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WEARABLE FULL FIELD AUGMENTED REALITY DISPLAY WITH WAVELENGTH-SELECTIVE MAGNIFICATION

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Abstract

A head mounted display (HMD) incorporates lenses that operate as pass-through optics for most wavelengths, but for incident light at certain wavelength(s), the lenses operate to effectively magnify such light. As such, when a user wearing the HMD device looks at a display device configured to display certain content using light having the specified wavelength, the displayed content is magnified and superimposed on the rest of the scene in the field of view. As such, the HMD device enables smaller screens to effectively present as much larger screens to the user, without requiring optics that magnify everything within the field of view indiscriminately.

Background

Portable display devices, such as smart watches, smart phones, tablet computers, and the like, typically implement relatively small display screens by virtue of their portability constraints. As such, the amount of content that may be displayed via a portable display device at any given time conventionally has been relatively limited. For example, the implementation of fully-featured mapping software on smartwatches has been impaired by the dimensions of the display screen of such smart watches, which often only measure a few centimeters on a side at best. Likewise, viewing of a film on a typical smartphone often is a frustrating experience that typically involves considerable squinting on the part of the viewer.

Description

To facilitate a portable display device to effectively "project" a larger display area than otherwise possible given the physical dimensions of the display screen of the portable display device, as shown by FIG. 1 the portable display device may be viewed through a lightweight, full field-of-view (FOV) HMD (implemented with a spectacles form factor or other form factor) which includes optical lenses that operate as pass-through optics for most wavelengths of light, but for one or more specific wavelength bands, the optical lenses operate as magnifiers or telescopes, and thus magnifying the display content represented by the light emitted by the portable display device in such wavelength bands.

FIG. 1

FIG. 2 below depicts an example of the wavelength-specific magnification provided by such an HMD. The image on the left represents how a smartphone displaying red text at a wavelength within a particular band (e.g., 650-710 nanometers (nm)) would be viewed by the naked eye. However, as illustrated by the image on the right, when this same smartphone is within the FOV of a user wearing the HMD with optics configured to magnify light in the 650-710 nm spectrum, the red text, being composed of light in this band, is presented in a semi-transparent magnified form to the user's eyes, with the magnified form of the red text superimposed on the rest of the unmagnified scene within the FOV. As illustrated by FIG. 2, this has an interesting effect of allowing the displayed content in this specified band to appear to spill out over the physical boundary of the display screen, and thus effectively allowing the phone to present a larger display area for this content than would otherwise correspond to the physical dimensions of the display screen of the phone.

FIG. 2

The HMD may be implemented in any of a variety of form factors, such as in a spectacle form factor, a goggle form factor, and the like. FIG. 3 below illustrates an example spectacle-type form factor for the HMD. The spectacles include optical lenses mounted in an eyepiece frame. In each optical lens a magnifying hologram is formed, with the magnifying hologram configured to magnify incident light within one or more specified wavelength bands while operating to pass through light outside of these specified wavelength bands without magnification, as with the rest of the optical lens. The magnifying hologram may be formed in each optical lens by, for example, using a laser to sweep through the optical lens and change the local index of refraction of the lens at corresponding points to as to form the pattern of the magnifying hologram in the lens. The optical lens itself may be flat, and thus not introducing optical power or prescriptive corrections, or the optical lens may be formed to introduce some general magnification or prescriptive corrections, in which case the magnifying hologram would be designed to account for such.

