DEPARTMENT OF COMPUTERSCIENCE

PRESENTATION

ON

BIONIC EYE

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ABSTRACT

Here, we present a description of a block scheme, specific features of design and results of testing for a prototype of a bionic eye, types of them and its applications. The bionic eye is intended to provide vision, partially to the visually impaired by use of the modern day electronics devices like CCD cameras. The bionic eye comprises a computer chip that sits in the back of the individual's eye, linked up to a mini video camera built into glasses that they wear. Images captured by the camera are beamed to the chip, which translates them into impulses that the brain can interpret. Although the images produced by the artificial eye were far from perfect, they could be clear enough to allow someone who is otherwise blind to recognize faces. The paper discusses the differences working methodologies used in each of them. During the tests and the clinical trails, this device made six blind people to regain their vision partially. The potential advantage of using bionic eye is to be able to remove the blindness completely by making the advances in the present research and improving manufacturing technologies. This break through is likely to benefit approximately one crore world population who suffer from the most common causes of blindness, Retinitis Pigmentosa, Macular Degeneration. The implant bypasses the diseased cells in the retina and stimulates the remaining viable cells. This is a revolutionary piece of technology and really has the potential to change people's lives. But we need to be aware it is still some way in the future.

INTRODUCTION

A visual prosthesis or bionic eye is a form of neural prosthesis intended to partially restore lost vision or amplify existing vision. It usually takes the form of an externally-worn camera that is attached to a stimulator on the retina, optic nerve, or in the visual cortex, in order to produce perceptions in the visual cortex.

These experimental visual devices are modeled on the cochlear implant or bionic ear devices, a type of neural prosthesis in use since the mid 1980s. These are an externally-worn microphone and processor that is attached to a stimulator in the cochlea, auditory nerve, in order to produce sound perception in the auditory cortex.

Scientific research since at least the 1950s has investigated interfacing electronics at the level of the retina, optic nerve, thalamus, and cortex. Visual prosthetics, which have been implanted in patients around the world both acutely and chronically, have demonstrated proof of principle, but do not
yet offer the visual acuity of a normally sighted eye

The ability to give sight to a blind person via a bionic eye depends on the circumstances surrounding the loss of sight. For retinal prostheses, which are the most prevalent visual prosthetic under development (due to ease of access to the retina among other considerations), vision loss due to degeneration of photoreceptors (retinitis pigmentosa, choroideremia, geographic atrophy macular degeneration) is the best candidate for treatment. Candidates for visual prosthetic implants find the procedure most successful if the optic nerve was developed prior to the onset of blindness. Persons born with blindness may lack a fully developed optical nerve, which typically develops prior to birth.

Visual prosthetics are being developed as a potentially valuable aide for individuals with visual degradation. The visual prosthetic in humans remains investigational.

Need for the BIONIC EYE:

It has been shown that electric stimulation of retinal neurons can produce perception of light in patients suffering from retinal degeneration. Using this property the eye and make uses of the functional cells to retain the vision with the help of electronic devices that assist this cells in performing the task of vision, we can make these lakhs of people get back their vision at least partially. A design of an optoelectronic retinal prosthesis system that can stimulate the retina with resolution corresponding to a visual acuity of 20/80—sharp enough to orient yourself toward objects, recognize faces, read large fonts, watch TV and, perhaps most important, lead an independent life. The researchers hope their device may someday bring artificial vision to those blind due to retinal degeneration.

ACTUAL EYE SYSTEM

Our ability to see is the result of a process similar to that of a camera. In a camera, light passes through a series of lenses that focus images onto film or an imaging chip. The eye performs a similar function in that light passes through the cornea and crystalline lens, which together focus images onto the retina—the layer of light sensing cells that lines the back of the eye.

Once stimulated by light, the cells within the retina process the images by converting their analog light signals into digital electro-chemical pulses that are sent via the optic nerve to the brain. A disruption or
malfunction of any of these processes can result in loss of vision.

How an Artificial Retina Works

Normal vision begins when light enters and moves through the eye to strike specialized photoreceptor (light-receiving) cells in the retina called rods and cones. These cells convert light signals to electric impulses that are sent to the optic nerve and the brain. Retinal diseases like age-related macular degeneration and retinitis pigmentosa destroy vision by annihilating these cells.

