-техникалық жобаларды бағалау зерттеу бастамаларының жаңашылдығын, орындылығын және әлеуетті әсерін талдауға теңгерімді көзқарасты талап ететін көп қырлы міндет болып табылады. Сараптамалық бағалаудың дәстүрлі әдістері шешімдердің сәйкессіздік және шектеулі қайталану қаупін тудыратын мамандардың субъективті қорытындыларына негізделген. Осыған байланысты бағалау рәсімдерінің сапасын, ашықтығын және тиімділігін арттыра алатын интеллектуалды ақпараттық жүйелердің маңыздылығы артып келеді. Мақалада ғылыми жобалардың сараптамалық бағалауын қолдауға арналған ақпараттық жүйелерде қолданылатын архитектуралық шешімдер, желілік модельдер мен технологиялардың жан-жақты шолуы берілген. Классикалық білімге негізделген тәсілдер де, жасанды интеллект әдістерін пайдаланатын заманауи шешімдер де қарастырылады: машиналық оқыту, табиғи тілді өңдеу (NLP), анық емес логика және генетикалық алгоритмдер. Сараптамалық процедуралардың сенімділігін, қауіпсіздігін және аудиттілігін қамтамасыз ету үшін блокчейн технологияларын пайдалануға ерекше назар аударылады. Шешім қабылдауды қолдаудың негізгі әдістері талданады, соның ішінде көп критериалды талдау әдістері, оңтайландыру алгоритмдері және сарапшылар арасында қосымшаларды автоматтандырылған тарату. Ғылыми сараптама жүйесінде бұлтты және бөлінген архитектураларды сәтті енгізу мысалдары келтірілген.

Түйін сөздер: интеллектуалды жүйелер, сараптамалық бағалау, ғылыми жобалар, ақпараттық жүйелер, жүйелер архитектурасы, машиналық оқыту (ML), анық емес логика, блокчейн, көп критериалды талдау, табиғи тілді өңдеу (NLP).

КОМПЛЕКСНЫЙ ОБЗОР ИНФОРМАЦИОННЫХ СИСТЕМ ДЛЯ ОЦЕНКИ НАУЧНЫХ ПРОЕКТОВ

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Оценка научных и научно-технических проектов – многогранная задача, требующая сбалансированного подхода к анализу инновационности, реализуемости и потенциального воздействия исследовательских инициатив. Традиционные методы экспертной оценки основаны на субъективных выводах специалистов, что создает риски противоречивости и ограниченной воспроизводимости решений. В этой связи возрастает значение интеллектуальных информационных систем, способных повысить качество, прозрачность и эффективность процедур оценки. В статье представлен комплексный обзор архитектурных решений, сетевых моделей и технологий, используемых в информационных системах, предназначенных для поддержки экспертизы научных проектов. Рассматриваются как классические подходы, основанные на знаниях, так и современные решения, использующие методы искусственного интеллекта: машинное обучение, обработка естественного языка, нечеткая логика и генетические алгоритмы. Особое внимание уделено использованию блокчейн-технологий для обеспечения надежности, безопасности и проверяемости экспертных процедур. Проанализированы основные методы поддержки принятия решений, включая методы многокритериального анализа, алгоритмы оптимизации и автоматизированное распределение заявок между экспертами. Приведены примеры успешного внедрения облачных и распределенных архитектур в систему научной экспертизы.

Ключевые слова: интеллектуальные системы, экспертная оценка, научные проекты, информационные системы, архитектура систем, машинное обучение (МО), нечеткая логика, блокчейн, многокритериальный анализ, обработка естественного языка (NLP).

Introduction. The development of scientific research activities and increasing competition for funding pose the challenge for the scientific community to modernize the procedures for assessing and reviewing projects. The existing practice of expert evaluation is usually manual, fragmented and subjective. This reduces the efficiency of research program management, increases the risks of unreliable decisions, and complicates the scalability of the process with an increase in the volume of submitted applications. In the context of digitalization and growing data volumes, it becomes necessary to move from the traditional expert model to intelligent information systems capable of providing a more accurate, objective and reproducible assessment of projects [1].

