Development of a hybrid software architecture based on artificial intelligence

Zilola D. Rasulova[a], Ilkhom I. Bakaev*[a]
[a]Bukhara State University, 11, M.Ikbol, Bukhara, 200118, Uzbekistan

ABSTRACT

This paper is devoted to the development of a hybrid software architecture based on artificial intelligence using UML case diagram to model the functional requirements of the system. The study considers the use of precedent diagrams as a tool for identifying and formalizing interactions between users and the system. The essence of the hybrid approach is that artificial intelligence components will be used to ensure that the software capability is increased. Particular attention is paid to the methods of describing and analyzing requirements, which allows you to accurately determine the system's behavior at the early stages of design. The work can be useful in creating complex artificial intelligence systems.

Keywords: artificial intelligence, precedent diagram, use case diagram, hybrid approach, software architecture, machine learning, neural networks, large language model.

1. INTRODUCTION

Today, the software industry requires new approaches to solve complex problems that can process big data. One of the modern approaches is the creation of a hybrid software architecture based on artificial intelligence methods and technology that can adapt to changing conditions. Hybrid software architecture allows making decisions and processing big data in real time. The relevance of these approaches is the application for solving the development of a system for assessing knowledge, which requires accuracy, adaptability and speed of processing user data. The main aspects of designing such systems are the formalization of its structure and behavior. With the help of UML [1] diagrams, you can visualize the functional requirements of the system and identify the main precedents of interaction between the user and the system. To determine use cases, precedent diagrams are used, which accurately contribute to the accurate formulation of tasks and the construction of an effective architecture. Hybrid architecture based on artificial intelligence provides the ability to scale and integrate new intelligent modules, which makes it a universal solution for creating systems focused on analyzing, interpreting and automatically assessing user knowledge.

2. LITERATURE REVIEW

The author of [2] research addresses the problem of enhancing creativity in the brainstorming process using large language model tools such as ChatGPT. The work presents the Creative Problem Solving framework, which includes goals, cues, and strategies for effectively working with artificial intelligence in the creative process. The Torrance test was also adapted to assess the creativity of ideas generated by artificial intelligence. The results showed that the proposed framework helps to stimulate creativity and improve the quality of ideas when using large language model in design.

This [3] study examines the integration of the Creative Problem Solving (CPS) model and the SCAMPER strategy in the educational process of architectural interior design. The study involved 70 third-year students who completed a seven-week experimental program. The results showed that students using the CPS+SCAMPER approach significantly improved creativity indicators, including fluency, flexibility, originality, and elaboration of ideas, and also demonstrated higher scores on motivation and creative traits. This method has proven its effectiveness in strengthening innovative abilities and can be applied in various disciplines.

* bakayev2101@gmail.com

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The paper [4] examines the impact of artificial intelligence on students' creative process in the field of primary and early childhood education. Participants were asked to compare their handwritten works with those generated by artificial intelligence. The results showed a positive perception of artificial intelligence, noting its contribution to idea generation and quality improvement. At the same time, the need for critical evaluation of artificial intelligence-generated proposals and maintaining the importance of human originality in the creative process was emphasized.

The main focus of the study [5] is on studying the impact of generative artificial intelligence (ChatGPT-3) on students' creative thinking and its application in the educational process. The study used mixed methods, including the application under test to assess flexibility, fluency, elaboration and originality of ideas. The results highlight the importance of a cautious approach to integrating artificial intelligence into creative learning, since although artificial intelligence can support creative thinking, it can also have negative consequences for students' creativity and confidence.

The study [6] examines the effectiveness of the meta-learning approach in improving students' metacognitive and creative skills. Using an experimental design with pre- and post-testing, the study found statistically significant improvements in participants' metacognitive abilities after applying meta-learning. The results confirm that meta-learning helps students become more aware of their learning processes, develop strategies, and manage cognitive functions, including the use of artificial intelligence. This approach also promotes creative thinking and out-of-the-box learning.

This study [7] examines the importance of designing cues to improve the quality of images generated using large language models. The work focuses on how well-designed cues can improve the efficiency of artificial intelligence in creating visuals. The study found that a group of students who received cues to create cues produced higher quality images that were more relevant to the concept than the group that worked without supervision. The results highlight the importance of designing cues to improve the quality of artificial intelligence -generated images and open up new possibilities for the application of artificial intelligence in design, education, and the creative industries.

