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CONCEPTUAL MODEL OF ARTIFICIAL INTELLIGENCE APPLICATION IN VIDEO GAME DEVELOPMENT PROJECT MANAGEMENT

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artificial intelligence, project management, video game development, automated testing, data analysis, feedback, procedural content generation, conceptual model, game industry.

The article focuses on developing a conceptual model for artificial intelligence application in video game development project management. It examines the complex relationships between game product creation stages and corresponding AI tools that optimize production processes. The research substantiates the relevance of this issue through growing competition in the video game market, dynamic technological changes, and continuously evolving user needs.

The paper identifies and analyzes in detail three fundamental principles of artificial intelligence integration: automation of routine processes through automated testing and data analysis tools; strategic planning and resource management to forecast project needs and optimize task distribution; and improving user interaction through real-time feedback collection and analysis.

The conceptual framework presented by the authors demonstrates the step-by-step integration of specific artificial intelligence tools, including ChatGPT, DALL-E, Unity ML Agents, IBM Watson, Nvidia DLSS, GameAnalytics and others, into development blocks – from idea generation and initial planning to testing, release, and user feedback analysis.

Special attention is paid to mechanisms of testing process automation, resource planning optimization, market trend forecasting, and analysis of player behavioral patterns. The paper describes AI application at each stage of the production cycle, noting specific benefits that development teams receive through the implementation of these technologies.

Research results confirm that systematic AI implementation contributes significantly to improving development efficiency, end product quality, risk reduction, and resource cost optimization. The developed conceptual model can serve as a theoretical foundation for creating methodological recommendations on AI integration into video game development project management processes, opening new opportunities for enhancing product competitiveness in this dynamic industry.

КОНЦЕПТУАЛЬНА МОДЕЛЬ ЗАСТОСУВАННЯ ШТУЧНОГО ІНТЕЛЕКТУ В УПРАВЛІННІ ПРОЄКТАМИ РОЗРОБКИ ВІДЕОІГОР

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штучний інтелект, управління проєктами, розробка відеоігор, автоматизоване тестування, аналіз даних, зворотний зв'язок, процедурна генерація контенту, концептуальна модель, ігрова індустрія.

Стаття присвячена розробці концептуальної моделі застосування штучного інтелекту в управлінні проєктами розробки відеоігор. Досліджено комплексні взаємозв'язки між етапами створення ігрових продуктів та відповідними інструментами ШІ, що дозволяють оптимізувати виробничі процеси. У дослідженні обґрунтовано актуальність проблематики зростаючої конкуренцією на ринку відеоігор, динамічними змінами технологій та постійно еволюціонуючими потребами користувачів.

У роботі визначено та детально проаналізовано три фундаментальні положення інтеграції штучного інтелекту: автоматизація рутинних процесів через інструменти автоматизованого тестування та аналізу даних; стратегічне планування та управління ресурсами з метою прогнозування потреб проєкту та оптимізації розподілу завдань; покращення взаємодії з користувачами через збирання та аналіз зворотного зв'язку в режимі реального часу.

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Statement of the problem

Effective management of video game development projects requires a comprehensive understanding of complex production processes that encompass both technical and creative aspects of creating a game product. Growing competition in the video game market, rapid technological development, and constantly changing user needs create the necessity to search for new approaches to optimize development processes and implement innovative project management tools. One of the promising directions for improving management processes is the integration of artificial intelligence into various stages of video game development.

Developing a system of models for applying artificial intelligence in video game development project management allows for improved planning and coordination of work, optimized resource utilization, reduced costs, enhanced quality of the final product, and securing competitive advantages in the market. Furthermore, considering the analytical capabilities of artificial intelligence is important in the context of developing modern game development technologies, such as procedural content generation, automated testing, adaptive gameplay algorithms, and other innovative solutions in the field of video game creation. Analysis and modeling of processes using artificial intelligence makes it possible to predict various scenarios for implementing these technologies and their impact on the overall effectiveness of project management.

However, in the conditions of rapid development of the video game industry, the emergence of new technologies and development methodologies, the application of appropriate models and methods is impossible without a deep understanding of knowledge that characterizes the subject area of research, constitutes its nomological foundation, and defines the information model of artificial intelligence integration into the management processes of video game development projects.

