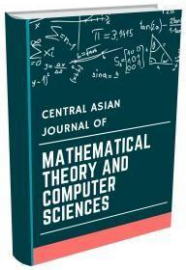

CENTRAL ASIAN JOURNAL OF MATHEMATICAL THEORY AND COMPUTER SCIENCES
https://cajmtcs.centralasianstudies.org/index.php/CAJMTCS
Volume: 06 Issue: 03 | July 2025 ISSN: 2660-5309

Article

The Role of Artificial Intelligence in Controlling Online Exams and The Principles of Modular Architecture

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Abstract: This article examines the problem of academic integrity in distance learning, the legal framework in Uzbekistan, and the relevance of control systems based on artificial intelligence. The study employed methods such as literature review and system modeling. As a key result, a robust, scalable, and flexible modular architecture for online proctoring was proposed. The study analyzes the primary components of the architecture, their interrelationships, and the associated advantages. This approach enhances the reliability and transparency of online assessments.

Keywords: Distance Learning, Artificial Intelligent, Autoproctoring, Modular Architecture, Academic Integrity, LMS (Learning Management System)

1. Introduction

As a result of the rapid development of modern technologies, distance learning platforms are becoming an integral part of the education system. These platforms removed geographical barriers between students and teachers, making educational processes more convenient, economical, and effective, especially in the context of the global pandemic. However, along with these conveniences, a serious problem arose - ensuring academic integrity in online exams. The absence of discipline provided by supervisors in traditional classrooms in a virtual environment casts a shadow on the fairness of assessment and the prestige of the diplomas issued.

The significance of this issue is also acknowledged at the national level in the Republic of Uzbekistan. Presidential Decree №PD-60, dated January 28, 2022, titled "On the Development Strategy of New Uzbekistan for 2022–2026", along with Cabinet of Ministers Resolution №559, dated October 3, 2022, "On Measures to Introduce a Form of Distance Education in Higher Educational Institutions", established the foundation for the legal and technical regulation of distance education [1], [2]. Most importantly, in the Regulation approved by this resolution, the integration of the "Autoproctoring" module into the platforms of distance learning management systems (LMS) is defined as a mandatory requirement. This has made the development of reliable control systems a practical necessity not only at the academic, but also at the state policy level.

In the context of the post-pandemic "new norm", online and distance learning should be reviewed not as a temporary substitute for traditional education, but as an independent form of education with its own advantages and disadvantages. The main task is the effective use of the unique capabilities of the online format [3].

Citation: Boynazarov I. M, Ochilova F. S, Ibadov T. A, Saidova A. B. The Role of Artificial Intelligence in Controlling Online Exams and The Principles of Modular Architecture. Central Asian Journal of Mathematical Theory and Computer Sciences 2025, 6(3), 724-729.

Received: 31th May 2025
Revised: 15th Jun 2025
Accepted: 25th Jun 2025
Published: 06th Jul 2025

This study presents the practical application of the development of an autoproctoring software module for monitoring online exams based on algorithms for analyzing information related to user activity (video, screen movements) on distance learning platforms. Within the framework of the research, the tasks of studying methods for controlling the examination process using artificial intelligence algorithms and creating a modular project operating on this basis are set.

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2. Materials and Methods

A comprehensive approach was applied throughout the research, incorporating several interrelated methods. These methods encompassed all stages of the study, from the development of the system's theoretical foundations to the design and testing of a functional prototype.

Theoretical analysis and literature review Nazariy tahlil va adabiyotlar sharhi.

In his foundational work Towards the Theory of Online Learning, Terry Anderson identified four essential components of an effective online learning environment. According to his framework, such an environment is shaped by the convergence of four complementary aspects: it must be student-centered, knowledge-centered, assessment-centered, and community-centered. The greatest opportunity of the Internet for education is the deep and multifaceted growth of opportunities for communication and interaction. Sufficient levels of deep and meaningful learning can be achieved if one of the three forms of interaction (student-teacher; student-student; student-content) is at a very high level. Deep and meaningful learning is a process that occurs as a result of students' active interaction with each other and with content. An effective online education project should be aimed at supporting and promoting these types of communication. While technology serves as a critical enabler, pedagogy remains the primary driving force behind meaningful learning experiences [4].

