HeadLight: Egocentric Visual Augmentation by Wearable Wide Projector

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ABSTRACT

Visual augmentation to the real environment has potential not only to display information but also to provide a new perception of the physical world. However, the currently available mixed reality technologies could not provide enough angle of view. Thus, we introduce “Headlight”, a wearable projector system that provides wide egocentric visual augmentation. Our system consists of a small laser projector with a fish-eye wider conversion lens, a headphone and a pose tracker. HeadLight provides projection angle with approx. 105 deg. horizontal and 55 deg. vertical from the point of view of the user. In this system, the three-dimensional virtual space that is consistent with the physical environment is rendered with a virtual camera based on tracking information of the device. By processing inverse correction of the lens distortion and projecting the rendered image from the projector, HeadLight performs consistent visual augmentation in the real world. With Headlight, we envision that physical phenomena that human could not perceive will be perceived through visual augmentation.

CCS CONCEPTS

• **Human-centered computing** → *Mixed / augmented reality*;

KEYWORDS

Head Mounted Projector, Mixed Reality, Augmented Reality, Visual Augmentation, Perception

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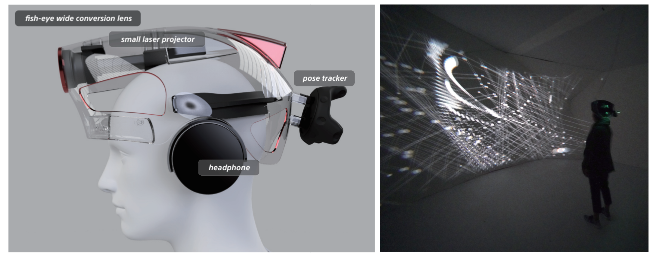

Figure 1: HeadLight : A wearable wide-angle projector system for Egocentric visual augmentation.HeadLight consists of a laser source small project with a wide conversion lens, a headphone and a pose tracker.

1 INTRODUCTION

Visual augmentation has a lot of potential including providing additional information of real world, mixed reality entertainment in the real environment. Moreover, making invisible information visible for human will lead us to extend our perception itself. However, especially optical see-through glass as the most possible technology for visual augmentation, it's field of view is limited up to approx. 35deg, which would be enough for providing information but not enough for immersive visual augmentation. As another potential technology, projection mapping enables immersive visual augmentation which aligns the real world. However, projectors are usually installed fixed position and not able to provide visual augmentation from the point of view of users. While previous research using wearable projector has been studied, the field of view was limited to narrow-angle [Harrison et al. 2011; Mistry and Maes 2009].

Then, we introduce a wearable wide-angle projector system called “Headlight” which allows us to augment egocentric visual environment. This is a head-worn system consists of a laser source small project with a wide conversion lens, a headphone and a pose tracker for the virtual reality system (Fig. 1). HeadLight enables wide angle visual projection from the point of view of user up to approx. 105 deg. horizontal and 55 deg. vertical, which covers a large field of view of human. The image of the projection is synchronized with the user head position and rotation. By providing three-dimensional data of the environment, HeadLight system allows us to see the augmented visual environment which aligns with the real world.

2 HEADLIGHT SYSTEM

2.1 Wide angle projection

A LED source projector usually requires the focus adjustment to provide a sharp image on the surface in the real world, hence, we employ a laser source projector which can be used for any distance with shape image. However, normal projector only provides limited field of view for projection. For instances, MP-CL1 which we employ for HeadLight provides 42.1deg for horizontal and 23.4 for vertical. We then attached a fish-eye conversion lens on the projector which enables much wider projection image with the diagonal angle up to 140 deg, minimum angle in horizontal 105 degree and vertical 55 degree (Fig. 2). The conversion lens produces strong distortion in the projected image with pincushion shape. Thus we model this distortion based on a fisheye model distortion. In addition, attaching the convention lens shifts the principal point

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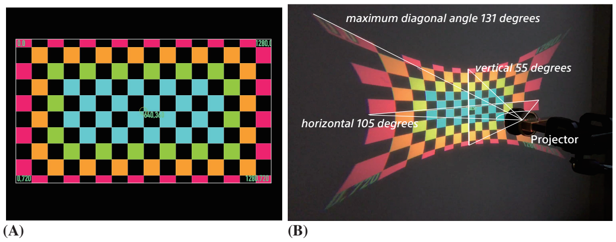

Figure 2: A laser projector with a fish-eye conversion lens provide wider projection. (A) shows checker board pattern output image for projector. (B) shows actual projector output at a screen plane.

