Acta Tecnología - International Scientific Journal about Technologies
Volume: 7 2021 Issue: 1 Pages: 35-39 ISSN 2453-675X

doi:10.22306/atec.v7i1.101 *Received: 18 Feb. 2021; Revised: 05 Mar. 2021; Accepted: 17 Mar. 2021*

DESIGNING VIRTUAL WORKPLACE USING UNITY 3D GAME ENGINE

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Keywords: methodology, Unity 3D, virtual reality, workplace
Abstract: Designing a workplace may be a challenging task. It is important to make sure that the new workplace will prevent unnecessary resource waste, but also create a safe working environment for employees. Therefore, creating a virtual copy of the workplace before its real-life implementation may help to eliminate design shortcomings. This article presents a methodology of creating a virtual workplace using a game engine – Unity 3D. The methodology describes basic principles and methods used for the creation of virtual workplace, from initial analysis to utilization. The user then can use a VR head-mounted device to see small details and possible shortcomings. Effectiveness of methodology was then evaluated by using it to visualize a bar-processing workplace.

1 Introduction

Nowadays, innovative solutions are rapidly proposed, and it is crucial to be able to implement these technologies most optimally [1]. Industry 4.0 influence creates an ideal environment for these implementations [2]. Virtual reality (VR) is slowly becoming a stable technology in many fields, such as aerospace, manufacturing, employee training, process simulation or manufacturing systems visualization [3,4]. Testing the proposed solution in a virtual world before its implementation can be crucial, especially with current trends focused on constant cost reduction [5]. Moreover, potential shortcomings and dangers can be captured in virtual simulations before a real-life implementation. Thanks to that, companies can focus on increasing the production speed and overall quality, while emphasizing the physical health of their employees [6]. Virtual reality can also become a new prime teaching method. With educational centres implementing this technology, VR can even become a new mass medium [7]. Virtual reality training programs for employees are also steadily rising in popularity.

However, to correctly integrate the technology into selected solutions, one needs to know the principles of creating VR capable environment. To ensure the sufficient immersion of VR user, it is important to create a virtual environment corresponding with its real-life counterpart, containing all its elements [8,9]. This is no easy task since correct replication of real environment requires simulation of its object, functions, and processes.

The presented methodology proposes a uniform method of creating a virtual workplace using a game engine Unity 3D. The methodology contains methods and principles to ensure the smooth workflow and minimalization of errors while focusing on creating an immersive virtual reality experience. The goal of the article is to enhance the current approach of virtual workplace design by unifying currently used methods into single methodology expanded with new principles to reduce total time and resources cost.

2 Methodology

The main purpose of the methodology is turning a designed workplace (2D layout) into virtual reality compatible form. It is a relatively complex process consisting of several tasks that need to be done. After completion of every necessary step, the user can walk through the created virtual workplace using a VR headset and additional accessories. such as controller (joystick). However, before the creation of a virtual workplace, some preparations are required. User must collect all necessary materials and references, such as layout, 3D models or

dimensions. After that, the process of building the virtual workplace using Unity 3D can begin.

A flowchart is presented in Figure 1. to ensure that methodology is straightforward and easy to understand. This flowchart shows all the necessary task and requirements for the project's completion step by step. The blue colour represents the preparation phase, where the user gathers and analyse all necessary data. These will serve as a foundation for the next stage to ensure accurate workplace design and visualization. The yellow colour represents the task done in the game engine Unity 3D. That includes 3D modelling of assets (with use of gathered references), virtual workplace creation and interaction programming (player movement). Finally, the design must be tested and found shortcomings corrected (green colour).

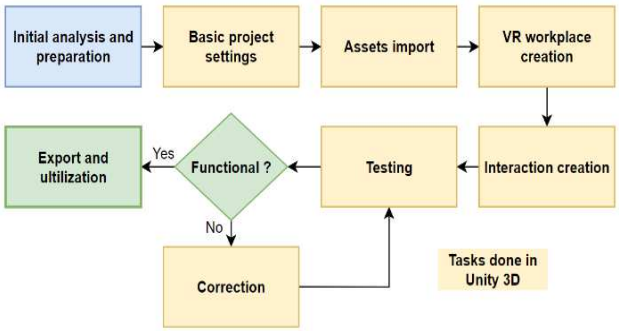

Figure 1 Virtual workplace creation methodology

2.1 Initial Analysis and Preparation

Initial analysis and preparation take place before the building of the virtual scene in Unity 3D. This stage includes every preparation task required for the successful completion of virtual workplace. When creating a virtual workplace, one of the most crucial requirements will often be its similarity with the real workplace. Therefore, the user must analyse every detail of the workplace, such as used machine tools, dimensions, or workplace layout. The best practice is to collect as many references as possible. This includes photos and video of the workplace, object dimensions and 2D layout. Appropriate references will make the creation of 3D assets and the virtual workplace itself much easier.

