An Overview - Artificial Eye (Bionic Eye)

K. Pradeep, K. Vasantha Kokilam and C. Sunitha

Abstract--- *India is now home to the world's largest number of blind people. In 37 million people across the globe 15 million blind people are from India. 75% of these are cases of avoidable blindness. On the other hand, while India needs 2.5 lakh donated eyes every year, the country's 109 eye banks in which 5 located in Delhi manage to collect a maximum of just 25,000 eyes, 30% of which can't be used. Meanwhile, shortage of donated eyes is becoming a huge problem. In 15 million blind people in India, three million that is 26% of whom are children who suffer due to corneal disorders. But only 10,000 corneal transplants are being done every year because of shortage of donated eye. The bionic eye aims to restore basic visual cues to people suffering from eye diseases such as retinitis pigmentosa, which is a genetic eye condition .A video camera fitted to a pair of glasses will capture and process images. These images are sent wirelessly to a bionic implant at the back of the eye which stimulates dormant optic nerves to generate points of light (phosphenes) that form the basis of images in the brain. Thus even blind people can have vision.*

Keywords--- *Bionic Eye, Artificial Silicon Retina, Implantation*

I. INTRODUCTION

BIOTECHNOLOGY has become the fastest-growing area of scientific research, with inventions of new devices. Technology has done wonders which help the mankind. prosthetics use to help overcome handicaps. A training system called brain port is letting people with visual and balance disorders bypass their damaged sensory organs and instead send information to their brain through the tongue. Now, a company called second sight has received FDA approval to begin U.S. trials of retinal implant system that gives blind people a degree of vision.

II. THE HUMAN EYE

We are able to see because light from an object can move through space and reach our eyes. Once light reaches our eyes, signals are sent to our brain, and our brain deciphers the information in order to detect the appearance, location and movement of the objects we are sighting at.

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The whole process, as complex as it is, would not be possible if it were not for the presence of light. Without light, there is no world.

The human eye is the organ which gives us the sense of sight, it allows us to learn about the surrounding world than any of the other senses.

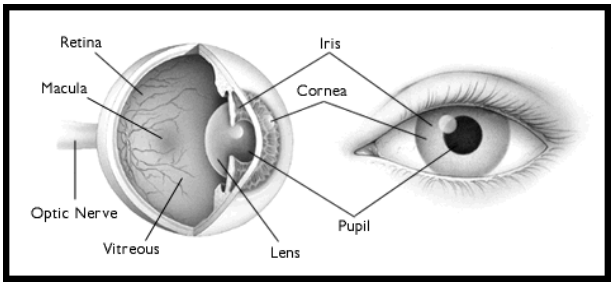

Fig. 1: How Human Eye Works

The eyeball is present in a protective cone-shaped cavity in the skull called the orbit or socket and measures approximately one inch in diameter. The orbit is covered by layers of soft, fatty tissue which protect the eye and enable it to turn easily. The important part of an eye is retina.

The retina lies at the back of the eye and it acts as though the film in a camera act by receiving and processing everything. [1]

III. THE BIONIC EYE

Bionic Eye is an artificial eye which provokes visual sensations in the brain by directly stimulating different parts of the optic nerve. Bionic eye consist of electronic systems which consist of image sensors, processors, receivers, radio transmitters and retinal chips.[2] There are also other experimental implants that can stimulate the ganglia cells on the retina or the visual cortex of the brain itself.

Technology paved way through a bionic eye to allow blind people to see again.

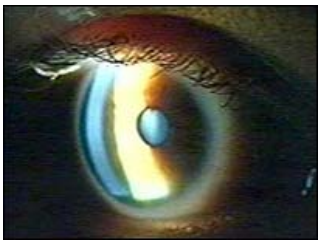

Fig. 2: Bionic Eye

It comprises a computer chip which is kept in the back of the individual's eye, linked up using a mini video camera built into glasses that they wear. Images captured by the camera are

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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 recognise faces. The breakthrough is likely to benefit patients with the most common cause of blindness, macular degeneration, which affects 500,000 people.[4]

This occurs when there is damage to the macula, which is in the central part of the retina where light is focused and changed into nerve signals in the middle of the brain. The implant bypasses the diseased cells in the retina and stimulates the remaining viable cells.