The object of the study is information systems designed to assess scientific and scientific-technical projects.

The purpose of this work is to form a holistic view of the architecture, technologies and algorithms underlying intelligent expert evaluation systems, as well as to identify areas for their further development and application in the practice of scientific administration.

The relevance of the topic is due to the growing interest in digital platforms for decision support in science, the emergence of new technological solutions, as well as state policy in the field of digital transformation of science. Despite the availability of private solutions, a systematic review combining architectural, algorithmic and

applied aspects of designing such systems is still insufficient in scientific literature. This creates a methodological gap between IS developers and specialists in the field of scientific expertise.

The scientific novelty of the study lies in the integrated approach to systematizing existing solutions: from classical expert systems and multi-criteria models to modern methods of machine learning, automated annotation, application distribution, blockchain registries and cloud architecture. The work offers a comparative analysis of the approaches used in the literature over the past ten years, with an emphasis on their applicability in scientific practice.

The hypothesis of the study is that the use of modular architectures and hybrid AI models in information systems can significantly improve the quality, transparency and adaptability of expert assessment processes.

Materials and Methods. The methodological basis of this study is a systematic review aimed at identifying, classifying and analyzing architectural solutions, technologies and algorithms used in intelligent information systems designed to evaluate scientific and scientific-technical projects.

The study was conducted in several stages:

1. Formulating criteria for selecting publications.

The review included scientific articles published between 2015 and 2025, primarily in English-language peer-reviewed journals indexed in the Scopus, IEEE Xplore, SpringerLink, ACM DL databases, as well as in authoritative Kazakh and Russian sources. The main selection criteria were:

- focus on expert evaluation information systems;

- availability of a description of the architecture, models or algorithms used;

- practical focus of solutions.

Articles devoted exclusively to administrative, sociological or political aspects of scientific expertise without a technical component were excluded.

2. Search and selection of sources.

To ensure complete coverage, the following keywords were used: expert evaluation systems, project assessment, decision support systems, AI in research evaluation, scientific project management, fuzzy logic, blockchain for science, multi-criteria decision making (MCDM). At the first stage, more than 40 publications were identified, of which 25 most relevant sources were selected after reference analysis.

3. Classification and systematization of data.

The publications were analyzed according to the following parameters:

- type of architecture;

- type of technologies used;

- decision-making methods used;

- scope and maturity stage.

4. Analysis of methods and algorithms.

Particular attention is paid to the analysis of algorithmic solutions:

- decision support systems based on multi-criteria models;

- machine learning methods for analyzing application texts and predicting;

- optimization algorithms;

- transparency technologies.

Each method was described in the context of its applicability to the task of scientific expertise, and its advantages and limitations were considered.

Architecture of intelligent assessment systems

Developing an intelligent project evaluation system requires a well-defined architecture that integrates data, expert knowledge, and analytical models. Early approaches often took the form of knowledge-based expert systems, where domain rules and criteria guided project evaluations. For example, Mutanov et al. [2] developed a decision support methodology using mathematical models to evaluate innovative projects along two key dimensions, “innovativeness” (I) and “competitiveness” (K), visualizing each project as a point on a K=f(I) matrix for expert panels. This architecture formalized how scientific and business metrics intersect in project value and allowed experts to compare projects using a graphical decision map. Such rule-based or

model-driven architectures lay the foundation by defining the criteria, metrics, and workflow for evaluation. Modern intelligent system architectures increasingly use cloud and network technologies to improve collaboration and scalability.

A prominent example is the remote peer review system developed by Yu et al. for urban planning projects [3]. The system architecture uses a cloud service platform to pool information resources and remote experts, enabling online project reviews even in resource-constrained regions. Key features include shared data repositories, GIS tools for spatial analysis, and secure access for geographically distributed evaluators. By virtualizing resources using cloud computing, this architecture achieves the integration of various data sources and supports a seamless workflow between multiple users, thereby improving the efficiency and "scientific nature" of the review process. This illustrates how distributed architecture can modernize the peer review process for scientific projects.

