Gamified Violin Playing in Virtual Reality Based Metaverse Environment

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Abstract—**Violin is one of the most significant musical instruments of both Turkish and western music. It is a stringed instrument played with a bow. Due to its fretless nature, it is relatively difficult to learn and play the instrument, compared with other musical instruments. In this study, a violin has been modeled to be played in virtual reality and metaverse environment is for a better and more entertaining violin education. Even if the student does not actually have a violin in hand, by means of virtual reality glasses, the modeled violin can be seen in the virtual reality environment. The camera of the Oculus Quest 2 Virtual Reality Glasses and haptic gloves are used to sense the both student's finger pressing and bow movements. By means of this study, the student does not need to own a real violin. Considering that a good violin has a high cost, the student will not need to spend high cost to buy the instrument. Besides, the biggest problem of the violin and other stringed musical instruments is the tuning of the instrument. Without a good tuning, the strings will not sound harmoniously and the student will not be able to play correctly because of not hearing the correct sound. Tuning ability needs some experience. But there is no tuning problem in the violin modeled in this study since it does not have real strings which means that even a beginner level student will not have a tuning problem. Also, in this study, while playing various exercises and songs, the musical notes needed to be pressed on the violin are highlighted to ensure that the student confirms whether to play correctly. The study is an alternative material of violin education in a more entertaining way.**

Keywords— **Metaverse, Virtual Reality, Gamification, Unreal Engine, Violin**

I. INTRODUCTION

Virtual reality (VR) applications were firstly seen in the 1960s and its use has been increasing since then [1]. Investments in virtual reality sector have also been increasing recently. For example, Facebook bought the Oculus brand in 2014 by spending billions of dollars [2]. Furthermore, Facebook changed its name to Meta to adapt to the concept of metaverse [3]. Virtual reality is used in many areas such as education, health, gaming, industry and daily life. There are many studies in the literature on virtual reality applications in different fields.

Han Fang et al. studied wearable haptic technologies for virtual reality and augmented reality (AR). By means of wearable accessories, body movements are perceived as well as hand and finger movements [4]. Adriano da Silva Marinho et al., for the first time, conducted a study on postural stability and cyber diseases in virtual reality game players [5]. Dai-Yun

Wu et al. worked on the application of virtual reality in the advertising industry [6]. Jingni Ma et al. studied mental improvement in adults by means of virtual reality [7]. Jing Wen et al. conducted a study in which an electrician explained some experiences to students in a virtual reality environment [8]. Alena Kostyk et al. conducted a study on virtual reality and customer-oriented marketing [9]. Babji Srinivasan et al. conducted a study to enhance chemical safety in laboratories and industry with the use of virtual reality [10]. There are also some studies in the literature on Unreal Engine. Eric Chu et al. suggested an alternative to the visual programming of the Unreal Engine game engine called Blueprints [11].

By means of this study, by using virtual reality glasses, the student can learn to play the violin in an entertaining way without spending high cost for the instrument. Also it allows players to come together online and make music together. The study includes virtual reality, blockchain, NFT and metaverse concepts and contributes to the literature.

II. MATERIAL AND METHODS

A. 3d Design

In this study, firstly, violins and accessories used in the virtual reality environment have been modeled by means of three-dimensional design programs. Software such as Blender, 3d Studio Max, Autodesk Maya can be given as examples of three-dimensional design and animation programs [12]–[14].

Fig. 1. Image of a modeled violin

Later, the created model has been imported to the Unreal Engine game engine as an asset. Many kinds of different assets from different marketplaces can also be used in Unreal Engine. A realistic image has been created by applying appropriate material to these objects in the mesh state. An example image of a modeled violin is shown in Figure 1. The

same process was applied to the other accessories and the materials used in the design have been created.

B. *Virtual Reality Glasses*

Although most of the virtual reality applications consist of games, applications of education and different sectors are also frequently encountered [15]. Virtual reality has its own rules and it doesn't have to be the same as reality. Thanks to the virtual reality glasses, the user of the glasses immerses into virtual environment [16]. By means of the controllers used with the virtual reality glasses interaction can be added to the game or application. These controllers have the ability of operations such as holding, firing and pressing. Some of the virtual reality glasses used today can be listed as Oculus Quest 2, HTC Vive, HP Reverb G2 and Samsung SM-R323. In this study, Oculus Quest 2 virtual reality glasses have been used to see the modeled violin and accessories in a virtual reality environment. The virtual reality glasses used in the study can be seen in Figure 2.

Fig. 2.   Oculus Quest2 Virtual Reality Glasses

C. *Sensing The Movements*

Body and hand movements of the users should be detected and transferred to the virtual environment in order to add interaction to the virtual reality application or to make it more similar to the real environment. Therefore, carrying, holding, and triggering can be done with the controllers of the virtual reality glasses, while body movements such as hand and finger movements or bending and jumping of the human can be transferred to the virtual environment through wearable technologies. Moreover, the process of touching an object in the virtual reality environment can be felt by the human by means of wearable technology [17].