Analysis of recent studies and publications

The modern development of the video game industry and information technologies is accompanied by growing scholarly interest in the integration of artificial intelligence into project management processes. Analysis of recent research reveals multidirectional approaches to AI application and its impact on the effectiveness of project management in video game development.

The fundamental research by Vasylchenko V.M. and Vakaluk T.A. [1] offers a comprehensive analysis of the transformational impact of AI on project management, identifying new opportunities for optimizing traditional practices and implementing innovative approaches. The authors emphasize that AI-based tools provide significant improvements in decision-making efficiency and risk prediction in the dynamic environment of video game development.

In the context of strategic AI implementation, the research by Teretchniy V. [2] is important, as it examines the features of artificial intelligence technology integration into business processes, focusing on organizational aspects and corporate environment optimization. These developments have direct application in forming project management strategies in the gaming industry, where resource and process optimization is critically important.

A significant contribution to understanding the risks and prospects of AI integration is made in the collection of professional development materials [3], which analyzes the possibilities of applying artificial intelligence in educational projects. These studies are especially valuable for developing educational video games that combine educational goals and game mechanics. This direction is complemented by Belinska Ya.V.'s research [4], which reveals the specifics of AI use in the educational environment.

Special attention should be paid to the research by Antipov K.O. [5], dedicated to the challenges of recognizing AI-generated texts. These developments have direct application in creating scripts, dialogues, and narrative elements for video games, where the quality and authenticity of text content directly affect the user experience.

An interesting aspect is the investigation by Antipova Zh.I. [6], which reveals the relationship between AI use and physical activity, which can be effectively applied in developing video games aimed at promoting healthy lifestyles and physical activity among users.

Theoretical aspects of AI use, including ethical and security issues of human interaction with intelligent systems, are thoroughly covered in publication [7]. These studies form an important foundation for understanding the ethical boundaries of AI application in video game development, especially in the context of interaction with users of different age categories.

The analysis of publications demonstrates active research in the field of AI application in various areas, including video game development project management. However, there is a need for further study of issues related to the comprehensive application of AI throughout the entire life cycle of a video game development project, which emphasizes the relevance of our research and the necessity to develop a conceptual model that would integrate best practices of AI application in all aspects of project management in the gaming industry.

Objectives of the article

The aim of the research is to develop a conceptual model for the application of artificial intelligence in video game development project management, which allows not only to structure and optimize the production processes of creating a game product, but also to account for complex interrelationships between different stages of development, from idea generation to user feedback analysis.

The main material of the research

Artificial intelligence, with its ability to analyze large volumes of data, predict risks, automate routine tasks, and adapt to changes, opens new opportunities for optimizing game project management. The peculiarity of video games as a product lies in their high requirements for user experience quality, dynamic and often non-linear development process, as well as a complex structure involving various specialists – from designers and programmers to analysts and marketers. In such complex production cycles and the need to adapt to rapidly changing market conditions, AI provides tools for creating a flexible, integrated project management model focused on end results and efficient resource utilization.

The application of artificial intelligence in such a model is based on the principles of a systems approach, where each component of the development process is connected with others and ensures constant data exchange. From forecasting resource needs and optimizing planning to interactive testing and adaptive user interaction, AI helps automate and improve key development stages. Additionally, the conceptual model involves using AI as a feedback tool, which allows not only responding to changes in user requirements but also actively involving the audience in the process of improving game content. This approach contributes to risk reduction, cost optimization, and ensuring high quality of the final product that meets player expectations and increases competitiveness in the video game market.

The concept of applying artificial intelligence in video game development project management should be based on several fundamental principles covering technological, organizational, and integration aspects.

Principle 1: The implementation of artificial intelligence in video game development should be aimed at automating and optimizing routine and repetitive processes. This includes automated testing, data analysis, and task execution monitoring. AI can effectively ensure high-quality testing and real-time analysis, which is especially useful for game projects with a large volume of

test scenarios and gameplay variations. Automation allows the development team to focus on creative and strategic aspects of the project without spending time on routine checks, which significantly accelerates the development process and reduces the likelihood of human errors.