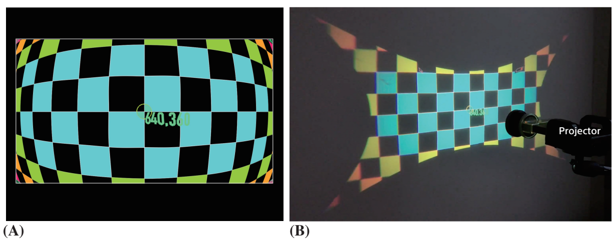

Figure 3: Head light system generates the output image to compensate the pincushion distortion. (A) shows inverse distorted output image for projector. (B) shows actual projector output at a screen plane.

of the projector. We calibrate these parameters in advance. Then the distortion coherence is also used to render the output image to compensate the pincushion distortion (Fig. 3).

2.2 Rendering projection image for visual augmentation

The head worn device including the projector is tracked with pose tracker (HTC Vive Tracker [1]) to get rotation and translation motion. Then the projector pose matrix can be acquired from tracker pose matrix with the pre-calibrated transformation between the tracker and the projector. Once the projector pose matrix is calculated, the computer graphics scene is rendered using this pose matrix to get mixed reality view image. The computer graphics include the three-dimensional data such as a building 3D model or point cloud data of real world environment. The final output of the projector is produced by using distortion process as we described before.

2.3 Egocentric projection design

In Headlight, three design of visual augmentation can be provided by egocentric projection. In the **Virtual screen mode**, egocentric projection by HeadLight system allows user to see the projected image itself regardless of the physical surface, even with complex surfaces with different distances. In the **Aligned rendering mode**, by using three-dimensional data of the physical environment as the source of the projected video of the system, HeadLight can project computer graphics aligned with the physical environment the user is watching. In this projection mode, the projected image appears to be existed on the physical surface. In the **Spatial rendering mode**,

[1]www.vive.com/eu/vive-tracker/

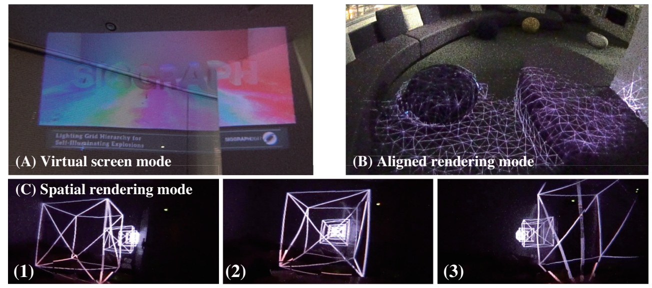

Figure 4: Three design of visual augmentation. Each picture shows the egocentric view captured at user eye position. (A) shows the virtual screen mode, (B) shows the aligned rendering mode and (C) shows the spatial rendering mode in continuous motion.

Figure 5: Example of visual augmentation with X-ray simulation. This allows user to see through the other side of the wall.

since the HeadLight system can generate image synchronously with the head movement, motion parallax can be generated by the change of the projected image. Due to the perception of depth caused by this moving parallax, the user feels that a virtual object exists in front of or behind the surface regardless of the physical arrangement of the actual projection plane.

3 LIMITATION AND FUTURE WORK

In the current implementation , since the conversion lens is mounted on the existing laser projector, the light quantity is limited. This problem would be improved by designing the projector device exclusively for Headlight. In addition, the current tracking range is limited with room-size. We expect that this restriction can be eliminated by changing to an inside out type tracking device.

With the HeadLight system, it is possible to visually express various invisible physical phenomena by immersive first person projection mapping. As an example, visualization of aerodynamics makes it possible to sensitively perceive the flow of air in the environment. As another example, by using the 3D data of the surrounding environment, it possible to induce X-ray like visual augmentation as if seeing through the other side of the wall. We envision that with this visual augmentation technology, HeadLight can provide a new sense of the physical world.

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