Virtual Retinal Display

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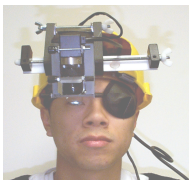
Outline

- Introduction
- How we perceive image
- VRD Technology Overview
- Safety Analysis
- Advantages
- Potential Applications
- Conclusion.

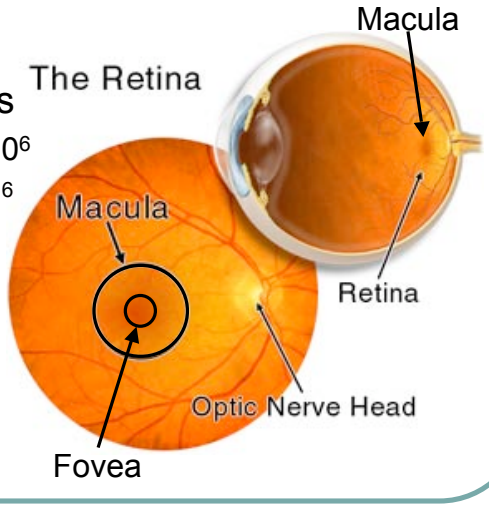
Introduction

- Virtual Retinal Display is a display technology which scans modulated laser light on the retina of viewer's eye to create an image.
- The viewer's perception & Virtual



How we perceive images

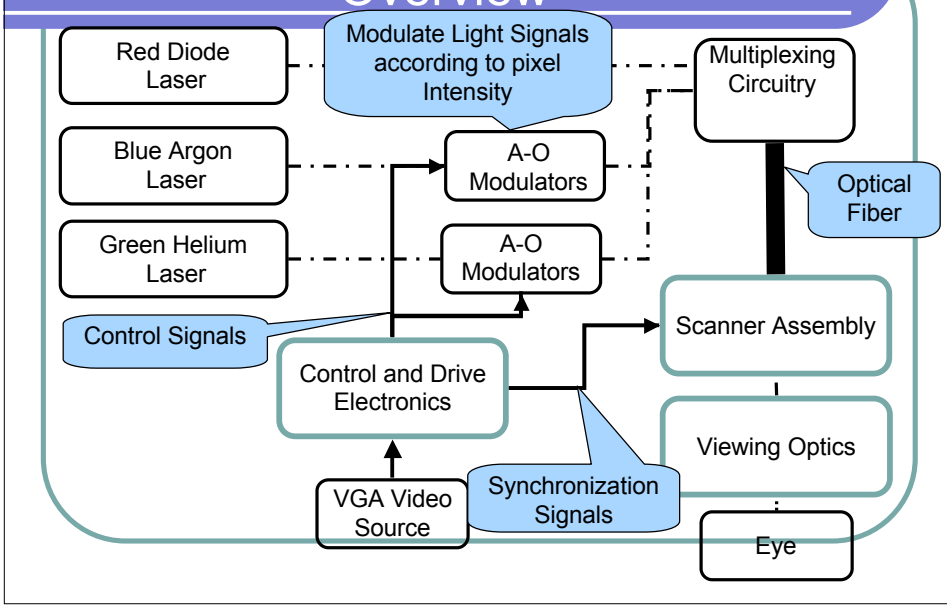
- Retina
  - Photoreceptors
    - Rods: 125 x 10^6
    - Cones: 6 x 10^6
  - Macula
    - Fovea



Virtual Retinal Display: Technology Overview

- System Description
  - Video Source
  - Control and Drive Electronics
  - Light Source
  - Scanner Assembly
  - Pupil Expander
  - Viewing Optics
- VRD with Eye Tracking

