TwinCam: Omni-directional Stereoscopic Live Viewing Camera for Reducing Motion Blur during Head Rotation

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Figure 1: TwinCam: 360-degree stereoscopic real-time rendering.

ABSTRACT

We developed an omni-directional stereoscopic live viewing camera (TwinCam) system to reduce the motion blur and latency during head rotation of a remote user wearing a head mounted display (HMD). The TwinCam system consists of two omni-directional live cameras (THETA S, Ricoh), rotation mechanisms with a motor, an image control PC, and an HMD. The camera base rotates synchronously with the azimuth angle of the HMD that the observer is wearing, while each camera lens is at a constant azimuth angle. This camera configuration greatly reduces image flow on the CMOS image sensor in the camera, and eventually, the motion blur on the HMD screens when the HMD rotates. The apparent image latency during the head rotation is minimized by the buffered image. A user study demonstrated that both reduced motion blur and compensated latency were effective in reducing the virtual reality (VR) sickness symptoms.

CCS CONCEPTS

• **Human-centered computing** → **Displays and imagers**; **Virtual reality**; • **Computing methodologies** → *3D imaging*;

KEYWORDS

Stereoscopic live image, motion blur, latency, telepresence

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1 TWINCAM SYSTEM

The TwinCam system captures two 360-degree real-time videos that are projected onto two spherical virtual screens from which left- and right-eye images are clipped to render them on the HMD as shown in Fig. 1. To maintain the correct binocular parallax, the camera base (Fig. 2) rotates to the same azimuth angle as the HMD

Figure 2: TwinCam head (fixed-azimuth rotation mechanism).

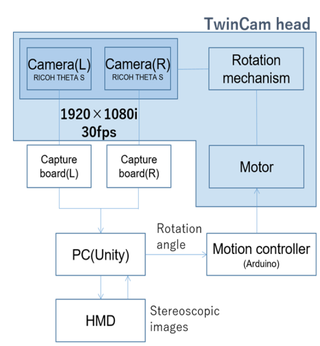

Figure 3: Schematic of the TwinCam system.

while the direction of the lens (i.e., the optical axis) maintains constant orientation. This design[1] has two major benefits, namely, low motion blur [Agrawal et al. 2009] and latency compensation during the head rotation. The motion blur is reduced dramatically as compared to a conventional setup of two cameras arranged with parallel axes because the TwinCam lens position change does not involve rotation. Although latency exists when the TwinCam head base rotates to capture a correct binocular image following the HMD rotation, the omni-directional images captured in the previous frame provide very close images to those obtained after the TwinCam is rotated. The TwinCam system consists of two omni-directional live cameras (THETA S, Ricoh), HDMI capture cards (Intensity Pro 4K, Blackmagicdesign), an image control PC, a motor controller (Arduino), a motor (RS405CB, Futaba) with rotation mechanisms, and an HMD (Oculus Rift CV1) as shown in Fig. 3.

2 EVALUATION

The captured image of vertical stripes (horizontal cycle length 120 mm), at a distance of 1.0 m, during a rotation of the cameras at 4.76 rad/s had far less motion blur when using the TwinCam configuration (Fig. 4) than that when using conventional parallel configuration (Fig. 5), in which the two cameras rotated symmetrically with the HMD.

A depth adjustment test of manually moving a piece of white paper 1.0 m away from the camera revealed that the depth perception by the TwinCam system was far more accurate than that in the monocular condition for a wide range of observation angles as shown in Fig. 6.

The intensity of the VR sickness symptoms was measured immediately after the participant performed 30 head turns in 60 s in case of both the TwinCam and the conventional parallel configurations. A 200 ms latency was introduced before the start of the motor rotation because such latency is often expected in a telepresence application. The results of the Simulator Sickness Questionnaire (SSQ) [Kennedy et al. 1993] showed that the TwinCam configuration significantly lowered the SSQ score, which suggests that the latency was compensated by the locally buffered image.

3 CONCLUSION

The TwinCam system achieved both a low motion blur and the latency compensation effect during the omni-directional stereoscopic live viewing involving fast head rotation. The VR sickness symptoms were relieved in case of the TwinCam system as compared to the conventional parallel camera configuration; the attendees in our booth will have experienced the effectiveness of this system.

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[1]Patent Application No.PCT/JP2017/ 5161

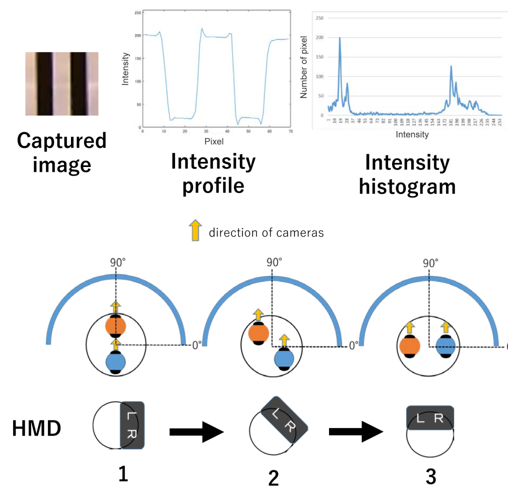

Figure 4: Very small motion blur in TwinCam configuration.

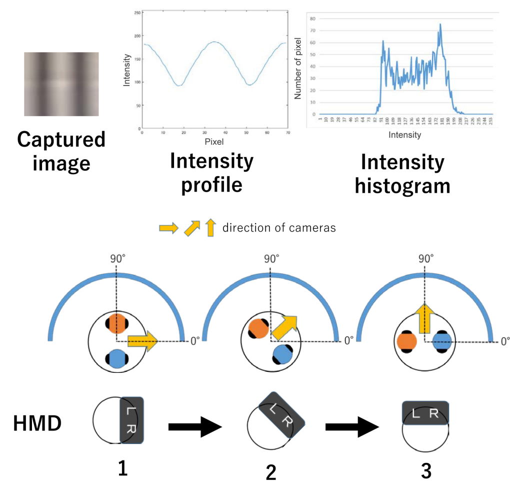

Figure 5: Large motion blur in conventional parallel camera configuration.

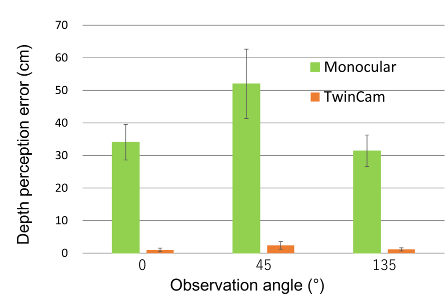

Figure 6: Depth perception error in TwinCam relative to the monocular (ordinary omni-directional live video) setting.