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A Review Paper on Bionic Eye

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Abstract

Human birth is the most prized birth among all kinds of existence. The human body is crucial to living a fulfilling life. The most priceless organ in the body, the eyes plays a crucial role in seeing or providing vision. Millions of people are unable to appreciate nature's splendor. They are completely sighted. The greatest number of blind individuals reside in India. In 2000, 18.7 million blind people were thought to be living in India. According to estimates, there would be 24.1 million blind people in India by the year 2010 and 31.6 million by the year 2020. The bionic eye is an excellent visual aid that can help blind people realize their dream of seeing the wonders of nature. It is a visual prosthesis that gives blind patients with various conditions either full or partial vision restoration. This paper provides an overview of the fundamental construction and operation of the bionic eye, vision through the bionic eye, implants, sight restoration, restrictions, and the bionic eye's potential in the future.

Introduction

Imagine, how you would feel if suddenly you lost your vision, you can't see anything and you knew there was nothing that you could do about it. This is a reality for thousands of people. So for these people, researchers are developed bionic eye.

Bionic Eye, Bio Electronic eye, is a device that can provide sight detection of light. Implantable bionic eyes are used to replace real eyes. Depending on which eye or prototype they are using, they employ various forms of technology. A bionic eye is surgically implanted into a human eye to allow for the conversion of light into electronic signals for people who have sustained severe damage to the retina or other eye diseases[1].

The idea of bionic is invented at Monash University in Melbourne. Australia has built the first bionic eye that promises to bring back vision with the help of a brain implant. More-advanced technologies developed since then have been used in newer models implanted into patients whose vision was affected by various eye disorders like macular degeneration, and retinitis pigmentosa. More-advanced technologies developed since then have been used in newer models implanted in patients whose vision was affected by retinitis pigmentosa. Scientists at Bionic Vision Australia (BVA) surgically implanted a prototype of the bionic eye in 54-year-old Dianne Ashworth, who suffers vision loss due to retinitis pigmentosa.

Researchers said the bionic eye technology relies on the patient having a healthy optic nerve and a developed visual cortex. They expect the bionic eyes to have the greatest benefit in people with retinitis pigmentosa, macular degeneration, and other eye disease.

Need

According to WHO at least 2.2 billion people in the world have a near or distant vision impairment. In these cases, almost half of, vision impairment could have been prevented or has yet to be addressed. These 1 billion people include those with moderate or severe distance vision impairment or blindness due to unaddressed refractive error (88.4 million), cataracts (94 million), age-related macular degeneration (8 million), glaucoma (7.7 million), diabetic retinopathy (3.9 million), as well as near vision impairment caused by unaddressed presbyopia (826 million). To overcome such problems bionic eyes are developed. we can make these lakhs of people get back their vision at least partially. There is hope for all the blinds in the form of Bionic Eyes.

Theoretical background

1. Overview of the human eye

Before the study of the bionic eye, we should have known about the human eye. The eye of a human being is like a camera. Much like the electronic device, the human eye also focuses and lets in light to produce images. So basically, light rays that are deflected from or by distant objects land on the retina after they pass through various mediums like the cornea and lens.

There are various parts of the human eye such as the Pupil, Eris, Cornea, Sclera, Lens, Retina, Macula, and Optic nerve as shown in the figure.

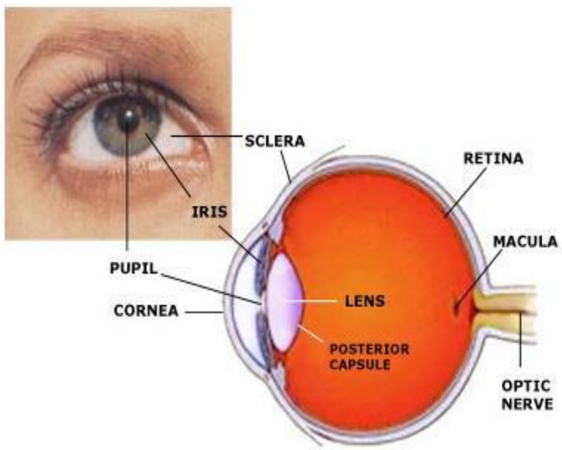


Figure 1: Biological structure of Human Eye

The eyes allow us to see and interpret the shapes, colors, and dimensions of an object. We can see objects around us because the light reflected from the object enters our eyes. The eye is connected to the brain and dependent upon the brain to interpret what we see.

