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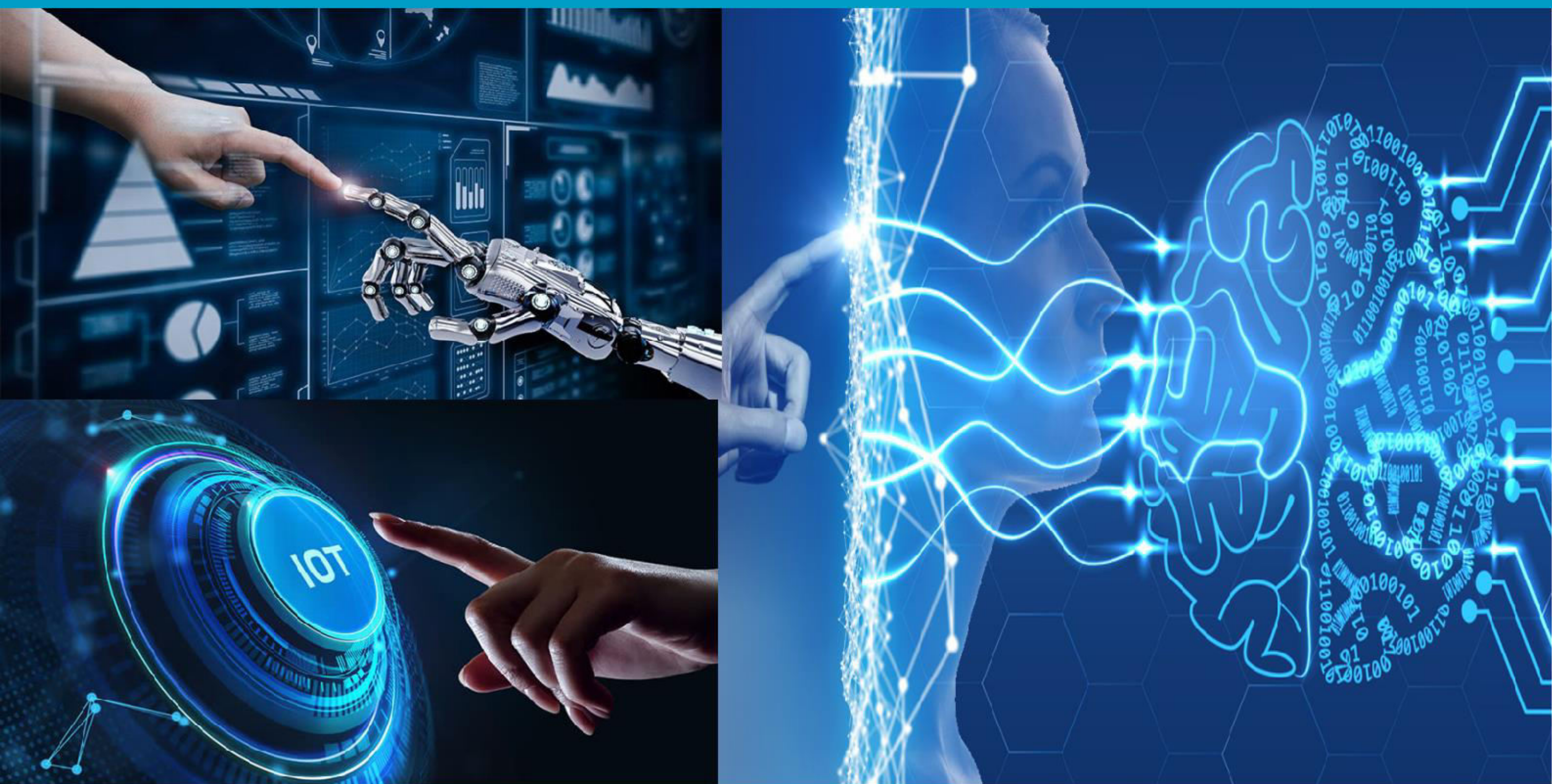

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Virtual Retinal Display

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ABSTRACT: The virtual retinal display (VRD) is a display system that generates images by scanning modulated laser light on the retina of the viewer's eye. The image is actually on the retina of the viewer's eye and not on the screen, despite the viewer's illusion that he is standing directly in front of a high resolution screen or projector. Similar to a regular CRT, the VRD scans an image one pixel at a time. The VRD receives video signals from a graphics card or video camera as an input, and then uses these data to modulate light from a light source—which may be a laser diode, a gas laser, or a light emitting diode—according to the intensity of each pixel.