IV. WORKING OF THE BIONIC IMPLANT

A bionic eye implant that could help restore the sight of millions of blind people could be available to patients within two years.

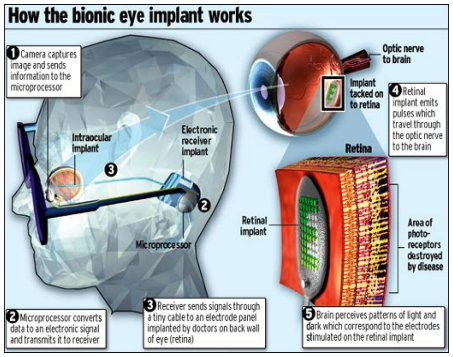

Fig. 3: How the Bionic Eye Implant Works

This device is 2 millimeters across and contains some 3,500 micro photodiodes which is placed behind the retina, this collection of miniature solar cells is designed to convert normal light to electrical signals, which are then transmitted to the brain by the remaining healthy parts of the retina. A Belgian device has a coil that covers around the optic nerve, with only four points of electrical contact. By shifting the phase and varying the strength of the signals, the coil can stimulate different parts of the optic nerve, rather like the way the electron guns in TVs are aimed at different parts of the screen. The video signal senters from an external camera and are transmitted to the implant through a radio antenna and microchip under the skin just behind the ear. Implants of a microchip, smaller than the head of a pin and about half the thickness of a sheet of paper were used to remove blindness.[3]

The eye-position monitor controls the image camera's orientation. If the image-acquisition camera is not mounted on the head, compensation for head movement will be needed. Finally, if a retinal prosthesis is to receive power and signal input from outside the eye via an IR beam entering the pupil, the transmitter must be aligned with the intraocular chip. The beam has played two roles: one is to sends power, and another is to send pulse - or amplitude - modulated to transmit image data. Using the control of eye movement, the main imaging camera for each eye can swivel in any direction. Each of these cameras--located just outside the users' field of view to avoid blocking whatever peripheral vision they might have captures the image of the outside world and transmits the information through an optical fiber to a signal-processing computer worn on the body.

The Argus II system uses a spectacle-mounted camera which is used to send information to electrodes in the eye. Patients who tested less-advanced versions of the retinal implant were able to see light, shapes and movement.

The function of Bionic eye is to take real-time images from a camera and convert into tiny electrical pulses that help the blind eyes to see.

1: Camera which is implanted on glasses helps to view the image.
2: Signals are sent to hand-held device
3: The information which processed is sent back to glasses and wirelessly transmitted to receiver under surface of eye.
4: Receiver sends information to electrodes in retinal implant.
5: Electrodes stimulate retina to send information to brain

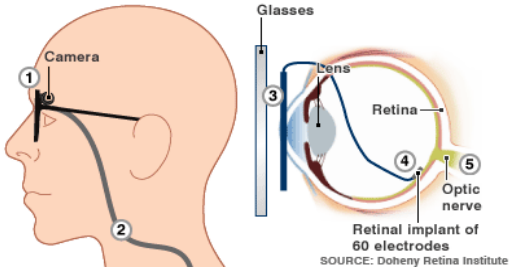

Fig. 4: Retinal Implant

Retinal implants can partially restore the vision of people with particular blindness caused by diseases such as macular degeneration or retinitis pigmentosa. About one and half million people worldwide have retinitis pigmentosa, and one in ten people over the age of fifty five have age-related macular degeneration. Both diseases cause the retinal cells which process light at the back of the eye to gradually diminish.[5]

The new device invented work by implanting an array of tiny electrodes into the back of the retina. A camera is used to capture pictures which consist of a processing unit about the size of a small handheld computer and worn on a belt helps to convert the visual information into electrical signals.

These are then sent back to the glasses and wirelessly on to a receiver just under the surface of the front of the eye, which in turn feeds them to the electrodes at the rear.

