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Impact of Visual Realism in Virtual Reality Exergames

Master thesis in the course Master informatics

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1 Introduction

Virtual reality is becoming increasingly popular worldwide [1]. This rise in interest is due to its unmatched ability to provide immersive experiences that surpass conventional forms of digital entertainment. It has opened up new ways for social engagement and entertainment, redefining the way we perceive and interact with technology.

Virtual reality exercise games, often referred to as exergames, also play a major role in this. They combine the excitement of gameplay with the benefits of physical activities to make exercise more engaging and motivating. By integrating game mechanics and physical movement seamlessly, exergames offer a novel approach to fitness. In exergames, players often actively control their in-game avatars through a series of physical movements. These movements, which range from simple gestures to full-body exercises, are closely interwoven with the gameplay.

Multiple studies have shown that engaging in virtual reality environments enhances performance across various physical exercises [2, 4]. This heightened performance is due to the increase in sense of enjoyment and dissociation, which in turn leads to higher levels of effort [5]. Despite these findings, there is only limited research that examines how specific modifications to the virtual world influence physical performance and user experience.

One such change that needs to be explored is the level of realism in virtual environments. Virtual worlds can be categorized by their level of realism, which includes a variety of factors from the number of polygons to the resolution of textures and more. To optimize the design and effectiveness of exergames, it is important to understand how variations in realism affect both physical performance and user engagement.

2 State of the Art of Research

As mentioned in the previous section, research has demonstrated the impact of virtual reality environments on user performance and the potential of virtual reality to enhance various activities. Furthermore, it has also been investigated that distraction by virtual reality surpasses the impact of other entertainment sources like music or traditional 2D games [3]. These results highlight the unique ability of virtual reality to engage users and immerse them in alternative realities.

The research conducted in [6] and [7] examined the importance of realism in virtual reality and showed that higher levels of realism elicit more positive affective responses in users. In addition, increased realism was associated with an increased sense of serenity and a stronger sense of presence in virtual environments. These results suggest that the degree of realism plays a central role in shaping user experiences and emotional responses in these environments.

Despite progress in understanding the effects of virtual reality on user engagement and emotional responses, there remains a notable research gap that relates specifically to exergames. Currently, there is limited empirical evidence on how modifications to the virtual environment, including the level of realism, affect both physical performance and user experience in the context of exergames.

Given the growing popularity of exergames and their potential to promote physical activity in a fun way, it is valuable to conduct a comprehensive research on their effectiveness and user responses. By understanding the impact of realism on performance and user experience in exergames, researchers can support the design and development of more effective and engaging fitness applications in virtual reality. Thus, there is a need for further research that systematically investigates the relationship between virtual environments, physical activity and user engagement in the context of exergames.

3 Goals of Research

The aim of this study is to investigate the relationship between the degree of realism of virtual reality environments and their effects on physical performance and user experience, particularly in the context of exergames. By examining how variations in realism contribute to the effectiveness of virtual reality in enhancing physical performance and user engagement, this study seeks to answer the following research question:

> *To what extent does the degree of realism of virtual reality environments influence the physical performance and user experience of individuals engaged in VR exergames?*

This research question includes several specific objectives:

1. **Quantifying the impact of realism:** The research aims to systematically evaluate how different levels of realism within virtual reality environments affect physical performance metrics such as exercise intensity, duration and accuracy. By manipulating the visual realism, the study seeks to quantify the impact of these variations on users' ability to perform exercise tasks effectively.

2. **Evaluation of player experience:** In addition to measuring physical performance, the subjective experiences and perceptions of users during virtual reality exercises should also be evaluated. This includes assessing factors such as immersion, presence, enjoyment and perceived exertion, which are essential to understanding the user's overall experience. By collecting qualitative feedback, the study aims to gain insights into how realism influences users' responses and engagement.

3. **Creation of design guidelines and recommendations:** Finally, the research aims to derive practical insights and recommendations for the design and development of virtual reality exercise applications. By summarizing findings from empirical studies and user feedback, the study aims to provide evidence-based guidelines for optimizing the level of realism in virtual reality environments to improve both physical performance and user experience. These guidelines can help in the development of more effective and engaging virtual reality exergames.

