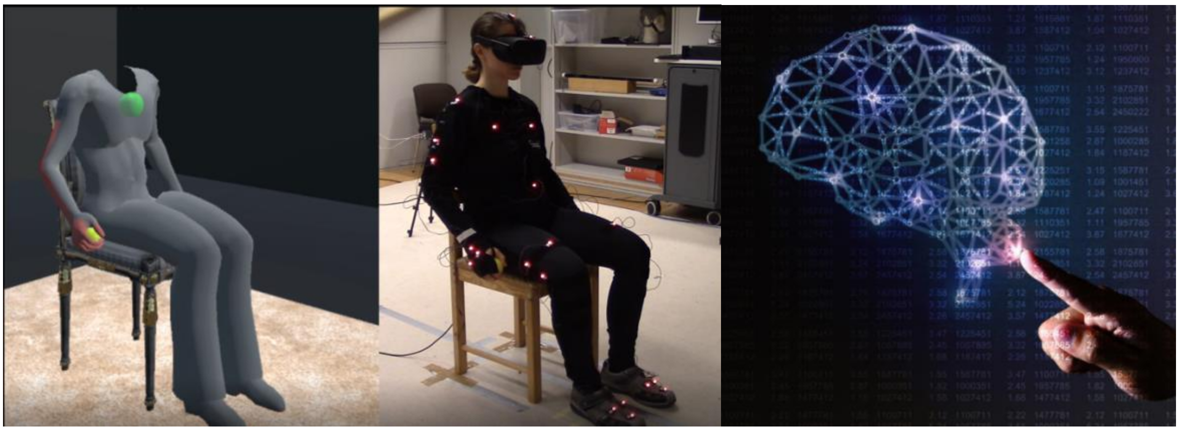
Semester project: Improving Embodiment with Reinforcement Learning in Virtual Reality.



Main Objective:

Implement a virtual world in Virtual Reality that can be adapted according to the user feedback. Indeed, we have developed a model to distort the user movement in real-time and we want to adapt the parameters of this model according to the user feedback.

Background:

Despite the great potential of recent VR devices, the current state of immersive full-body interaction is still far from a plug-and-play approach allowing to perform motor tasks in virtual environments with the same ease as in the real world. Within that frame of mind our specific aim is to demonstrate that the avatar can even be programmed to be better at executing a given task or to perform a movement that is normally difficult or impossible to execute precisely by the user. The challenge here is to introduce a subtle distortion between the position of the real hand and the position of the virtual hand, so that the virtual hand succeeds in performing the task while still letting subjects believe they are fully in control.

Project Idea:

Our implementation of a distortion function successfully led participants to report being in control of the movement (agency) and being embodied in the avatar (body ownership) even when the distortion was above a threshold that they can detect. However, in order to achieve this result, we needed to identify the participants' tolerance to such action deformations for each user individually **offline**.

We want to achieve the same result **online**. We want that our model to learn from the user in order to achieve the best result possible. We will achieve this by first gathering explicit user feedback through a set of simple experiments illustrating movement deformations resulting in various types of discrepancies: visuo-motor, visuo-tactile or visuo-proprioceptive. Reinforcement learning will be used to find the ideal parameters for the distortion model from these explicit feedbacks.

Finally, this would enable a subject-specific characterization that we intend to exploit in real-time in order to ease the interactions and improve the user experience.

Master final project:
Eventually, this should allow us to propose a neurofeedback loop for the automatic adjustment of the user-avatar mapping of movement.

Goal:

- Implement and choose the right reinforcement leaning policy to find the parameters
- Design a protocol to train the distortion model.
- Implement the protocol in Unity with the major VR headset and motion capture suit.

Master final project:

- Implement the loop to adjust the distortion model in real-time thanks to EEG.

Requirements:

- Unity (scripting in C#/DLL in C++)
- Reinforcement Learning (Keras, TensorFlow with Python)
- 3D geometry and quaternions (Vectors, cross products, rotations)
- Matlab/R/Python (statistical tool).

Information, materials and resource:

Unity3D game engine: http://unity3d.com/learn
Final IK: http://root-motion.com/
The Unity project with the distortion system, the full body tracking (Inverse Kinematic, Calibration) and the VR headset will be given.

References:

Iturrate, I., Montesano, L., & Minguez, J. (2010). Robot reinforcement learning using EEG-based reward signals. In 2010 IEEE International Conference on Robotics and Automation (pp. 4822–4829). IEEE. https://doi.org/10.1109/ROBOT.2010.5509734

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