Master Thesis

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Department of Computer Graphics and Interaction

SIMR

Simulating the phenomena of altered states of consciousness using virtual reality

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Diplomová práce

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SIMR

Simulace fenoménů pozměněných stavů vědomí pomocí virtuální reality

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Abstract

TODO

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1 | Introduction

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1.1   Problem Statement

This thesis is focused on the development of a virtual reality (VR) application that simulates select aspects of altered states of consciousness (ASCs; further defined in 2.1.1) typically induced by classical psychedelics such as LSD and psilocybin/psilocin. We focus primarily on the recreation of the ASCs' effects on sensory perception using an analytical approach.

1.2   Motivation

Due to their high degree of immersion, VR systems, with head–mounted displays (HMDs) in particular, offer a unique opportunity for recreating certain aspects of ASCs.

1.2.1   Art and Media

ASCs of various forms have had a significant influence on art for millenia. Earliest signs of inductions of ASCs via neurotropic substances have been found possibly as early as 60,000 BC (Guerra-Doce 2015). ASCs continue to be depicted in or influence contemporary popular media.

An analysis and a recreation of certain aspects of ASCs may serve as a reference point for recreating those aspects of ASCs in popular media.

1.2.2   Education

While experiencing a simulation of an ASC is unlikely to be fully representative of the ASC the simulation is modelled after, we propose that the simulation may be significantly less inducive of difficult experiences coloquially known as "bad trips".

This may be a viable alternative form of experiencing certain aspects of ASCs, while the possession or consumption of mind–altering substances is illegal in most countries. The resulting VR application may serve as an educational tool about ASCs which would not require as controlled of an environment as is required in psychedelic–assisted psychotherapy.

1.2.3   Research and Psychotherapy

Aday, Davoli, and Bloesch (2020) make an interesting observation, that psychedelics and VR are utilized in tandem to enhance the experience of recreational users. Moreover, the authors claim that VR could also be used to optimize and tailor the therapeutic setting during psychedelic sessions.

Most importantly, however, the authors state, that:

> [...] VR may be a useful tool for preparing hallucinogen-naïve participants in clinical trials for the sensory distortions experienced in psychedelic states.

Nonetheless, as mentioned previously, care should be taken to ensure that users experiencing the simulation are informed about the simulation not being fully representative of the ASC it is modelled after. While a VR simulation may be suitable for simulating sensory effects of ASCs, other effects, such as the effects on cognition, may be much more difficult, if not impossible, to directly replicate via VR technologies alone. If uninformed, users may gain a false impression about the ASC.

1.2.4   Understanding of the Human Mind

Finally, without any immediate application, the study of the effects of ASCs may help contribute to our understanding of the human mind. Particularly, for instance, analyzing the invariant effects of classical psychedelics on sensory perception may improve our understanding of the visual cortex and the way it functions. Further research involving perceptual phenomena and pharmacodynamics of psychedelics and their mechanisms of action may contribute to our understanding of the significance of certain receptors in processing visual or other sensory information.

1.3   Related Work

1.3.1   Recreations of Visual Phenomena

In this section, we explore the way ASCs have been depicted in contemporary art and media and recent attempts at recreating aspects of ASCs in the scientific domain.

1.3.1.1   Quake Delirium

In the original paper about Quake Delirium (Weinel 2011), the author divides video games portraying ASCs into two categories:

1. Games which feature literally portrayed dreams, intoxication or hallucinogenic experiences.

2. Games which feature graphical or thematic content which audiences may consider to reflect states of dream, intoxication or hallucination, but without any direct or literal reference to these states.

This categorization is not only useful for examining video games, but also the rest of art and media.

The first category describes media that attempts to recreate ASCs with an explicit reference to a specific induction method, cause or origin. For example, the games

in this category, such as Grand Theft Auto: Vice City[1] or Duke Nukem 3D[2], may temporarily portray a character under the influence of a psychoactive drug. However, psychoactive substances are not the only form of ASC induction portrayed in video games. One such exception is LSD: Dream Emulator[3], a game with narrative based on a dream diary and an overall dream-like surrealist aesthetic.

The second category contains media that does not communicate explicitly any ASC method of induction, cause or origin. Despite this, the media that falls into this category may be viewed equally as *psychedelic* or more than that of the first category. This could be considered to be the case of Yoshi's Island[4]. While the creators may not have intended the video game to reflect ASCs, because of it's brightly colored surrealistic visual themes, it may resemble ASCs of games from the first category.

The *Quake Delirium* project itself is a modification of the game *Quake* that makes use of an external digital signal processing (DSP) audio patch for modifying the resulting audiovisual output the game produces. The visual effects consist of changes in:

1. field of view (FOV);

2. camera swaying;

3. fog density and color;

4. game speed;

5. stereo vision (for 3D red cyan glasses);

6. gamma;

7. hue.