Recommendation systems in e-learning personalize the learning process by offering students educational materials, courses, and assignments that meet their individual needs, knowledge level, and interests. This can significantly increase the motivation and level of assimilation of students [5]. As video content occupies a central place in e-learning, recommendation systems based on the analysis of students' interaction with the video (watch time, stopping points, reviews) provide much more accurate and effective results than traditional approaches [6].

Evaluation of the e-learning platform should not be limited to measuring its technical capabilities. The most important criteria include user satisfaction, learning effectiveness, and the platform's contribution to achieving pedagogical objectives [7].

In the article Learning Analytics and Educational Data Mining: Towards Communication and Collaboration by Ryan Baker and George Siemens, both Learning Analytics (LA) and Educational Data Mining (EDM) are focused on using data to improve education. However, it is emphasized that LA is more focused on supporting learners, EDM tends to focus on the implementation of automated systems and predictive modeling.

Educational Data Mining (EDM) creates new opportunities for understanding student behavior on online platforms, predicting learning difficulties, and personalizing the learning process. This field aims to increase the effectiveness of education by analyzing how students learn [8].

Systematic approach and modeling

A systematic approach based on the principles of modular architecture was applied in the design of the system. This approach involves dividing the system into independent, but interconnected components. The design process includes eight specific stages: requirements analysis, system division into functional parts, designation of interfaces (e.g., REST API) for each module, independent development of modules, their integration, system testing, introduction into production, and maintenance. Also, a method of mathematical modeling of the processes of automatic assessment and control of the examination process using artificial intelligence technologies was used. In particular, artificial intelligence helps to abandon the traditional "one-size-fits-all" learning model and create an educational environment adapted to the needs, learning styles, and preferences of each student. The integration of artificial intelligence into education has the potential to revolutionize personalized learning by adapting teaching methods, content, and pace to the individual needs of students. The design of knowledge-based educational technologies, unlike traditional approaches, places pedagogical and didactic principles at the center of the system. Technology should not be just a means of delivering content, but an intellectual system that models and supports the student's path of learning [9]. Building on this foundational understanding, several researchers have further emphasized the transformative impact of AI on personalized learning systems.

Aliev A. also highlighted the issues of personalization of education using artificial intelligence. Artificial intelligence platforms can provide adaptive resources that adapt the content and pace of learning to each student's individual work and needs through smart algorithms. In addition, a significant increase in student motivation and participation was observed due to the fact that AI tools allow for independent learning [10]. Despite these advantages, implementing AI-based personalization comes with notable challenges that must be addressed to ensure educational equity and effectiveness.

When creating personalized e-learning systems based on artificial intelligence, there are serious difficulties, such as data confidentiality, the fairness of algorithms, and pedagogical problems that may arise as a result of excessive automation of the educational process. Solving these problems is the key to the successful implementation of the systems [11].

Recent studies emphasize that AI-enhanced learning systems are evolving beyond mere content delivery, moving toward dynamic, context-aware educational experiences. In the era of artificial intelligence, personalized learning is not just about adapting educational materials. It becomes adaptive systems capable of dynamically changing the learning process, assessing the student's emotional state, cognitive load, and motivation in real time [12]. The role of artificial intelligence in personalizing online education consists in offering the student flexible learning directions, identifying gaps in their knowledge level, and providing real-time assistance. This creates conditions for each student to learn at their own pace and in their own unique style [13].

Experimental and statistical analysis

In order to validate the theoretical framework and the proposed system architecture, practical testing and evaluation were carried out using a purpose-built module. The developed module for testing the practical effectiveness of the theoretical model and architecture was tested, and practical results were analyzed. It is planned to use statistical methods to measure the effectiveness of the module and objectively assess the results. Initial assessments provided key insights into user experience and system performance, particularly in relation to interface usability.

