AffectiveHMD: Facial Expression Recognition in Head Mounted Display Using Embedded Photo Reflective Sensors

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Figure 1: Snapshots of AffectiveHMD and a virtual avatar which reflects facial expression of the HMD user.

ABSTRACT

We propose a facial expression mapping technology between virtual avatars and Head-Mounted Display (HMD) users. HMDs allow people to enjoy an immersive Virtual Reality (VR) experience. A virtual avatar can be a representative of the user in the virtual environment. However, the synchronization of the virtual avatar's expressions with those of the HMD user is limited. The major problem of wearing an HMD is that a large portion of the user's face is occluded, making facial recognition difficult in an HMD-based virtual environment. To overcome this problem, we propose a facial expression mapping technology using photo-reflective sensors. The sensors attached inside the HMD measure the reflection intensity between the sensors and the user's face. The intensity values of five basic facial expressions (Neutral, Happy, Angry, Surprised, and Sad) are used for training a classifier to estimate the facial expression of a user. In Siggraph 2019, the user can enjoy two application, the facial expression synchronization with the avatar, and simple manipulation experience for a virtual environment by facial expressions.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; • **Hardware** → **Emerging interfaces**; • **Computer systems organization** → **Embedded systems**.

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KEYWORDS

facial expression recognition, classification, avatar

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1 INTRODUCTION

HMD is getting popular and affordable for consumers these days. It can be predicted that virtual reality (VR) is going to be widely used by individuals for various purposes such as gaming and communicating with people in remote locations in the near future. The advantage of VR is that it is possible for the user to have an immersive experience in the virtual world, as if the user is actually present in the virtual environment. Also, people who do not prefer to expose their face in the virtual world in terms of privacy can be able to communicate smoothly through the use of a virtual avatar. However, nonverbal communication cannot be expressed when user communicates in a virtual environment through an avatar. The listener may feel unnatural if the facial expression of the avatar is unchanged while the avatar talks with different kinds of emotions and intonations. In order for the avatar to imitate the facial expression of the user, it is necessary to estimate the current facial expression of the user, but camera-based methods show limited capability to recognize the facial expression in the situation because the HMD covers up the upper half of the face.

We propose a facial expression recognition technique using optical sensors that can be used even when wearing a HMD. Figure

Figure 2: The concept of our facial expression recognition technique.

2 shows basic concept of AffectiveHMD. The optical sensors can detect the reflection intensity between the sensors and skin surface. We estimate the facial expression of the user with a classifier by learning the sensor values that are depending on basic facial expressions. This work is an extension of [Suzuki et al. 2017].

2 SYSTEM OVERVIEW

We designed a sensor array and printed circuit board (PCB) that can be mounted in the interior of the Oculus Rift. We installed 16 photo reflective sensors (Kodenshi SG-105) inside of the HMD. We placed 14 optical sensors around the eyes and two optical sensors on the bottom part of the HMD device to measure the movement of the user's cheeks. Figure 3 shows the sensor layout around eyes for Oculus CV1. As for the reasons for choosing this layout, we found that the movement of skin at these positions is prominent and that the sensor values scatter when facial expressions change to the extent that discrimination is possible. Individual differences would make it impossible to place the sensors over muscles. We ensure usability by not taking the position of muscles into account. Each sensor is connected to Microchip 16F619. The sensor values are passed to a computer by a serial communication via USB. The optical sensors can measure the reflection intensity from our facial skin surface in front of the sensor by radiating infrared light and receiving the light that is reflected [Masai et al. 2016]. The fact that

Figure 3: Photo Reflective Sensors inside of a Head Mounted Display.

size of the sensor is small enough, and it has a small power consumption allows multiple sensors to be attached in the interior of the HMD. The circuit board is used to measure the distance between the sensor and the surface of the skin, which slightly fluctuates as facial expression changes. The data obtained by the sensor can be used for estimating the current facial expression through Support Vector Machines (SVMs) with membership probabilities.

3 DEMONSTRATION

Our method can estimate the facial expression of the HMD user as probabilistic values. Based on this technology, we have developed an application to reflect the user's facial expression to the avatar's face by mixing facial parameters of basic facial templates. Another application is to manipulate virtual environment by facial expressions to show the capability of our facial expression technology.

The user experience is as follows. For the first application, the user wears the HMD and the software sets the data sample at the position as the baseline. Then, the user sees the avatar which changes the expressions at a certain interval. The user mimics its facial expressions. While the avatar makes a certain expression, we collect the data samples of the sensor data and the label associated with the avatar's expression. The data are used for multi-class classification and regression. After that, it is possible to reflect the user's facial expression to the avatar using the classifiers: SVMs. It enables the user to embody with the avatar by syncing the facial expressions. The training process takes a few minutes. It is possible to recognize facial expressions by resetting the baseline if the HMD is removed and worn in the middle of the experiment. The datasets can be reused for the same individual. When the wearer's facial expression is reflected in the avatar, the avatar's facial expression changes smoothly because of sensor values.

For the second application, the user will be asked simple operation in the virtual environment using his/her facial expression. The user will make the facial expressions that fit to the operation. Through this process, the user can control the virtual elements by making their "own" facial expressions. The user can experience simple gaming task.

4 CONCLUSION

In this demonstration, we present our facial expression recognition technology by embedded photo-reflective sensors and machine learning. By using this technology, we are able to reflect facial expressions of HMD users in various Virtual Reality systems.

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