neomento - Towards Building a Universal Solution for Virtual Reality Exposure Psychotherapy

Adam Streck
Aging & Congition
DZNE
Berlin, Germany
adam.streck@dzne.de

Philipp Stepnicka
Aging & Congition
DZNE
Berlin, Germany
philipp.stepnicka@dzne.de

Jens Klaubert
Aging & Congition
DZNE
Berlin, Germany
jens.klaubert@dzne.de

Thomas Wolbers
Aging & Congition
DZNE
Magdeburg, Germany
thomas.wolbers@dzne.de

***Abstract*—We present the neomento project, a solution for virtual reality (VR) exposure therapy (VRET). In our work we have created specific rendering methods and virtual environments (VEs), designed and published a novel form of behavioural control for virtual agents (VA), included biophysiological measurements directly into the experience, and created an asymmetric gameplay system to assure the correct progress of a therapy session. The combination of above allows us to overcome multiple of the limitations that were hindering the previously published VRET solutions.**

***Index Terms*—virtual reality, virtual agents, exposure therapy, cybersickness, biophysiological measurements**

I. Introduction

Mental disorders, like anxieties and addictions, are a massive, world-wide problem and constitute an enormous challenge for the healthcare systems everywhere. The patients are currently facing long waiting periods before being admitted to treatment, which leads to prolonged suffering, as well as a high number of untreated cases [1]. Traditional confrontation therapy—in which the patients are repeatedly exposed to the stimuli causing the stress, fear, or craving—is an effective method, however it is often prohibitively expensive and laborious. Additionally, the quality of the therapy can also be significantly increased if the biophysiological parameters of the patient (e.g. heart-rate, eye focus) can be taken into account during the progress of the therapy in order to control the degree of exposure, which is not always possible to measure during the exposure in the real world.

The neomento project aims to address this issues by employing a VR based software solution for the therapy of anxiety and addictive disorders. To this end we create virtual representation of realistic situations which are then presented to the patient in the form of a VR experience, while being controlled by the therapist. This approach considerably decreases the financial and time expense to the therapist, while offering the ability to measure and display the physiological state of the patient and immediately react to it.

While this approach has been already developed and successfully demonstrated in the past [2], a mass adoption has so far not occurred. This is arguably due to two factors: until recently the cost of VR devices has been disproportionately high and the quality and functionality of the simulations has not been sufficient to persuade either the therapist or the patients. While the first problem has been alleviated by the massive drop in the cost of VR devices in recent years, the second problem remains, in our opinion, to be addressed. The aim of the neomento project is to combine multiple areas of human-computer interaction research in order to maximize the persuasiveness of the method, thus allowing for practical use.

978-1-7281-1884-0/19/$31.00 ©2019 IEEE

II. Virtual Environment

The life-likeness of the VE is paramount to the immersion, which in turns directly affects the quality of the therapy. To this end we are creating representations of seven real-world environments like classroom, library, bar, etc. These had to be hand-crafted to satisfy two requirements:

- lack of visual disruptions: the effect of the therapy could be diminished if the patient registers objects that are too out of place or too peculiar and they can consequently focus on their quaintness rather than on the stimulus.
- relatability: to elicit the anxiety related to a specific location (e.g. classroom), the virtual representation of this space needs to match the expectation of the patient about the space [3]. We have therefore focused on developing in the style of modern European architecture, while equipping the environments with contemporary objects.

Even more important than the environment are however the VAs, which also are the primary source of stress for example in the case of social anxiety. To maximize the visual quality we have built our custom shader solutions for rendering of the skin and hair. However, even a high degree of visual realism is not sufficient condition for overcoming the uncanny valley (UV) problem, which is detrimental to presence. To minimize UV we have employed randomized blinking and eye-movement which have been shown to have significant effect [4] as well as lip synchronization and upper-face emotional expression. To avoid the issues of feeling of stiffness in the motion of virtual characters we are making use of a motion capture suit which on top of the desired animation also provides realistic noise to the human motion. Lastly we have observed that traditional game AI approaches are not fitting for environments of mostly idle characters and developed a probabilistic state control machine, published in [5].

III. Patient-Therapist Interaction

Our approach is, in its core, an asymmetric two-player game, where the patient is placed in the VE, while the therapist is granted control of the running simulation and can trigger challenges (e.g. trigger a cell phone) and assume control of the VAs (see Fig. 1). This approach solves two problems:

- by giving the control of the environment to the therapist, they can assure that the amount of induced stress follows the pattern necessary for successful habilitation of the patient [6]. This is manifested for example by the amount of attention the VAs pay to the user.
- since a natural conversation is difficult even for the most complex chatbots, we avoid risk of an immersion-breaking dialogue between the patient and an agent by granting the ability to control the conversation to the therapist, who then selects appropriate reactions of the VA, while it is interacting with the patient.