Another important architectural trend is the incorporation of blockchain networks into the system design. Blockchain technology, originally known as cryptocurrency, is now seen as a "software connector" that can link system components in a decentralized, tamper-proof manner. Xu et al. described blockchain as a new connector in software architecture that can ensure data integrity and trust between distributed modules [4]. In project evaluation systems, this implies that project proposals, reviews, and decisions can be recorded on a blockchain ledger to prevent unauthorized changes and improve transparency. Zyskind et al. demonstrated how blockchain can be used to protect personal data by decentralizing access control [5]. By applying this, an evaluation system can protect sensitive information about proposals while allowing authorized experts to access the data through cryptographic keys.

In general, the architecture of an intelligent project evaluation system is often modular, combining a data layer, an intelligence layer, and an interface layer. Indeed, national science management strategies are moving towards unified digital ecosystems: for example, the concept of science development in Kazakhstan for 2023–2029 envisages the creation of a unified information system "Science of Kazakhstan", which digitalizes all scientific processes using data science, big data, and other digital tools [1].

Network Models and AI Methods in Project Evaluation

Intelligent systems use advanced AI models or "network models" to analyze and interpret the complex data used in project evaluation. By "network models" in this context, we mean neural networks and deep learning models that have revolutionized the processing of unstructured data. In a review, Jordan and Mitchell identified machine learning as a transformative technology and predicted that learning algorithms will increasingly work collaboratively and process multiple data sources [6]. Indeed, modern intelligent evaluation systems use a combination of AI models:

- Natural language processing (NLP) and text mining: Project proposals and research papers contain a lot of text. Deep learning models can analyze documents to extract key information. Recent research has led to the creation of large-scale datasets and models for summarizing multiple documents. For example, the Multi-News dataset presented by Fabbri et al. contains thousands of clusters of news articles with summaries, allowing neural models to learn to generate consistent summaries from multiple sources [7]. Building on this, Lu et al. created Multi-XScience, a dataset for summarizing multiple scientific articles related to a given topic [8]. Akhmetov et al. proposed an extractive summarization method for scientific articles based on greedy optimization, demonstrating how AI can automatically highlight the most important sentences in a paper [9]. Integrating such summarization tools into an expert system allows a reviewer to instantly obtain a summary of the literature on a sentence or previous results, saving time and improving understanding.

- Knowledge graphs and semantic networks: Intelligent systems can represent domain knowledge as concept graphs, for example by linking projects to related scientific fields,

experts, or previous works. This helps recommend suitable expert reviewers or identify collaboration opportunities [10-12].

- Plagiarism and integrity checking: Ensuring the originality of submissions is an important part of project review. Machine learning techniques have improved plagiarism detection by learning patterns of textual similarity. Kamath and Ghosh proposed a machine learning approach to plagiarism detection that can be used to compare a new submission with a database of existing documents to detect potential copying [13].

- Question and answering and information retrieval: Domain-specific question and answer systems can help experts find facts quickly. Sabieva et al. developed a legal question answering system that uses machine learning to extract accurate answers from legal texts [14]. Similarly, a quality assurance module in a project appraisal system could allow an expert to ask questions such as "What was the success rate of projects in area X last year?" or "What projects similar to this one have been funded before?" and receive an immediate answer from a knowledge base.

- Deep learning for forecasting: Neural network models are also used to predict project outcomes or estimates. Given enough historical data, a model can be trained to predict the probability of success. LeCun et al. noted that deep learning enables multi-layered representation learning, achieving remarkable results in pattern recognition and forecasting tasks [15]. Sikimić and Radovanović attempted to use machine learning to predict project performance in high-energy physics proposals but found that accurately predicting project success based on proposal data alone is non-trivial [16]. This highlights that while neural models are powerful, their predictions must complement human expert judgment.