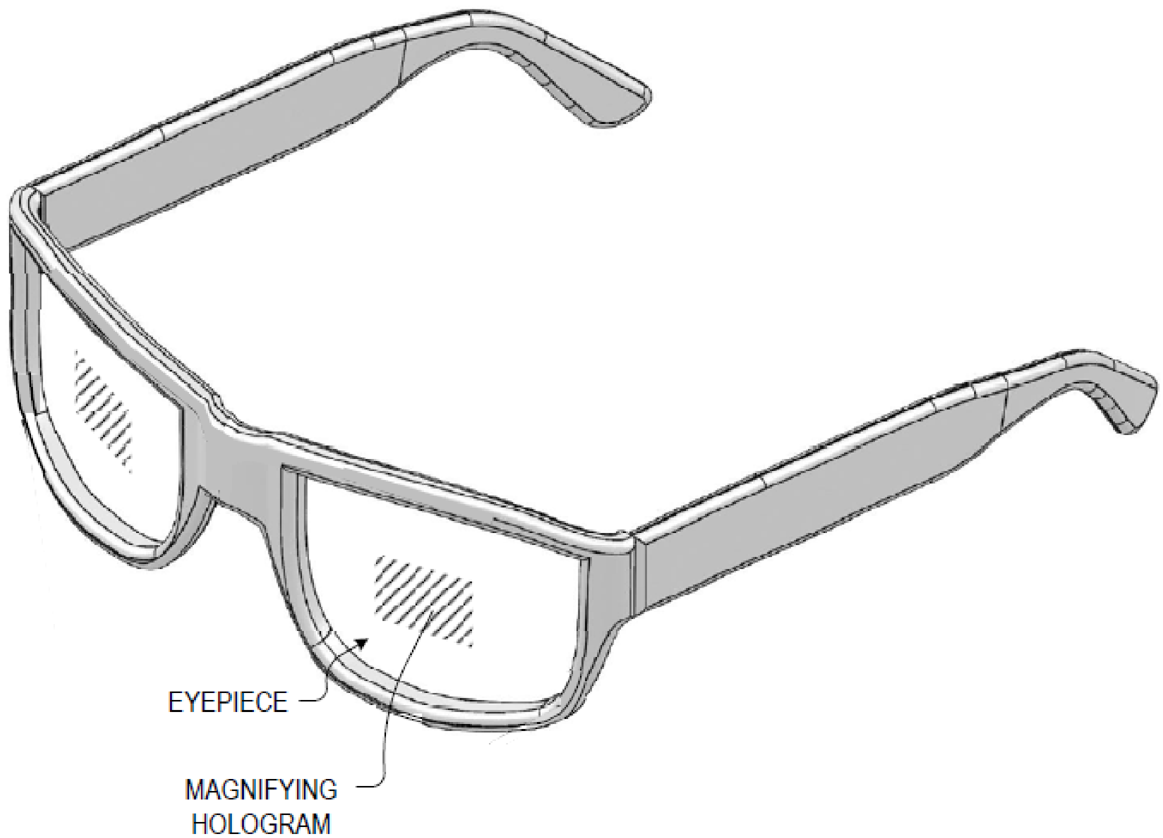

FIG. 3

FIG. 4 below depicts an equivalent optical system to demonstrate the operation of the HMD with magnifying holograms embedded in the optical lenses. As shown, this configuration operates in a manner similar to the illustrated tilted reflecting telescope that uses a dichroic mirror as the secondary mirror. For a narrow band of wavelengths, the dichroic mirror acts as a reflector, while appearing optically transparent for all other wavelengths. As such, this setup is pass-through for most wavelengths, and acts as a telescope for a chosen wavelength.

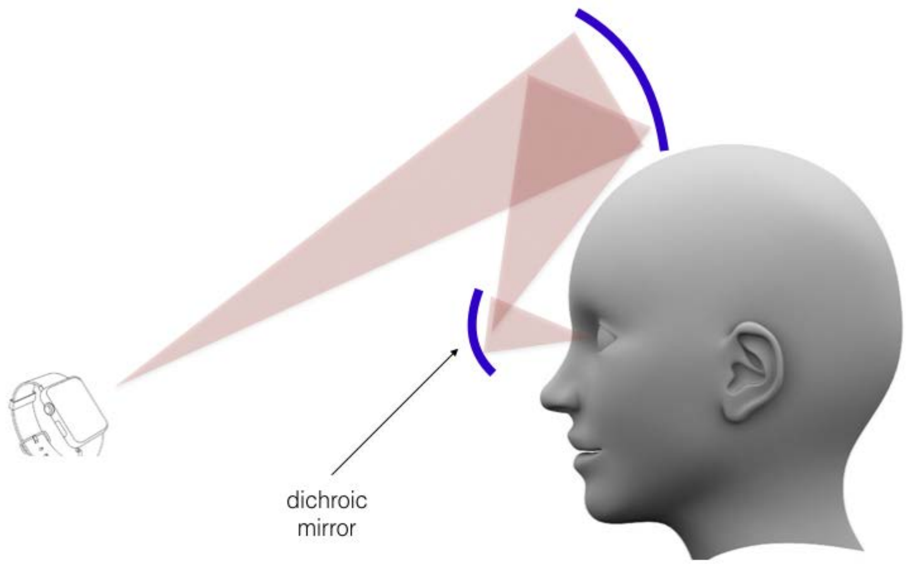

FIG. 4

The magnifying hologram may be designed and implemented using any of a variety of techniques. In one approach, a telescope in the manner of FIG. 4 above may be holographically recorded under a multitude of wavelengths, and this recording then reproduced as the magnifying hologram in the optical lens. That is, instead of holographically recording a 3D object, the designer may holographically record the optics of the telescope set up at narrow bands of red, green, and blue light, and at other wavelengths holographically record air, and use the resulting holographic recordings to reproduce a corresponding hologram in the optical lenses. In another approach, the holograms may be computational designed by analytically designing a thick Bragg grating for various angles of arrival, and imprint as a thick hologram a mixture or combination of these thick Bragg gratings.

As the HMD magnifies display content represented by light in certain wavelength bands, the portable display devices intended to work with the HMD should be configured to project light within these specific wavelength bands for display content intended for magnification. This configuration is already in place for conventional laser pico-projectors and other conventional laser-based displays, as such displays project light in narrow bands. However, the light emitting diode (LED) and organic LED (OLED) display screens currently implemented for tablets, watches, and phones generally project broad spectrum light, and thus the magnified display content would be relatively faint. However, this can be addressed by instead implementing display screens in such devices using liquid crystal display (LCD) backlights illuminated by laser diodes, which project in narrow bands, and thus the resulting colors projected by the display can be limited to narrow bands of light.

In sum, the implementation of wavelength-specific magnification in the optical lenses of an HMD allows a paired portable display device to project display content that is perceived by the viewer as being larger than the dimensions of the content on the display screen, and thus enabling the viewer to enjoy a better viewing experience than otherwise would be possible given the physical dimensions of the display screen. Moreover, because this selective magnification is achieved through configuration of the optical lenses of the HMD, the HMD does not require a built-in battery, processor, network interface, or light source to provide this selective magnification, and thus may be manufactured to appear like ordinary spectacles.