Apart from the interactions enabled by the therapist, there are multiple methods available to the patient. In particular, it is necessary that the patient can navigate through the VE. For example in case of an anxiety inducing stimulus, it is necessary for the patient to gradually approach the situation [6] on their own accord. For this we have developed an on-the-rail motion method, continuously triggered by the patient. Unfortunately it is well known that all forms of motion in VR that are not matched by appropriate physical motion are potentially inducing cybersickness. To minimize the effect of this we are currently conducting a user study (n=40) with variable motion parameters to find the least disruptive and sickening method of motion.

In addition to the above, our approach depends on collection of biophysiological data, in particular the heart-rate (HR), HR variability (HRV), electrodermal activity (EDA), and eye movement. These are displayed to the therapist in real-time, allowing them to observe short-term physiological reaction to the stimuli. In particular both HR and EDA are strongly correlated with the stress response [7]. Unfortunately these metrics are also correlated with cybersickness and we aim to use the data from the aforementioned study to be better able to distinguish between the two. In addition to the display of stress level to the therapist, we use HRV and EDA to provide a so-called competence score—a metric evaluating the skill of the patient during the therapy, in order to demonstrate a between session progress and increase the adherence. Lastly, we are currently in a process of developing a bio-feedback therapy solution, i.e. creating VEs that are affected directly by the HR and EDA values, where the goal of the patient is to reach a certain positive goal by lowering their HR and EDA below a pre-defined limit. Lastly, the eye-tracking information is used to directly show to the therapist what is the point of focus of the patient, as one of the typical reactions to stressful stimuli is avoidance, which has to be overcome by the patient, and thus allows the therapist to directly request the patient to focus on particular objects—something that is not possible in the *in vivo* therapy.

Fig. 1. The classroom: an example scene for social anxiety scenario with control panel for the environment (left), biophysiological measurements (right), and control of the session (bottom).

IV. Conclusion and Further Work

We believe that due to recent developments in the VR technology and real-time rendering, it is now possible to overcome the shortcomings of the previous generation of VRET solutions.

In our work we have developed a prototype solution for the treatment of social anxiety disorders, which has been successfully piloted with patients and demonstrated high potential. We are currently in the process of extending the solution and conducting clinical testing to certify as a medical device.

As we believe our technology is universally applicable to the different areas of exposure therapy, we are starting to develop solutions related to other disorders, in particular addiction and agoraphobia, with the hope of our method of VRET becoming a standard solution for use in practical treatment.

Acknowledgements

This project has been funded by the European Research Council project 780453, and the German Federal Ministry for Economic Affairs and Energy project 03EFMST031.

The project has been created using the Unity game engine, an HTC Vive headset, and a Shimmer GSR+ device.

References

[1] A. Hhnel, B. Weigel, J. Hoyer, S. Helbig, "Wartezeit fr Psychotherapiepatienten und wie sie zu nutzen ist." Verhaltenstherapie 14, pp.294-302, 2004.

[2] K. Merel, et al. "Virtual reality exposure therapy of anxiety disorders: A review." Clinical psychology review 24.3, pp.259–281, 2004.

[3] A. Vipin, and D. Khazanchi. "Sense of place in virtual world learning environments: A conceptual exploration.", Information Systems and Quantitative Analysis Faculty Proceedings & Presentations 8, 2010.

[4] K. Miriam, et al. "Overcoming the uncanny valley: Displays of emotions reduce the uncanniness of humanlike robots." The Eleventh ACM/IEEE International Conference on Human Robot Interaction. IEEE Press, 2016.

[5] A. Streck and T. Wolbers. "Using Discrete Time Markov Chains for Control of Idle Character Animation." 2018 IEEE Conference on Computational Intelligence and Games (CIG), IEEE, 2018.

[6] J. S. Abramowitz, B. J. Deacon, and S. P. H. Whiteside. Exposure therapy for anxiety: Principles and practice. Guilford Press, 2019.

[7] J. Taelman, et al. "Influence of mental stress on heart rate and heart rate variability." 4th European conference of the international federation for medical and biological engineering. Springer, Berlin, Heidelberg, 2009.