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Technical Brief

Gesture Recognition - VR use by LEAs

DISSEMINATION LEVEL PUBLIC

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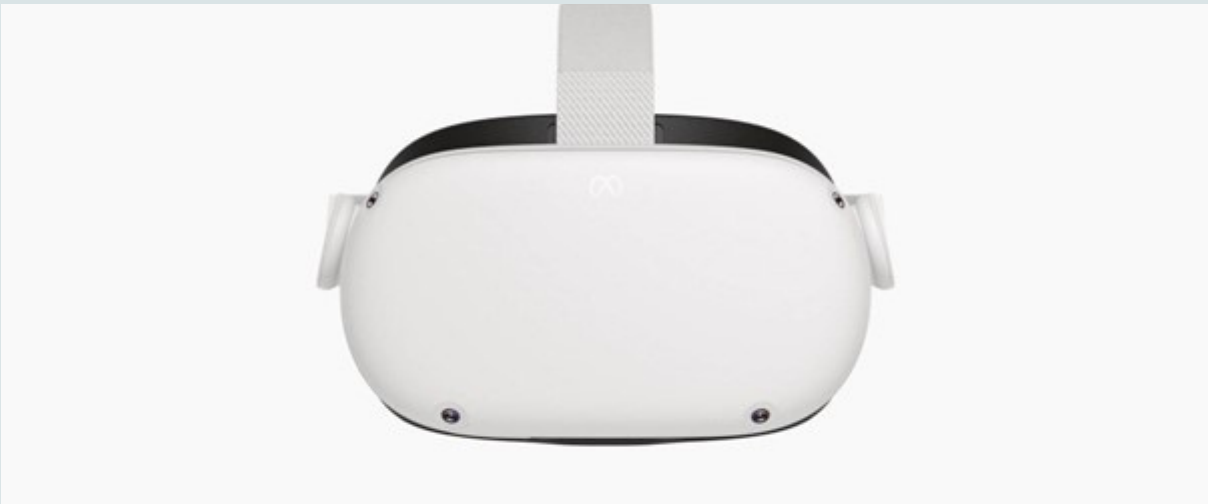

Figure 1: Meta Quest 2 VR headset

1. Introduction[1]

Gesture Recognition is a hot research field that is drawing more attention over the years. From science fiction to reality, gestures were always considered a futuristic feature and a rather impressive one. Where gestures really shine is to replicate a sequence of actions and by just a simple movement of the hand or the VR controller to have the same result. In general gesture recognition is a timesaver that could replace the "Point & Click" methods and in the next chapters gesture recognition will be linked with the INFINITY project and how gestures may result in better experience, easier navigation inside the Virtual environments and faster communication between the users.

2. Background

Meta Quest 2 (previously named Oculus Quest 2) is a Virtual Reality (VR) headset developed by Meta.[2] Meta Quest 2 is a standalone device, meaning that it can be used without connecting directly to a computer or depending on another device to function properly. With that being said, Meta Quest 2 requires no cables to navigate into the VR environment, which could assist the INFINITY project and the end users to feel more immersive in the environment and focus on the investigation without being distracted or frustrated by other factors. What Meta Quest 2 really brings to the table is a dramatic improvement in hand tracking, as the user can navigate by using either his hands or the VR controllers. We created 2 gesture recognizers one for controllers and one for hands, that the end users may use to perform gestures and navigate inside the INFINITY environment.

Meta unveiled the Meta Quest 2 in September 2020 and released it about a month later, making it accessible to most countries around the world. Since then, we suggested being the main VR headset of the INFINITY project, given all the improvements and novelties it brings to the table and could be beneficial for INFINITY, such as better resolution and frame ratio, which are very important once connected to the Virtual environment to avoid undesired effects, attached audio and sound for the end users to communicate without any extra equipment, and also the opportunity to work with or without cables.

Communication within VR was never easier, given that the Head Mounted Display (HMD) itself provides both audio and visual input to the user, who is able to communicate with others by using Avatars to get optical feedback and have a live chat, quite similar to any real-life conversation with people all around the world by just wearing an HMD.