A raterized image is created by the VRD by directly projecting a modulated beam of light (from an electrical source) onto the retina of the eye. The source image seems to the viewer to be visible from two feet away when seated in front of a 14-inch display. The retina of its eye, not a screen, is where the image is actually located. He or she is viewing an excellent-quality image with stereo vision, full colour, a large field of view, and no shimmering features.

I.INTRODUCTION

The new paradigm for visual engagement with graphical environments is represented by virtual reality (VR) and augmented reality (AR) technologies. Immersion and interactivity are characteristics of VR. A visual display with a high resolution and wide range of vision is required to achieve these features. A visual display that enables immediate real-world viewing and superimposes computer graphics is required for augmented reality. The limitations of current display technology preclude the complete adoption of VR and AR.

The Virtual Retinal Display (VRD), a novel display technology, was developed. The advent of virtual and augmented reality has seen a requirement for a display device which is more suitable for visual interaction. A wide field of view, which can be achieved in a pixel based display by either making a curved display or a curved lens, but this would just be increasing the cost which would just discourage this tech to take off commercially.

The VRD would scale down (to a great extent) the size of display while providing the higher quality picturealong with an immersive experience. It would alsooffer a more personal viewing experience which would be not just a luxury but a necessity in certain applications such as in surgical practices. So, what better way to view images than through the biological way in which eyes receive direct light from our surrounding environment.

The VRD technology uses scanned light beams projecteddirectly onto the retina. A small spot on the retina is focused on which the whole image is casted in theraster image form (array of color spaces but different from pixels). The production costs to develop the laser and optical systems will be inexpensive when mass produced. Affordable light sources, optics, and controllers make up the VRD system. The assembled piece ought to be compact enough to mount on a spectacle frame. In recent years, the use of personal computers in theworkplace has become prevalent. This ubiquity is apparentinallagegroups,eventheolder-agedones.Infact, 50.7 percent of American workers aged 50–59 years old and 32.6 percent of American workers 60 years old and over use a computer at work (1). A small but significant portion of computer users in the workforce are individuals with low vision, many that are in these older age groups. It is estimated that over 14,000 low-vision individuals are actively working in Washington State alone Individualswith poor vision required to work with computers can find thecurrentstandardinterface,a Cathode Ray Tube (CRT)monitor,ahindrancetotheirproductivity.

Adaptations made by low-vision individuals to thestandard computer interface may have limited effectiveness and can even reduce job performance. For example,pagenavigationwiththeuseofmagnifierscanmake screen navigation tedious, actually slowing reading speed and requiring a very large screen size (2). Inaddition to this, common practice of increasing image size on the retina by moving the eyes closer to the displayscreenisapoorlong-termsolution,because of the induced visual and musculoskeletal strain (3). An alternative approach to simple enlargement is a fundamentally different strategy that can provide increased visualacuity, hence requiring less magnification to read displayed text. A possible alternative visual interface is the virtual retinal display (VRD), which is initialretinallight-scanning system specifically intended for use as adisplay.The analysis serves two goals:(1)the evaluation of VRDasanalternativelow-visioncomputer interface and (2) to provide the theoretical motivationforimplementingtheVRD(aretinallightscanningdevice) in low-vision population. We compare theVRD with the CRT by utilizing visual acuity and test of readingspeed.

TheVirtual Retinal Display

Bright, high-contrast, and high-resolution images are formed by the VRD scanning modulated, low-power laser light directly on the retina. This technology is similar to that of the scanning laser ophthalmoscope (SLO) (4), but its main purpose is image presentation rather than image capture. The VRD accepts the standard (RGBcolor or monochrome) output of a computer and generates a raster-scannedimage similar to the CRT monitor.TheportableVRDused in this studyconvertstheVGA(redonly)videooutputofacomputerinto a signal that modulates the laser diode light source.The modulated beam of light (636 nm) is scanned horizontally(15.75kHz)andvertically(60Hz)bytwomirrors.
Alenssystem converges the raster-scanned beam to a 0.8-mmexit pupil. When the viewer aligns his or her eye at theexitpupil,thecollimatedbeamsofscanninglightcreatea virtual image that appears in the distance. A detailedexplanation of the Virtual retinal display (VRD) during early development at university of Washington is found in JohnstonandWilley(5).

