Frameless

Volume 1 | Issue 1 Article 19

2019

Transverse Chromatic Aberrations in Virtual Reality Devices

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Abstract: *We demonstrate a method for measuring the transverse chromatic aberration (TCA) in a virtual reality head-mounted display (VR HMD). This procedure was used to characterize the optical performance of the Oculus Go VR HMD. Results show a measurable TCA for angles larger than approximately 6◦ from the center of the field of view. TCA can be thought of as a wavelength dependent magnification, and as a result, the relative size of objects vary based on the rendering color. In addition, this leads to color changes in the image due to mixing with neighboring pixels, which impacts image quality. The test results for the Oculus Go show promise for characterizing TCA across different HMDs.*

INTRODUCTION

Advances in display technology, computing capabilities, and optical fabrication have lead to a revived effort in the development of virtual (VR) and augmented reality (AR). While the majority of this new momentum has been mo- tivated by the entertainment industry for consumer device applications, these advances are also highly relevant for more professional applications, such as displaying and visualizing 3D medical data. Some of the medical applications currently being explored included displaying MRI segmentation [1], therapeutic uses [2], and training [3].

While AR and VR open new frontiers for medical ap- plications, it also raises unanswered questions concerning the performance of the devices. An important aspect of the performance are the optical aberrations, which alter the visual representation of the input data. One example is transverse chromatic aberration (TCA), which is a color dependent magnification [4]. Therefore, TCA could present a significant challenge for accurately rendering 3D segmentation data. Here we demonstrate a digital test pattern and setup to characterize the transverse chromatic aberration (TCA) of a device. We tested our method on the Oculus Go and found noticeable TCA for angles above approximately 6°.

METHODS

Figure 1 shows a sketch and picture of the experimental setup for characterizing a VR HMD. An achromatic lens (f = 25 mm) focused the light from the HMD onto a monochrome CCD camera. The optical setup has rotation and translation degrees of freedom, as shown. In this illustration, a single off-axis white pixel is illuminating the measurement setup. As the light passes through the lens in the VR HMD, the RGB components are focused to different lateral locations on the detection CCD. The displacement on the CCD and the image of the HMD can be used to provide a measure of the TCA.

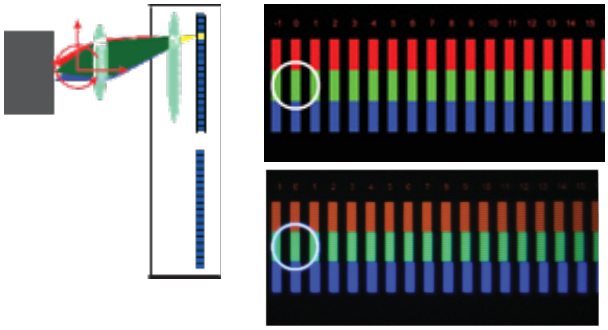

Fig. 1. (a) Sketch of a virtual reality head-mounted display (VR HMD) with transverse chromatic aberration (TCA). (b) TCA test pattern sent to Oculus Go, where the white circle is the center of the field of view. (c) Resulting monochrome image acquired using the setup shown in (a).

The TCA was tested by displaying the test pattern, shown in Figure 1 b, on the of the Oculus Go and the resulting image is shown in Figure 1 c. As can be seen in this image, the test pattern bars are blurred and displaced on the extrema of the field of view. This effect is more significant for the blue bars (top row) than for the red bars (second to bottom row), which is an indication of TCA in the system.

CONCLUSION

These results demonstrate that our test pattern and optical setup provide a straight forward method for measuring the TCA of a HMD. While the presented results are only for the Oculus Go, this same approach is suitable for other devices and provides a convenient method for characterizing TCA in virtual reality devices. As the development of HMDs continues to increase as well as the applications for medicine, the necessity for suitable testing methods will continue increase.

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