1 Background

Gaze awareness and eye contact contain important nonverbal information for the smooth communication among multiple people. In a shared mixed-reality (shared MR) space, however, the gaze awareness is lost as a side-effect of wearing a head-mounted display. When we try to use the shared MR space for some collaborative tasks, the loss of gaze awareness becomes a critical problem.

We have proposed a scheme to restore gaze awareness and eye contact by diminishing the HMDs using MR technologies [Takemura and Ohta 2002]. This is realized by synthesizing the user’s CG face with natural eye-expressions in real time and by overlaying it on the real user’s face wearing an HMD, which is to be diminished. Figure 1 illustrates a snapshot of a partner’s view of the system. The goal of this work was to reproduce the user’s CG face with complete fidelity and to overlay the CG face to the real face as seamlessly as possible.

In this sketch, we propose the concept of “enhanced eyes.” The “enhanced eyes” do not pursue high fidelity but they do pursue natural appearance. The CG eyes are deformed to enhance gaze awareness without losing the natural face appearance. The gaze awareness in a shared MR space with “enhanced eyes” may be better than that in a real space with “real eyes.” We present three schemes of “enhanced eyes” and show their effectiveness by subjective evaluations.

2 Enhanced eyes

Controlling highlight for awareness of eye-contact: In a real space, we do not feel any difficulty in using eye contact. In an MR space, however, the awareness of being looked at or not by a partner is not easy. It is necessary to perceive the difference between the two cases to use eye contact in an MR space. We propose to artificially make the difference by switching the highlight in the eyes. Our idea is as follows. When the partner is looking into our eyes, his eyes are highlighted naturally. When the partner is not looking into our eyes, the highlight is removed from his eyes (figure 2). We have conducted a subjective evaluation to show the effectiveness of the highlight switching. The results of subjective evaluation are summarized as follows: 1) the presence of highlight has large effect on the feeling of gaze: 2) the effect of the highlight increases as the gaze direction becomes smaller.

Deformation of eyelids for enhancing eye motion: The gaze direction is represented by the orientation of eyeball. On a real face, the eyelids are deformed when the eyeballs rotate. We think the deformation of eyelids is an important factor for the perception of gaze direction. When artists draw rough sketches of faces, it is well known that they deform the eyelids stronger than the real deformation (figure 3). Based on an investigation of typical rough sketches of faces, we found an interesting fact that the motion of eyelid is enhanced almost quadruple that of the real one. We have conducted experiments on the strength of eyelid deformation from the viewpoints of naturalness and easier perception of gaze motion. The results of subjective evaluation are summarized as follows: 3) an enhanced deformation of the eyelid, more than double that of the real one, helps to perceive the gaze motion: 4) an enhanced deformation of the eyelid, up to double that of the real one, does not affect the natural face impression.

Adjusting eyeball rotation for correct perception of gaze direction: Joint visual attention is an action to estimate the gaze direction of one’s partner and to recognize the object the partner is looking at. It is reported that there are systematic errors between the real gaze direction and the estimated one. We have conducted experiments to compensate the errors by adjusting the eyeball rotation angle on the synthesized face in order to realize better joint visual attention in an MR space. The results of subjective evaluation are summarized as follows: 5) adjusting the eyeball rotation angle of synthesized face is effective for correct perception of gaze direction.

Based on this knowledge, we can control the feeling of gaze by switching the highlight in the eyes, by deforming the eyelids, and by adjusting the eyeball rotation in a shared MR space. It will be possible to improve the gaze awareness in an MR space better than in a real world.

References