Biomechatronic Systems

Unit 6: Visual Prostheses

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Introduction

“... According to a 2014 World Health Organization (WHO) report, about 39 million people worldwide are totally blind, and a further 246 million are visually impaired.

To date, the most successful and widely used visual prosthesis for the blind is the white cane.

High-tech devices have been on the market for many years but appear to lack utility and consequently are not as widely used ...”
Visual System: Anatomy and Physiology

- Sclera
- Choroid
- Retina
- Fovea centralis
- Optic nerve
- Central artery and vein of the retina
- Optic disc (blind spot)

- Ciliary body
- Ciliary zonule
- Cornea
- Iris
- Pupil
- Aqueous humor (in anterior segment)
- Lens
- Scleral venous sinus (canal of Schlemm)
- Vitreous humor (in posterior segment)
Visual System: Anatomy and Physiology

Source: Google Images
Electromagnetic Spectrum

Source: kullabs.com
Photoreceptor Cells
Sensitivity to light intensity

![Graph showing sensitivity to light intensity with peak at 507 nm and 555 nm wavelengths.]

Ellips 56w WhiteMoonlight

HPS 250w

Source: Google Images
Visual Impairments

Source: Google Images
Visual Impairments

- Refractive Errors (light is not focused properly)
  - Myopia (nearsightedness)
  - Hyperopia (farsightedness)
  - Astigmatism (cornea not perfectly shaped)
  - Presbyopia (farsightedness due to aging)

- Cataract (clouding of the lens)
- Glaucoma (increased pressure of the fluid inside the eye)
- Amblyopia (or lazy eye, one eye has worse vision than the other)
- Keratoconus (cornea begins to bulge into a cone shape)

- Age-Related Macular Degeneration (gradual damage to the cells of the macula)
- Diabetic Retinopathy (damage to the blood vessels of the retina caused by diabetes)
- Retinal Detachment (tear in or detachment of the retina)
Visual Orthosis

Source: Google Images
Refractive Errors

Myopia

Hyperopia

Astigmatism

Source: Google Images
Causes of Blindness

- Cataracts
- Glaucoma
- Diabetic Retinopathy
- Macular Degeneration (MD)
- Retinitis Pigmentosa (RP)
- Accidents
- Cancers
Sonar-based Visual Prostheses

Source: Google Images
Sonar-based Visual Prostheses

- Computation of free path
- Optional audio signal
- Optional tactile signal
- Earphones
- Skin stimulator
- Ultrasonic sensors

Source: Google Images
Laser-based Visual Prostheses

Smart glasses to help partially sighted people
Oxford University under the lead of Stephen Hicks is developing smart glasses that can boost vision for partially sighted people

1. Infra-red laser beams out hundreds of spots of light
2. Infra-red camera picks up reflecting spots from objects
3. Camera with specially designed software interprets the nearby surroundings
4. Screen in glasses
   The glasses add a simple image on a screen of who or what is around to augment the wearer's existing vision

Distant objects appear less bright
Close objects appear brighter
Near objects
Visual Implants

Video camera
NIR (900 nm) image projection system in video goggles

Processed image on LCD
pulsed IR illumination

NIR (900nm) beam

Subretinal photodiode array
NIR image on the retina

Source: Google Images
Visual Implants

Epiretinal Implant
Electrode
RGC
Amacrine Cell
Bipolar Cell
Horizontal Cell
Cone
Rod
Subretinal Implant

Retina
Epiretinal Implant
Subretinal Implant
**Visual Implants**

**Novel strategies for retinal stimulation.**
Photothermal stimulation *(left)* requires photo-absorber that absorb light energy and transfer it to heat, which in turn activates the cells in their near vicinity. Photovoltaic stimulation *middle* requires photoresponsive surfaces inducing capacitive stimulation upon light absorption and charge generation. In ultrasonic stimulation *right*, ultrasonic waves are transmitted into the eye and interfere to create a projected pattern for exciting retinal neurons.

Published online 2015 Aug 20.

*Retinal prostheses: progress toward the next generation implants*
By: Diego Ghezzi
Visual Implants

1. Camera on the patient's glasses captures a scene.
2. Video sent to a portable processor.
3. Video converted to data and sent back to the glasses.
4. The data is wirelessly transmitted to an array of electrodes that are part of the retina implant.
5. The electrodes transform the information into electric impulses stimulating the retina to produce images.

Source: secondsight.com