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A Study on Bionic Eye Technology

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***Abstract*: Globally the number of people of all ages who are visually impaired are estimated to be 2.2 billion out of which 1 billion are estimated to be blind. Most of them blind due to eye diseases such as macular degeneration and retinitis pigmentosa which cannot be corrected by using lenses. Blind people are forced to live their entire life in darkness and are unable to fulfill their dreams. Even though braille script helps them read there should be an efficient solution for their agony. In the present era of advancing technologies, gadgets such as bionic eye provide aid and enhance the life of blind. This paper is a study on how bionic eye technology can bring a revolutionary change in the life of blind people.**

***Keywords*: Macular degeneration, Retinitis pigmentosa, Braille script.**

1. Introduction

The word 'bionic' was coined by Jack E. Steele which is a portmanteau from biology and electronics. These are devices which are created by engineers to help physically challenged people do chores like normal people. Bionic eye is one such device that was made intending to help the blind who lost their vision due to diseases like macular degeneration or retinitis pigmentosa. These are diseases that affect the retina of the eye due old age causing vision impairment. Even normal treatment procedures cannot cure people with such a disease. This is where bionic eye comes in for help. As we all know that no technology can be a replacement for human eye. Human eye has a very complex structure and is also one of the 5 sense organs. It allows light perception, color vision and depth perception. It helps us visualize the things around us. Mimicking the human eye is a difficult but not impossible. Over past decades mankind has shown skill in developing technologies beyond imagination which made life easier. Research on human eye is the one continuing for years. Bionic eye that is available at present is still at a very early stage in its development. But if we are successful it will bring back sight to those who are blind.

2. Overview of human eye

A human eye can distinguish up to 10million colors. It is not a perfect sphere but a fused 2-piece unit consisting of a posterior and anterior segment. Light enters the eye through cornea, passes pupil and then lens. The part of the eye that is connected to the brain is the called retina. Retina consists of 2 types of photoreceptors- Rods (provide vision during dim light) and Cones (provide vision during bright light). The photoreceptors convert light to electrical signals and send them to brain via optic nerve. The optic nerve is made up of ganglionic cells or nerve cells.

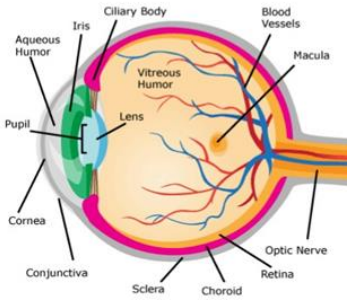

Fig. 1. Human eye


Fig. 2. Optic nerve connected to the brain

3. Parts of Bionic Eye

As we discussed earlier, bionic eye is a visual prosthesis that help blind restore functional vision. These devices consist of both exterior and interior components. The exterior components are simply fixed on patient's body while interior components are implanted by means of surgery.

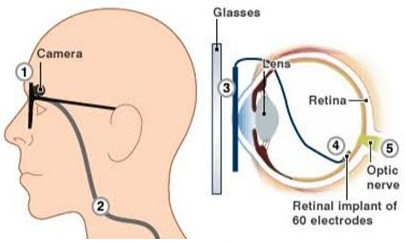

Fig. 3. Parts of bionic eye

The exterior components are a pair of sunglasses, video camera and connection wires. The interior component is a retinal implant as shown in the figure. The pair of sunglasses is used to hold the video camera in straight position. The video camera contains powerful lenses to capture the external environment in the form of a video which is then send to the retinal implant by means of connection wires. The retinal implant is a device that converts the data obtained by the camera to an electrical impulse and transfers them to the optic nerve because the retinal cells are not able to do their function.

There are 2 types of retinal implants:

a) Epiretinal implant: Implants that are placed in the internal surface of retina.
b) Sub-retinal implant: Implants that are placed between the outer retinal layer and the retinal pigment epithelium.

The retinal implant consists of 60 electrodes to increase the speed and efficiency of the device. The implant is usually a semiconductor chip with 2mm diameter and 1/1000 inch in thickness.

