

# Virtual Reality and Using the Unity 3D Platform for Android Games

Nurdaulet Nurym

Al-Farabi Kazakh National University  
Almaty City, Kazakhstan

Raushan Sambetova

M. Auezov South Kazakhstan State University  
Shymkent City, Kazakhstan

Muhit Azybaev

M. Auezov South Kazakhstan State University  
Shymkent City, Kazakhstan

Nurassyl Kerimbayev

Al-Farabi Kazakh National University  
Almaty City, Kazakhstan

**Abstract**—Nowadays, under the influence of the development of computer and information technologies, a particular approach to such concepts as “virtuality” and “virtual reality” is emerging. Modern technology provides with the possibility to dive into the virtual world, in which things and events cannot be distinguished from the reality. However, virtual reality differs from objective reality. The concepts of “virtuality” and “virtual reality” are considered and studied in psychology, philosophy, social science, esthetics and other sciences, which define criteria for different types of reality. Issues of virtual reality are contemporary for the cognitive and practical activity of humanity, the nature of virtual reality should be explained, theological fundamentals of the development of the world and existence should be revealed, the existence and activity of the substance in various types of reality should be reasoned.

Computer technology and virtual 3D devices extensively applied in the industry of video games play roles of great importance in the development of virtual reality.

Designing virtual games contributes to the development of new achievements in the sphere of graphical and sound-related capabilities used when constructing systems of virtual reality.

**Keywords**—*virtual reality (VR); unity 3D; virtual environment; 3D glasses*

## I. INTRODUCTION

Virtuality in the modern world is interactive, mentally replacing an object by its interpretation and with an impact transforming reality materially. Nowadays, using technology, created virtual reality is really becoming some real world, to which in some way a human being dives [5, 6].

Philosophically speaking, virtual reality is considered as a set of objects modeled by real processes, but the content and the form of which do not conform to these processes. Virtual objects exist separately from reality, and the virtuality itself is defined relative to the “principle” activity subjecting it. Basic properties of VR are the following ones [3]:

- Being generated (creating a virtual reality by the reality external to it);
- Timeliness (virtual reality exists in a given place at a given time, at the moment of observation);
- Autonomy (an existence of its own laws of time, space, and an existence of virtual reality);
- Interactivity (virtual reality is independent, but it can interact with other realities).

Modeling in virtual reality on a computer is an ontological reproduction, imitation of real objects. In this case, virtuality has the same pragmatic effects as its real world equivalents.

The scientists Searle J. R. [12], Brey P. [4] claim that only two types of physical objects and processes can be reproduced on computers ontologically:

- 1) *physical objects defined in terms of visual, acoustic or computational properties, which can completely be realized on multimedia computers;*
- 2) *“institutional structures”, that is subjects, definite conditions or functions assigned to them within a social institution or practice.*

Such objects include images, films, pieces of music, stereo systems and calculators. A fast computer can successfully reproduce basic physical or formal properties of institutional structures.

Examples of institutional structures are such activities as buying, selling, voting, which in reality can deal with money, documents, contracts, etc. Most of institutional structures do not depend on the physical environment because they depend only on the status or the function assigned to them. If an institutional essence exists physically then it can also exist virtually.

Nowadays, entertainment industry stimulates the development of most of VR technologies.

Many works are devoted to the work in this environment.

Danling Wang [15] in “Gamified learning through unity 3D in visualizing environments” aims at creating an immersive 3D learning environment where a game is integrated into virtual exhibitions so as to inspire high-school students’ motivation and raise learning performance in humanities courses.

In “A truly meshless method based on partition of unity quadrature for shape optimization of continua”, W. Zou, J. X. Zhou, Z. Q. Zhang, and Q. Li presented a numerical method for shape design optimization using a truly meshless method based on partition of unity (PU). This method does not rely on a partition of the integration domain into small cells as a background mesh, but rather on a PU by a set of overlapping patches covering the domain [16].

A boundary-representable partition of unity for image magnification is described in the paper by Yukie Nagai, Yutaka Ohtake, Hideo Yokota, and Hiromasa Suzuki.