The authors of [8] of the study touched upon the issue of the impact of the use of artificial intelligence tools in higher education institutions on the formation of professional competencies of future specialists in the field of arts. The study used both quantitative and qualitative methods, including pedagogical experiments and student surveys. As a result, it was shown that students assess their level of proficiency in artificial intelligence as above average, and that the use of artificial intelligence contributes to the formation of various components of professional competencies.

This paper [9] discusses the use of the Generative AI-supported Co-Regulated Learning approach to improve the effectiveness of project-based learning for students. The author of the paper addresses the problem of insufficient support and feedback in the traditional Generative AI-supported Co-Regulated Learning approach, which can lead to disappointing project results. The study conducted an experiment with 46 students divided into an experimental group using Generative AI-supported Co-Regulated Learning and a control group using Generative AI-supported Co-Regulated Learning. The results showed that the Generative AI-supported Co-Regulated Learning approach significantly improved students' performance, motivation, creative thinking, and self-efficacy compared to the traditional approach. The paper [10] discusses the impact of network technologies on art education. The rapid development of technologies improves the educational process, contributes to the improvement of students' scientific and mathematical abilities. The need to move from a teacher-centered approach to a student-centered one is emphasized. The paper also explores the use of pedagogical content knowledge in teaching fine arts and the role of artificial intelligence in this process. To improve the effectiveness of artificial intelligence in teaching, performance analysis models including clustering methods have been developed. These methods help to explore the heterogeneity of students and develop their abilities in the arts.

This study [11] examines the impact of off-campus tutoring and tutoring services on engineering education, with an emphasis on the use of information technology and artificial intelligence. The author examines the problems associated with plagiarism and the need to develop effective assessment criteria to achieve the goals of engineering education. The study is based on data from the National Assessment of Educational Progress and surveys of engineering students at the Metropolitan State University of Denver.

The integration of artificial intelligence into future software makes creativity assessment an important task in educational and creative processes.

Carefully designed artificial intelligence prompts offer more accurate and effective approaches that support students' creativity and ability to generate ideas. The studies noted above point to the importance of applying artificial intelligence

in various creative fields, from brainstorming to architectural design and meta-learning, confirming that artificial intelligence contributes to improving results and developing creative skills.

3. METHODS

To develop and model the information system, an approach based on the use of UML diagrams was used, which allowed us to clearly represent the architecture of the system, its components and the interaction between them. The main entities of the system are a student, a teacher, an administrator, and an artificial intelligence application programming interface.

Student: uploads their creative work, receives the assessment results.

- Teacher: views the students' results, can adjust the assessments.
- Administrator: manages users and system settings.
- AI API(artificial intelligence application programming interface): analyzes and assesses creative works.

Main use cases:

Upload work: Student uploads their work for assessment.

- Rate work: artificial intelligence application programming interface analyzes the student's work.
- Get result: Student receives the assessment or comments.
- View results: Teacher views the students' results.
- User management: Administrator manages students and teachers.

To detail the precedent "Loading work", we introduce some notations: let S be a set of students, W be a set of uploaded works, F be a set of acceptable file formats, artificial intelligence be an automatic evaluation system.

The function of loading work is defined as:

$$U : S \times W \to \{Success, Failure\}$$

Where: Success – means successful file upload, Failure – means an error during upload (e.g. unsupported format or exceeded size).

The work file format must match the acceptable formats:

$$\forall w \in W, format(w) \in F$$

The file size of the work must not be larger than $M_{\max}$

$$\forall w \in W, size(w) \le M_{\max}$$

Once successfully uploaded, the work is passed to the artificial intelligence application programming interface for evaluation:

$$Evalute : W \to Score$$

Where - $Score$ is a numerical score determined by artificial intelligence.