Another important part of the preparation phase is object identification. The real workplace consists of many objects, however, not every object needs to be modelled for satisfactory workplace visualization. Therefore, the user must identify crucial objects that need to be recreated in 3D. This includes every part of the workplace, that is necessary for its correct functioning, such as machine tools, storage units, manipulation units or transport vehicles. On top of that, objects should not be as detailed as in real life. A number of details significantly increases performance requirements [10]. For most objects, it is enough that they are recognizable on sight. Only objects that can be more detailed are the main entities of the workplace, such as machine tools.

If the user has access to all models beforehand, it is good practice to check all of them before using them. Some of them may have to be simplified to reduce their performance impact. Simplification process can be done in 3D modelling software. The complexity of an object is determined by the number of vertices (number of points), which represents the total quantity of vertices used to build a 3D model. Vertices are basic elements of a 3D model. With an increasing number of vertices increases the complexity of its geometry, therefore the performance requirements.

Available computing power is limited and so should be limited the number of vertices of the entire virtual workplace. A number of vertices in one 3D model determines the impact on the performance of virtual workplace application. If the said object is used multiple times, the impact is multiplied. Many vertices will allow an object to look very detailed, but slower computers may have trouble to handle a lot of detailed objects. Therefore, if objects do not belong in the category of the most important workplace objects, they should be simplified as much as possible.

2.2 Basic Project Settings

With the competition of all necessary analysis and preparation, the user has all necessary information to proceed. The following task will be completed using the game engine Unity 3D. Unity 3D is a game engine used for the creation of various games and application. For this project, the user will not use any complex Unity 3D function, so even a complete beginner can learn basics quickly, and then proceed to follow the methodology itself.

Firstly, the user needs to decide on a platform that scene will be built on. The two most valid options are PC (Windows) or a smartphone (Android, iOS). However, these two variants offer a different experience. Smartphone VR headset offers a cheap, but mobile VR experience, in exchange for low immersion and interaction options. On the other hand, desktop VR headset offers much vivid experience with a rich spectrum of interaction, complemented by a much higher price. Depending on the chosen platform, the user then may download a software development kit (SDK) that contains a lot of useful tools. SDKs such as GoogleVR or SteamVR can be downloaded from the internet for free. Subsequently, it is time to create a new project in Unity 3D and set basic parameters depending on preferred options. User must select platform he/she decided on, import SDK, if necessary, and finally, fill in basic project settings (such as name or concrete VR hardware) Figure 2 shows the process of platform and project setup.

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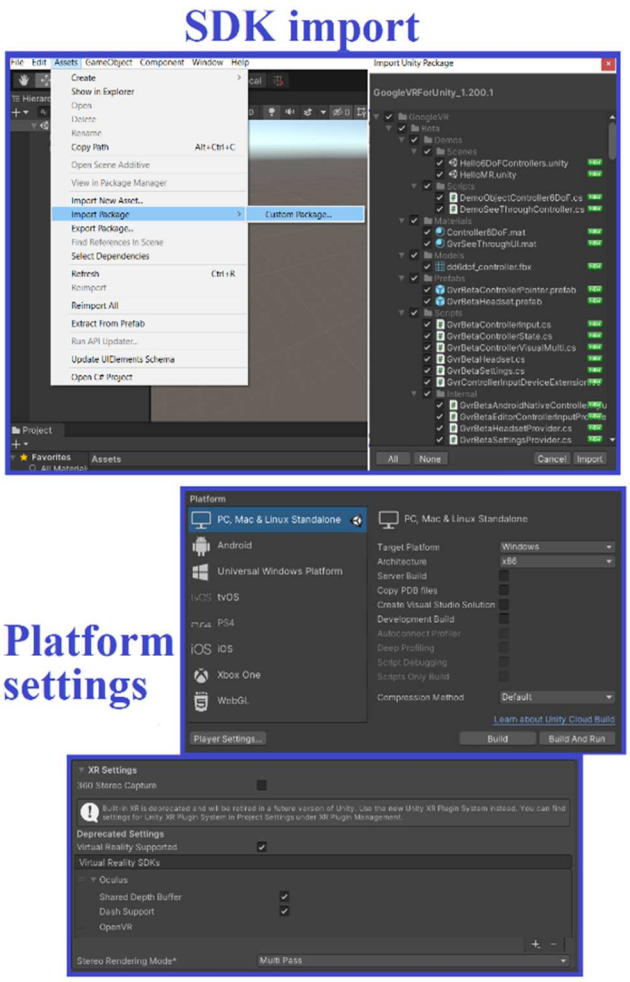

Figure 2 Basic project settings

2.3 Assets Import

Initial preparation should provide the user with all necessary 3D models needed for virtual workplace creation. Before building a virtual workplace itself, all these models (assets) need to be imported into Unity 3D (Figure 3). User needs to make sure that models are in a format supported by this game engine.