The working of the eye is as follows:

1. Light reflects off objects and travels in a straight line to your eye.
2. Light passes through the cornea, into the pupil, and through the lens.
3. The cornea and lens bend (refract) the light to focus on the retina.
4. Photoreceptors on the retina convert the light into electrical impulses.
5. The electrical impulses pass along the optic nerve to the brain.
6. The brain processes the signals to create an image [1].

2. Vision Impairment

Blindness can be caused by an accident, if something hurts the eye. That's why it's so important to protect your eyes when you play certain sports, such as hockey.

Vision problems can develop before a baby is born. Sometimes, parts of the eyes don't form the way they should. A kid's eyes might look fine, but the brain has trouble processing the information they send. The optic nerve sends pictures to the brain, so if the nerve doesn't form correctly, the baby's brain won't receive the messages needed for sight [2].

3. Causes of Blindness.

a) Retinitis pigmentosa:

Retinitis pigmentosa is an eye disease in which there is damage to the retina. The retina is the layer of tissue at the back side of the inner eye. Retinitis pigmentosa is a genetic disorder and its symptoms start in childhood [3].

b) Age-related macular degeneration:

Age-related macular degeneration affects the middle part of the vision. People with age-related macular degeneration can't see people or things directly in front of them.
This common age-related problem occurs in people over the age of 50.

c) Cataract:

When a cataract occurs, the lens becomes opaque or cloudy. Light does not pass through easily, and vision becomes blurry, like looking through a fogged-up window. The cloudier the lens, the harder it will be to see.

d) Glaucoma:

Glaucoma is a common eye condition where the optic nerve, which connects the eye to the brain, becomes damaged. It is caused by fluid building up in the front part of the eye, which increases pressure inside the eye**.** So this can lead to the loss of vision. It can affect people of all ages but most of them in the 70s - 80s

e) Optic neuritis:

Optic neuritis is a common eye problem where inflammation affects the optic nerve leading to impairment of vision in the affected eye [4-5].

Bionic eye

Currently, many researchers are working on visual artificial devices and several are in the early stages of trials. Many types of bionic eyes have been designed and research is still going on different approaches and concepts. The most successful research thus far has focused on the bionic eye. Such devices have shown promise in patients with retinal degenerative diseases such as age-related macular degeneration, and glaucoma. The bionic eye aims at restoring the sense of vision to people living with blindness and low vision [6]. A bionic eye is also called a prosthetic device or retinal implant. Bionic eyes consist of electronic systems which consist of image sensors, processors, receivers, radio transmitters, and retinal chips.

The function of the bionic eye is to improve light sensitivity and creates a sense of vision for people who have advanced vision loss. A bionic eye is an electrical implant that is surgically inserted into the eye. The device is replaced in place of the retina part of the eyes. [7]

Construction of bionic eye

The bionic eye consists of the following components.

1. Camera: The system consists of pair of glasses and a camera is built on that. It captures the - images and sends them to the video processing unit.

2. Microprocessor: The microprocessor chip is surgically implanted behind the retina. It can convert data into electronic signals.

3. Radio transmitter: A radio transmitter that wirelessly transmits pulses to a receiver implanted above the ear or under the eye.

4. Radio Receiver: A radio receiver for sending pulses to the retinal implant. The receiver sends the pulses to the electrode array at the back of the eye. [8-9]

Working of the bionic eye:

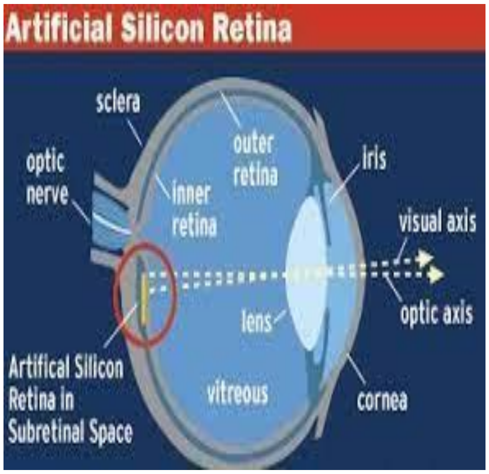
The bionic eye system involves a camera that is mounted on pair of glasses so the person can wear it. The small chip is surgically implanted behind the retina at the back side of the eye. The thin cable is provided for sending the single to an electrode. [10] When the camera captures the image in the form of pixels and the camera sends this image to the microprocessor. The microprocessor converts the pattern of pixels into electrical pulses and sends them to the radio transmitter. [11] After the conversion of electric pulses, it will transmit to the radio transmitter and then the radio transmitter sends to a receiver which is implanted above the ear or under the eye. This receiver is directly connected to an electrode array using a wire placed at the rear of the eye. This receiver is directly connected to an electrode array using a wire placed at the rear of the eye and it transmits pulses straight down the wire. The array acts as the retina's photoreceptors. The pulses stimulate the electrodes. The electrical signals are induced by the stimulation of the electrode; these pulses travel along optic nerves to the brain. The brain interprets the signals and patients can see an image. [12]

