THE IMPACT OF ARTIFICIAL INTELLIGENCE ON IMPROVING VIRTUAL REALITY IN GAME DEVELOPMENT ON THE UNITY PLATFORM

Abstract. The article examines the impact of artificial intelligence on the process of improving virtual reality in the development of games on the Unity platform. The problem of scientific research is the insufficient study of the role of artificial intelligence and its influence on the improvement of virtual reality in the process of developing games on the Unity game engine.

The subject of scientific research is the factors of the influence of artificial intelligence on the improvement of virtual reality, and the process of introducing artificial intelligence tools and their use in the subsequent development of games on the Unity platform is chosen as the object.

The purpose of the article is to determine the role of artificial intelligence and evaluate the effectiveness of its tools in improving virtual reality during the development of games based on the Unity game engine. To achieve this goal, the current study considered the main tools of artificial intelligence in the context of game development and the features of implementing virtual reality in them. reality, the specifics of the Unity game engine and the advantages and disadvantages of its use.

The basis of the study was the reviewed and analyzed scientific literature, which was pre-selected according to the thematic direction: publications of Ukrainian and foreign scientists on the studied issues and the results of independent observations. A number of general scientific methods were also used, including: the method of abstraction, which was used in order to highlight the main concepts and categories, the method of analysis and synthesis (to identify the most influential elements of the researched object), abstract-logical and dialectical methods of scientific knowledge, as well as the method scientific abstraction, which helped to form the necessary theoretical generalizations and conclusions and clarify the conceptual apparatus.
The scientific novelty of the research lies in the fact that for the first time in the history of domestic (Ukrainian) scientific thought, the extent of the influence of artificial intelligence on the process of improving virtual reality in the development of games on the Unity platform was determined.

The theoretical result of the study was the identification of the main connections between the implementation of artificial intelligence tools and the improvement of virtual reality in the development of games on the Unity platform.

**Keywords:** machine learning optimization, user experience enhancement, procedural content generation, real-time interaction algorithms, 3d modeling efficiency.

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**АННОТАЦІЯ.** У статті розглянуто питання впливу штучного інтелекту на процес вдосконалення віртуальної реальності в розробці ігор на платформі Unity. Проблемою наукового дослідження визначено недостатність вивчення питання ролі штучного інтелекту та його впливу на вдосконалення віртуальної реальності в процесі розробки ігор на ігровому рушії Unity.

Предметом наукового дослідження визначено фактори впливу штучного інтелекту на вдосконалення віртуальної реальності, а об’єктом обрано процес впровадження інструментів штучного інтелекту та їх застосування в наступній розробці ігор на платформі Unity.

Метою статті є визначення ролі штучного інтелекту та оцінка ефективності його інструментів у вдосконаленні віртуальної реальності під час розробки ігор на основі ігрового рушія Unity. Для досягнення поставленої мети в ході поточного дослідження були розглянуті основні інструменти штучного інтелекту в контексті розробки ігор та особливості впровадження в них віртуальної реальності, специфіка ігрового рушія Unity та переваги і недоліки його застосування.

Базою дослідження стала розглянута та проаналізована наукова література, що була попередньо відібрана за тематичним спрямуванням: публікації українських та іноземних вчених з досліджуваної проблематики та результати незалежних спостережень. Також було використано ряд загальнонаукових методів, серед яких: метод абстрагування, що застосовувався з метою виділення основних понять та категорій, метод аналізу та
синтезу (для ідентифікації найвпливовіших елементів досліджуваного об’єкта), абстрактно-логічний та діалектичний методи наукового пізнання, а також метод наукової абстракції, що допоміг сформувати необхідні теоретичні узагальнення й висновки та провести уточнення поняттєвого апарату.

Наукова новизна дослідження полягає у тому, що вперше в історії вітчизняної (української) наукової думки було визначено міру впливу штучного інтелекту на процес вдосконалення віртуальної реальності в розробці ігор на платформі Unity.

Теоретичним результатом дослідження стало виявлення основних зв’язків між впровадженням інструментів штучного інтелекту та вдосконаленням віртуальної реальності в розробці ігор на платформі Unity.