Principle 2: Integration of AI as a tool for strategic planning and resource management. Artificial intelligence allows not only analyzing past projects but also predicting needs for the current project based on the data obtained, optimizing resource allocation, and adapting the work schedule depending on variable factors. In the context of video game development, this means that AI helps make decisions regarding the necessary number and specialization of personnel at each stage, proper distribution of tasks, and time management. As the project progresses, artificial intelligence can help the team adapt strategies, identify potential delays, and provide suggestions for problem-solving based on historical data and predictions. This principle is especially important for video game projects with complex and long-term production cycles, where accuracy and flexibility in planning are critical.

Principle 3: Concerns improving user interaction and strengthening feedback at all development stages. AI can collect and analyze large volumes of feedback from players based on their behavior in the game environment, reviews, and other actions. This allows the development team to better understand the needs of their audience, respond to their needs in a timely manner, and increase user engagement. Such feedback enables not only improving game mechanics and gameplay but also increasing audience satisfaction by adapting the game to user requests and preferences in real-time. For video game developers, this ensures a continuous improvement process that meets modern market requirements and allows creating games that remain competitive and relevant.

The application of AI in video game development project management is one of the key factors that allows for significant optimization of each stage of the development process and ensures a high level of adaptability and flexibility in resource and process management. The diagram (Figure 1) shows how the integration of AI into various management blocks improves the quality, accuracy, and speed of development, from initial idea planning to post-release feedback analysis. Each process block is connected with AI to achieve specific goals and objectives aimed at automation, efficiency, and flexibility in project management.

Let's proceed to a detailed examination of the first stage of development. At this initial stage – *Video Game Development*, the main goal is to create a video game that would meet user demands and market requirements. This goal is the foundation for all other stages, which are united by the integration of artificial intelligence tools with various aspects of project management, such as planning, development, testing, release, and feedback analysis. AI in this context is used to ensure the automation of repetitive and routine tasks, which allows focusing on creative and strategic processes.

Idea & Planning (Idea Generation and Initial Planning). At this stage of video game development,

artificial intelligence plays a key role in forming a successful project concept. AI becomes an indispensable tool for the development team, helping not only to generate new and innovative ideas but also to evaluate their viability and relevance to market needs. Using powerful analytical capabilities of AI, such as machine learning and natural language processing, teams can analyze large volumes of data from various sources: social networks, forums, statistical reports, and market research. AI tools, for example, ChatGPT [8] or Google Trends [9], allow developers to gain a deeper understanding of current industry trends, identify popular genres, mechanics, and themes that resonate with the audience. AI supports the creative brainstorming process, generating various game development scenarios, suggesting innovative game mechanics and storylines. It can quickly assess the potential of each idea, analyzing possible game development options and considering specific characteristics that users will best perceive. Thanks to this, the team can focus on the most promising concepts, saving time and resources. In addition, AI helps predict potential risks and challenges associated with implementing certain ideas. It can model the target audience's reaction, forecast market demand, and determine optimal strategies for promoting the future game. This allows the team to make more informed decisions at early stages of the project.

Concept Development (Розробка концепції). На цьому етапі розробники переходять до Concept Development. At this stage, developers move to the detailed development of the game concept, which includes gameplay, plot, characters, objects, and other important aspects. Artificial intelligence plays a key role, helping to create concepts and prototypes using generative models such as DALL-E [10] and Midjourney [11]. These tools allow automatic generation of concept art, characters,

objects, and environments for the game, which significantly accelerates the visual development process. Automation of routine processes related to visual elements allows the team to quickly test different concepts and make informed decisions about their further development. For example, using DeepMotion [12] to automate animation creation facilitates prototype preparation and allows the team to focus on improving gameplay and other creative aspects of the game. Additionally, AI contributes to the creation of scripts and core gameplay mechanics, tailoring them to the target audience and game style. It allows the automation of many processes related to conceptual development, such as creating characters and landscapes, which significantly reduces time and expenses for routine tasks. This enables the team to focus on more unique and innovative elements, enhancing the overall quality and competitiveness of the future product. Thus, at the concept development stage, artificial intelligence becomes an indispensable tool that not only optimizes processes but also opens new opportunities for creativity and innovation in video game development.