Decision Support Methods and Algorithms

In addition to the architecture and artificial intelligence components, intelligent project evaluation systems rely on a large literature on decision support methodologies. Project selection is inherently a multi-criteria decision problem, where there are several evaluation criteria that need to be considered simultaneously [17]. Many quantitative methods have been developed and applied over the past decades:

- Multi-criteria decision making (MCDM) methods: classical methods such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), TOPSIS, DEMATEL. For example, AHP allows pairwise comparison of projects for each criterion to obtain priority scores, while ANP extends this by considering interdependencies between criteria. Integrated approaches are also common: researchers combine to exploit their complementary strengths. Also, an expert system can use a knowledge base of rules to determine the appropriate MCDM method in each context, then perform calculations and present a ranked list of projects to decision makers [18-20].

- Fuzzy logic and uncertainty handling: Evaluation of scientific projects often involves uncertainty - data may be incomplete, expert judgments may be subjective. Fuzzy logic provides the ability to model uncertain or imprecise information. Many of the above-mentioned MCDM methods have fuzzy extensions to account for ambiguity in expert assessments. The integration of fuzzy sets allows an intelligent system to reason in linguistic terms ("high risk", "moderate innovativeness") and still perform quantitative analysis. This leads to more robust decision support that can reflect confidence levels or variations in expert opinions [21-24].

- Optimization algorithms: project selection may require portfolio optimization under constraints. Evolutionary algorithms and other optimizers play a role here. Genetic algorithms (GAs), described by Goldberg, mimic natural selection to find optimal solutions and have been applied to project selection problems [25]. Esengalieva investigated GA in the context of evaluating research projects that are likely to optimize the combination of projects that maximize the overall benefit under given constraints [26]. Similarly, researchers have used data envelopment analysis (DEA) to measure project performance by treating projects as decision units transforming inputs into outputs. For example,

Namazi et al. used a fuzzy DEA approach to evaluate the performance of R&D projects under uncertainty [27]. These optimization and performance analysis techniques can be embedded in intelligent systems to suggest an optimal set of projects or identify inefficient projects.

- Automated reviewer assignment: Intelligent decision support can help here by modeling the expertise and workload of reviewers. Liu et al. presented an approach to intelligent assignment of reviewers for research project selection, implemented as an assignment decision support system [28]. Their system analyzes project topics and reviewer profiles to recommend optimal reviewer-project matches. This type of subsystem is often part of the overall architecture of modern grant management platforms.

To provide a structured overview of the technological components used in intelligent project evaluation systems, Table 1 summarizes the key methods, their core purposes, and supporting literature. The table consolidates architectural solutions, artificial intelligence techniques, and decision support tools that collectively enhance the objectivity, efficiency, and transparency of evaluation processes.

Table 1 - Key Components and Methods in Intelligent Project Evaluation Systems

Component / Method	Purpose	References
Mathematical Models	Graphical evaluation model of projects by innovativeness and competitiveness	[2]
Cloud Architectures	Remote access, collaboration, scalability	[3]
Blockchain in Evaluation Systems	Data immutability, transparency, and access control	[4], [5]
Neural Network Models (NLP, DL)	Text analysis, prediction, information extraction	[6]
Summarization Tools	Extracting key ideas from proposals and research papers	[7]; [8]; [9]
Knowledge Graphs / Semantic Networks	Structuring domain knowledge and linking to experts	[10-12]
Plagiarism Detection (ML)	Detecting textual similarities and copying	[13]
Question Answering Systems (QA)	Fact retrieval and statistics from knowledge bases	[14]
Forecasting (DL, NN)	Predicting probability of project success	[15]; [16]
Multi-Criteria Decision Making (AHP, ANP, TOPSIS)	Ranking based on multiple criteria	[17]; [18-20]
Fuzzy Logic	Modeling uncertainty in expert opinions	[21-24]
Genetic Algorithms (GA)	Portfolio optimization under constraints	[25]; [26]
DEA (Data Envelopment Analysis)	Efficiency assessment using inputs and outputs	[27]
Reviewer Assignment Systems	Matching reviewers by topic and workload	[28]

Results and Discussion. This study allowed us to systematize and analyze modern architectural and algorithmic solutions used in information systems designed for expert evaluation of scientific and technical projects. The review covers publications over the past ten years, primarily from the Scopus and IEEE databases, as well as several significant domestic sources, which ensures a broad coverage of both the international and local context.