Ключові слова: оптимізація машинного навчання, покращення взаємодії з користувачем, процедурна генерація контенту, алгоритми взаємодії в реальному часі, ефективність 3D моделювання.

**Formulation of the problem.** Investments in the development of games in 2020 amounted to more than 33 billion dollars. This money was divided between game companies, teams and startups. During 2021, this indicator increased by 5 billion dollars, already reaching 38 billion dollars. One of the main factors stimulating investment is the constantly growing demand in the segment of mobile games, which in recent years occupies the largest share in the market structure, but the emergence of new technologies such as virtual reality (VR) and augmented reality (AR) is also important, which also attract investors and help attract even more funds [1].

The history of development of game development in Ukraine demonstrates that at this stage of development (based on a nationally oriented approach), the study of VR and AR technology is being actualized, as Ukrainian studios widely involve them in the development of their products. Examples of the use of virtual reality by domestic developers are the studios ByOwls with the Rival Ride project and Mirowin with the TinShift project, which have gained considerable fame on the Steam platform [2].

As one of the founders of the American game development company, Sugar Games, Keisha Howard stated: “The rapid pace of change, from mixed reality to blockchain and artificial intelligence, has left many confused, questioning their relevance and direction” [3].

From all this, it became clear that for the further development of the game development industry and the deeper immersion of players in the game process, it is necessary to investigate the issue of the impact of artificial intelligence on the process of improving virtual reality in game development, which will allow creating an even closer to reality product, attracting increasingly large groups of players.
The problem of scientific research is the inadequacy of studying the impact of artificial intelligence on the process of improving virtual reality in game development and the role of Unity game engine tools available to developers.

**Analysis of recent research and publications.** Domestic researchers O. Tkachenko, A. Mamaev, V. Volynets, V. Gabrusev, A. Velgach, O. Kulyanda, S. Shevchenko, O. Negodenko and I. Reznichenko devoted a number of works to the issue of the impact of artificial intelligence on the process of improving virtual reality in game development and defining the features of the Unity game.

In the work of O. Tkachenko and A. Mamaev [4], an analysis of the use of artificial intelligence, in particular generative, during the development of computer games (to optimize the creation of games and reduce budgets) and the formation of the corresponding game space was carried out. The impact of artificial intelligence tools on the balance between integration and immersion in the surreal world is also determined.

In the course of the study by V. Volynets [5], the issue of the lack of clear typology criteria and appropriate methodological approaches was highlighted, which complicates the process of classifying types of virtual reality and provokes a significant gap between theory and practice.

An important source of information about the features of the Unity 3D engine and the principles of its use during game development is the work of V. Gabrusev, A. Velgach and O. Kulyanda [6], which defines a number of advantages of the Unity engine over other platforms based on a comparative analysis and describes the process of modeling the scene of a gaming computer application in the Unity 3D environment.

A joint study by S. Shevchenko, O. Nehodenka, and I. Reznichenko [7] is devoted to the problem of studying various software and hardware tools for the implementation of virtual reality. During the research, an application based on the Unity game engine was also developed.

Among the foreign researchers who devoted their work to the question of the impact of artificial intelligence on the process of improving virtual reality in game development and defining the features of the Unity game engine, we can mention T. Ribeiro de Oliveira, J. Hocking, A. Chia, A. Jungherr and D. B. Schlarb.

In the study of the team led by T. Ribeiro de Oliveira [8], a systematic review of the literature on artificial intelligence tools that can be applied to virtual reality solutions was conducted. It was found that machine learning is the most applied scientific method of artificial intelligence in VR applications. In the book J. Hocking [9] there is a review of aspects of the game development process, from the initial work to the creation of user scenarios and the integration of virtual reality using artificial intelligence methods. A. Chia [10] investigated the issue of automating game mechanisms as platform tools for designing and modeling interactive 3D worlds in games.
It is also necessary to consider the study of A. Jungherr and D. B. Schlarb [11], which proves the increased competition between engine development companies (Epic Games and Unity Technologies) due to the growth of the field of augmented, virtual and augmented reality applications. The relevance of the topic chosen within the framework of the current research is due to the constant development of artificial intelligence and the rapid introduction of virtual reality technologies into games, along with the improvement and modification of the Unity game engine, which requires additional theoretical foundations, since the reviewed scientific works lack a description of artificial intelligence tools that affect on the process of improving virtual reality in the development of games on the Unity platform.