The study of Nagai Y. et al. [8] proposes a simple yet effective algorithm to magnify 2D/3D images while preserving discontinuities of intensity. The algorithm is based on the partition of unity (PU) approximation. This algorithm is suitable for magnifying a variety of images, including scanned documents, pictures, and CT-scanned images. To demonstrate the effectiveness of the proposed method, some experimental results for 2D/3D images are demonstrated.

In the work by S. Andringal et al. [1] the authors describe the search for Gamma Ray sources, which have become one of the main concerns for astrophysics. The reconstruction method uses two spatial variables that can be understood as the emission angle and the point of emission of each Cherenkov photon. The tests performed so far indicate errors of about 10 m for the core position and a deviation of about  $0.08^\circ$  in the shower direction. The proposed variables for the separation of  $\gamma$  and proton showers seem to allow an efficient separation for the distances considered. An estimator is built to account for the number of telescopes in use, the distance of each telescope to the core position and the good region for each variable.

Hasan Ayaz, Sarah L. Allen, Steven M. Platek, Banu Onaral [2] in the paper “Maze Suite 1.0: A complete set of tools to prepare, present, and analyze navigational and spatial cognitive neuroscience experiments” note that Maze Suite can be used to design and edit adapted 3D environments, as well as to track subjects’ behavioral performance.

The experience of working with virtual reality takes place in different spheres of human activities: in psychology, cognitive ethology, medicine, etc.

Madis Vasser, Markus Kängsepp, Murad Magomedkerimov, Kälver Kilvits and others in “VREX: an open-source toolbox for creating 3D virtual reality experiments” present VREX, a free open-source Unity toolbox for virtual reality research in the fields of experimental psychology and neuroscience. As the authors note, “A high level of presence in a virtual study environment might yield stronger cognitive ethology, resembling the high perceptual and computational demands present in real life behaviors”. There is a wide variety of Unity

add-ons assisting the generation of interactive virtual worlds. By adding many powerful features and a simple user interface, the tool the authors present is designed to empower researchers with no or little prior knowledge in game engines to start working with VR [14].

Cognitive Ethology and exploring attention in real-world scenes are presented in the work by D. Smilek, E. Birmingham, D. Cameron, W. Bischof, A. Kingstone. The authors sought to understand what types of information people use when they infer the attentional states of others [12].

T. D. Parsons [9] considers a virtual reality for improving the ecological sustainability and an experimental control in clinical, affective and social neurosciences.

In “Immersive virtual environment technology to supplement environmental perception, preference and behavior research: a review with applications”, J. W. Smith [13] describes a relatively simple workflow for creating and displaying 360° virtual environments of built and natural settings and presents two freely-available and customizable applications.

P. Scarfe and A. Glennerster [10] in the article “Using high-fidelity virtual reality to study perception in freely moving observers” consider sensory perception in humans and animals. In their work the authors pay attention to: (a) the research questions the VR allows experimenters to address and why these research questions are important, (b) the things that need to be considered when using VR to study human perception, (c) the drawbacks of current VR systems, and (d) the future direction vision research may take, now that VR has become a viable research tool.

Therefore, the technology of 3D virtual reality is used in many spheres of science and human activities.

The purpose of this paper is to describe the development of the virtual game in Unity 3D for Android, the toolkit used to create the game.

## II. TOOLS FOR DEVELOPING A VIRTUAL GAME

As a form of human activity, the game appeared in a very deep antiquity. The game is a method of a child’s perception of the world. While playing children develop their physical and social skills. A playing child is an active participant of the game. A virtual game provides with a complete virtual reality experience. Players can change and transform that virtual world achieving their own goals. A virtual game is an educational type of activities, which develops child’s activity, attention, thinking, and spatial orientation. It contributes to improving child’s affective, motivational, operational and technical activities, providing the child with the possibility to change positions and coordination.

The reality of the virtual environment is defined by one of such indicators as the sense and the level of immersion in this environment. Mary Witton suggests that a poorly designed interaction can dramatically reduce the sense of immersion. That is why designers face the problem of introducing the virtual world as realistically as possible, of making it interesting and attractive for users. The basic quality of “virtual reality” is its

interactivity. Interactivity implies a possibility to change the environment of the virtual world. A sufficiently designed virtual environment should react to user actions.

Interactivity depends on many factors, one of which is speed, range and display. The speed depends on actions of a user included in a computer model. The range means how many possible outcomes can be a result of some specific user action. The display is the ability of the system to produce natural results in response to user actions. One of forms of interactivity is navigation.