Virtual Retinal Display: Technology Overview



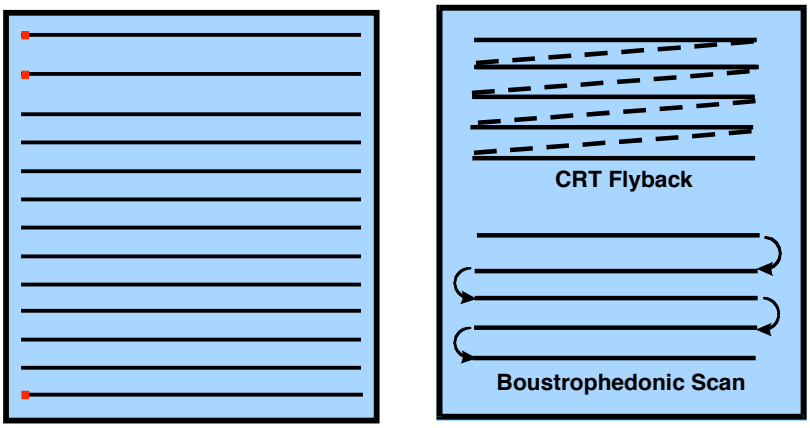
System Description

- Control and Drive Electronics:
  - Processing of input video signal.
  - Generation of control Signals for the acoust-optical modulators.
  - Synchronization of the vertical and horizontal scanner.
  - Overall system timing.

System Description (Light Source)

	Type	Wavelength[nm]	Optical Power[mW]
Red light source	Diode laser	650	3.0
Green light source	Helium-Neon	543.5	1.5
Blue light source	Argon laser	488	14.5

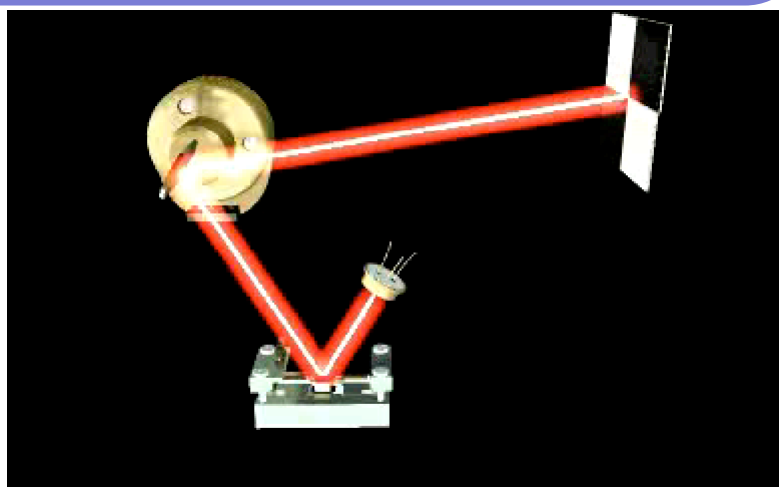
System Description :Raster Scanning



System Description:Scanner Assembly

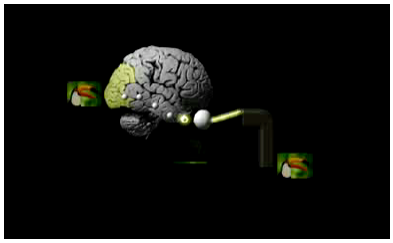
- Horizontal Scanner
  - Mechanical Resonant Scanner (MRS) :
    - Operating frequency = 15.75 KHz ~18.9 KHz
    - Contain neither moving magnet or moving coil.
    - Torsional spring and mirror configuration with mirror (3mm X 6mm).
  - MEMS (Micro Electromechanical System)
- Vertical Scanner
  - Galvanometer with a second mirror (60 Hz).
- Constraints: Resolution, field of view or image size

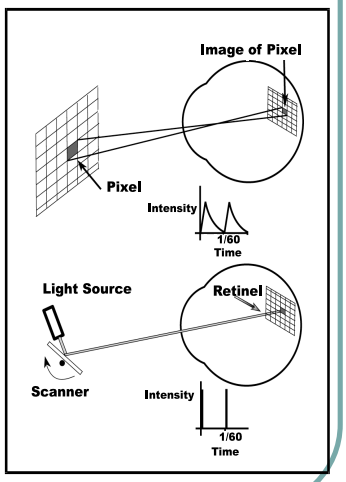
System Description:Scanner Assembly



System Description: Perception

- CRT Methodology :
  - Phosphorous persistence
- VRD Methodology:
  - How ? Visual Cortex

