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ARTIFICIAL RETINA

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Abstract: *In this world, there are many people who are visually impaired. Although, they have got eye gears for rectification, but for the completely blind people we don't have any alternative option. So, in this research paper, we are going to discussed about implant system where a video camera captures images, a chip processes the images and an electrode array transmit the images to the brain. It's called* ***Cortical Implants.*** *This paper gives an overview of various retinal implant techniques in channelizing the subjects vision through artificial intelligence and if it is commercialized, it becomes the potential device for the blind subjects to see and interpret the colorful world.*

Keywords: **Retinitis pigmentosa (RP) and age-related macular degeneration (AMD), sub-Retinal Implant, Epi-Retinal Implant, Artificial Eye.**

1. Introduction

The science has done several wonders to the mankind. We always have seen prosthetics which helped in overcoming handicappers. Biomedical engineers play an important role in shaping the course of the pros-the tics. Now Artificial vision provides us bionic eyes that is very helpful for the visually impaired persons. It cannot be possible by a single person, yet all Bio-medical, Computer, Electrical, or Mechanical Engineers –have a vital role to do this. Now, every blind person is blessed with this excellent technology. This is a great revolution in the field of medical & science technology.

2. How Retina works

The eye is one of the most important organs in human body. To understand the functionality of artificial vision, let's first see the role of Retina.

- Firstly, the scattered light comes from the object and enters into the Cornia.
- Then it is sends to the brain via optic nerve.
- The brain read the image thoroughly and understand it.

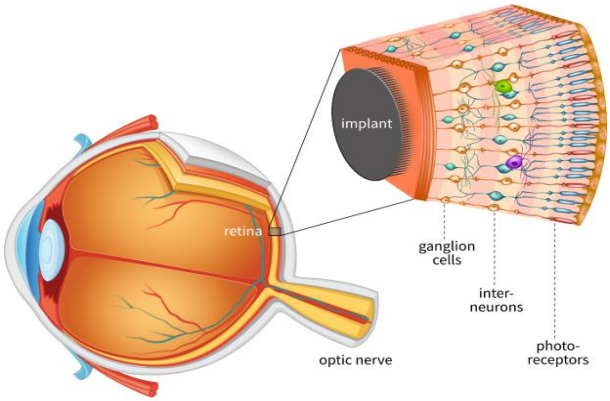

Fig 1: Structure of Human Eye

Retina is very important part of human eye. It placed at the back of the eye. It sends and receives data to the brain. There are three main cells in an eye that helps retina to do its functionality-

- Rods
- Cones
- Ganglion cells

3. What happens when light strike the eye?

The rods and cones are received the information and sends them to the ganglion cells. There are about 1 million ganglion cells in Human eyes. The main function of these cells is to interpret the messages and send them to immediately to the brain.

There is some retinal illness that outbreak these cells, which are the reason of blindness. Some most common eye diseases are **retinitis pigmentosa (RP)** and **age-related macular degeneration (AMD)**. Both of these diseases attack the retina, due to which either loss of peripheral vision or complete blindness occur. However, these diseases neither affects the ganglion cells nor the optic nerve. So, if we develop the artificial rods and cones, information could be transmitted to the brain.

If we channelize the functional cells to hold the vision with the help of electronic devices that support these cells in performing the task of vision. Thus, we can make partially vision for the patients so that they can face yourself towards object, recognize others, read

newspaper, watch TV and perhaps they can lead an independent life.

What is Artificial eye?

Artificial Intelligence (AI) means human intelligence in machines so that they think and work as a human. *Artificial eye* means a lab generated eye that we can used to fixed at visually impaired or damaged eye.

AI provides a great direction to the medical science. The first successful automated systems for healthcare were made in early 1970s. Stanford University (Buchanan and Shortliffe, 1984), developed a system called MYCIN. It was failure because of its weak performance.

4. Structure of Bionic Eye

Bionic eye can regenerate the lost vision which is also known as *retinal implant*. This device helps the blind to see the things around them. It is an experimental device that restores functional vision. It generally looks like an externally-worn camera that is close to a stimulator on the retina, optic nerve, or in the visual cortex, in order to manufacture perceptions in the visual cortex. Bionic eye works as an artificial eye does. It has image sensors, processors, radio-transmitters, radio-receivers and the retinal chip connected together in a single domain. This is a tiny device that can be placed at retina. Since the device is a silicon-based chip that delivers stimulation, which decodes radio signals. This signal transmits to the retinal ganglion cells, after that optical nerve then to brain.

Argus II (A Second-generation device) is a 60-electrode array with a small receiver. It is fixed around the eye and surgically implanted onto the retina. The electrode array is sending electrical signals to the brain. It does not only send but also receive visual data. For this, the patient has a pair of glasses with a tiny video camera that captures all data. This data is sent wirelessly to a computer which filters and processes the video signal to the electrode array.