These visual effects are made available to the DSP patch, the control of which can be automated using multi-track audio sequencing software. This enables the effects to onset slowly and gradually become more severe over time.

The project demonstrates a method of combining multiple partial effects that results in a complex audio-visual effect that is more sophisticated than many of the existing games exhibiting phenomena of ASCs surveyed.

Interestingly, the authors went on to experiment with a dynamic way of controlling the intensity and parameters of the simulated effects in a follow-up study (Weinel et al. 2015). Rather than controlling the parameters using a *pre-determined automation path* via multi-track audio sequencing software, this modification introduced biosensor as a way of influencing the simulation parameters – specifically, they used the commercial *NeuroSky MindWave* electroencephalograph (EEG) device. The study ultimately concludes, that "while the use of EEG to control

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[1]Grand Theft Auto: Vice City, Rockstar Games, 2003. PC (Windows) CD-ROM.
[2]Duke Nukem 3D, 3D Realms, 1996. PC (Windows) CD-ROM.
[3]LSD: Dream Emulator, Asmik Ace Entertainment, 1998. Playstation.
[4]Super Mario World 2: Yoshi's Island, Nintendo, 1995. Super NES.

psychedelic visual effects is conceptually appealing, the current system would also need to be improved to provide a more tangible connection between the headset and the ASC effects in the game."

There is no straightforward way to map EEG signals onto visual effects. The EEG signals need to be interpreted, so that relevant information is extracted. Mapping the extracted information onto specific simulation parameters is then at the artist's discretion. A more sophisticated approach might examine correlations between observed ASC phenomena and EEG signals, then use those correlations to model the mapping from EEG signals onto the visual effects.

1.3.1.2 Crystal Vibes feat. Ott.

Outram et al. (2017) describe *Crystal Vibes feat. Ott.* as a project originally developed to demonstrate the full-body vibrotactile *Synesthesia Suit*, further discussed in 1.3.2.1. The experience places the user into an abstract geometric environment procedurally generated from a soundtrack:

> Crystal Vibes does not use any 3D modelling, 2D design, or hand animation. Instead, the environment is generated using sine and Bézier functions, Bravais lattice structures and Fourier transforms of the audio. Crystal Vibes exploits the innate beauty of 3-dimensional crystal structures, and leverages the artistry of rhythm and form in the music for visual beauty.

The article describes in detail the methods employed to simulate audiovisual synesthesia using sound visualization, with an attempt to be "as physically and biologically defensible as possible". The methods include compensation for the non-linear perception of both auditory and visual information:

> This includes the fact that humans perceive equal pitch differences corresponding roughly to equal differences in the log of audible frequency, that our perception of volume varies over the audible range, and how humans interpret colour from a visible spectrum.

Another technique used to aid in distinguishing different voices of the soundtrack, such as drums and synths, is spatial separation. Each voice would impact a separate region of the visualization. This way, the user can form an association between spatial regions and their corresponding voices.

Finally, the last employed technique of improving the perception of sound via sight is to provide temporal information; instead of only visualizing the current instant of the soundtrack, a roughly 1 second long moving slice of the soundtrack is visualised.

The authors report that users found the visualization compelling, even those who experience synesthesia in their daily lives. Synesthesia is of our interest because it is a prominent phenomenon of some ASCs.

1.3.1.3 Isness

(Glowacki et al. 2020)

1.3.1.4 Hallucination Machine

(Suzuki et al. 2018)

1.3.2 Tactile Stimulation Interfaces

1.3.2.1 Synesthesia suit for Rez Infinite

(Konishi, Hanamitsu, Outram, Minamizawa, et al. (2016), Konishi, Hanamitsu, Outram, Kamiyama, et al. (2016) and Synesthesia Lab (2016)) further improved by (Furukawa et al. 2019) Outram et al. (2017)

1.3.2.2 Synesthesia X1 - 2.44

(Synesthesia Lab 2021)

1.3.2.3 Subpac

(SUBPAC (2013), Drempetic and Potter (2017)) used in (Zimmermann, Helzle, and Arellano 2016) and studied on deaf people (Schmitz, Holloway, and Cho 2020)

1.4 Contributions

We develop a VR application for HMDs that simulates select aspects of ASCs. We perform a study in which we measure the influence of the created VR application on the human mind. This measurement is done via the 11-factor altered states of consciousness questionnaire (11-ASC; Studerus, Gamma, and Vollenweider (2010)), that is used in clinical studies of psychedelic drugs.

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List of Acronyms

11-ASC 11-factor altered states of consciousness questionnaire

ASC altered state of consciousness

DSP digital signal processing

EEG electroencephalograph

FOV field of view

HMD head–mounted display

VR virtual reality

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