Market Research. At this stage, artificial intelligence performs an extremely important function, providing deep and comprehensive analysis of the market and target audience behavior. Using AI tools such as SimilarWeb [13], IBM Watson [14], and Google Analytics [15], developers can conduct multifactor analysis of large data volumes. These tools allow studying market trends, popularity of genres and game mechanics among different audiences, as well as analyzing user behavior on competitive platforms. Thanks to artificial intelligence capabilities, teams can identify which types of games and mechanics are most popular among certain demographic groups, which genres are in highest demand, and which elements are critically important for attracting and retaining users. AI helps understand the needs, preferences, and values of potential players,

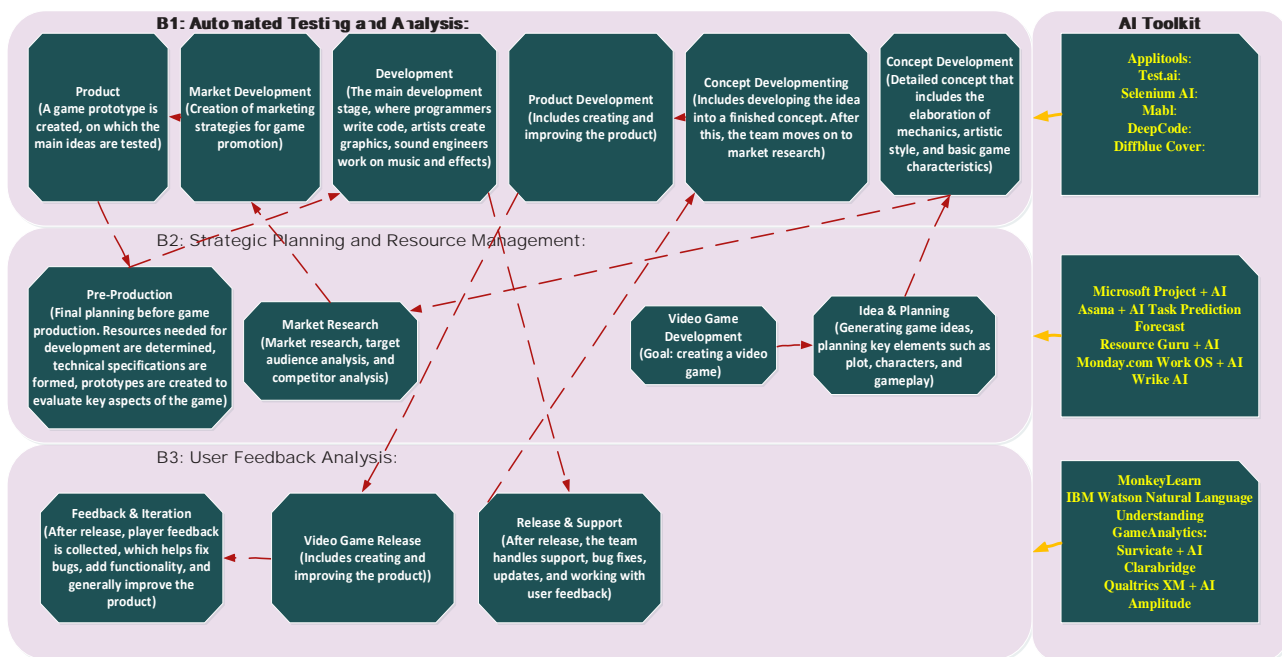


Fig. 1 – Conceptual scheme of artificial intelligence application in video game development project management

allowing developers to more precisely tailor the game to the expectations of the target audience. Additionally, artificial intelligence can predict future market trends by analyzing historical data and current patterns of user behavior. This gives the team the ability to proactively respond to market changes, adapting game development and marketing strategies. AI also assists in audience segmentation, helping identify the most promising market niches and optimize advertising campaigns.