VR gloves can be assumed as an alternative for VR controllers. By means of the VR gloves, one can feel the immersion at a higher degree. Beside making the controller actions, haptic feedback gloves can also sense the feeling, adding even more immersion into the metaverse. Interaction with virtual objects is possible with hands instead of a controller by wearing VR gloves with haptic feedback technology. It is possible to feel the 3d objects by hands and fingers which is ideal for VR training and simulations, to create an immersive learning experience. When touching an object in 3d environment, haptic gloves provide feedback making vibrations on the fingertips and so it causes to feel the existence of an object [18].

As a sensing element, the built-in camera of the Oculus Quest 2 or the haptic VR gloves seen in Figure 3 are used to detect the user's finger pressing and bow pull and push in this application.

Fig. 3.   Haptic feedback gloves

D. *Game Engine*

The operation of the system is provided by the Unreal Engine 5 game engine. Game engines such as Unity and Unreal Engine are software used to make more beautiful and detailed games in a shorter time [19]. While Unity is programmed with C sharp language, Unreal Engine is programmed with both C++ and a visual programming technique called Blueprints [20]. The demand for the Unreal Engine game engine has been increasing recently, since it does not need a programming language. Therefore, the Unreal Engine game engine has been used in this study. A view from Unreal Engine 5 can be seen in Figure 4.
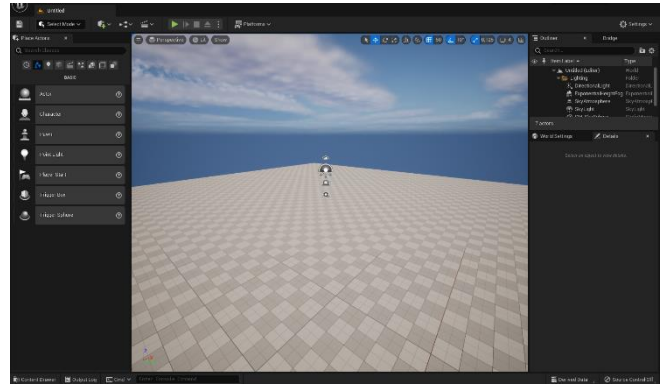

Fig. 4.   A view from Unreal Engine

E. *Gamification*

Gamification is the process of adding game features and visuality to an activity that is not actually a game. Gamification is an activity increasing motivation in education. Especially, pedagogically supported gamification contributes to the versatile development of students [21]. Gamification not only increases cognitive development, but also makes it easier to learn a foreign language [22].

Gamification makes learning more entertaining in order to achieve the desired result in learning. Rewarding in the game environment can provide an interactive environment for the

student. In order to ensure the digitalization of higher education in Turkey, the "YÖK (Council of Higher Education) Digitizing" project was implemented. The Ministry of National Education of the Republic of Türkiye is also switching from traditional systems to digital methods. Therefore, the usage area of gamification is expanding [23]. A view from gamification of the simulation made in the study can be seen in Figure 5.

Fig. 5.   A view from Gamification

F. *Location to Play*

In this study, some locations are modeled and the student can choose the location where to play the violin. This may be a seaside, concert hall or any other place. The student feels to exist in the place of the virtual environment. This may increase the motivation to learn or play the violin. A view from a seaside location can be seen in Figure 6.

Fig. 6.   Seaside location

G. *Metaverse*

The word "metaverse" was firstly used in the Novel Snow Crash written by Neal Stephenson in 1992 [24]–[29]. Even though there is no specific definition, there are recognized technologies and features that are being adopted, such as XR (Extended reality) and blockchain that facilitate the integration and interoperability of decentralized systems to create realistic, immersive virtual worlds and experiences that can be accessed by anyone and any number of concurrent users [30], [31].

Nowadays it is defined as an evolving state medium that can mimic the real world. It is mostly hard to distinguish the human based applications made in the real world and the virtually created world. It is shaped by the specific needs of the users (as engaging in life-like remote collaborations across geographies). It relies upon emerging technologies to support its various requirements (such as verifying a digital object created by a specific person or guaranteeing the success of a financial transaction between two entities) [26], [29]. According to another definition it is described as a medium created by users to be used for other users.

H. *NFT*

Non-fungible tokens (NFT) are used for recording, verifying and tracking the ownership of the unique assets either physical or digital. Moreover, NFTs can be utilized to represent artworks, futures contracts, music scores, books, and real estate, etc. – any type of item considered as unique or rare. NFTs can be minted, stored and transferred on a blockchain, and hence cannot be obtained by bad intentions [32].

NFTs also indicate the authenticity, transparency and stability of digital work. By means of NFTs having a high degree of confidentiality and transparency, the artworks and other products are not sold in the galleries. Instead, they are sold as NFT and delivered to the user very shortly [33].

Creators can generate both active and passive income by selling virtual assets to consumers who use them for various focuses (such as collaborations, entertainment, data interface, and education). It provides a symbiotic relationship between producer and consumer that fosters the adoption and lasting use of the "metaverse" where creators can earn a living and people can buy digital products, services and experiences. NFTs are a mechanism to facilitate this process via their unique digitalized smart contracts that enable secure transactions based on the blockchain protocol The NFT of the virtual asset is permanently linked to the creator. Additionally, it contains rules of sale to enable both active incomes (direct development of the asset for sale to a user) and passive income.

