ENSURING SELF-HAPTIC CONSISTENCY FOR IMMERSIVE AMPLIFIED EMBODIMENT

Sidney Bovet and Ronan Boulic
EPFL, Lausanne
Contact: ronan.boulic@epfl.ch

CONTEXT

With the rise of consumer-grade Virtual Reality (VR) technologies, high quality VR equipment now becomes widely available. This opens up a lot of possibilities, one of which appears to be in health-related applications and in particular for rehabilitation. The latter is of interest to us, especially the motor recovery process. It is a long, tedious and often demotivating process, currently treated through exercises and movements of an affected limb. This unrewarding process often leads the patients to live with their handicap rather than treating it. Understandably, as argued by Flores et al. [1], the more a patient participates to a rehabilitation task the greater the motor recovery will be. Keeping participants motivated during such tasks is thus essential.

Serious games can definitely help in this regard by making the recovery process more rewarding and involving. A notable example is the solution developed by Lambda Health System involving a pair of robotic arms used for lower limb rehabilitation. It can be included in a Serious Game in VR, as proposed by Gobron et al. [2]. We explore two tracks as to how we can involve users even more, and have them keep using their paretic limb: a VR game that not only transposes but also amplifies their movements in a virtual environment where they are required to reach for targets at various locations on both their body and in the air. We assume that patients using such an application will stay motivated by seeing that they can achieve more.

SELF-HAPTIC CONTACTS

In many VR applications, the provided sense of Presence can be improved by introducing accurate contact reproduction - that is, producing convincing haptic feedback. Improving the sense of Presence is key because it makes users more involved in the game or task, which aligns with our motivation goal. It is quite hard to implement proper general haptic feedback: reproducing the tactile feeling of any object requires a complex motorised exoskeleton. On the other hand, assuming that the user’s body is partially or fully tracked, it is easy to know where various body parts are. This piece of information can therefore be used to ensure that at least these physical objects are well represented in space and induce proper haptic feedback.

Our work focuses on such an improvement to VR applications. Its implementation is eased by a new formalism proposed by Molla et al. [3], which defines positions not in world coordinates, but rather with respect to nearby body surfaces. A hand held in front of the face is hence expressed in terms of a relative displacement vector from said head portion, instead of using absolute coordinates. A self-contact thus translates into a zero vector and can be accurately represented.

We are currently running an experiment to understand how well the brain accepts when such self-contact are altered with an offset: when the user touches their thigh, a given offset is added between the avatar’s thigh and hand. The goal of this experiment is twofold: issuing guidelines about the importance of self-haptic consistency and acquiring a better understanding of what our tolerance is regarding such self-contacts.

MOVEMENT DISTORTION

Additionally, we focus on the elaboration of a movement distortion algorithm aimed at amplifying a user's movement. We propose a modification of the coordinate system proposed by Molla et al. [3] to apply a distortion to the movements of a tracked performer, while preserving self-haptic consistency. In other words, we introduce a way to create an application in which, when patients touch their skin the virtual avatar does so as well, but when they lift their hand away from the surface of the skin, the avatar may show an amplified gap between hand and skin if a positive distortion is applied.

We include in the aforementioned experiment a condition in which we assess acceptance to movement distortion. It is key here because we do not want patients to detect the distortion, or at least not too heavily. Indeed, if their eyes constantly remind them that what they see is not what they achieve, we might lose the motivating effect we are looking for.

CONCLUSION

This work explores amplified embodied interactions and aims to issue guidelines as to how developers can produce efficient embodiment through self-haptic consistency for all sorts of VR applications. We intend to pursue more research in this area to improve treatment efficiency and life quality for rehabilitation patients, as well as for VR experiences in general.

REFERENCES

[1] E. Flores, G. Tobon, E. Cavallaro, F. I. Cavallaro, J. C. Perry, and T. Keller, "Improving patient motivation in game development for motor deficit rehabilitation", Proc. of the 2008 Int. Conference on Advances in Computer Entertainment Technology, ACM, 2008, pp. 381–384.

[2] S. C. Gobron, N. Zannini, N. Wenk, C. Schmitt, Y. Charrotton, A. Fauquex, M. Lauria, F. Degache, and R. Frischknecht, "Serious games for rehabilitation using head-mounted display and haptic devices", Int. Conference on Augmented and Virtual Reality, Springer, 2015, pp. 199–219.

[3] E. Molla, H. Galvan Debarba, and R. Boulic, "Egocentric mapping of body surface constraints", to appear in IEEE Trans. Viz. Comput. Graphics, 2017.