Market Development. At this stage, artificial intelligence plays a key role in game promotion and optimization of marketing efforts. AI helps the development team more effectively determine channels for product promotion and positioning, allowing more precise identification and reach of the target audience. AI tools such as Facebook Ads AI [16] enable automatic configuration of advertising taking into account user interests and behavior, which increases the effectiveness of marketing activities and audience engagement. HubSpot AI [17] analyzes the effectiveness of different promotion channels, optimizing marketing budget allocation for maximum user reach. AI can automatically analyze data on the effectiveness of various marketing strategies, segment the audience, and configure personalized messages for different groups. This increases the effectiveness of marketing efforts, allowing better results with fewer expenditures, increasing product visibility in the market and audience engagement. Thanks to artificial intelligence capabilities, teams can apply strategically important methods of promotion adapted to specific groups, which enhances the game's competitiveness.

Pre-Production. At this stage, which involves preparation for active game development, artificial intelligence is used to optimize resource allocation, organize tasks, and create detailed schedules. Project management tools with AI integration, such as Microsoft Project with AI [18] or Asana with AI Task Prediction [19], provide automatic schedule creation and resource usage forecasting. They allow automatic predictions for each task and assessment of its impact on the overall project schedule. AI helps the team avoid overloads and downtimes, automatically adapting the project plan depending on available resources and requirements. This automation optimizes task execution and resource usage, increasing the efficiency of the preparatory stage. Thanks to this, the team can minimize risks associated with planning and ensure timely completion of all necessary tasks before active development begins.

Development. At this stage, or development, artificial intelligence plays a significant role in automating many aspects of code creation and gameplay optimization, which significantly increases the efficiency and quality of the final product. AI tools such as Unity ML Agents [20] support the creation of procedural levels and game elements, allowing developers to quickly generate large game worlds with minimal time and resource expenditure. This is especially useful for creating diverse maps, characters, and other elements that can be procedurally generated, providing a unique experience for players. Additionally, technologies such as Nvidia DLSS (Deep Learning Super Sampling) [21] are used to increase game performance by optimizing graphics without overloading the system, which provides

smoother and visually appealing gameplay even on less powerful devices. AI also facilitates automatic code generation, allowing developers to focus on more creative and strategic aspects of development, reducing the time needed for writing and debugging routine code. Additionally, artificial intelligence can be used for code analysis, error detection, and game performance optimization. This ensures high quality of the final product, reducing the number of bugs and increasing game stability. Thanks to AI capabilities, development teams can create complex and multilayered game mechanics more quickly and efficiently, corresponding to modern industry standards. Integration of artificial intelligence at the development stage not only automates many routine processes but also opens new possibilities for creativity and innovation, ensuring a high level of productivity and game quality.

Product. At this stage, the Product block is responsible for creating and testing game prototypes, ensuring high quality of the final product before its release. Artificial intelligence plays a key role in automating testing processes, which significantly reduces the time and resources necessary for error detection and code optimization. AI-based tools such as AppliTools [22] and Test.ai [23] allow automated testing of visual game elements, detecting anomalies and errors in the user interface in real-time. This is especially useful for multiplayer games and games with large open worlds, where the complexity and scale of the project require thorough quality control. Additionally, tools such as DeepCode [24] and Diffblue Cover [25] analyze game code, suggesting fixes and automatically generating unit tests, which increases code quality and reduces the risk of bugs. DeepCode uses machine learning to identify potential problems in the code and offers recommendations for their correction, allowing developers to quickly respond to detected deficiencies. Diffblue Cover, in turn, automatically creates test scenarios, ensuring code test coverage without the need for manually writing each test, which significantly saves team time. AI also helps create realistic simulations of user behavior, allowing testing of different scenarios and verifying how the game will function in real conditions. This includes modeling player interaction with the game, analyzing their actions and reactions, which allows identifying potential problems in gameplay and game balance at early stages of development.