Another futuristic feature, provided by the complete absence of cables, lies in the play area of the user. Older generation headsets present several limitations, due to their cable-dependent functions, meaning that you must stay all the time really close to your personal computer, which provides power to the HMD. Users could go as far as the cable's length allowed. However, connecting the VR with a cable could be also desirable and that comes from the fact that while connected with a cable the battery is also charging allowing the investigator to spend more time inside the environment, although it is not suggested as they may get cybersickness.[3] Cables may also be useful in case of a low battery where the end-user has no spare time to charge the device and should connect immediately. For the INFINITY project, the end users to connect without cables in the VR environment, they need a powerful personal computer and a 5GHz Internet connection. In the final version of INFINITY, as is designed to be used by LEAs, each user will be in their base with their own personal computers which are by default way more powerful and more stable than a laptop with the same components and more stable than a laptop with the same components.

3. Hand Gesture Recognition

Hand Gestures Recognition (HGR) has been an active research field for a long time, which draws the attention of more scientists worldwide. Combining Hand Gesture Recognition[4] with Artificial Intelligence (AI) leads to some breakthrough discoveries and can be used to improve the user's experience inside VR in many ways.

The rapid developments in the field of deep learning open new ways to take advantage and develop some features that, not so long ago, seemed like a distant dream. In recent years there were two different approaches to tracking hand movements, one is vision-based analysis and the other is glove-based analysis. The former includes the use of a device placed somewhere around the user (not a headset) or by using a camera or sensors, it could create a Human-Computer Interaction that could provide input to the computer. The pipeline was rather common, firstly as Image capturing and processing, then extracting features and translating them as feature vectors and finally classifying these vectors to recognize some predefined gestures. The latter approach involved the use of a wearable globe, that tracked specific parts of the hand and could extract information about the movements and then the computer could process this information and recognize some gestures. Meta Quest 2 provides a revolutionary way to record gestures, which is rather easier but also faster than older methods. The sensors attached to the headset track both hands at all times and can compute any hand movement or rotation the user performs with either hand.

Gesture Recognition works really well in the immersive environment of Virtual Reality. Gestures may function like shortcuts and enhance the experience of the user while wearing an HMD (Fig 2). While the scope of introducing gestures in VR apps is yet to be determined, the functionality and usability of them are undeniable. Static to dynamic gesture recognition and also motion-based gestures are a blazing hot research topic and many improvements are expected in the upcoming years. Another topic that is also trending lately is creating new gestures, from the user himself/herself, while wearing the HMD. The Artificial Neural Networks[5] that are used inside the applications are being trained before the application is launched publicly and this training is time-consuming, meaning that it possibly requires days to be trained to recognize specific gestures let alone identify new ones created at playtime.[6]

The first application records hand gestures and the second application utilize hand gestures to perform actions inside an office-based environment as seen in figure 2 below.

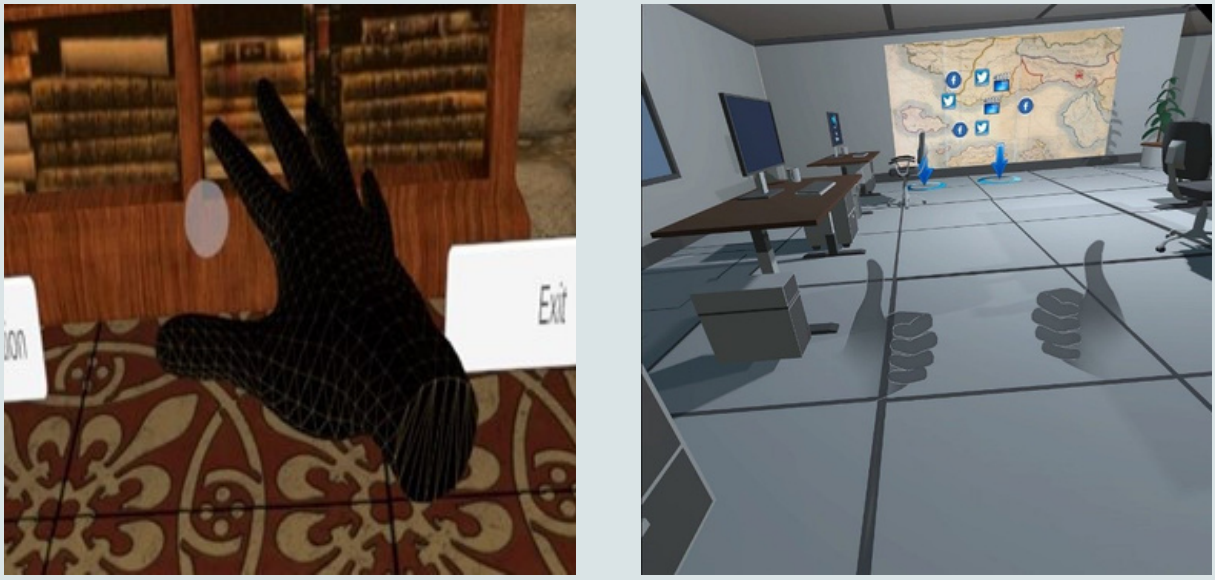

Figure 2: Hand Gesture Recognition applications developed by CERTH for INFINITY.

