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Combining Microsoft Kinect and Hololens for a Novel Type of Augmented Reality Rehabilitation

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Abstract

A growing number of technological devices and systems have been recently used to increase the interest and engagement in performing rehabilitation activities, with the goal of achieving greater effectiveness in treatment. Two of the most used solutions, based on **Microsoft Kinect** or **Magic Leap Controller** on the one side, and **Virtual Reality** (VR) **Head Mounted Display** (HMD), either present valuable features and limitations. In this work, the authors would like to present a possible way to combine the best features of the two technologies, by integrating a recent Augmented Reality (AR) device (**Microsoft Hololens 2**), and **Microsoft Azure Kinect**. The result has been developed during the MIT Reality Hackathon, held at the beginning of this year at MIT Media Lab in Boston, and it is here presented as the first attempt to combine the two devices for what can be defined **Augmented Reality Rehabilitation**.

Activity Description / Materials and Method (with charts, photo, etc)

In January 2020, during the MIT Reality Hack (https://www.mitrealityhack.com/), we tried to integrate Kinect and Hololens 2, to combine the best features of both technologies. The aim was to develop a proof of concept (PoC) solution, tracking all the body segments, while providing the patient an immersive and engaging experience though Hololens 2, without losing contact with reality.

The integration of the two devices can be described looking at Fig. 1. Hololens may only track the position of the hands (whenever they are in the line of sight of the sensor). On the other hand, Kinect may provide continuous tracking of the whole body segments. The information about the body joints' positions, derived on the processing computer connected to the Kinect, is then transformed in real-time on the same device by a custom developed software that translates the Kinect coordinates (coordinate reference in green) into Hololens coordinates (coordinate reference in red). This can be done because the Hololens, once started and having localized within the room, automatically define an absolute coordinate reference system that will be used for the spatial computing processing. The parameters of the transformation previously described are calculated through an initial process of calibration. Such an integration has a particularly important meaning, since it may offer, in an egocentric view, motor/cognitive rehab activities that are usually performed in an allocentric (i.e. third person) perspective.

As for the activities, two simple exercises were developed: one regarding the upper limbs, and one involving the whole body. All these activities are presented to the subject through a funny videogame approach.
Unfortunately, in the two and half days of the hackathon we achieved only a partial result, because the integration of the Hololens 2 and Azure Kinect was primitive and not in a completely usable form. However, we successfully realized a demo to show a couple of possible rehabilitation activities. Moreover, a general scenario for the exercises and a story were invented, thinking about a possible alien invasion, and a virtual environment was developed for the two simple exercises.
The first one (fig. 3), specifically meant for the upper limbs, consisted in hitting with the hands a certain number of virtual flying saucer that were moving around the subject.

The second exercise (fig. 4), was designed to exploit the integrated capabilities of the two devices, hence consisting in moving around a small virtual town, projected onto the real world rooms, and finding little green aliens that were standing (usually on the top of the buildings). Once an alien was found, the subject had to pick it up using one hand, and throw it away to eliminate it.

The resulting experience was reported as funny and engaging by all the participants in the hackathon who tested the developed solution.

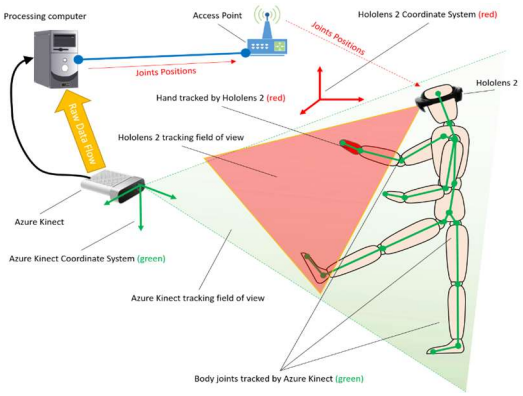

Fig. 1. Schematic representation of the setup proposed, combining Azure Kinect and Hololens 2.

Fig. 2. Azure Kinect (left) and Microsoft Hololens 2 (Center). On the right, some examples of the mixed reality experience provided by the Microsoft Hololens.

Findings / Impact

AR is a really interesting and promising technology that will be increasingly used in rehabilitation. It allows novel ecological treatments, where patients remain in their reality, while overlapping virtual elements which could be used to improve their motor and/or cognitive capabilities. However, exercises based only on the HMD present some major limitations, for they can only exploit hands/upper limbs positions.

Instead, a real Augmented Rehabilitation would probably require the use of external devices, which could be wearable, or based on fixed devices, like Azure Kinect, as the pilot project presented in this work.

Despite all the limitations, the solution presented here has a lot of potential and deserve to be adequately fostered. In particular, the unique capabilities of the Hololens 2 related to the AR potential above described and other features (i.e. front camera, eye-tracking and spatialized sound) makes this system very promising for a near future adoption.
Moreover, the relevance of these solutions increases in the light of the current pandemic, which is forcing to stay at home many people who are in the need to undergo some kind of rehabilitation. We hope to contribute in the near future to further applied research and studied in the field.

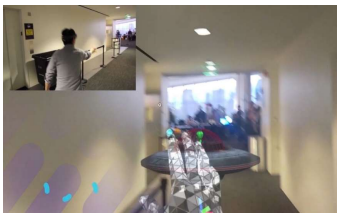

Fig. 3. A picture representing the first exercise, aimed at hitting virtual flying saucer with the hands. In the upper left corner an actual view of the scene, captured by an external camera, while in the rest of the picture there is the scene as perceived by the subject through the Hololens 2. In particular, it is visible the real MIT corridor (where the scene has taken place), the flying saucer and the hand tracked by the Hololens.

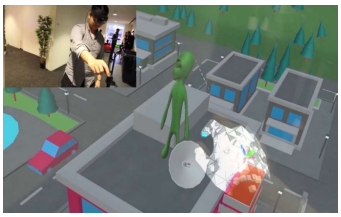

Fig. 4. A picture describing the second exercise, in which the subject has to walk within a virtual city, look for some green aliens that have invaded the Earth, pick them up with the hand and literally throw them away. In the upper left corner, the actual view from an external camera.