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The Virtual Retinal Display: A New Technology for Virtual Reality and Augmented Vision in Medicine.

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Abstract

Introduction: The Virtual Retinal Display (VRD) is a new technology for creating visual images. It was developed at the Human Interface Technology Laboratory (HIT Lab) by Dr. Thomas A. Furness III. The VRD creates images by scanning low power laser light directly onto the retina. This special method results in images that are bright, high contrast and high resolution. In this paper, we describe how the VRD functions, the special consequences of its mechanism of action and potential medical applications of the VRD, including surgical displays and displays for people with low vision. A description of its safety analysis will also be included. In one set of tests we had a number of patients with partial loss of vision view images with the VRD. There were two groups of subjects: patients with macular degeneration, a degenerative disease of the retina and patients with keratoconus. Typical VRD images are on the order of 300 nanowatts. VRD images are also readily viewed superimposed on ambient room light. In our low vision test subjects, 5 out of 8 subjects with macular degeneration felt the VRD images were better and brighter than the CRT or paper images and they were able to reach the same or better level of resolution. All patients with Keratoconus were able to resolve lines of test several lines smaller with the VRD than with their own correction. Further, they all felt that the VRD images were sharper and easier to view. The VRD is a safe new display technology. The power levels recorded from the system are several orders below the power levels prescribed by the American National Standard. The VRD readily creates images that can be easily seen in ambient roomlight and it can create images that can be seen in ambient daylight. The combination of high brightness and contrast and high resolution make the VRD an ideal candidate for use in a surgical display. Further, tests show strong potential for the VRD to be a display technology for patients with low vision.

1. Introduction

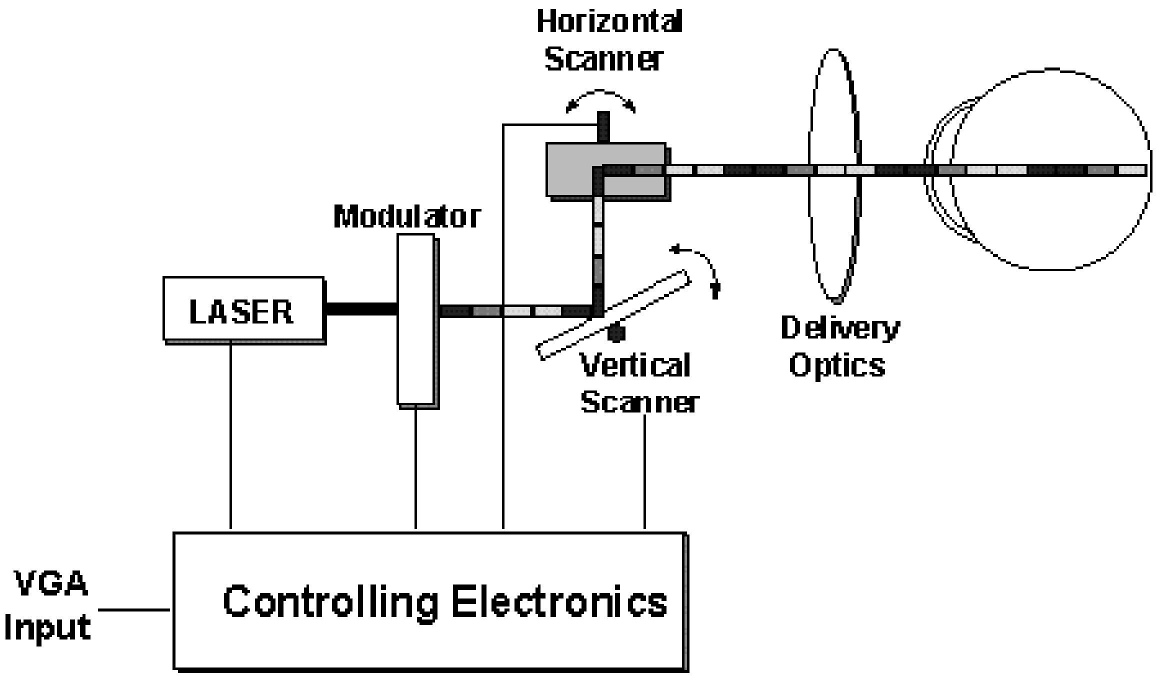
The Virtual Retinal Display (VRD) is a new technology for creating visual images. It was developed at the Human Interface Technology Laboratory (HIT Lab) by Dr. Thomas A. Furness III. The VRD creates images by scanning low power laser light directly onto the retina. This special method results in images that are bright, high contrast and high resolution. Current prototypes of the system produce full color images at a true 640 by 480 resolution.

The technologies of virtual reality (VR) and augmented reality (AR) are the new paradigm for visual interaction with graphical environments. The features of VR are interactivity and immersion. To achieve these features, a visual display that is high resolution and wide field of view is necessary. For AR a visual display that allows ready viewing of the real world, with superimposition of the computer graphics is necessary. Current display technologies require compromises that prevent full implementation of VR and AR. A new display technology called the Virtual Retinal Display (VRD) has been created. The VRD has features that can be optimized for the human computer interfaces.

The VRD is a visual display device that uses scanned light beams. Instead of viewing a screen, the user has the image scanned directly into the eye. A very small spot is focused onto the retina and is swept over it in a raster pattern. The VRD uses very low power and yet can be very bright. The technology has been developed such that the scanning element will cost only a few dollars in mass production. Low cost light sources, optics and controllers will make up the rest of the system. Ultimately, the overall device should be very inexpensive yet it will be small enough to mount on a spectacle frame.

The development of this device has been driven by the need for a ubiquitious display that is lightweight, full color and high resolution. In particular, the demands for displays for virtual environments and augmented vision are most pressing. In the past, virtual environments displays have been very heavy, low resolution and have a small field of view. To create compelling virtual environments, the opposite is needed. The demands of displays for augmented reality, where the computer graphics image is superimposed on the real world, include a bright, high contrast image, and color that is appropriate. For example, an augmented vision display for a surgeon, which might provide him anatomic navigation information, would need to be unobtrusive during most of the procedure, produce bright enough images to be seen under the lights of the operating theatre and have color matched images that correspond to what the surgeon is seeing. The special characteristics of images from the VRD may make it very useful for people with partial loss of vision.

Figure 1 is a block diagram of the VRD. Laser sources are introduced into a fiber optic strand which brings light to the Mechanical Resonance Scanner (MRS) (patent pending). The MRS is the heart of the system. It is a lightweight device approximately 2 cm X 1 cm X 1cm in size and consists of a polished mirror on a mount. The mirror oscillates in response to pulsed magnetic fields produced by coils on the system mounting. It oscillates at 15 KHz and rotates through an angle of 12 degrees. The high frequency of scanning allows the fine resolution in the images produced. As the MRS mirror moves, the light is scanned in the horizontal direction. Because the mirror of the MRS oscillates sinusoidally, the scanning in the horizontal direction has been arranged for both the forward and reverse direction of the oscillation. The scanned light is then passed to a mirror galvanometer or second MRS which then scans the light in the vertical direction.The horizontally and vertically scanned light is then introduced to the eye. The light can be sent through a mirror/combiner to allow the user to view the scanned image superimposed on the real world.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