July 2023

Head-Mounted Displays with Integrated Cameras to Capture 360-degree Video

Ajit Narayanan

Head-Mounted Displays with Integrated Cameras to Capture 360-degree Video

ABSTRACT

Capturing videos in 360 degrees currently requires use of a standalone 360-degree camera. Playback of such videos in 360 degrees requires a separate head-mounted device (HMD). In many 360-degree videos, the person controlling the camera is unintentionally visible, distracting the viewer. This disclosure describes techniques to overcome these barriers by equipping HMDs with the capability to capture 360-degree video cameras via multiple cameras positioned on the front, sides, and back of the HMD. Multiple, aligned videos are obtained by capturing images from the various cameras in the form of a video stream and aligned to provide a 360-degree video. Unintentionally captured body parts can be removed digitally from the captured 360-degree videos to create a more precise point-of-view video. The HMD with integrated cameras can act as a capture and viewing device.

KEYWORDS

- 360-degree video
- 360-degree photo
- 360-degree capture
- Augmented Reality (AR)
- Extended Reality (XR)
- Virtual Reality (VR)
- Mixed Reality
- Head-Mounted Display (HMD)
- Wearable camera
- Smart glasses

BACKGROUND

Users can capture videos in 360 degrees by using standalone 360-degree cameras. In some cases, users generate a traditional video using the footage captured by a 360-degree camera by post-processing the captured video to reframe shots with greater flexibility. Users can view the 360-degree video in its original form on a traditional screen by using accelerometer- or mouse-based interactions to change the viewing angle as needed. Alternatively, users may watch the original 360-degree video via a head-mounted display (HMD), such as a virtual reality (VR), augmented reality (AR) or extended reality (XR) headset.

Viewing 360-degree video footage using an HMD can provide an immersive experience superior to viewing such videos on a traditional display. Traditional video capture devices such as a smartphone enable users to capture and view video on the same device. In contrast, cameras that capture 360-degree videos are devices that are distinct from the HMDs on which users view the videos. Although there have been attempts to create 360-degree cameras in a spectacle form, there are no VR/AR/XR headsets with such features.

Moreover, 360-degree video captured by a user has an angle from which the person controlling the camera is visible. Such an angle can be distracting in cases in which the person controlling the camera is not the focus of the video. While integration of a 360-degree camera within smartphones can avoid the need for the user to carry a standalone 360-degree camera, it does not eliminate the issue of the camera holder being in the frame. Software provided with 360-degree standalone cameras typically includes functionality to erase selfie sticks from video frames via digital methods. Such functionality is similar to smartphone features that enable users to remove unwanted people and artifacts from photos.

DESCRIPTION

This disclosure describes techniques to equip head-mounted devices (HMDs), such as AR/VR/XR headsets, with the capability to capture 360-degree video via multiple cameras integrated into the device. The integration of multiple cameras within the device enables users to record and play 360-degree video footage with the same device. Since the multiple cameras integrated within an HMD are positioned around the user's head, any unintentionally captured body parts can be removed digitally from the captured 360-degree videos to create a more precise point-of-view video.