Bionic eye projects

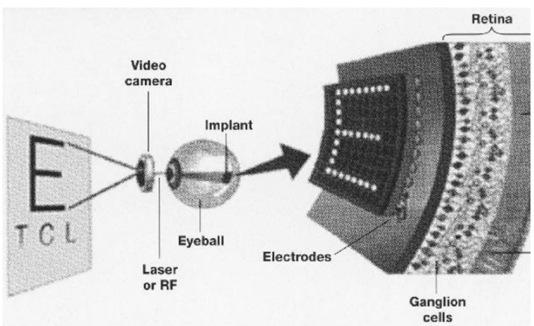
The bionic eye approaches various systems like Artificial Silicon Retina (ASR), Argus II retinal prosthesis, and Multiple units of artificial retinal chipset system.

1. Artificial Silicon Retina (ASR)

   The artificial retina prosthesis system is done by using an artificial silicon retina. The ASR is a tiny silicon chip and the size of that chip is 2mm and it is implanted surgically. The ASR Contains 3,500 micro photodiodes having their own electrodes that help to convert the light energy from images into thousands of tiny electrical impulses. ASR detects the light and convert it into an electric impulse.



2. Multiple units of artificial retinal chipset system(MARC)



The multiple-unit artificial retina chipset consists of a camera that sends the image to the secondary receiving coil in the form of electric signals. The image has a resolution of 100 pixels, which is achieved using a 10 × 10 array. An external mini low-power CMOS camera was attached to an eyeglass frame. Here the external camera captures images of the viewer that are encoded in the data stream creating higher frequency carrier signals which are stimulated on the retina of the patient. However, for this, the optic nerve of the person needs to be at least partly functional. The MARC system is compact in size of 6 mm × 6 mm. The main advantage of MARC has good diagnostic capability and low stress on the retina.

3. Argus II retinal prosthesis

Argus II retinal prosthetic system is approved by US Food and Drug Administration(FDA). It is the world's first approved bionic device for commercial use in Europe and USA. This is act as a photoreceptor and converts visual information into electrical neural signals in patients. The Argus II is the most widely implanted retinal prosthesis device worldwide. this improves visual functions like object recognition, letter reading, and mobility tasks in people with retinitis pigmentosa [1]. The Argus II Retinal Prosthesis System includes a receiver, electronics, and an electrode array that are surgically implanted in and around the eye. The array has 60 electrodes which are arranged in a rectangular grid. The small electronic device is placed on the patient's retina during the surgery. Patients wear a pair of glasses on which the camera is mounted and a battery-powered video processing unit.

The camera captures the image, and it gets processed and then sent wirelessly to the implant in the patient's retina. Later this information is gets stimulates the living cells in the retina and the brain interprets these patterns as light. and through the Argus II, the patients learn to interpret the signals and in some cases even read the large printed text [2].

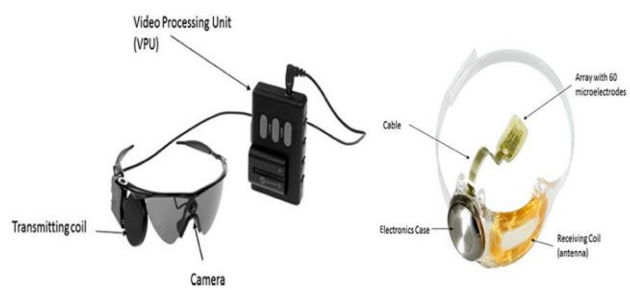


Fig. Argus II Retinal Prosthesis System

CONCLUSION

In this paper, the bionic eye is presented to describe the importance of such a technical invention for blind people. 1.3 billion people suffering from blindness and this device is a golden opportunity for such people. The bionic eye is yet not able to regain vision but it partially restores the sight of the blind individually after the surgical implantation. and it helps to identify the position and approximate size of the object and detects movement of nearly objects and people. Restoration of sights is a dream for people today and the bionic eye made this true. and we are grateful for science and technology.

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