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Retinal Imaging Laser Eyewear with Focus-Free and Augmented Reality

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Abstract

Retinal Imaging Laser Eyewear has a miniature laser projector inside the frame which provides the wearer with digital image information through the pupil using the retina as a screen. This compact universal-design eyewear features focus-free and augmented-reality image independent of the wearers' visual acuity and point of focus. This talk describes the background of this technology, the principle of focus-free imaging, the device with a trademark of RETISSA®, and its laser safety analyses based on international guidelines and standards.

1. Objectives and Background

The process of scanning laser light on the retina was first used by Webb et al. in 1980 [1] to develop the scanning laser ophthalmoscope (SLO). In the SLO, the laser beam is scanned two-dimensionally through the pupil of the eye onto some part of the retina, and the reflected beam passing back to the outside is detected allowing an image of the retina to be displayed. This technology has been adopted for fundus imaging and retinal function testing in ophthalmic applications [2,3]. Webb et al. also noted that when the input laser beam was modulated by a video source, the subject would see an image [1].

Based on this concept of scanning an image directly on the retina of the eye, the virtual retinal display (VRD) was invented at the Human Interface Technology Laboratory (HIT Lab) by Thomas A. Furness III in 1991 [4]. A tiny spot is focused onto the retina and is swept over it in a raster pattern. Instead of viewing a screen, the user has the image scanned directly into the eye. Two prototypes, a full-color bench mounted and a monochrome portable unit, were assembled with VGA (640 by 480) resolution image at 60 Hz in the '90s [5]. Using these prototypes, the HIT Lab studied virtual reality (VR) and augmented reality (AR) for visual interaction with environments [6,7] as well as a visual computer interface which enabled low-vision people to have higher visual acuity and reading speed [8].

In this talk, "Retinal Imaging Laser Eyewear" is presented as a universal-design compact eyewear, which has a miniature laser projector inside the frame and provides the wearer with digital image information through the pupil using the retina as a screen [9].

2. Results

The talk starts with studying the geometric optics of the Maxwellian view to project an image of the light source on the plane of pupil [10,11]. We illustrate that the retinal laser imaging under the Maxwellian view combined with a parallel and narrow RGB laser beam realizes focus-free feature, meaning picture clarity is independent of the wearer's focusing ability and point of focus. Then, we show a standard optics configuration of retinal laser imaging based on RGB lasers and a compact new optics of the Retinal Imaging Laser Eyewear RETISSA®.

Figure 1 shows the compact optics for Retinal Imaging Laser Eyewear with only one non-axisymmetric free-surface reflecting mirror. The free-surface mirror is designed to collimate the RGB semiconductor laser beam scanned by the MEMS mirror and to converge it in the center of the pupil, projecting an image through the pupil onto the human retina.

Figure 2 shows the prototype device with the trademark of RETISSA® [9] : (a) Eyewear and pocket-sized controller, and (b) inside optics. The eyewear is connected to the controller with a sealed line 4mm in diameter combining an optical fiber and electric lines. The controller includes an RGB laser combiner module, laser/MEMS controllers, an image processor, and a chargeable battery. The frame includes the projection unit consisting of the MEMS mirror package, the free-surface reflection mirror, and collimating optics. The free-surface reflection mirror and collimating optics form a parallel and narrow RGB laser beam with a diameter of 0.5 mm. The input to the controller is the HDMI signal of 1280×720×60 Hz (HD 720P). The laser beam modulated according to this signal is conveyed from the controller to the synchronized MEMS mirror via the optical fiber to scan the image. The ND filter attenuates each laser power to about 1 to 2 μW at the converging point.

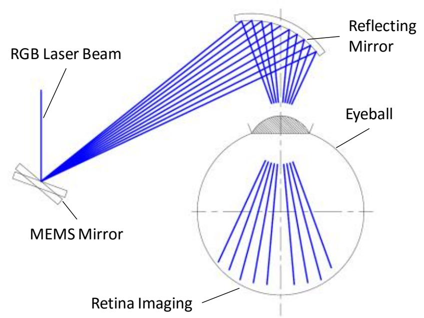
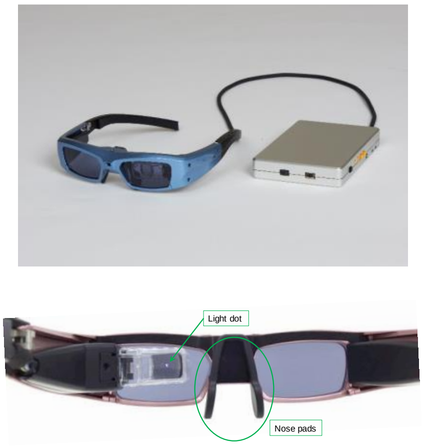


Figure 1 New compact optics of Retinal Imaging Laser Eyewear Eyewear with only one non-s¥asymmetric free-surface mirror



(a)

(b)

Figure 2 (a) RETISSA with a pocket sized controller and (b) inside optics.

This laser power assures that Retissa belongs to class 1 laser product, which is safe under all conditions of normal use. This means the maximum permissible exposure (MPE) cannot be exceeded when viewing a laser with the naked eye or with the aid of typical magnifying optics [12,13].

The wearer can enjoy laser scanned full-color image from a digital camera installed in the center of the frame as well as from a digital device connected to the controller via the HDMI connector. The weight of eyewear is 50g.

3.Originality and Impact

The features of Retissa is summarized as follows:

1. Focus free, i.e., image clarity is independent of individual focusing function and the focal position of the eye lens.
2. Universal design like normal correcting or sunglasses, owing to small optics inside the glasses frame,
3. Augmented reality, i.e., a digital image is augmented in the real-world environment, independent of the focal position of the wearer since the image is always clear on the retina.

To date, no other wearable devices have achieved these three features whether the devices are using VRDs or conventional liquid color displays [14-17]. These characteristics will enable RETISSA® to be used in a variety of application segments from low-vision aids, workplace support, retinal testing medical equipment, entertainment to the consumer-oriented smart glass.

A variety of activities and demonstrations will be provided in the symposium presentation, i.e., ongoing clinical study in Japan and Europe as low-vision aids using the focus-free feature [18], navigation surgery demonstration using augmented reality in the sense of not missing image while the surgeon concentrating on the operation field, the concept of novel retinal medical testing, and so on.

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