The results of the assessment based on the SURE model showed that although the reliability and effectiveness of the e-learning system are highly appreciated by users, it is necessary to eliminate some shortcomings in terms of its usability. This means the need to improve the user interface [14]. Beyond technical performance, maintaining academic

integrity in online assessment emerges as a central concern in the development of AI-driven learning environments.

Ensuring academic integrity in online assessment depends more on institutional culture and pedagogical approaches than on technological control. The approach of seeing the process of forming and evaluating integrity values in students as part of the study is more important than technical limitations [15]. Nevertheless, hybrid approaches that combine pedagogical strategies with technological tools can lead to more robust and fair assessment practices.

Ensuring the reliability and fairness of online assessment in higher education is one of the most pressing problems. Studies show that by combining various assessment methods (such as project-based assignments, open book exams, and proctoring systems), it is possible to increase academic integrity and achieve more effective assessment than traditional exams [16]. Technological innovations such as AI-powered proctoring are being explored as scalable solutions to uphold academic standards in remote learning environments.

Proctoring systems, based on monitoring the student's head position using a webcam, allow increasing academic integrity by identifying suspicious behavior (such as looking away, communicating with strangers) during online exams. This approach can be an automated and effective alternative to traditional proctoring systems [17].

3. Results and Discussion

Requirements for distance learning platforms

As a result of the study, it was established that an effective distance learning platform must meet a number of fundamental requirements. The user interface (UI) and design should be user-friendly, intuitive, responsive, and aesthetically appealing. Data Management Systems (LMS) should have broad capabilities, such as managing educational content, users, and the entire educational process, assessing knowledge, ensuring interactivity, and automating processes.

Controlled capabilities of artificial intelligence

Artificial intelligence (AI) provides unprecedented opportunities for controlling online exams. The study identified the following main functions of proctoring systems based on AI:

1. Proctor systems - real-time monitoring of student behavior through webcam, audio, and screen monitoring;
2. Biometric identification - verification of the student's identity by face or voice before and during the exam;
3. Behavior analysis - automatic detection of suspicious actions, such as inactivity, leaving the camera field, appearance of strangers;
4. Plagiarism detection - the detection of plagiarism by comparing written works with existing databases.

Architecture of the proposed autoproctoring module

Based on these requirements and capabilities, a modular architecture project for the online proctoring system was developed. This architecture ensures that the system consists of independent, reusable, and easily scalable components. The main components of the system are:

1. User registration and authentication module - manages access to the system (OAuth 2.0, JWT);
2. Exam creation and management module - allows teachers to configure exams;
3. Control (proctor) module - monitors student activities using AI (face recognition, eye movement monitoring);

4. module for processing and evaluating exam results - automatically checks answers and identifies plagiarism;
5. Database Management Module - stores all data (SQL/NoSQL hybrid approach);
6. System Monitoring and Logging Module - monitors the system's operation (ELK Stack, Prometheus).

These modules are interconnected through the REST API interface, which ensures the system's flexibility and easy integration with other LMS platforms.

4. Conclusion

The proposed modular architecture has a number of important advantages in the creation of complex systems, such as online proctoring. Flexibility and scalability are among the most important achievements. In the future, to add new functions (for example, more advanced AI algorithms), it is not necessary to rewrite the entire system, it is enough to add a new module or update the existing one.

The ability for independent development allows different teams to work in parallel on different parts of the system, which accelerates the development process. The principle of error isolation prevents failure in one component of the entire system and increases the overall reliability of the system.

This architecture is not only a technical solution, but also of strategic importance for ensuring the quality of distance learning in Uzbekistan. It provides higher educational institutions with a practical and approved model for fulfilling the "Auto-procurement" requirement established by law. This approach, combining the principles of artificial intelligence and modern software engineering, serves to strengthen the overall prestige of distance learning by increasing the transparency, fairness, and reliability of online assessment processes.

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