The Argus II Retinal Prosthesis System can provide vision to that persons who are suffering from eye diseases like *macular degeneration and retinitis pigmentosa*. These diseases disable the eyes' cones, rods and retina that distinguish light patterns and pass them on to the brain in the form of nerve impulses, Here, these are then decoded as images. The ArgusII system is a substitute of the photoreceptors. It consists of:

- **Digital-Camera**: It is fixed into a pair of glasses. It captures the images and sends them to a microchip.
- **Video processing Microchip:** Its catalysis images (captured by digital camera) into electrical impulses that represents the light and dark patterns.
- **Radio-Transmitter**: It transmits the impulses into a receiver wirelessly.
- **Radio-Receiver:** It sends impulse to the retinal implant.
- **Retinal-Implant**: it is a chip with 60 electrode array that measures 1 mm by 1 mm.

The whole system is controlled by a battery pack and images are in the form of **light** and **dark** pixel patterns. These images are video processed and converted into the 3d structured patterns and are decrypted to artificial "light" and "dark" patterns. These pulses transmit to a radio transmitter situated on the glasses, then it is transmitted to a receiver implanted in the patient's skin. The receiver and electrodes are connected to each other and sends the pulses to the brain. Thus, these impulses are then interpreted by the brain and a message is displayed about the object.

5. Working

When the light falls on the cones & rods and interpreted by the retina through optic nerves, we can see the things. For this, Optical signals are changed into electric pulses and transmitted through to the brain through optic nerve. Retinal diseases like *Age Related Macular degeneration (AMD)* and *retinitis pigmentosa (RP)* weak these cells and destroy them. With the help of bionic eye, a small camera captures the images and sends them to a micro controller unit. Here, data is converted into electronic signal and re-transmit it to a receiver on the eye. The receiver transmits them to the microelectrode array, where pulse emission generated. In this way, the artificial retinal device avoids default photoreceptor cells and transmitted as electrical signals directly to the retina's remaining workable cells. These signals send to the brain through optic nerves and brain obtained light and dark patterns according to the signals. Patients learn these visual patterns. They are not habitual for this. so, they need some time to understand that patterns. Researchers are going to deploy a third version in which thousands of electrodes will be available on the retinal implant and people can reads and recognize facial impression.

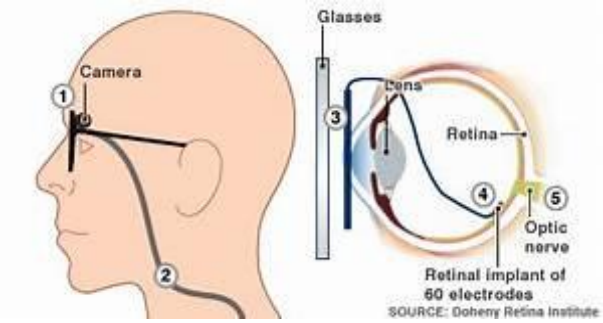

Fig 2: Function of Retinal Implant System

Epi-Retinal Implants

An Epi-retinal implant is a microchip or a tiny computer device that is surgically placed on the retinal surface, on the nerve fiber layer, directly stimulating ganglion cells. It inspires the light receptors present in the retina to restore eye-vision. Retina sends all the electronic signals to the brain.

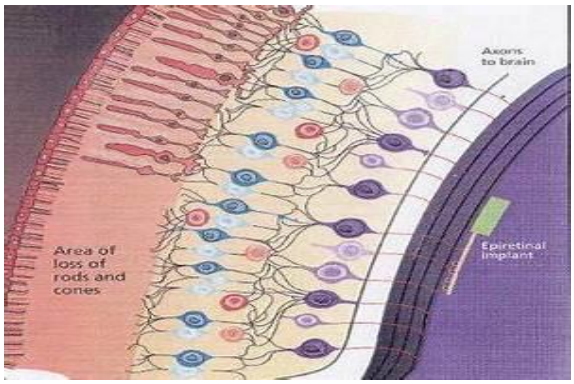

Fig 3: Epi-Retinal System Implant

The technical problems occur in the design of the retinal encoder is:

- Bio-Compatibility
- Chip development
- RF Telemetry and power systems

5.1 Bio-Compatibility:

For the retinal implant production, all the materials must be bio-compatible and also corrosion resistant.

- The electrodes are connected to the nerve cells, such that the electronic current can pass through the photo elements into the tissue.
- Technology should be developed by micro-electronics.
- The used materials should be completely biologically and compatible with the nervous system and should not be harmful for the human body.