The purpose of the article is to define the role of artificial intelligence and evaluate the effectiveness of its tools in improving virtual reality during the development of games based on the Unity game engine. To achieve the defined goal of the scientific article, the following research tasks were formulated:

- consider the features of the Unity game engine;
- identify the main advantages and disadvantages of Unity for creating games and highlight the means of their development;
- describe methods of using artificial intelligence tools in the development of games based on the Unity platform;
- to evaluate the impact of artificial intelligence on the process of improving virtual reality in the development of games created on the basis of the Unity engine.

Presenting main material. To begin with, you need to consider what the Unity game engine is and its features. Unity is an integrated development environment that allows you to create various games and interactive applications such as simulations and visualizations. Unity supports most of the existing operating systems and platforms, including Windows, MacOS, Linux, Android, iOS, as well as game consoles and VR systems. The Unity engine has grown and evolved, thanks in part to the rapid development of mobile technology, allowing it to become one of the most popular mobile game engines. Unity has become known for its multi-platform capabilities, supporting not only mobile platforms, but also most game consoles and computer systems [12].

Next, the main advantages and disadvantages of using the Unity engine in the development of games are determined, which revealed the need to use artificial intelligence algorithms in the development of games based on this platform (Table 1).
Table 1. The main advantages and disadvantages of the Unity engine in the context of game development

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
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<tbody>
<tr>
<td>Cross-platform (the same source code that is written by a group or a single programmer can be ported to different platforms)</td>
<td>It is relatively expensive to develop complex games or programs</td>
</tr>
<tr>
<td>The presence of a visual development environment</td>
<td>Unity's lack of support for links to external libraries</td>
</tr>
<tr>
<td>The engine is always evolving and has a large community developers around the world</td>
<td>Unity projects require a large amount of RAM</td>
</tr>
<tr>
<td>Availability of C# programming language</td>
<td>Specialists have to put up with a lot of unnecessary tools specifically for their tasks</td>
</tr>
<tr>
<td>Great integrated level editor</td>
<td>Need to spend extra time on setup</td>
</tr>
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</table>

Source – developed based on [13, 14]

Analyzing the advantages and disadvantages of using the Unity engine for game development, it should be noted that none of the identified disadvantages is an obstacle either for the implementation of virtual reality or for the use of artificial intelligence methods. Any engine has its own development tools that provide opportunities for faster and better game product creation. The Unity platform is no exception, as it also provides developers with a fairly wide set of tools, which is shown in Fig. 1.

Fig. 1 Development tools provided by the Unity engine

Source – developed based on [15]

Since the basis of almost any game is sound, graphic, physical and animated interaction, it is necessary to consider in more detail the means of their implementation in the Unity engine:

1. Physics System: Unity has a built-in physics system that allows you to create realistic behavior of objects in the game. Developers can set physical
properties of objects, such as mass, collisions, gravity, motion dynamics, etc. This allows you to create realistic physical effects and interaction of objects.

2. Animation System: Unity has a powerful animation system which allows developers to create movements and animations for objects in the game. It supports hierarchical animations, skeleton animations, morphing and many other techniques. Developers can control animations through scripts or use the built-in GUI to customize animation parameters [16].

3. Sound System: Unity has a built-in sound system that allows developers to add and control sound effects in the game. It supports various sound formats, the ability to mix sounds, adjust the effects of echo, reverberation, 3D sound and other aspects of sound processing.

4. Graphics System: Unity has a powerful graphics system that allows you to create impressive visual effects in the game. Developers can adjust lighting, shadows, textures, materials, special effects and other graphical parameters to achieve the desired visual quality of the game.

Among the main features of Unity 3D, it is necessary to note the built-in support for working in a network environment, the use of the Ageia PhysX physics engine, mixing 3D graphics in real time with streaming audio and video. The Unity 3D engine consists of four main modules, the main functions of which can be seen in Table 2.