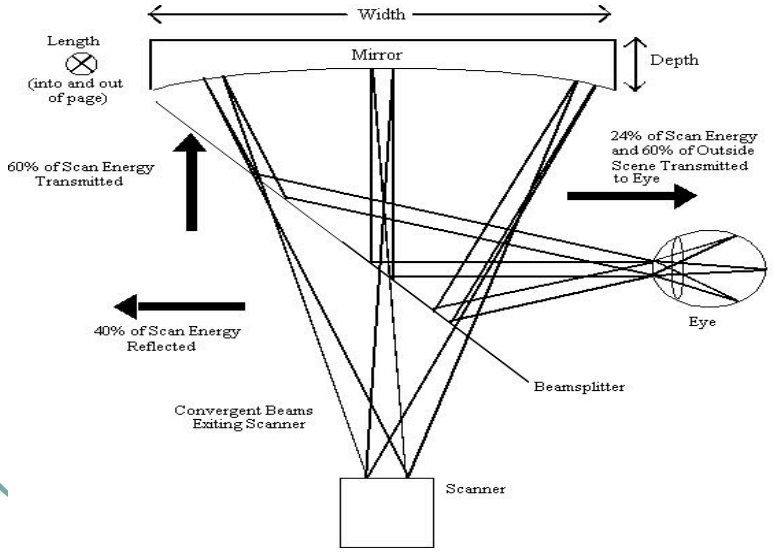




System Description

- Viewing Optics
  - Exit pupils
  - Photodetector.
  - Contain special assembly for occluded or augmented vision

System Description: Viewing Optics



The VRD With Eye Tracking

- A map of landmarks (fovea, optic nerve) of retina is generated.
  - Unmodulated Light reflected from the retina is monitored.
  - Changing content of reflected light is sampled at the sampling rate.
  - Scanner position at the time of each sample is used to correlate the position of sample.
  - Sample position and the content represent a map.

The VRD With Eye Tracking

- Relative position of landmarks is used to track the viewing direction of eye.
  - Relative position of generated map or pattern will vary according to the viewing direction.
  - By identifying the pattern and correlating relative orientation of pattern to referenced pattern orientation, viewing direction is determined at the current instant

Safety Analysis

- Maximum Permissible Exposure (MPE)
  - The level of exposure or irradiance which can be thought of as the theoretical border between safe and potentially harmful.
  - The output power of VRD is in the range of [100-300] nano watt.
  - Worst case analysis is performed to check the safety bounds. ANSI Z136.1 (8 hour continuous exposure, sweep time for each pixel= 40 nano sec, frequency=60 Hz)

Safety Analysis

Source Used	MPE in watts
MPE for Pulsed Lasers	0.13watt
MPE for Continuous Wave Sources	0.16watt
MPE for extended Sources	1.05×10^{-3}watt

TAB. 1 – MPE For Different Sources

Wavelength(nm)	MPE microwatts
400-550	0.385
600	2.17
640	8.62
670	24.29
700	68.47

TAB. 2 – MPE Values as a Function of Wavelength in case of Scanner Failure

Comparison of Energy levels

Stimulus	Brightness measurements CRT ($Cd\ m^{-2}$)	CRT (nW)	VRD (nW)
Blue 1	25.68	314	133
Blue 2	50.54	618	199
Green 1	29.91	366	59
Green 2	48.91	598	83
Red 1	18.49	226	249
Red 2	11.39	139	210
White 1	35.30	432	173
White 2	22.17	271	124

Advantages

- Color range: High saturated pure colors
- Luminance and Viewing Modes (60nW ~ 300nW)
  - See through mode (Augmented mode)
  - Occluded mode.
- Contrast Ratio:
- Power Consumption:
- Cost:

Applications: Head Mounted Displays

- Common Characteristics: NOMAD

Resolution	SVGA 800 x 600 pixels
Field of View	23 degrees x 17.25 degrees (equivalent to 17-inch monitor at arms length)
Display Color	Monochrome red
Grey Levels	32 shades of gray
Refresh Rate	60 Hz
User Controls	4-button keypad

TAB. 3 – Some Common Characteristics of VRD based HMDs

Applications: Head Mounted Displays

- NOMAD
  - Commercial purposes:
  - Defense purposes

Resolution	SVGA 800 x 600 pixels
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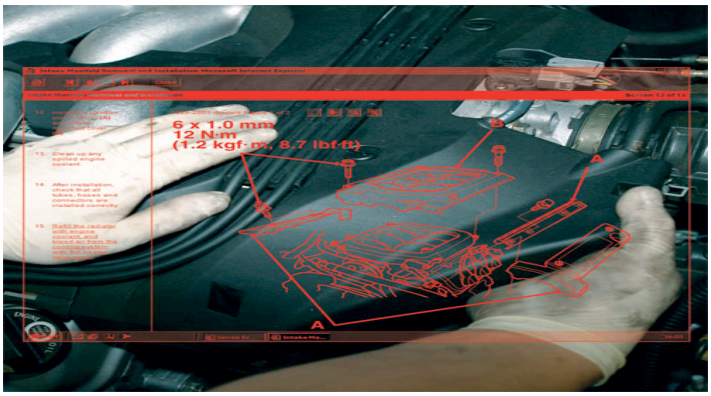
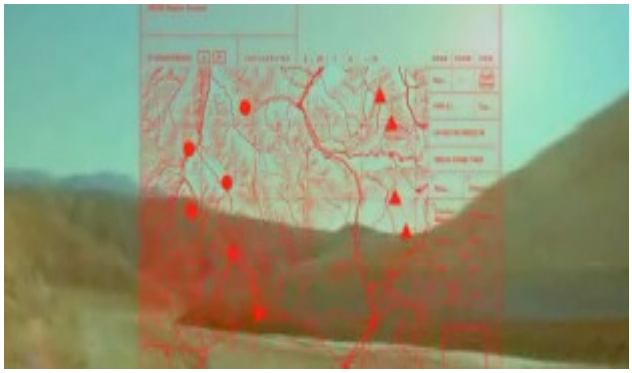
- Commercial Purposes:



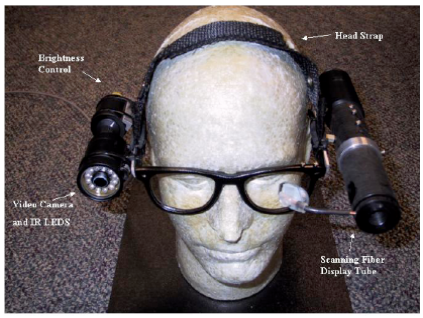
Applications: Head Mounted Displays

- Defense Purpose:



Applications : Low Vision Aid

Get Input From Camera → Apply machine Vision Algos to detect Obstacles → Input to VRD with Enhanced Information



Applications: Low vision Aid

Applications: Interactive VRD

- Pilot's Dilemma : Spent about 50% time while looking down on the navigational scales to identify their locations which causes serious hazards.

Applications :

- Automotive Industry : Superimposed maps on driver's view
- Medical: To aid image guided surgery.
- Consumer Products:

Conclusion

- Sufficient amount of work still left
  - Color displays
  - Size
  - Resolution limitations
  - Stereo displays.
  - Detailed safety analysis
- Current research issue
  - MEMS based one scanner for both horizontal and vertical scanning.

Questions: ?

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[2] Richard S.Johnston, Stephen R.Willey, Development of a Commercial Virtual Retinal Display, Proceedings of Helmet- and Head-Mounted Displays and Symbology Design,2-13,1995.

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[7] Head-up Display, http ://www.microvision.com/hud.html

[8] US patent EP1053499, Virtual retinal display with eye tracking