Retinal Scanning Technology in Low Vision

Scanned laser light for use in low-vision research and rehabilitation has previously been considered advantageous by several authors (6–9). Laser sources, as used within the VRD, can produce images beyond the brightness and contrast of conventional displays, such as CRT and liquid crystal display (LCD). For example, miniature LCD displays used for purpose of a wearable low-vision aid, project inferior images in terms of contrast and brightness to compare with CRT (10). Since a scanned laser beam is capable of intensity beyond what is safe for human eye, VRD has been designed and shown (11) to produce images at safe levels, well lower than the maximum permissible exposure levels as defined by ANSI- and FDA-regulated standards. The capacity of a display to produce bright images is important for low-vision use. Cornelissenetal. (12) tested partially sighted individuals with a wide range of maladies and reported a noticeable improvement in visual acuity at greater illuminance levels.. Specifically, higher illuminations have been suggested to improve reading speed for patients with macular
degeneration(MD)(13).

II.RELATED WORK

[1] R. Robinson et.al[1] in this paper "TowardsWashington Virtual retinal display technology:Unrecognised and unregistered visual impairment."

Visual impairment is defined by the World Health Organization. This includes definitions about what constitutes visual impairment, such as legal blindness or partial blindness.There are numerous potential causes of vision deterioration, and they could include other causes as well. Infections and diseases are perhaps the most common causes. The leading causes of vision impairment and blindness are uncorrected refractive errors and cataracts. however, vision loss can affect people of all age.

[2] J.RLavery presenteda prospects of and challenges of VRD,Vision loss among the elderly is a major health care problem. Approximately one person in three has some form of vision-reducing eye disease by the age of 65. The most common causes of vision loss among the elderly are age-related macular degeneration, glaucoma, cataract and diabetic retinopathy. Age-related macular degeneration is characterized by the loss of central vision. Primary open-angle glaucoma results in optic nerve damage and visual field loss. .[4]

[3] M. Yap and J. Weatherillet.al[2]in this paper "Virtual retinal display technology:Causes of blindness and partial sight, equipped with strong capabilities. [7]

A retrospective review of the BD8 forms submitted for the period 1980–85 in the Bradford Metropolitan District was conducted to ascertain the incidence and causes of blindness and partial sight. A total of 1485 cases were registered in this period of which 755 (50%) were included in the Blind register and 730 (49.2%) in the Partially Sighted register. Age-related macular degeneration was the most important cause of visual handicap, accounting for 43.9% of all registrations, followed by glaucoma (16.2%), diabetic retinopathy (6.3%), myopic degeneration (6.1%), optic atrophy (4.4%), cerebrovascular disease (3.8%), cataracts (3.6%), retinal vascular occlusive disease (3.2%), corneal opacities

(3.0%), congenital anomalies (2.7%), retinitis pigmentosa/tapeto-retinal degeneration (1.9%), retinal detachment (1.8%) and others (3.1 %). The ratio of female to male registrations was 1.8:1. Eighty-four percent of this sample population was above 60 years of age at the time of registration.

[4]**J. Brabyn et.al[4] in this paper "Problems to be overcome in high-tech devices for the visually impaired."**

A portable demining kitto handle urgentsituationsFor the blind, numerous helpful technological apps have been created. Numerous other gadgets have been created remain on laboratory shelves; others again have experienced problems in achieving widespread acceptability due to such problems as training, maintenance, cost, human factors considerations, difficulty in production, and other factors. The present paper examines some of these factors in order to shed light on how such problems might be avoided or solved in the future. To date, more effort in high technology has been brought to bear on problems of the blind than those of the partially sighted, so examples are drawn from the former as well as the latter to illustrate thepoints made here.

Most blind people do not use amouse and they are not able to see the icons on the desktop. The company also needs to know enough about the two major screen readers so that they understand what is heard when clicking on an icon on the display. Manuals be available in accessible format when possible.[10]

[5] B. Collins and J. Silver et.al[5] in this paper "Recent experiences in the management of visual impairment in albinism."

Review of 100 albinism patients seen at Moorfields Eye Hospital's Low Vision Clinic over the course of four and two years. They fall under the category of "Partially-sighted" rather than "blind," and they are mostly young.

Clinical techniques are discussed, and the distribution of various loaned appliance kinds is surveyed. Low ametropia and emmetropia are uncommon in this population. Most patients use binocular systems and telescopic lenses for distance vision. In a clinical setting, more than half can see newsprint-sized print without additional magnification, yet they frequently choose to do so for particular tasks. With ageing, close vision aids become more necessary.