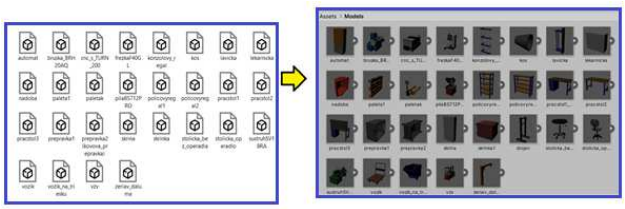

Figure 3 Assets import

2.4 VR Workplace Creation

With the library of 3D models imported into the game engine, the user can proceed to build a virtual workplace. Virtual workplace creation is a relatively simple process. The main goal is to place each object according to its position in a real workplace. Depending on the virtual workplace purpose, distances between may be required to be identical as in the real workplace design. Therefore, built-in tools, such as a coordinate system may help to achieve this requirement. While building the virtual workplace, the user simply chooses the 3D model from the library and place it in the correct position. An example of Unity 3D workflow is shown in Figure 4.

It is a great practice to establish a uniform method of virtual workplace creation to avoid mistakes. Placing objects in an orderly fashion will make the process faster and more straightforward [10]. Objects can be divided into groups depending on:

- Type of the object.
- Purpose of the object in the workplace.
- Position of the objects in the layout.
- Importance of the object for the workplace processes.

After creating a group of particular types, objects can be divided into them according to set parameters. These groups organized into a specific order. The user will then follow this order to place the group into the scene.

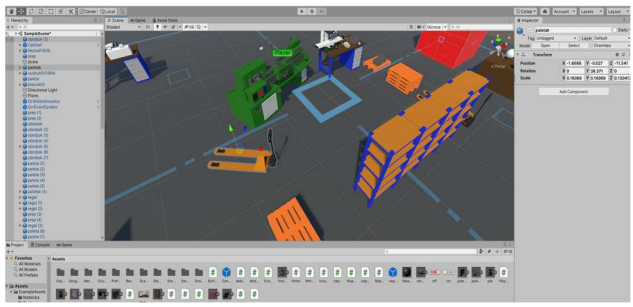

Figure 4 Virtual workplace creation

2.5 Interactions Creation

After completing the previous step, the virtual workplace is built. However, the application still lacks the means of movement for the user. This can be achieved by creating a script. Scripts are programs created with programming language supported by selected software. This methodology uses the game engine Unity 3D, therefore scripts were created using C#, which is a programming language supported by Unity 3D. However, depending on software selection, many other programming languages can be used, such as C++ or JavaScript. They allow the user to create various scenarios to make a scene interactable and more vivid. The most basic script for the virtual workplace is the addition of horizontal movement for a player. This may be enough if the goal of the scene is to showcase the created workplace that represents a real or designed space. User needs to know the purpose of the VR scene he/she is creating and write required scripts accordingly. However, it is possible to find various scripts online, so even user with little programming experience can use and combine those, to achieve the state he/she needs.

2.6 Testing

Before exporting the application, it is important to check if everything is working correctly. Player movement may have some flaws or virtual workplace does not precisely copy initial workplace design. Testing can take place in Unity 3D, the application does not have to be exported. After plugging in the VR hardware, the application can be built and launched directly in Unity 3D. Fixing every occurred problem is necessary for the smooth functioning of the application. Any inaccuracies can hinder the usability of the application, or even make it obsolete.

3 Practical use

For presented methodology utilization, it is crucial to evaluate the potential and effectiveness of the methodology. The methodology provides needs to provide all necessary information, while remaining concise and easy to use. To demonstrate the capability of the presented methodology, it was tested in practical use. Concrete VR ready virtual workplace was created using its principles. Firstly, a 2D layout of a bar material processing workplace was designed. The objective was to transform the assigned 2D layout into VR ready virtual workplace as a form of project visualization. This VR workplace was then used for the presentation of the proposed workplace. Presentation participants could use the VR headset and controller to walk through the virtual 3D representation of the designed 2D layout. A simple mobile VR headset was used, but for the presentation purpose, which minimize the user interaction options, it is a viable and significantly cheaper method. Thanks to that, participants had an opportunity to get a much closer look at every detail of the proposed project. Written scripts and VR hardware allowed them to explore every part of the virtual workplace. Figure 5 shows the process of creating a virtual workplace from the assigned 2D layout. Figure. 6 shows the VR application itself.

