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An intrinsically eye safe approach to high apparent brightness augmented reality displays using digital holography

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Abstract
Achieving the luminance of real-world scenes is a challenge for many display technologies when seeking to deliver an experience that approaches the dynamic range of the human eye. Digital holography offers a number of significant advantages in this respect, due both to the high optical efficiency, and the ability to redistribute available luminous flux to individual points as required. This property is especially important when the aim is to present sparse digital elements that need to be clearly perceived against a bright real-world background in an AR or MR application. In this work we show that a configuration capable of delivering apparent display brightness equivalent to that of the daytime sky is achievable with components viable for a consumer head mounted display, and identify the constraints necessary to ensure that such a device would be intrinsically eye safe.

1. Context and motivation

To create a convincing reproduction of real-world scenes, the brightness of the image produced may be required to reach of the order 10'000 cd/m^2 to display content over a daytime sky. Reproducing this level of brightness is a challenge for traditional display technologies, as the correspondence between a display pixel and a point in the replay field limits the peak brightness, and is a particular limitation where sparse areas of high brightness are required. Although displays with individually light-generating pixels, such as OLED, offer an improvement over backlit displays, they still present the challenge that in order to achieve extremely high brightness, each pixel must still be capable of generating significant radiant flux, and hence have current handling requirements that are challenging for a high-resolution display.

2. Achieving high brightness and efficiency using diffractive, holographic display

Holographic displays, utilizing a phase-only liquid crystal spatial light modulator (LC SLM) as an image-forming device, present a range of advantages over competing technologies. Because phase modulation is performed in the Fourier plane (as opposed to amplitude modulation in the image plane), a relatively large fraction of the initial luminous flux can be arbitrarily re-directed into a selected number of image points [1]. This plays a crucial role for Augmented and Mixed Reality devices, which have an inherently small image coverage. Because the laser illumination of the holographic display is separate from the modulator itself, high optical efficiency can be achieved without dissipating significant amounts of heat at the display (as it is the case in traditional LCD displays).

3. Methodology and Results

We analyzed the efficiency of the optical components in the holographic setup as well as the power requirements. As an example, Figure 1 shows a sample Augmented Reality scene as shot through VividQ's benchtop holographic projector [3].

The display presented achieved object brightness in excess of 10'000 cd/m^2 from 1mW of optical power. This figure can be significantly surpassed for sparse replay fields. We discuss the optical requirements and demonstrate, how such a display is made intrinsically eye-safe.

Figure 1: Holographic display demonstrating exceptional optical efficiency [3]

4. About VividQ

VividQ is a Cambridge based start-up developing unique holographic technologies that enable realistic, true-to-life viewer experiences. We are building software solutions for the next generation of holographic 3D display, aimed at Augmented and Mixed Reality applications.

5. References

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