5.2 Chip-Development:

Encoder Epi Retinal –

To make Encoder Epi Retinal, is not an easy task. The design of this encoder is much more complex than the sub retinal encoder, because it has to feed the ganglion cells. Here, an Epi retinal encoder is placed in the retina. A retina stimulator and retinal ganglion cell layer are near to each other and connected to a no. of retinal ganglion cells.

5.3 RF-Telemetry:

The wireless RF telemetry system works as the transport channel b/w the Retinal Encoder and the retinal stimulator. A basic semiconductor technology is used in production of a power and the signal receiving chips that initiatives current & stimulates the retinal neurons. There should not be any contact between heat dissipating devices and the retina.

Sub Retinal Implants:

In Retinitis pigmentosa disease, the retinal pigment epithelial cells (RPE) destroyed and the person starts losing the vision gradually. Subretinal implant works as a substitute of RPE cells. In this implant, a *micro photodiode array (MPD), a silicon manufactured device,* or *semiconductor micro photodiode array (SMA)* is used. All these apparatuses are positioned behind the retina between the sclera and the bipolar cells. The incident light ray is transformed into electrical potentials that encourage the bipolar cells to make an image.

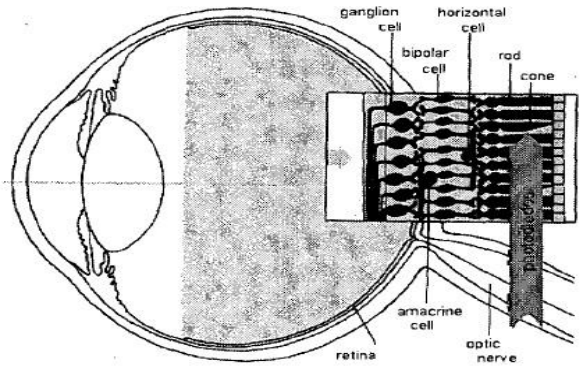

Fig 4: Structure of replacement of lost photoreceptors by a MPDA in the subretinal space.

6. Advantages

- This technology is very helpful for those who are suffering from AMD and individual RP.
- This technology can improve quality of life of blind people.

- There is no any surgical processor.
- There is not any battery implanted in the body.

7. Disadvantages

- Not helpful for Glaucoma patients.
- There is no useful for those people who are blind by birth.
- Implantation is complex and costly.

8. Challenges

- There are lots of difficulties in this technique because human eye is one of the most sensitive technology of our body. A small error can create disorder in the eye.
- In eye, there are millions of rods and cones and making a replacement for these cells is not so possible.
- In Bionic eye, Photo detector are made of Silicon and Silicon is toxic to our body & reacts negatively with visual eye fluids.
- There is a doubt as how the brain will respond to that signals generated by artificial light sensors.
- There is a big challenge is that how the implant will react in the eye for decades without causing scarring, immune system responses, and general degradation from daily usage.
- These artificial retinas are not so feasible because they are too expensive, too heavy, and too delicate for an ordinary person.

9. Conclusion

This is an innovative and revolutionary technology and really has the potential to change people's lives. Bionic Eye is such a boon for medical field. No field in medical science has been scientifically blessed as much as retina in recent years. Retinal diseases are spread widely and people are getting lost their vision but now it is the good news for them. About 1.5 million people around the globe have retinitis pigmentosa, and 1/10 people (above 55) have age related macular degeneration. This invention can help those people. In spite of the pros & cons of this system, if this system is fully developed it will change the lives of millions of people around the world. We might not restore the vision completely, but by this technology they can at least find their paths, recognize faces, read books, and lead an independent life as they want.

10. References

1. Bionic Eye: What does the future hold" by Jack Kerouac.
2. "A Bionic Eye comes to market" by Kurzweil Al.
3. "Ashley Hall, "Diamond shines as basis for bionic eye prototype", ABC News, December 09, 2010.
4. Sahana Satish, "Artificial Vision – A Bionic Eye", Scribd, 2010.
5. Australian Research Council, "Bionic Eye", Retina Australia (Qld).
6. "Bionic Eye Technology: An Advanced Version of Artificial Vision", Academia, Volume 2, Issue 7, July, 2012.
7. "Artificial eye" https://www.seminarsonly.com/electronics/Artificial%20Eye.php
8. Kosta Grammatis, Rob Spence, "Building the bionic eye; Hacking The human", Future of Journalism conference.
9. "Doe Technologies Drive Initial Success of Bionic Eye", Artificial Retina News, U.S. Department of Energy office of Science, 2009.
10. Praveenkumar Narayana, Guhan Senthil, "Bionic Eye Powered by Nanogenerator", Singapore.

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