The process of workplace visualisation using virtual reality was executed using the proposed methodology. After analysing provided data and collecting necessary references, every missing 3D asset was created. Created assets and references were then used to create a virtual copy of a workplace using the Unity 3D game engine. To ensure the means of movement for the virtual workplace, a C# was created and integrated into the application. Finally, the virtual workplace was tested to fix any problems. After that, the application was ready for its utilization.

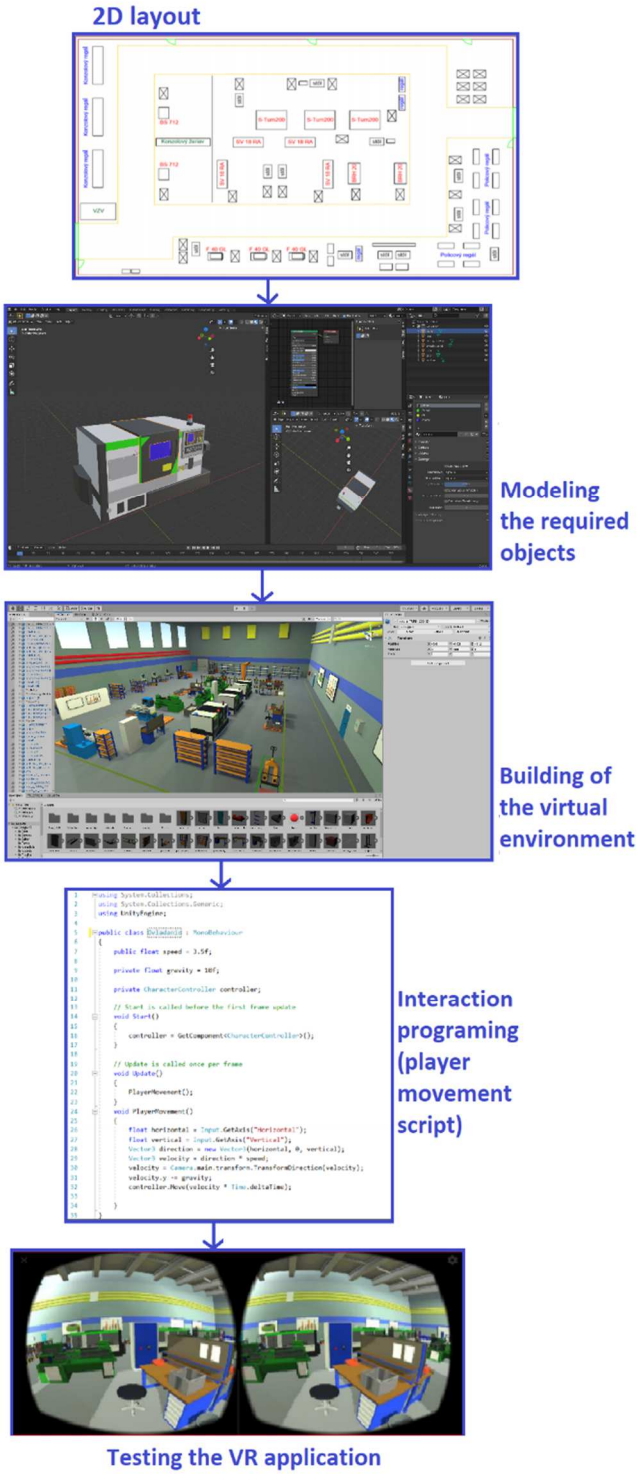

Figure 5 Creating a virtual workplace using Unity 3D

Figure 6 VR application

4 Conclusion

The presented article proposes the methodology for the design and visualization of the virtual workplace. The methodology presents and straightforward way of virtual workplace creation, covering every necessary stage and its methods and principles. The methodology attempts to streamline the process of virtual workplace creation, unifying known methods and enhancing them ensuring smooth workflow and more effective use of time and resources.

The effectiveness of the methodology was evaluated in practical use. A concrete VR ready scene was created. The main goal was to turn an assigned 2D layout of a bar-processing manufacturing system into VR capable 3D environment. The user used the presented methodology for every necessary step. As the result, the user-created a virtual environment capable of VR immersion suitable for its goal, which was the presentation of the proposed workplace.

The practical test shows that the methodology is suitable for the process of virtual workplace creation. In the near future, additional tests will be held to improve the workflow to make it an even more powerful tool in the field of virtual reality.

Acknowledgement
This article was created with support of KEGA project no. 017ŽU-4/2019.

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Review process
Single-blind peer review process.