Next, we will describe the functional requirements of the system for the use cases “Loading work” consists of the following points:

- The system must check the compliance of the loaded file with the established requirements:

$$Check(w)=\begin{cases}Success,\ if\ format(w)\in F\ and\ size(w)\le M_{\max}\\ Failure,else\end{cases}$$

- The work is saved in the database if the check is successful:

$$Save(w)=\begin{cases}True,if\ Check(w)=Success\\ False,else\end{cases}$$

- The work is transferred to the artificial intelligence application programming interface only upon successful loading:

$$SentToAI(w)=\begin{cases}Evalute(w),if\ Save(w)=True\\ None,else\end{cases}$$

The functional requirement of the system for "Evaluate Work" consists of the following points:

- Transferring work to the artificial intelligence application programming interface:

$$SendToAI(w)\to AI(w)$$

Where *w* is the student's work submitted to the assessment system.

- Artificial intelligence application programming interface evaluation formula:

$$E(w)=f(C_1,C_2,\dots$$

Where $C_1,C_2,\dots$ is the evaluation criteria, and f is the function that aggregates them into the final score.

- Saving the assessment in the database:

$$Save(E(w))\to DB$$

Where DB is the database.

- Viewing the student's grade:

$$View(Student,w)=E(w)$$

- Correction of the assessment by the teacher:

$$G(w)=\begin{cases}E(w),\text{if the teacher did not change the grade}\\ G'(w),\text{if the teacher changed the grade}\end{cases}$$

- Artificial intelligence application programming interface parse error:

$$if\ AI(w)=\varnothing,\ then\ Notify(Student,\text{"Analysis error. Please restart your work."})$$

- Resend in case of communication error:

$$if\ ConnectionError,then\ Retry(w)$$

The functional requirement of the system for the "Get Result" and "View Results" cases consists of the following points:

- The work evaluation should be available only after successful processing of the artificial intelligence application programming interface:

$$Processed(w) \Rightarrow True \Rightarrow ResultAvailable(w) = True$$

Where $Processed(w)$ is a flag indicating that the job w was successfully evaluated by the artificial intelligence application programming interface.

- A student can only receive a result for his work:

$$RequestResult(s,w) \Rightarrow Owner(s,w) = True$$

Where $Owner(s,w)$ means that student s is the author of paper *w*.

f the job has not yet been processed, the system should return the status “In processing”:

$$Processed(w) = False \Rightarrow Status(w) = \text{"In processing"}$$

- If the work is successfully assessed, the system should provide a numerical result:

$$Processed(w) = True \Rightarrow Result(w) \in R$$

- If the grade has been adjusted by the teacher, the student should see the updated result:

$$Adjusted(w) = True \Rightarrow FinalResult(w) = G(w)$$

Where $G(w)$ is the grade adjusted by the teacher.

- if the teacher has not made any changes, the final result matches the artificial intelligence application programming interface assessment:

$$Adjusted(w) = False \Rightarrow FinalResult(w) = E(w)$$

Where $E(w)$ is the original score given by the artificial intelligence application programming interface.

The functional requirement of the system for the "User Management" use case consists of the following points:

- Only the administrator can manage users:

$$Role(u) = Adm \Rightarrow ManageUsers(u) = True$$

Where $Role(u)$ defines the role of user *u*.

- The administrator can create a new user:

$$CreateUser(a,u,r) \Rightarrow Exists(u) \Lambda Role(u)$$

Where *a* is the administrator, *u* is the new user, *r* is his role.

The administrator can delete an existing user:

$$DeleteUser(a,u) \Rightarrow \neg Exists(u)$$

- The administrator can change the user's role:

$$ChangeUser(a,u,r') \Rightarrow Role(u) = r'$$

Where r′ is the new user role.

- The administrator can block and unblock the user:

$$BlockUser(a,u) \Rightarrow Status(u) = \text{"Blocked"}$$
$$UnblockUser(a,u) \Rightarrow Status(u) = \text{"Active"}$$

- The user can change his/her credentials only by himself/herself:

$$UpdateCredentials(u,cred) \Rightarrow Owner(u,cred) = True$$

- The administrator can change the credentials of any user:

$$UpdateCredentials(u,cred) \Rightarrow Role(a) = Adm$$

The user must be registered in the system to log in:

$$Exists(u) \wedge AuthDataValid(u) = True \Rightarrow Login(u) = True$$

Based on these system requirements, a USE CASE diagram, presented in Figure 1, was compiled to assess students' creative works.