The depth of an in-suit sensor camera, motion controllers and natural human interfaces create a sense of telepresence for a user. Nowadays, there are various devices and manipulators enhancing the effect of “immersion” in a virtual game as a part of the virtual environment. Ordinary 2D controllers, such as a mouse, provide with the possibility to indicate a point in the plane, but when we use a mouse in 3D games, we have to use an additional device in order to add one more dimension; for example, a keyboard. At present time, there are also more combined manipulators, which provide with the possibility to work in 3D immediately. When using them a user holds a joystick, whose position in space is monitored by a computer. The most popular 3D controllers used in games are Wii Remote and PlayStation Move.

### III. UNITY 3D EDITOR FOR ANDROID APPLICATIONS

The tool for developing two- and three-dimensional applications and games is Unity operating under Windows, Linux and OSX operation systems. Created using Unity applications operate under Windows, OS X, Windows Phone, Android, Apple iOS, Linux operation systems, including Wii, PlayStation 3, PlayStation 4, Xbox 360, Xbox One game consoles and MotionParallax 3D displays (devices for reproducing virtual holograms), for instant, Nettlebox. There is an opportunity to create applications for launching in browsers using a special Unity plug-in (Unity Web Player), as well as trough realizing WebGL technology.

The Unity editor has a simple Drag&Drop interface, which is easily adjusted and consists of various windows enabling to carry out game debugging directly in the editor. The engine supports the three scenario languages: C#, JavaScript (modification), Boo (a Python dialect). Boo is removed in the fifth version. The PhyS physical engine from NVIDIA carries out all physical calculations. A project in Unity is subdivided into scenes (levels), i.e. separate files containing their game worlds with their sets of objects, scenarios, and setups. Scenes can contain both actual objects (models) and empty in-game objects, i.e. the objects, which do not have models (“empty shells”). Objects in their turn contain sets of components that scripts utilize. Besides, the objects have names (Unity allows the existence of two or more objects with the same name); any object may have a tag and a layer in which it is supposed to be displayed. Thus, any object of the scene must have a Transform component, which stores the coordinates of the location, the rotation and the size of the object in three axes. Objects with visible geometry also by default have Mesh Renderer component, which makes the model visible. Collisions can be applied to

objects (the so called colliders in Unity). There are several types of colliders:

- Character controller, the type of a physical model created specifically for using it for game characters;
- Box collider (a physical object forms a cube, in which the whole model of the object enters);
- Sphere collider (a physical object forms a sphere, in which the whole model of the object enters);
- Capsule collider (a physical object forms a capsule, in which the whole model of the object enters. Unlike the previous type, the sizes can be changed both in one and three axes simultaneously);
- Mesh collider (a physical model entirely simulates the real geometry of the object);
- Wheel collider (a physical model of a wheel);
- Terrain collider (the type of a physical model created specially for using on an object of Terrain type, generated by the Unity editor with the capacity of sculpting and area coloring).

Besides, Unity supports physics of solids and material, including physics of Ragdoll type (rag doll). In the editor there is a system of object inheritance; son objects will repeat all the changes of position, rotation and scale of the parent. Scripts in the editor are attached to objects in the form of separate components.

Unity editor has a component for creating animation; besides, animation can be created previously in a 3D editor and imported along with a model, and then subdivided into files.

In addition to an empty game object and models, the following GameObject-type objects can be added to a scene:

- System of particles;
- Camera;
- GUI text;
- GUI texture;
- 3D text;
- Point light;
- Directional light;
- Perimeter lighting;
- Light source imitating the Sun;
- Standard primitives;
- Trees;
- Terrain.

#### IV. RESULTS

In the game “Maze”, you have to find an exit from a maze and collect 12 keys. When creating the game additional assets have not been used.

It is a first person game, where you can look around using your virtual reality glasses (Fig. 1, Fig. 2).

This game was created using the Unity3D editor for Android application. The developed computer game “Maze” has a lot of analogues for various platforms. We have developed a virtual game “Maze” with 3 D glasses support.