4. Evolution of Bionic Eye

Years of research in the field of bionics has led to creation of many bionic eye systems. Some of the recently developed devices are: Artificial Silicon Retina (ASR) and Multiple-unit Artificial Retina Chipset (MARC) system. Artificial Silicon Retina (ASR) is silicon chip that contains approximately 3,500 microscopic solar cells called microphotodiodes. Each photodiode has its own stimulating electrode. These photodiodes convert light energy from the images and convert them to electrical impulses and then send them to the brain via optic nerve. The device is powered by charging of solar cells using the light that enters the eye.

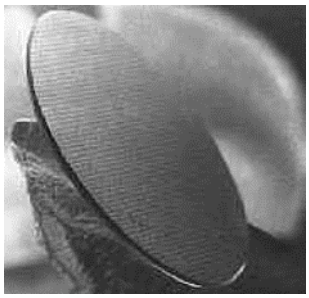

Fig. 4. Enlarged image of ASR

Multiple-unit Artificial Retina Chipset (MARC) is a device that replaces the function of defective photoreceptors in the eye. This device consists of a transmitter and receiver module. The transmitter module is kept outside the patient's body which sends the data on external environment. The receiver module receives the data and stimulates the electrodes in the retinal implant. The retinal implant is fixed on the inner wall of retina by using cyanoacrylate glue. The data transfer between transmitter and receiver modules is obtained by means of RF telemetry coils. The operating power is also obtained during this transfer.

5. Reliability of the device

A patient who obtains this device will not have the same vision as that of a normal person. They can only differentiate between light and darkness or a flickering light. This vision that consists of light and dark dots is called phosphene vision. As the number of electrodes used in this device increases, better the quality of the image seen by the patient. The graph in Fig.5 shows the relationship between number of electrodes and quality of the vision.

One of the major challenges researchers face is that the retinal cells respond differently for different visual inputs due to its complex structure. There is also quite a bit of difficulty carrying the device even though it is integrated to a pair of glasses. Also over stimulation of retinal cells may lead to blurred outlines and indistinct shapes.

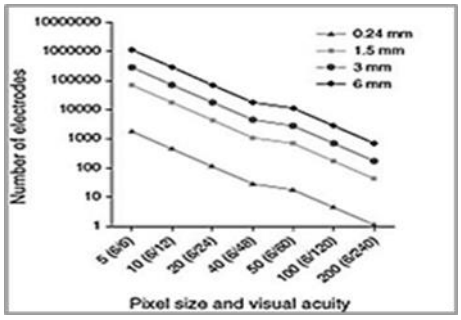

Fig. 5. Number of electrodes versus pixel size graph

Fig. 6. (shown below) clearly explains how the change in number of electrodes in an array varies the number of pixels in a phosphene image. As the number of pixels available increases, the image is more identifiable to the user.

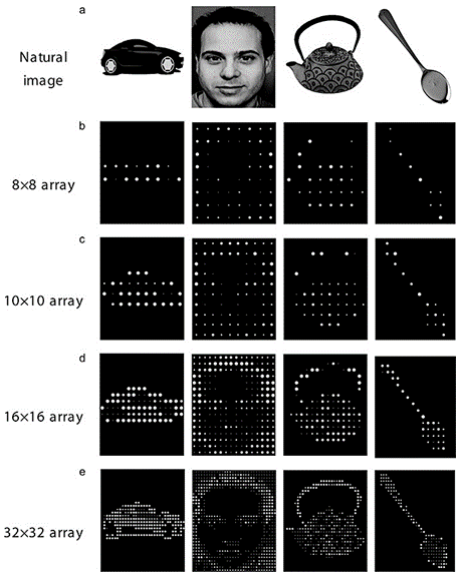

Fig. 6. How bionic eye user see the above objects

6. Conclusion and Future Scope

Engineers are searching better ways to implement this device to bring a much clear and identifiable image to patients. The founder of Argus II retinal prosthesis system Wentai Liu said" *More the microchips you have higher the resolution of the image. Eventually the ability to see colors can be added*". Also researches are going on to identify the probability in implementing a camera inside the eye! This is to reduce the size of this device and increase its efficiency. Let us hope that the upcoming discoveries in this field will bring a better reliable device than the present ones.

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