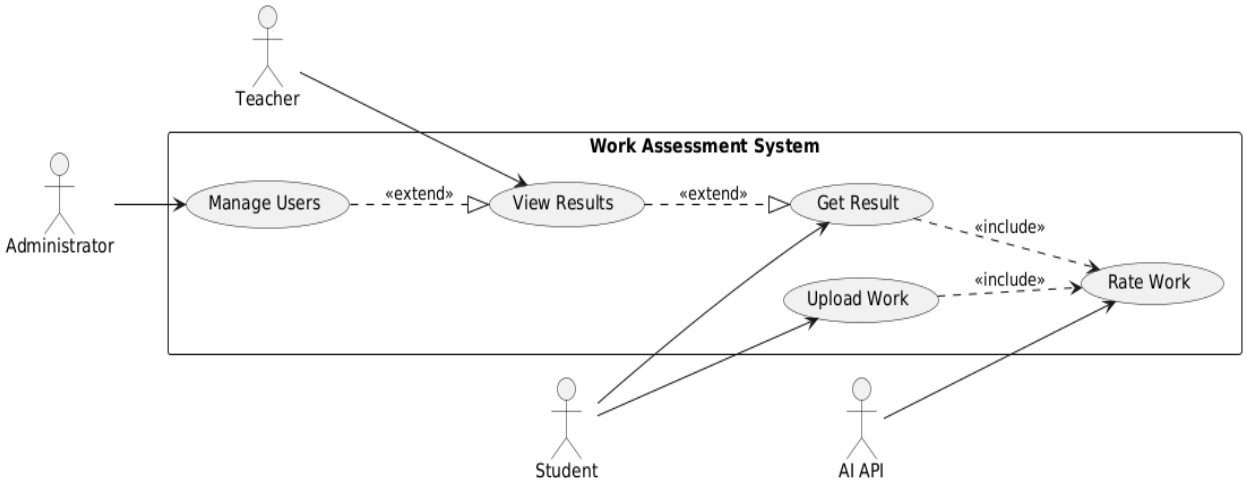

Figure 1. Diagram of use cases of the evaluation system.

4. RESULTS

The experiment involved Bukhara State University, Karshi State University and Navai State Pedagogical Institute of Uzbekistan. 544 students majoring in pedagogy took part in the experiment. The tests were completed in the form of essays. The results of the tests are shown in Tables 1 and 2.

The same assessment criteria were set for teachers and artificial intelligence. The assessment criteria for artificial intelligence were prepared in the form of a prompt.

Based on the analysis conducted by artificial intelligence application programming interface and verified by humans, it was found that significant positive changes in students' knowledge levels were observed in the experimental groups of all three universities. The assessment obtained by artificial intelligence application programming interface has small discrepancies with the results obtained by humans. This confirms the high accuracy of the automated method, but also highlights the need for expert analysis for the final interpretation of the data.

Table 1. Final results after checking teachers.

University	Group	Number of students	Great (%)	Fine (%)	Satisfactory (%)	Unsatisfactory (%)
Bukhara State University	Experimental	86	6	57	23	0
	Control	86	2	36	58	2
Karshi State University	Experimental	115	6	60	24	0
	Control	113	3	38	56	3
Navai State Pedagogical Institute	Experimental	78	7	55	30	0
	Control	66	2	35	60	3

Table 2. Final results after checking artificial intelligence application programming interface.

University	Group	Number of students	Great (%)	Fine (%)	Satisfactory (%)	Unsatisfactory (%)
Bukhara State University	Experimental	86	7	56	22	1
	Control	86	3	35	57	3
Karshi State University	Experimental	115	5	61	23	1
	Control	113	4	37	55	4
Navai State Pedagogical Institute	Experimental	78	6	54	31	1
	Control	66	3	34	59	4

5. CONCLUSION

The developed artificial intelligence-based system for assessing students' creative abilities has demonstrated high efficiency. Experiments at universities have confirmed that artificial intelligence assessments correspond to teachers' results and that students' academic performance has improved. The system's architecture clearly structures the interaction of participants. Further development includes improving algorithms, taking into account individual characteristics of students, and adapting to different educational programs. The integration of machine learning will increase the accuracy and flexibility of the system, promoting the development of creative thinking.

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