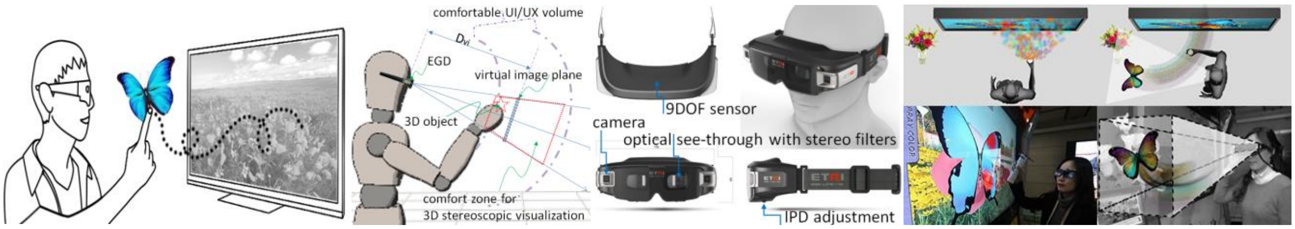
Wearable Display for Visualization of 3D Objects at Your Fingertips

Ungyeon Yang
Electronics and Telecommunications Research Institute
Daejeon, Korea
uyyang@etri.re.kr

Ki-Hong Kim
Electronics and Telecommunications Research Institute
Daejeon, Korea
kimgh@etri.re.kr



(a) (b) (c) (d)

Figure 1. *(a) expected user's experience; 3D butterfly sit at fingertip, (b) concept of the near-body space interaction, (c) features of Eye-Glasses-type-Display 3.0, (d) 3D virtual graffiti prototype; drawn butterfly protrudes from 3DTV to the vase.*

1. Introduction

Many interrelated factors of visual perception are utilized in the recognition of a three-dimensional (3D) space. And, the 3D consumer electronics are not enough to deliver the fantastic experiences of 3D contents in such mediums as movies and commercial films, and it also has many limitations and side effects, for safety and human factor problems that can develop from long-term 3D viewing. In order to solve this problem, [Yang, et al. 2013] proposed the Expanded 3D (E3D) display platform that expands the natural 3D visualization space by seamlessly combining multiple comfortable zones of homogeneous and heterogeneous displays into one. In order to verify the practicality of the E3D concept, we have conducted several implementations such as figure 1 by simply combining the Eye Glasses-type Display (EGD that outputs SXGA images with 41° field-of-view) 2.0's output to the other display's output. However, we found that this was still not enough to get a natural feeling of exact position or direct interaction within the near-body space close to the user's eye. We researched the characteristics of various commercial Head Mounted Displays (HMDs), this led us to discover that the cause of the unnaturalness phenomenon is caused by a particular common aspect of the optics system. The HMD technology was derived from the Head Up Display (HUD) system in airplanes and some automobiles. The purpose of a HUD is to enable the pilot's visualization of flight information at a far distance. The optical position of the virtual information screen (i.e. focused plane) was therefore designed at infinity (or far distance) by setting the convergence angle to zero or applying parallel vision. Therefore, we presume that the existing optics system of HMDs is not suitable for expressing 3D objects in the near-body space.

2. Our Approach

As figure 1, the EGD 3.0 has a mirror-type optical see-through system that has advantages such as a low chromatic aberration with a lensless design and a simple structure with an image panel, a half-mirror, and an aspherical concave mirror. Within the environment of E3D platform, the user must see inner 3D images with EGD and outer 3D stereo displays at the same time, so we selected an optical see-through type optics system instead of a video-based see-through. To increase the field-of-view (FOV) while preserving the outward form shape of the EGD, we used higher-density materials for such components as the prisms. This increased the angle of refraction within the optical path from the eye to the micro-display panel. This excessive increase in FOV inevitably decreased the Eye Pupil Distance (EPD) to small, so we added a function of Inter Pupil Distance (IPD) adjustment. We designed the distance to the virtual image of the optics system to be 43 cm from the Eye's Pupil (EP) to support near-body space interaction. According to the Banks Lab.'s report [Shibata, et al. 2011], we expect the optimal range of the comfortable zone is to be from about thirty centimeters (near) to about sixty centimeters (far). And, the hybrid stereoscopic filters (LCD switching shutter and Film Pattern Retarder) were integrated together in the EGD 3.0 to deal with both active and passive stereoscopic images from external displays at the same time and place. Finally, these parameters must be statistically verified with subject-based experiments in the future works.

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