4. Controller Gesture Recognition

Controller gesture recognition has not been an active research field, as limited bibliography can be found in this area. There are not many papers related to controller gesture recognition nor many available datasets. This is due to the fact the controllers have been wireless so far resulting in limitations regarding movement and orientation. Meta Quest 2 is launched with wired controllers and also wireless HMD. These open up new ways to explore and exploit actions with controllers.

According to surveys[7] related to whether hands are preferred by users over controllers, the results present a higher preference for controllers over hands. This was explained since many of the participants have never used bare hands to perform actions before, while controllers have been around for a long time. With that being said, controller gestures are easier to train and perform than hand gestures and that is related to the fact that controllers consist of just one solid object, while the hands are separated into more parts, namely fingers, palm, and wrist which must be tracked on moving and rotating. As said before, limited research is available online, yet there are suggestions that controller gestures are more valuable than hand gestures and could be used in more situations.

A huge benefit of controller gestures is that both the user and the recognizer should not be worried over random activation or how long the gesture lasts (Fig 4). All the user has to do is press a predefined controller button and hold it down until the gesture is done (Fig 3.). This is not applicable for hand gestures as there is no trigger button and other more complicated methods must be used to identify whether a user is performing a gesture or simply moving his hand. What controller gestures bring to the table is actually a rapid implementation and completion of tasks without using extra panels, which creates a positive feeling to the user and a sense of better understanding of the application.

Further research[8] on user emotions suggests that performing gestures successfully increases the user's self-confidence and self-assurance, making him/her more comfortable inside the environment and tempting him/her to try again and perform more gestures to check the outcome. Controller gestures are drawing the attention of the AI community and together with hand gestures will experience breakthrough improvements over the next few years.

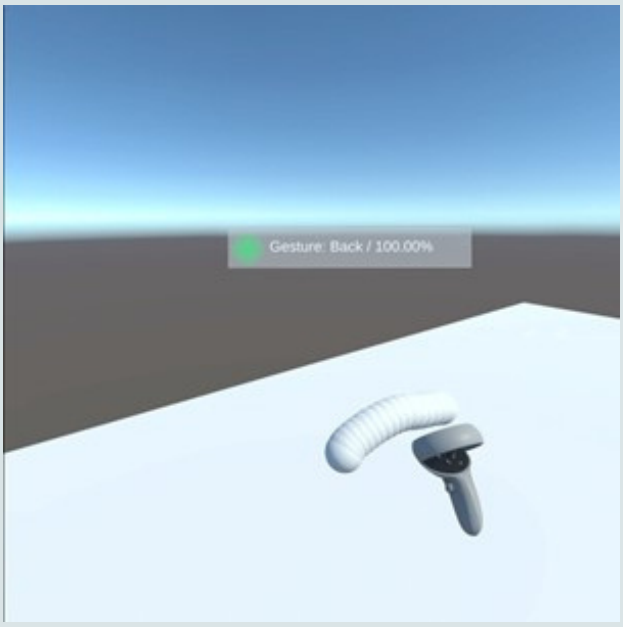

Figure 3: Controller gesture Recognition application developed by CERTH for INFINITY