**Table 2.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Module Name</th>
<th>Description</th>
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</table>
| 1   | Module Overview              | - object module  
- event processing module  
- camera module  
- module for rendering |
| 2   | Object Module                | - components, scenarios, and buttons are staging objects  
- objects are fundamental units  
- objects can be assigned to a script code |
| 3   | Event Processing Module      | - alters the state of stage elements  
- modifies properties of the stage object  
- used to modify the level object's characteristics |
| 4   | Camera Module                | - inspired by 3D stage design  
- user's device content varies with the camera's content  
- scripts determine camera location and angle  
- user validation of stage interface, situation, or role modifications  
- camera switches for transitioning between stage scenarios |
| 5   | Module for Rendering         | - calculates real-time effects  
- includes models, animations, lighting, and special effects  
- displays effects on the screen  
- high skill level impacts stage output quality |

*Source – developed based on [17,18]*
Unity has continued to innovate in recent years, recently introducing the Unity XR Toolkit, a unified framework for building VR and AR applications. This toolset greatly simplifies the development process by providing developers with a number of tools to create interactive and intuitive VR experiences. Features such as hand tracking, spatial audio, and advanced physics have further enhanced the realism and immersion of VR gaming [19]. All this becomes the basis for improving the interaction with the user during the game.

To create a game based on the Unity engine with the involvement of artificial intelligence and virtual reality, you need to perform the following steps:

1. Setting up Unity for VR Game Development: using the XR interaction Toolkit package (use the XR Interaction Toolkit package instead of Google's VR package), finding a pre-set VR project (use a finished VR project as a basis for your game).

2. Implementing Player Controls (creating a game scenario using artificial intelligence and testing it).

3. Enemy AI and Interactions (creating engaging enemy AI and interactions).

4. Adding Assets and Visuals (creating an immersive VR experience that involves the integration of relevant resources and visual elements).

5. Setting up the Scene (organizing the environment, placing interactive objects, adjusting lighting and camera angles, and fine-tuning the overall visual experience) [20].

It should be remembered that the generated scenarios, as a rule, require optimization for production quality. However, it has become clear that AI has huge potential in helping with VR game prototyping, debugging, and game jamming.

Also, it should be noted that artificial intelligence plays an important role in optimizing the workflow of VR game development. Optimized machine learning algorithms can analyze user interactions to improve user experience, making VR applications more intuitive and engaging. In addition, AI-based tools can streamline content creation, helping developers create realistic environments and interactive elements. This full integration of artificial intelligence into the development of virtual reality games not only increases productivity, but also ensures the creation of high-quality, immersive experiences for users by shaping them in real-time interaction algorithms [21]. The main functions of using artificial intelligence in game development are shown in Figure 2.
Fig. 2 The main functions of using artificial intelligence in the development of games in the context of task automation

Source – author’s development

Based on the considered features of the Unity engine and the definition of the development tools and frameworks to which it provides access for developers, its popularity today becomes clear. With an extremely high efficiency of 3D modeling, considering the relative simplicity and convenience of Unity, it is able to improve user interaction by introducing virtual reality into games, which can be based on the work of artificial intelligence. This allows you to interact with game elements in real time, getting deep immersion, without the need to use third-party software. Thus, it becomes clear that the future of the game industry lies in the use of artificial intelligence to improve virtual reality in the development of games on the Unity platform.

Conclusions. Therefore, the conducted research allows us to state that although it is not possible to assess the impact of artificial intelligence on the process of improving virtual reality in the development of games on the Unity platform, it is one of the factors of the rapid growth of the game market. Even Ukrainian game application development companies have games involving virtual reality in their portfolio, which allows them to compete with foreign firms. The results of the study made it possible to understand the popularity of the Unity engine, the basis of which is its large toolkit for using algorithms of artificial intelligence and virtual reality.

If previously game developers had to use third-party libraries and frameworks to integrate virtual reality into games, Unity XR Toolkit has changed the rules of the game, as it is a universal framework for introducing virtual reality capabilities into games and other applications.

A promising development of the research is a thorough study of the impact of artificial intelligence on the process of improving augmented reality in the development of games on a platform other than Unity, which will then allow us to compare the degree of influence for each of the types of reality and the game engine.
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