The main purpose of this study is to learn a musical instrument like the violin, which is difficult to play and learn, with a lower budget and having fun. For this reason, education is divided into levels by gamification. To advance to the next level, the previous level must be completed. When the student wears glasses, the exercise appears on the screen and the student can see the note and its duration also sees where to press on the violin. In addition, the student can customize the color or type of violin. Different colors of violins or accessories can also be bought as NFT (Non Fungible Token) over the Ethereum network.

III. PROBLEMS

The violin is a sensitive and difficult musical instrument to learn, because of its fretless and relatively small keyboard [34]. A beginner level violin is inexpensive, but since it is made up of low quality material, it has a short life and it may

have a disturbing sound. Therefore, even as a beginner, the student should buy a good violin, however this requires a relatively high cost. Another difficulty encountered while playing the violin is that the resin applied to the bow causes allergic effects in some people [35]. One of the biggest problems of the violin and all stringed musical instruments is the necessity of tuning. Tuning is the process of adjusting the strings to the required frequency and musical note [36]. The strings of the violin and the required musical note and frequencies are given in Table 1.

TABLE I.   NOTE S AND FREQUENCIES OF THE STRINGS OF VIOLIN

	1st String	2nd String	3rd String	4th String
Note name	Sol (G)	Re (D)	La (A)	Mi (E)
Frequency (Hz)	196,00	293,66	440,00	659,26

Since the tuning process requires experience, the student may not tune correctly at the beginning. Even if the tuning is done by the trainer, when the student goes home, then the violin will get out of tune again as a nature of the stringed instruments, and if the student cannot tune, this will cause the string to sound disharmoniously. A tuner is usually used for tuning. The strings are loosened or tightened by the pegs. The tuner indicates whether to loosen or tighten the strings and when the target frequency is achieved, it displays it on the screen. In Figure 7, the picture of a tuner is presented. If there is no good tuning, the musical instrument will not sound properly and the student cannot learn correctly or music cannot be made together with other musical instruments in harmony which may cause the student to give up the musical instrument and stop learning it. One of the real-life problems is that when a student goes home after the class, the student may be unsure of the accuracy of playing, during practicing or doing homework

Fig. 7.   A view from Gamification

Since there is no trainer at home, the student may not be sure about playing correctly. Another problem in real life is that people may not come together and therefore may not make music together in case of pandemics and epidemics.

This study was made to be a solution to the problems mentioned above.

IV. DISCUSSIONS

In this study, a virtual reality application is developed aiming to popularize and support violin education and to play it in a funny and more effective way under Unreal Engine 5 platform. The project can also be assumed as a simulator which is just for entertainment but will support real life

education. One of the advantages of the study is that there is no need to buy a musical instrument at high cost, since a real violin is not needed. Similarly, there is no need to apply real resin since real bow is not used. Therefore, thanks to this study, the allergic effect of the resin will also be prevented. Another contribution of the study is that it eliminates the tuning problem. Because the modelled violin does not have real strings, the sounds are at the exact frequency and there is no tuning problem.

Thanks to this study, education has been made fun by using the Unreal Engine 5 game engine and gamification. In order to popularize the education, a model called Play2Earn was applied. As the student progresses, they earn coins and can shop with them in the system. Accessories are sold as NFT. The student can buy violins or accessories in any color and feature. Blockchain and Ehereum infrastructure is used for shopping.

Another advantage of the study is that when putting on the virtual reality glasses, the location where should be pressed on the violin and where the next note corresponds on the violin can be visualized. Therefore, the student is sure about whether to sound correct pitch.

In addition, in this study, several people can make music together at the same time. It allows musicians who cannot come together due to the pandemic and epidemic disease or because they are far away, to make music together.

This study is not a replacement for real life violin education since no methods such as Suzuki method [37] or Ömer Can method [38] which are the most famous violin education methods in Turkey, are followed. In future work, the education can be made by following the methods and it may become an alternative education.

V. CONCLUSIONS

This study will contribute to the literature, especially in the field of virtual reality applications. Those who want to learn the violin will learn to play the violin lovingly and willingly in a more fun and gamified way. Thanks to this study, the high cost of the musical instrument can be saved, and the absence of a tuning problem is another advantage of this study. Coins earned as you level up encourage continuous leveling up. By means of gamification, student wants to learn and play more willingly. This study also integrates virtual reality and haptic feedback wearables. In addition, thanks to this study, distant friends can come together in a metaverse environment and make music together through the same system. The shortcoming of this study is the lack of fine details of playing techniques such as legato and staccato. As the next study, more efficient and entertaining educational material will be created by applying a similar system to other musical instruments. It is aimed to increase the quality of education with new glasses and wearable technologies.

Although there are many applications of virtual reality in education sector, due to the developing technology, more detailed applications with more feeling and immersion will be achieved. By means of gamification, a better education can be supplied together with haptic feedback virtual reality applications.

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