Visualizing Gaze Presence for 360° Cameras

Figure 1: An illustration of the KumoCrown prototype in operation in a lecture hall. A remote viewer is watching the presentation with the highlighted viewport (left). The corresponding viewport is visualized on the ceiling mounted device by illuminating the same field of view using LED rings (right).

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ABSTRACT

Advancements in 360° cameras have increased their related livestreams. In the case of video conferencing, 360° cameras provide almost unrestricted visibility into a conference room for a remote viewer without the need for an articulating camera. However, local participants are left wondering if someone is connected and where remote participants might be looking. To address this, we fabricated a prototype device that shows the gaze and presence of remote 360° viewers using a ring of LEDs that match the remote viewports. We discuss the long term use of one of the prototypes in a lecture hall and present future directions for visualizing gaze presence in 360° video streams.

CCS CONCEPTS

• **Information systems** → **Web conferencing**; *Multimedia streaming*; • **Human-centered computing** → Visualization.

KEYWORDS

360°, video, streaming, visualization

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Figure 2: The 360° desk camera demo looking forward.

INTRODUCTION

Low cost 360° cameras have entered the consumer camera market. And while streaming applications have become popular for broadcasters and video conferencing systems, 360° cameras have unique asymmetries that require additional visual context [4]. In a recent study on video conferencing, researchers found participants in a room with a 360° camera liked having a non-articulating camera that can see everything but also felt uneasy not knowing where a remote viewer might be looking [3]; an ignored problem in most commercially available 360° conferencing devices. To address these issues, we propose augmenting 360° video streaming cameras with a device that

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provides gaze and presence information to stream local participants (*gaze presence*). We illustrate this with a demonstration of two prototypes that use a ring of LEDs to visualize the gaze presence of logged in viewers and their respective viewports. One prototype is affixed to a lecture hall while the other is a portable design for smaller conference rooms.

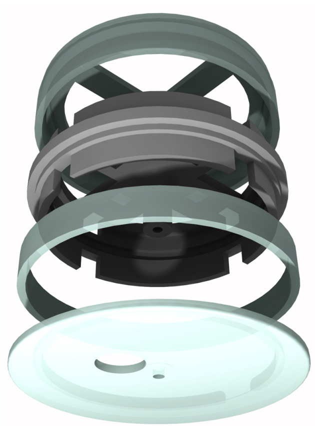

Figure 3: An exploded view of the initial prototype.

360° LED CROWN

The core feature here is to visualize where a remote viewer might be looking. To do this, we built a DotStar LED ring to surround the base of a commercially available Ricoh Theta R camera. When a viewer logs in, the width and angle of their active viewport is represented in the LED ring around the camera. The mapping is *mostly* direct, with some set minimum and maximum tolerances that are a function of the resolution of the DotStar strip and the avaliable LEDs. This gives a direct 360° visualization of where a remote participant is looking, see Figure 1. Previous research has shown that remote viewers look at users (gaze forward) or at objects (gaze down) [2, 3]. To visualize gaze forward or gaze down, a second LED ring is stacked on the prototype. With two rings, one can accurately visualize pitch and yaw (typically there is no roll in 360° viewers). Figure 3 shows an exploded view of the initial prototype's 3-D printed layers.

In many cases, multiple remote users need to be in a video-calling room. As each participant enters the 360° livestream, they are assigned a distinct color. If two or more viewers are looking at the same region, the overlapping region is displayed as white. In our tests, approximately 5 users scanning the room are perceptible to the local participants in a meeting. In a lecture hall environment, this number can be higher as most viewers will only be looking forward at the speaker and/or presenting slide.

VIDEO STREAMING FRAMEWORK

With the device, we required a video streaming framework that could receive the needed 360° information from the client. For this, we used a standard PC with a commercially available 360° camera (Ricoh Theta R). A Node.js and webrtc-node broadcasts the video to a Janus gateway server. When a web browser client connects to the Janus gateway server, websockets and webrtc receive the video. The received equirectangular video is rendered in WebGL in the browser using three.js. A secondary websocket[1] connects from the client to a RaspberryPi ZeroW that is connected to the DotStar strips in the prototype. This secondary socket transmits viewer and viewport information which is ultimately rendered by the device. Animations are played when clients move the viewport, connect, or disconnect.

[1] The websocket transmits: FOV, PITCH, REMOTE-ADDRESS, ROLL, SESSION-ID, USERNAME, YAW on each movement of a the client's viewport along with client connect messages.

DEPLOYMENT AND FUTURE WORK

We installed the first prototype in the ceiling of a 40-person lecture hall in an office space. The device became known as KumoCrown by the office workers: a merge of the lecture hall's name, Kumo, and the device looking like a lighted crown in the center of the room. In operation for 9 months as of this article, the workers have come to rely on the device and have requested features, such as the ability to see who is on the call and what color are they on the device—from both local and remote viewers alike. These interactions were built into a secondary screen in the room, as well as into the office chat channel as a bot. The setup also offers VR-viewer support as this modality is also growing in popularity [1]. We also fabricated a second, portable prototype[2] for use on a conference room desk. Finally, we plan to integrate an AI-autopilot into the system that would automatically move the viewport to the active speaker or action in the scene via a trained attention model that uses fine grained activity recognition. We envision future streamable 360° devices could have similar gaze presence indicators built into the camera, much like a red recording light on a traditional video camera (see Figure 4).

[2]This is what we plan to bring to the demo session (as seen in Figure 2) along with the submitted video figure.

Figure 4: A fictional design sketch of the LED ring build into a consumer camera.

RELATED LINKS

Referring software and hardware used in the demo (accessed in March 2019):

- Webrtc-node https://github.com/jumpchat/webrtc-node,
- Janus Gateway https://github.com/meetecho/janus-gateway
- DotStar https://learn.adafruit.com/adafruit-dotstar-leds/overview
- Node.js https://nodejs.org/,
- Ricoh Rhttps://ricohr.ricoh/,
- Three.js https://threejs.org/
- Raspberry Pihttps://www.raspberrypi.org/

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[2] Terrance Mok and Lora Oehlberg. 2017. Critiquing Physical Prototypes for a Remote Audience. In *Proceedings of the 2017 Conference on Designing Interactive Systems (DIS '17)*. ACM, New York, NY, USA, 1295–1307. https://doi.org/10.1145/3064663.3064722

[3] David A. Shamma, Jennifer Marlow, and Laurent Denoue. 2019. something Collaboration with 360° Videochat: Challenges and Opportunities. In *Proceedings of the 2019 Conference on TV and Video Experiences (TVX '19)*. ACM, New York, NY, USA.

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