With an artificial retina device, a miniature camera mounted in eyeglasses captures images and wirelessly sends the information to a microprocessor (worn on a belt) that converts the data to an electronic signal and transmits it to a receiver on the eye. The receiver sends the signals through a tiny, thin cable to the microelectrode array, stimulating it to emit pulses. The artificial retina device thus bypasses defunct photoreceptor cells and transmits electrical signals directly to the retinas remaining viable cells. The pulses travel to the optic nerve and, ultimately, to the brain, which perceives patterns of light and dark spots corresponding to the electrodes stimulated. Patients learn to interpret these visual patterns.

The U.S. Department of Energy Artificial Retina Project is funding an effort to develop an implantable microelectronic retinal device that restores reading ability, facial recognition, and unaided mobility in people with retinitis pigmentosa and age-related macular degeneration. Developed with funding from this program, the Argus II retinal implant from Second Sight is currently undergoing clinical testing in Europe.
The Bionic Eye System

The entire system runs on a battery pack that's housed with the video processing unit. When the camera captures an image -- of, say, a tree -- the image is in the form of light and dark pixels. It sends this image to the video processor, which converts the tree-shaped pattern of pixels into a series of electrical pulses that represent "light" and "dark." The processor sends these pulses to a radio transmitter on the glasses, which then transmits the pulses in radio form to a receiver implanted underneath the subject's skin. The receiver is directly connected via a wire to the electrode array implanted at the back of the eye, and it sends the pulses down the wire.

When the pulses reach the retinal implant, they excite the electrode array. The array acts as the artificial equivalent of the retina's photoreceptors. The electrodes are stimulated in accordance with the encoded pattern of light and dark that represents the tree, as the retina's photoreceptors would be if they were working (except that the pattern wouldn't be digitally encoded). The electrical signals generated by the stimulated electrodes then travel as neural signals to the visual center of the brain by way of the normal pathways used by healthy eyes -- the optic nerves. In macular degeneration and retinitis pigmentosa, the optical neural pathways aren't damaged. The brain, in turn, interprets these signals as a tree and tells the subject, "You're seeing a tree."

It takes some training for subjects to actually see a tree. At first, they see mostly light and dark spots. But after a while, they learn to interpret what the brain is showing them, and they eventually perceive that pattern of light and dark as a tree.

The first version of the system had 16 electrodes on the implant and is still in clinical trials at the University of California in Los Angeles. Doctors implanted the retinal chip in six subjects, all of whom regained some degree of sight. They are now
able to perceive shapes (such as the shaded outline of a tree) and detect movement to varying degrees. The newest version of the system should offer greater image resolution because it has far more electrodes. If the upcoming clinical trials, in which doctors will implant the second-generation device into 75 subjects, are successful, the retinal prosthesis could be commercially available by 2010. The estimated cost is $30,000.

Researchers are already planning a third version that has a thousand electrodes on the retinal implant, which they believe could allow for facial-recognition capabilities

**ASR Device**

Optobionics’ Artificial Silicon Retina microchip was invented by Dr. Alan Chow and his brother Vincent Chow. Dr. Chow is an ophthalmic surgeon and assistant professor and his brother Vincent is an electrical engineer. The ASR was designed to stimulate damaged retinal cells from within the retina to allow the cells to recreate visual signals that are processed and sent to the brain. The ASR microchip is a silicon chip 2 mm in diameter, 25 microns in thickness and is less than the thickness of a human hair. It fabricated using technology similar to that used in the fabrication of computer chips and contains approximately 5,000 microscopic solar cells called “microphotodiodes,” each with its own stimulating electrode.

In retinas with retinal degeneration, these micro photodiodes convert light energy contained in images into electrochemical impulses that stimulate the remaining retinal cells. The ASR microchip is self-contained, powered solely by incident light and does not require the use of external wires, batteries, headsets or ancillary computers.

When surgically implanted under the retina—in a location known as “sub retinal space”—the ASR chip is designed to produce visual signals similar to those produced by the photoreceptor layer. From their sub retinal location, these artificial “photoelectric” signals from the ASR microchip can induce visual signals in the remaining functional retinal cells which may are then processed and sent via the optic nerve to the brain.

In initial laboratory testing, animal models implanted with ASR devices responded to light stimuli with retinal electrical signals (ERGs) and sometimes brain-wave signals (VEPs). The induction of these biological signals by the ASR chip indicated that visual stimulation had
occurred. Based on these studies, the FDA approved the conduct of clinical trials in collaboration with several university and VA medical centers that began in June 2000. These centers included the Hines, Cleveland and Atlanta Veterans Administration Medical Centers, Rush University Medical Center, Johns Hopkins Wilmer Eye Institute and Emory University Medical Center.