- *Growing Dots*

First-generation, low-resolution devices have already been fitted to six patients.

- *Brain Change*

The new implant has a higher resolution than the earlier devices, with 60 electrodes.

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V. RETINAL PROSTHESIS SYSTEM

Fig. 5: Second Sight

Second Sight Medical has just received USFDA Investigational Device Exemption (IDE) to begin clinical trials for their Argus II Retinal Prosthesis System.

At Second Sight, their retinal prosthesis uses an array of electrodes to stimulate the retina. It restores a low level of vision in patients with degenerative diseases. Their first implant had sixteen electrodes; the new Argus II has 60 electrodes.

The Argus II implant consists of an array of electrodes that are attached to the retina and used 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 sixteen electrodes, is ongoing at the Doheny Eye Institute at the University of Southern California. The Argus 16 was implanted in six Patients between 2002 and 2004 and has enabled them to detect when lights are on or off, recognize an object's motion, count items, as well as locate and differentiate basic objects in the surrounding.[6]

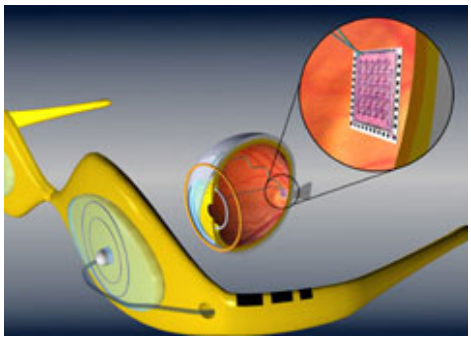

Fig. 6: Argus II

The next generation Argus II retinal stimulator is designed with 60 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.

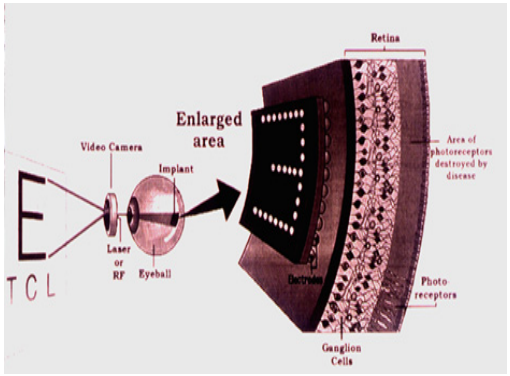

Fig. 7: Working of Artificial Eye

Fig. 9: Artificial Eye

VI. CERAMIC PHOTOCELLS

Scientists at the Space Vaccum Epitaxy Centre (SVEC)[9] based at the University of Houston, Texas, uses a new material, comprising tiny ceramic photocells that detects incoming light and repair malfunctioning human eyes. Scientists at SVEC are conducting preliminary tests on the biocompatibility of this ceramic detector. The artificial retinas constructed by SVEC consist of 1,00,000 tiny ceramic detectors, each1/20th the size of a human hair. The assemblage is so small that surgeons can't safely handle it. So, the arrays are attached to a polymer film one millimeter in size. After insertion into an eyeball, the polymer film will simply dissolve leaving only the array behind after a couple of weeks.[8]

ADVANTAGES

- It helps to correct the vision.
- There is no necessity to suffer from long and short sights.
- It can be easily implanted
- It is the one approved by FDA

DISADVANTAGES

- There are 120 million rods and 6 million cones in the retina of every healthy human eye.
- Creating an artificial replacement for these is a risky task.
- Si based photo detectors have been tried in earlier attempts. But Si is toxic to the human body and reacts unfavorably with fluids in the eye
- it cost about 30,000$
- It will not be helpful for glaucoma patients.

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VII. CONCLUSION

Restoration of sight for the blind is no more a dream for people today. Bionic Eyes have made this true. Though there are a number of challenges to be faced before this technology reach the common man, the path has been laid. This paper has tried to present the concept of Artificial Vision called “Bionic Eyes”. It is just a matter of time, may be 4-5 years that the blind will be able to see through these Bionic Eyes, with thanks to Science and Technology.

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