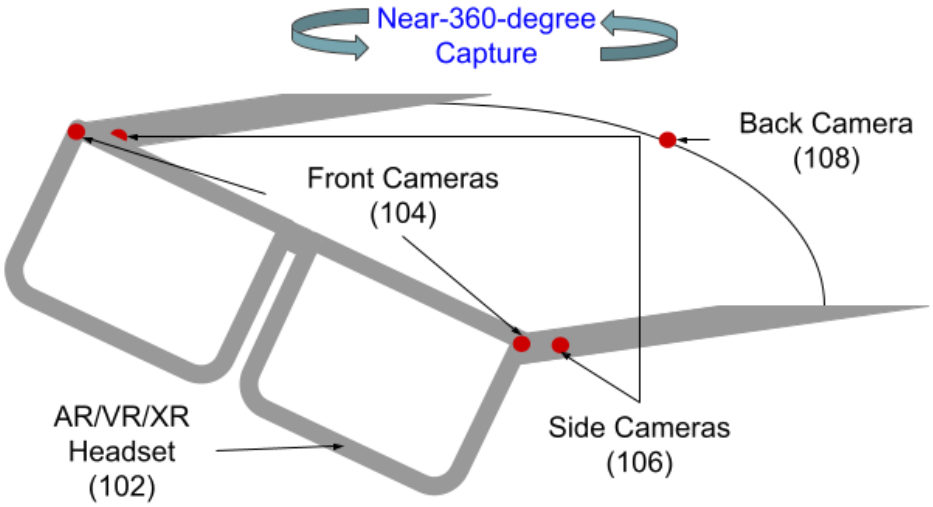

Fig. 1: Embedding cameras within an AR/VR/XR headset to capture 360-degree video

Fig. 1 shows an example operational implementation of the techniques described in this disclosure. A head-mounted device (102), such as an AR/VR/XR headset includes one or more cameras on the front (104), sides (108), and back (106). Such a configuration results in cameras being positioned in front of, on the sides of, and behind the head of the user wearing the HMD. The combination of the front, side, and back cameras can capture a near-360-degree field of view. A 360-degree model of the space around the user can be created by geometrically aligning

the image frames captured by the cameras. Multiple, aligned videos can be obtained by capturing such image frames from the various cameras in the form of a video stream. Any state-of-the art techniques can be employed to align the videos frame-by-frame for creating a point cloud that can serve as a 360-degree video.

Since the cameras in the HMD surround the head of the user, the images captured by the cameras as described above are unlikely to depict any part of the user's body, depending on the angle of the field-of-view of the camera lenses. In some cases, the captured frames may capture a portion of the user's body, such as hands or torso. In such cases, these can be removed simply by constraining the angle of the 360-degree playback. Other unintentionally captured body parts can be digitally erased, if needed, to create 360-degree video that does not depict any part of the user shooting the footage.

Since an AR/VR/XR headset includes a display, users can play back the captured 360-degree video footage immediately on the HMD. The capability for immediate playback also allows users to edit 360-degree videos right after capture. After reviewing and editing the 360-degree video, users can choose to share it with others via social media, online video platforms, virtual worlds, etc.

The techniques described in this disclosure can be implemented for any type of HMD, including any AR/VR/XR headsets. Any suitable cameras, such as cameras with wide-angle lenses, can be used to capture video. The cameras integrated within an HMD as above can be powered by batteries within the HMD frame, or from a standalone battery located in a convenient location, such as behind the user's head.

Implementation of the techniques described in this disclosure enables users to capture and view 360-degree video footage with the same device, eliminating the need to carry a separate

360-degree camera. The 360-degree footage excludes or has minimal depiction of the user operating the cameras. As a result, the techniques enhance the user experience (UX) of capturing, viewing, editing, and sharing 360-degree videos and increase the capability and utility of HMDs, such as AR/VR/XR headsets.

CONCLUSION

Capturing videos in 360 degrees currently requires use of a standalone 360-degree camera. Playback of such videos in 360 degrees requires a separate head-mounted device (HMD). In many 360-degree videos, the person controlling the camera is unintentionally visible, distracting the viewer. This disclosure describes techniques to overcome these barriers by equipping HMDs with the capability to capture 360-degree video cameras via multiple cameras positioned on the front, sides, and back of the HMD. Multiple, aligned videos are obtained by capturing images from the various cameras in the form of a video stream and aligned to provide a 360-degree video. Unintentionally captured body parts can be removed digitally from the captured 360-degree videos to create a more precise point-of-view video. The HMD with integrated cameras can act as a capture and viewing device.

REFERENCES

1. Ho, Tuan, Ioannis D. Schizas, K. R. Rao, and Madhukar Budagavi. "360-degree video stitching for dual-fisheye lens cameras based on rigid moving least squares." In *2017 IEEE International Conference on Image Processing (ICIP)*, pp. 51-55. IEEE, 2017.
2. "ORBI Prime: The First 360 Video Recording Eyewear" available online at https://www.indiegogo.com/projects/orbi-prime-the-first-360-video-recording-eyewear#/ accessed June 19, 2023.