With these research objectives, this study aims to further evaluate the effectiveness of virtual reality in promoting physical activity. By highlighting the impact of realism on physical performance and user experience in virtual reality exergames, the research seeks to improve our understanding of how technology can be used to increase fitness engagement and motivation in novel and immersive ways.

4 Methodology

To investigate the impact of realism on performance and user experience, a virtual reality exergame that challenges the user's physical abilities in different ways is to be created. Then, based on this game, three variants that have different degrees of realism are created. To enable an accurate comparative analysis, it is essential that all variants have similar environmental characteristics and create comparable ambient impressions.

One variant is going to be designed deliberately unrealistic, featuring simple, stylized graphics with low polygon counts and basic textures. The environment will be designed with minimal detail and only basic lighting effects are going be used.

Another variant, in contrast, is designed to be as realistic as possible. The textures will have high resolutions, the objects are going to have a large number of polygons and the shadows are going to be designed realistically. The environment will have a lot more detail than in the previous variant.

There is also going be an intermediary variant that is situated between the realism levels of the variants just mentioned, which allows a differentiated investigation of the effects of realism gradients.

Once these variants have been created, a user study is conducted where participants play with each variant while their performance is closely evaluated and recorded. Surveys are also conducted to more

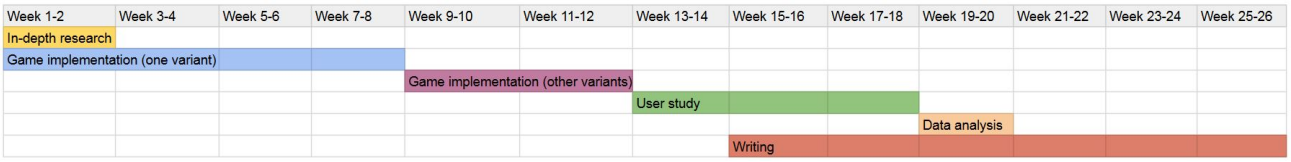

Figure 1: Time schedule of the planned thesis.

accurately capture the user experience. This user-centered approach will allow for a detailed assessment of how different levels of realism affect user performance and user experience during exergaming sessions.
The overarching hypothesis is that higher levels of realism have a positive impact on user performance, primarily due to the increased sense of immersion created by realistic environments. The aforementioned experiments aim to validate this hypothesis and analyze the impact of realism on user engagement and physical performance in the context of virtual reality exergaming.

5 Preliminary Structure

This section explains the preliminary structure of the master thesis itself.
The first section will serve as an introduction and explains my research work. It will give a broad overview of the research topic and is going to state the research question as well as the research objectives mentioned in section 3. This section will also show the significance of the study.
The second section is going to cover the background and related work. It will provide deeper insights on the underlying topics like virtual reality, exergaming, game design, and realism. This section aims to set the theoretical basis and also mentions related work.
The next section will cover the game architecture, including technical details, requirements, as well asdesign information of the virtual reality exergame implemented.

The fourth section will be the most comprehensive, explaining the conducted user study. It is going to include multiple subsections, the first one being about the taken measures and hypotheses. It will define the specific performance metrics and user surveys and hypotheses formulated to test the effects of realism on user experience and physical performance.
The second subsection will be about the materials utilized in the user study, especially the implemented virtual reality exergame with all its variants.
The last subsection is going to be about procedure, outlining how participants were recruited, instructed, and engaged with the exergame variants The fourth subsection will present demographic information about the participants involved in the study, including sample size, age range, gender distribution, and other relevant characteristics.
The following section is going to include the results of the user study, including quantitative data from user performance metrics and qualitative feedback from participants.
The sixth section will interpret the results, exploring the implications of the findings and addressing any limitations or unexpected results.
The next section is going to explain the limitations of the study, such as sample size constraints, methodological limitations and other potential boundaries. Suggestions for future research directions and opportunities for further exploration will also be discussed.
The final section will be the conclusion. It is going to summarize the key findings of the research and highlight the results of the three research objectives.

6 Time Schedule

See Figure 3.

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