Release & Support. The final stages of video game development include Release & Support – game release and its subsequent support, as well as Feedback & Iteration – collection and processing of player feedback. Artificial intelligence plays a key role in these processes, providing effective user support and continuous product improvement. For user support, integrated chatbots and automated systems are used, such as Zendesk Chat [26] and Intercom [27], which can promptly process requests, providing instant responses and solving common problems without human intervention. This significantly improves user experience, providing them with quick access to help at any time. Additionally, AI-based tools, such as IBM Watson Natural Language Understanding, analyze player feedback in real-time, collecting data from various platforms, social networks, and forums. These systems automatically classify user reviews by sentiment and emotions, allowing developers

to quickly respond to negative comments, identify potential problems, and implement necessary changes to increase player satisfaction. Thanks to this, the team can promptly correct game deficiencies, implement improvements, and adapt the product to user expectations, which contributes to game loyalty formation and its successful market positioning. AI integration at the Release & Support stage also optimizes support service work, automating routine tasks and allowing the team to focus on more complex and creative aspects of user service. This ensures high-quality support, reduces response time to requests, and increases the overall effectiveness of marketing and support activities. Thus, using artificial intelligence at the stage of game release and support not only improves user interaction but also contributes to continuous product improvement.

Feedback Analysis. User feedback analysis is a critical stage in video game development, ensuring a continuous process of product improvement based on player behavior and needs. Artificial intelligence plays a key role in this process, helping to collect and analyze large volumes of data about user actions in the game in real-time. Tools such as MonkeyLearn [28], Clarabridge [29], and GameAnalytics [30] allow developers to deeply understand player behavioral patterns, analyze their actions, and identify problematic moments in gameplay. Thanks to this, AI can detect which game elements evoke interest and which cause disappointment, which allows adapting mechanics and gameplay according to user needs. For example, tools such as GameAnalytics [30] or Amplitude [31] can identify player churn points – moments where players most often leave the game. This gives the team the opportunity to make timely changes to improve player retention and increase their engagement. Additionally, sentiment and emotional reaction analysis using tools such as IBM Watson Natural Language Understanding [32] allows classifying user reviews as positive, negative, or neutral, which helps quickly respond to negative comments and improve the game according to player expectations. AI also contributes to creating realistic simulations of user behavior, allowing testing of different scenarios and verifying how the game will function in real conditions. Thus, artificial intelligence integration at the feedback analysis stage provides a deep understanding of player needs and behavior, allowing developers to promptly improve the game, enhance its quality, and ensure high user satisfaction. This contributes to product loyalty formation and its successful positioning in the video game market.

All stages of the production cycle – from idea and planning to release and support – demonstrate how artificial intelligence integration provides automation of routine processes, more efficient resource allocation, and dynamic change management. Through the use of analytical tools for feedback, such as MonkeyLearn, Clarabridge, and GameAnalytics, developers gain a deeper understanding

of user needs and their behavior, which allows promptly adapting the product and improving its quality. AI contributes to coordinated team work at every step of the process, helping avoid human errors, accelerating routine task processing, and providing additional tools for deep analysis and game improvement. This leads to risk reduction, cost optimization, and maintaining market competitiveness. Artificial intelligence integration into each block of video game development contributes to creating a quality and competitive product that meets current market demands and ensures maximum user satisfaction. Such comprehensive and all-encompassing application of AI covers both technological and managerial aspects, requiring constant improvement of artificial intelligence models and adaptation to the specific requirements of each new project.

Conclusions

The application of artificial intelligence in video game development project management is a complex and multifaceted process that has a significant impact on development efficiency and final product quality. The importance of researching this area is confirmed by the rapid development of the video game industry and high competition, which requires developers to use innovative approaches to organizing production processes.

In the modern dynamic environment of the gaming industry, the integration of artificial intelligence becomes a factor of economic efficiency and competitive advantage. At the same time, the specifics of the subject area is extremely important, which considers a set of actions and tools that reflect the peculiarities of video game development as both a creative and technical process.

This article proposes a conceptual model for applying AI in video game development project management, reflecting key aspects of artificial intelligence technology integration at various stages of the production cycle. The research confirmed the complexity and multidimensionality of video game development management processes and the need for a systematic approach to AI implementation.

As a result of the research, a conceptual scheme was developed that demonstrates the relationships between different blocks of the development process and corresponding AI tools. This model serves as an informational foundation for further improvement of project management systems in the video game industry and can serve as a basis for developing practical recommendations regarding the implementation of artificial intelligence technologies.

Creating a conceptual model allows for identifying key directions for further research and appropriate analysis methodologies for optimizing video game development processes using artificial intelligence, which opens new opportunities for improving project management efficiency in this dynamic industry.

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