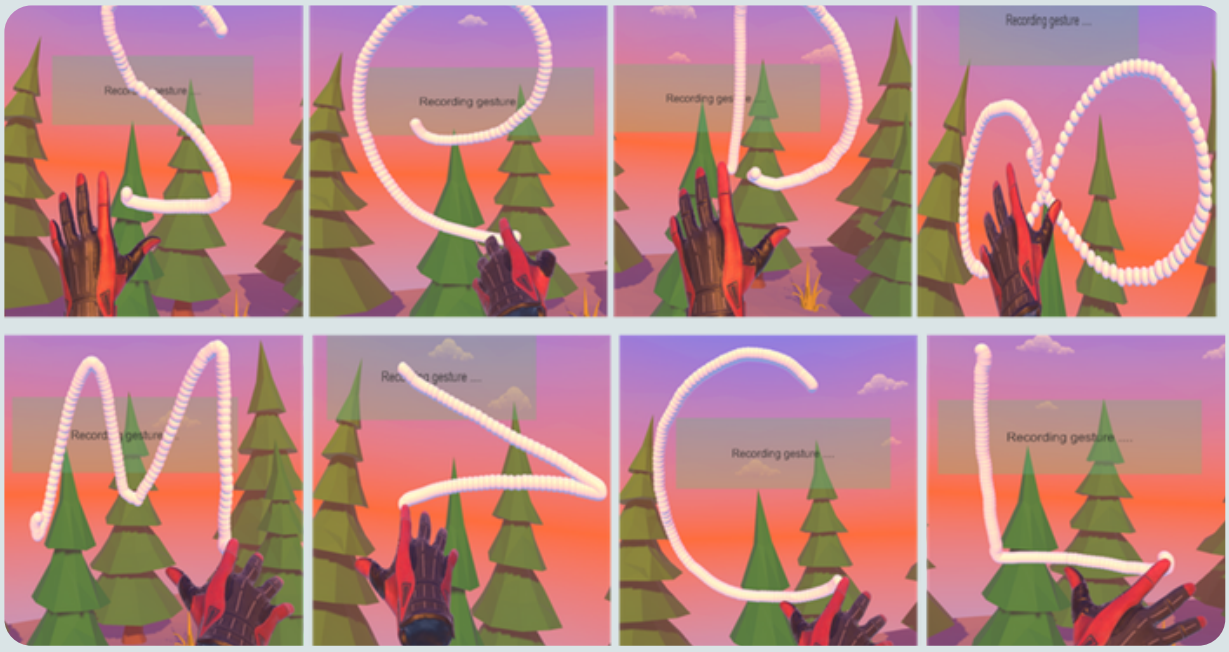

Figure 4: Controller gesture recording application developed by CERTH for INFINITY. The designed controller gestures were integrated in the I3CE environment and in GraphXR.

5. Future Challenges and Opportunities

Although hand gesture recognition has been a research field for a long time, not until recently has been utilized to its potential. The latest rapid improvements in hand tracking that the Meta Quest 2 provides open new possibilities in exploring and applying gesture recognition. The steep rise of artificial neural networks and the rapidly growing deep learning community are affecting many research areas that could not until recently fulfill their potential. As of now, hand gesture recognition systems and applications were quite limited, but this is subject to change in the near future. Combining different research areas may result in extraordinary outcomes and also provide real-time gesture recognizers both with hands and controllers. However, it is still challenging to receive only a sample of a gesture, especially in real-time VR applications, and build a recognizer that is able to identify again similar gestures as the one drawn before. That comes from the fact that even the same person does not perform exactly the same way a gesture two or three times in a row and this variation tends to confuse the recognizers and produce chaos if not handled the right way. Another challenge lies in the fact that each person's hands may vary from those of others and the size of the palm and also the fingers may cause troubles to the recognition systems.

However, these research fields are fairly new, which raises the opportunity for researchers to innovate, explore and provide some unique and very interesting research in a fast-paced developing research field such as gesture recognition.

References

1. The Policy brief was prepared by CERTH, as part of T10.5.
2. Cf. meta.com.
3. Cf. Weech, Séamas, Sophie Kenny, and Michael Barnett-Cowan (2019), "Presence and cybersickness in virtual reality are negatively related: a review", in: Frontiers in psychology 10 (2019), p. 158.
4. Cf. Badi, Haitham (2016), "Recent methods in vision-based hand gesture recognition", in: International Journal of Data Science and Analytics 1.2 (2016), pp. 77-87.
5. Cf. Asadi-Aghbolaghi, Maryam, et al. (2017), "A survey on deep learning based approaches for action and gesture recognition in image sequences", in: IEEE, 12th IEEE international conference on automatic face & gesture recognition (FG 2017).
6. Cf. Köpüklü, Okan, et al. (2020), "Online dynamic hand gesture recognition including efficiency analysis", in: IEEE, Transactions on Biometrics, Behavior, and Identity Science 2.2 (2020), pp. 85-97.
7. Cf. Huang, Y.J., Liu, K.Y., Lee, S.S., Yeh, I.C. (2021), “Evaluation of a hybrid of hand gesture and controller inputs in virtual reality”, in: International Journal of Human–Computer Interaction 37(2), pp. 169-180.
8. Cf. Vicario, Carmel M, and Anica Newman (2013), “Emotions affect the recognition of hand gestures”, in: Frontiers in Human Neuroscience 7 (2013), p. 906.