III.METHODS

Subjects

Our study included 13 individuals with poor vision, and was conducted at the Washington State Departmentof Services for the Blind (WSDSB). All subjects gaveapproved, informed consent. The 13 low-vision volunteers wererecruitedbytheWSDSBtocompriseavarietyof vision conditions. (All 13 individuals, exceptone,werein the workforce or enrolled in graduate school.Thesubjectsrangedinagefromgroup of 28 to59 years oldwitha mean age of 41.2 years old (SD=10.3). Each subjectwas surveyed regarding his or her vision history and cur-rent eye condition, and each survey was verified frompatientrecordsat WSDSB.

Materials andApparatus

Using the Landolt"C's," test, we evaluated visual acuity following the specification that the width of the "C" and thegap in the "C" are one-fifth the dimension of the height.The "C's" on the acuity chart had a variety of sizes of 4.7ºto0.3º,correspondingtoa20/1130to20/70visualacuityrange. While the subjects were seeing the VRD with red on black colour contrast and the CRT with white black colour contrast, acuity was measured. The VRD was set at itshigher light output power level, matching the CRT interms of retinalilluminance.

A unique reading speed test based on the Minnesota Low-Vision Reading test (MNRead™) (16) was used tocompare performance between the CRT and the VRD.Rather than implementing scrolled text or rapid serial visual presentation (RSVP) to overcome FOV constraints, we chose to design entire words that more closely simulated the selective reading involved in actual computing. The words were presented in an unrelated manner because Legge et al. (16) have demonstrated that reading pace of unrelated words correlates directly with normal sentence reading. Three words were shown to the subject at a time during testing: one five-letter, one four-letter, and one three-letter word. The three words were on three separate lines within the display field. The order (3-, 4-, or 5- letter) and placement (top, middle, bottom) were randomized. For each subject, no group of three words appeared together more than once. Individual words that appear repeatedly was rare (frequency ⌋1 percent). Lists of words were color video signal using a directly modulated laser diode (636 nm). A PC laptop computer produced the VGAnoutput at 640×480 resolution. Sans serif Arial type font was chosen, because it allowed more letters to fit on the portable display, which had a measured FOV of 33º horizontal by 26º vertical. The VRD can have a much wider FOV, but this particular version was calibrated with those parameters. During testing, subjects heads were maintained still using a chin rest that was created in the lab.

A 17-in. CRT (EIZ0 Flexscan TX-C7, Nanao Corp.) was used for the comparison testing. Its full white- screen luminance was 107 cd/m2. Spectrascan PR-650 spectrophotometer (Photo Research, Inc.) was used to test all luminance and illuminance levels.In addition, the spectrophotometer was used tomeasure the peak wavelength of the CRT red screen (628 nm) and the VRD (636 nm). Using a silicon diode optical meter (model 1835-C,NewportCorp.) the contrast and power levels for laser power were measured.

IV.RESULTS AND DISCUSSION

The results for 13 of 15 low-vision volunteers are reported here. Subject A4 requested to be withdrawn from the testing because of fatigue. Subject A14 was unable to locate the VRD exit pupil and maintain a stable image on the small functional portions of peripheral retina. Therefore, we removed these two subjects from thestudy. Although visual acuity can be a poor predictor ofreading speed (20), it can be a measure of non-readingperformance; for example, improved acuity may allowforfasterandmoreaccuraterecognition of graphical user interface icons. The increase in acuity shown by 6 of 13subjectsmaybeattributedtothe VRD'snarrowexitpupil, which has two effects. The first is that the collimated light at the exit pupil produces a large depth offocus.Theextendeddepthoffocusallowsretinalscanneddisplays like the SLO and VRD to remain unaffected bymoderate refractive errors in the eye.

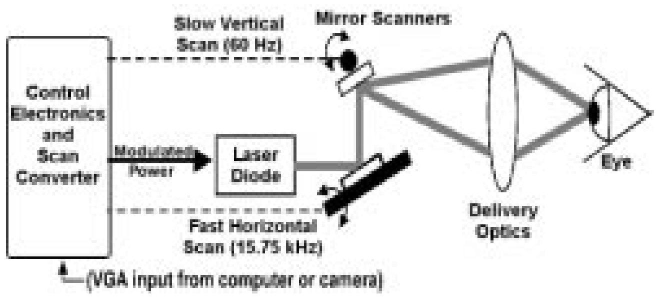

Fig:Schematicdiagramoftheportable VRD

Fig:Virtual retinal display

IV.CONCLUSION

Various strategic agencies have already begun collaborating with the VRD and with so much at stake, status reports on progress are not readily available. Nevertheless we can state that at this movement, all those engineers, fighter pilots and the people who are partially sightedare working with VRD will be struggling with different facets of the same problem.

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