Argus Retinal Prosthesis

2nd Sight Medical has just received USFDA investigational device exemption (IDE) to begin clinical trials for their Argus II Retinal Prosthesis System. Incase you haven't been following Second Sight, their retinal prosthesis uses an array of electrodes to stimulate the retina, restoring a low level of vision in patients with degenerative diseases. Their first implant had 16 electrodes, the new Argus II has 60...

The Argus II implant consists of an array of electrodes that are attached to the retina and used in conjunction with an external camera and video processing system to provide a rudimentary form of sight to implanted subjects. An IDE trial of the first generation implant (Argus™ 16), which has 16 electrodes, is ongoing at the Doheny Eye Institute at the University of Southern California. The Argus 16 was implanted in six RP subjects between 2002 and 2004 and has enabled them to detect when lights are on or off, describe an object's motion, count
discrete items, as well as locate and differentiate basic objects in an environment. Five of these subjects are now using their Argus 16 retinal prostheses at home.

The next generation Argus II retinal stimulator is designed with 60 independently controllable electrodes, which should provide implanted subjects with higher resolution images. Second Sight remains the only manufacturer with an actively powered permanently implantable retinal prosthesis under clinical study in the United States, and the technology represents the highest electrode count for such a device anywhere in the world.

**Implantable Miniature Telescope**

Currently the smallest telescope in the world, the implantable miniature telescope (IMT), invented by Dr. Isaac Lipshitz, has roughly the diameter of an apple seed. It can be seen balanced on a fingertip. Though not yet FDA approved, the device was helped two out of three patients achieve a three-line or better improvement on eye chart tests in a recent trial.
In this picture of an IMT before it is implanted into an eye, the structure of the device can be seen. Through the front window, one of the tiny glass lenses is visible.

This artist's rendering of the IMT at work shows how the device redirects light entering the eye away from the macula -- the spot on the back of the eye that is damaged in patients suffering from age-related macular degeneration. By aiming this light at healthy cells within the eye, the patient is able to better view objects in the middle of their field of vision. The tiny telescope is nestled within the capsular bag -- the natural structure designed to hold the lens. A side view of the IMT in the eye of a patient. The blue ring around the telescope is a light restrictor, which is necessary to block excess light from entering the eye and fouling the image created by the device. A cut-away side view of the IMT. Here, the intricate series of lenses can clearly be seen. Researchers who have studied the lens say it may offer the best chance yet of restoring vision to patients who have suffered from severe age-related macular degeneration in both eyes.

Virtual Retinal Display

This technology describes how the source image is projected directly onto the retina.
The VRD technology eliminates any screen outside of the eye and addresses the retina with a single stream of pixels. The retina has no persistence like phosphorus. Moreover, there is no flickering and the produced image is very bright with very high resolution. The time each pixel is projected onto the retina is very small (30-40ns). Furthermore, these devices consume very little amount of energy. They also provide a wider field of view.

The VRD was invented at the University of Washington in the Human Interface Technology Lab (HIT) in 1991. The development began in November 1993. Using the VRD technology it is possible to build a display with the following characteristics:

* Very small and lightweight, glasses mountable
* Large field of view, greater than 120 degrees
* High resolution, approaching that of human vision.
* Full color with better color resolution than standard displays
* Brightness sufficient for outdoor use
* Very low power consumption
* True stereo display with depth modulation
* Capable of fully inclusive or see through modes. A very sophisticated representation of how the beam is projected through the pupil can be found in the HIT Lab of Washington University (VRD animations).

**CONCLUSION**

- It's been 40 years since Arne Larsson received the first fully implanted cardiac pacemaker at the Karolinska Institute in Stockholm.
- Researchers throughout the world have looked for ways to improve people's lives with artificial, bionic devices.
- Bionic devices are being developed to do more than replace defective parts.
- Researchers are also using them to fight illnesses.
- Providing power to run bionic implants and making connections to the brain's control system pose the two great challenges for biomedical engineering.
- We are now looking at devices like bionic arms, tongues, noses etc.
- Hence the success of any technology depends not on what it promises to
achieve but on what it is actually able to deliver.

BIBILOGRAPHY

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