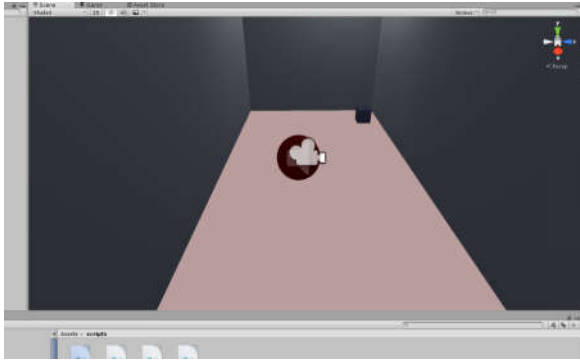


Figure 1. Form of the game

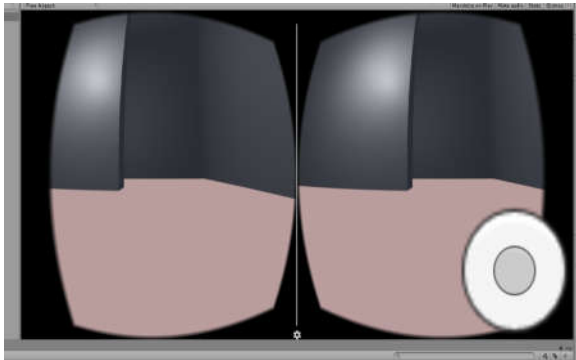


Figure 2. Form of the game for virtual reality glasses [7]

This game is created using the Unity3D editor for Android application. The developed computer game “Maze” has a lot of analogues for various platforms. We have developed a virtual game “Maze” with 3 D glasses support.

We set and solved the following problems: a user moves using buttons of the keyboard, a mouse and a “joystick” aiming at finding the exit from the maze within a definite period of time; it is necessary to realize the statistics of players’ running the game, which indicates a player’s name, the time of completing the game, and points gained during this time. Points are assigned

according to the time spent on finding the maze exit; the function of the maze editor is developed.

The game “Maze” requires a user’s attention and good reaction which contributes to developing thinking and logic. The game has a unique function of editing the maze, complicating stages of completing it. In the game developed there is a statistics of completed games that we created. Before saving an edited maze one must place a “character” in the place where it should be before the start of a new game. In order to save changes in the maze one should push “File” on the top panel and choose the option “Save”, in this case the original maze, to be exact, the array of numbers is overwritten into the same text file where it was originally while being read.

The best scientific evidence available shows that emotions play an important role in taking decisions, perception and learning. They affect the very mechanisms of rational thinking.

A computer game can motivate learners, but at the same time it can generate disappointment when it does not go in the way the player would like it to.

In order to clarify aspects of learners’ emotional state in relation to an educational game, the time of playthrough, the process of improving motor and cognitive reactions, we conducted an empirical study. In the study we considered users’ cognitive and motivational state using the interaction between a user’s screen and relevant systems.

Using computer registration the system can continuously collect objective data for further analysis and interpretation.

One of the main indicators of skills development is the faster execution of operations and the emotional behavior of the participants during the game and after they solve the labyrinth of a game.

Taking into account the results of the empiric study we consider:

- The time that a learner needs for making a decision in what direction to move. In such a way we can measure the speed of decision-making and completing the task;
- The time suspension after the system answers. This is the time during which the computer “stands idle” while the player analyzes whether he/she made the right choice.

At the end of the game a user can see a report with the conclusions the system made. Such report contains some comments and suggestions of the system, and categories of the errors the player made.

The system monitors how many times a player pushes joystick move buttons and how confident he/she is when moving in this or that direction. The player’s movements in the virtual space of a game show the level of the player’s concentration, his/her accuracy while moving in the given direction, and his/her ability to orientate in the three dimensions.

Learner’s activities can be monitored using the average speed of actions and the degree of certainty. If a learner makes repeated errors playing fast, it can mean his/her concern and anxiety. Repeated errors with lengthy intervals mean that the

player cannot choose a correct solution, that he/she has difficulties in choosing a proper direction, or that he/she has problems with the navigation.

We studied 30 learners at the age of 9 – 12 years old who were offered “The Labyrinth” educational game. The participants were informed about the game length and its main rules. The analysis includes the following criteria:  $T$  (duration),  $t$ -the value for playing through the game,  $t$ -the criterion for correlated models, and the  $t_a$ -criterion (the time spent on application of actions).