Architectural solutions and structural approaches

The analysis showed that three main types of architecture are most widely represented: centralized, modular, and distributed. Centralized solutions are typical for internal systems of universities and foundations, where all processes - from applying to forming a rating - are closed within a single platform. Such systems are relatively easy to implement, but they are poorly scalable and vulnerable to the human factor.

Modular architecture, on the contrary, demonstrates a high potential for adaptability. They assume the presence of separate components: data storage, analytics, interfaces for interaction with experts, as well as subsystems for analyzing scientific information. Such solutions are easier to scale and integrate with external services, including international databases of scientific publications. Platforms that support API integration with ORCID, Scopus, and Web of Science demonstrate higher flexibility and relevance of data.

Distributed and cloud solutions deserve special attention. Some publications propose conceptual models based on blockchain technologies that ensure transparency, immutability, and decentralization of examination processes. However, such approaches have not yet been widely used in existing systems and require additional research in terms of their legal and organizational support.

Evaluation algorithms and intelligent methods

Among algorithmic solutions, the most widely used are multi-criteria analysis methods: AHP, TOPSIS, ANP and their modifications with elements of fuzzy logic (Fuzzy AHP). They are used both to form project ratings and to rank the evaluation criteria themselves - such as scientific novelty, compliance with priorities, expected return, applicant' s reputation, etc.

In recent years, there has been a noticeable increase in interest in the use of machine learning methods. The areas of automatic classification of projects, predicting their success, as well as automated summarization of the substantive part of applications using natural language processing (NLP) models are developing especially actively. This allows them to partially relieve experts and speed up the primary sorting process.

Optimization methods, in particular genetic algorithms, are also used in the tasks of distributing applications among experts considering their specialization, conflicts of interest and workload. Such approaches ensure a fairer and more balanced distribution and minimize the influence of the subjective factor.

Practical aspects of integration and application

In practice, the greatest difficulty is integration with external systems and platforms, especially with international scientific databases. It was found that only a limited number of solutions provide full API support for verifying data on publications, patents, and other results of scientific activity.

In addition, compatibility issues between various assessment systems, including within one state, were identified, which complicates the implementation of uniform standards and unified approaches. Several studies note the need to create a reference architecture - a universal template based on which it is possible to design flexible and adaptive expert platforms.

Critical comments and limitations of existing solutions

Despite the high degree of elaboration of individual components, most systems are still at the prototype or pilot implementation stage. Common limitations are fragmentary architectures, weak automation of processes, low reproducibility of expert assessments, as well as the lack of tools for interpreting results based on the principles of Explainable AI.

Many proposed solutions are not accompanied by sufficient empirical validation. This complicates an objective assessment of their effectiveness and applicability in real conditions, especially in public scientific management systems.

Current trends and promising areas

Based on the analysis, several key trends can be identified:

- Active implementation of hybrid systems that combine expert assessments with AI algorithms;

- Growing interest in Explainable AI in decision-making tasks in the scientific field;

- The emergence of distributed models based on blockchain to ensure transparency and traceability of procedures;

- Development of digital platforms with the ability to customize to the specifics of various grant competitions and scientific programs.

Conclusion. The evaluation of scientific projects is evolving from traditional expert-based approaches towards more intelligent, automated, and transparent systems. This review has outlined a wide range of architectural solutions, AI-driven methods, and decision-support algorithms applied to the expert assessment process. Modular and distributed architectures, often enhanced with cloud and blockchain technologies, allow for better scalability, traceability, and collaboration among stakeholders. Methods such as fuzzy logic, multi-criteria analysis, and genetic algorithms address the complexity and uncertainty inherent in research evaluation, while natural language processing and machine learning streamline the analysis of unstructured data.

Despite promising developments, most current systems remain in experimental or pilot stages, facing challenges related to standardization, integration, and explainability. Future research should focus on building interoperable, customizable platforms that combine expert knowledge with transparent AI algorithms and provide measurable improvements in the efficiency and fairness of the evaluation process. The emergence of explainable AI and integration with international data infrastructures will play a key role in the next generation of intelligent evaluation systems for scientific and technical projects.

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