According to the results of playing through the game the participants were divided into three categories (Table 1):

TABLE I. THE RESULT OF TIME AND ACTION FREQUENCY WHILE PLAYING THROUGH

	Categories	Number	Average time (0–20 minutes)	$t$ -value	$t$ -criterion	$t_a$ -criterion
1	Participants who finished the game on time	12 (40%)	15-20	15.25	1.6	2.3
	9-10 years old	5 (40%)	15-20	15.30	1.7	2.4
	11-12 years old	7 (60%)	15-20	15.20	1.5	2.2
2	Participants who finished the game before the time passed	10 (33%)	10-15	10.30	1.3	1.8
	9-10 years old	3 (30%)	10-15	10.35	1.75	2.0
	11-12 years old	7 (30%)	10-15	10.20	0.8	1.6
3	Participants who could not finish the game on time	8 (27%)	More than 20	35.10	>2.0	2.6
	9-10 years old	5 (60%)	> 20	35.8	2.8	2.8
	11-12 years old	3 (40%)	>20	25.0	2.5	2.6

The results of the empiric study demonstrated age differentiation in time and quality of playing through this educational game. Older children navigate in three dimensions better, make fewer incorrect actions, and find a proper solution faster.

On finishing the game the participants were asked the following questions aimed at clarifying their emotional state and their interest in the game (Table 2, Fig. 3):

- 1) Was the game interesting for you?
- 2) Are you satisfied with its results?
- 3) Would you like to play this game again?
- 4) Would you like to play a more complicated version of this game?

TABLE II. THE RESULTS OF THE PARTICIPANTS' QUESTIONNAIRE ON THE OUTCOMES OF PLAYING THROUGH THE GAME

#	Questions /Answers	Yes	Rather yes	No	Rather no	I don't know, it's hard to answer
1	1 question	26 (88%)	2 (6%)	1(3%)	1 (3%)	0 (0%)

2	2 question	22 (76%)	2 (6%)	3 (9%)	2 (6%)	1(3%)
3	3 question	20 (70%)	8 (24%)	1(3%)	0 (0%)	1(3%)
4	4 question	23 (79%)	2 (6%)	3(9%)	1(3%)	1(3%)

The results of the conducted study proved the efficiency of this game, which can be applied to the educational process with the aim of developing such thinking skills as spatial thinking, attention, and savvy. During the game participants develop the following learning activities: navigation and perception of three-dimensional rotations, and ability to find proper solutions. The game affects one's emotional state. The correctness of choice and the success in playing through the game has a positive influence on participants' mental and emotional state. The number of collected keys is an indicator of the correctness of executed actions, and it motivates learners to play further in order to solve the labyrinth, which in its turn cultivates learners' perseverance and commitment. The use of 3D-glasses provides players with a complete virtual reality experience generating their interest in the game and wish to act.

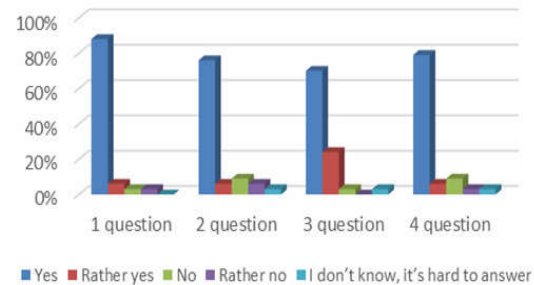


Figure 3. Questionnaire results on the outcomes of playing through the game

## V. CONCLUSION

Thus, Unity 3D is a multiplatform tool for developing two- and three-dimensional applications and games operating under the Windows and OS X operation systems. Applications created using Unity operate under the following operation systems: Windows, OS X, Linux, Android, Apple iOS, Windows Phone, BlackBerry, and on the game consoles such as Wii, PlayStation 3 and Xbox 360. Besides, it is possible to create Internet applications using a special Unity browser plug-in, and using an experimental realization in Adobe Flash Player module.

Unity 3D is a gameplay (game engine). This gameplay provided us with the possibility to create the virtual game “Maze” with 3D-glasses support. While developing this game – the Unity 3D tool, in spite of its simplicity, it has provided with great opportunities for modeling in formats FBX, COLLADA, 3DS, DXF.

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