The concept of a bionic eye biology essay

Bionic eye is used to provide vision to blind people by implanting VLSI chips on their eye. The word Bionics (also known as biomimetics, biognosis, biomimicry, or bionical creativity engineering) is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. A visual prosthetic 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. This can be used by people who are blind because of

The chip is the size of half a rice grain-3 millimeters and allows users to perceive 10 degrees of visual field at a time. It’s a flat rectangle of plastic (eventually a silicon version is has been developed) with one corner snipped off to create asymmetry so surgeons can orient it properly during implantation. One design includes an orchard of pillars: One side of each pillar is a light-sensing pixel and the other side is a cell-stimulating electrode. Pillar density dictates image resolution, or visual acuity. The strip of orchard across the top third of the chip is densely planted. The strip in the middle is moderately dense, and the strip at the bottom is sparser still. Dense electrodes lead to better image resolution but may inhibit the desirable migration of retinal cells into voids near electrodes, so the different electrode densities of a current chip design allow the researchers to explore parameters and come up with a chip that performs optimally. Another design-pore electrodes-involves an array of cavities with stimulating electrodes located inside each of them.

But there are a few problems with the chip “ MADE OF SILICON”. Silicon is toxic to the human body and reacts unfavourably with fluids in the eye. Furthermore, all of the nutrients feeding the eye flow from the back to the front. If a large, impervious structure [like the silicon detectors] in the eye is implanted, nutrients can’t flow and the blockage of nutrients flow to the eye happens and the eye will atrophy.

The current path that scientists are taking to create artificial vision received a jolt in 1988, when Dr. Mark Humayun demonstrated that a blindperson could be made to see light by stimulating the nerve ganglia behind the retina with an electrical current. This test proved that the nerves behind the retina still functioned even when the retina had degenerated. Based on this information, scientists set out to create a device that could translate images and electrical pulse that could restore vision.

Researchers working for the Boston Retinal Implant Project have been developing a bionic eye implant that could restore the eye sight of people who suffer from age-related blindness. The implant is based on a small chip that is surgically implanted behind the retina, at the back of the eyeball. An ultra-thin wire strengthens the damaged optic nerve; its purpose is to transmit light and images to the brain’s vision

system, where it is normally processed. Other than the implanted chip and wire, most of the device sits outside the eye. The users would need to wear special eye glasses containing a tiny battery- powered camera and a transmitter, which would send images to the chip implanted behind the retina. The new device is expected to be quite durable, since the chip is enclosed in a titanium casing, making it both water-proof and corrosion-proof. The researchers estimate that the device will last for at least 10 years inside the eye.

In our case, the intermediary device is the MARC system . The schematic of the components of the MARC to be implanted consists of a secondary receiving coil mounted in close proximity to the cornea, a power and signal transceiver and processing chip, a stimulation-current driver, and a proposed electrode array fabricated on a material such as silicone rubber [3, 14], thin silicon[9], or polyimide[25] with ribbon cables connecting the devices. The biocompatibility of polyimide [10, 11] is being studied, and its thin, lightweight consistency suggests its possible use as a non-intrusive material for an electrode array. Titanium tacks[12] or cyanoacrylate glue[13] may be used to hold the electrode array in place.

C. Overall System Functionality:

The MARC system, will operate in the following manner. An external camera will acquire an image, whereupon it will be encoded into data stream which will be transmitted via RF telemetry to an intraocular transceiver. A data signal will be transmitted by modulating the amplitude of a higher frequency carrier signal. The signal will be rectified and filtered, and the MARC will be capable of extracting power, data, and a clock signal. The subsequently derived image will then be stimulated upon the patient′s retina.

The MARC system would consist of two parts which separately reside exterior and interior to the eyeball. Each part is equipped with both a transmitter and a receiver. The primary coil can be driven with a 0. 5-10 MHz carrier signal, accompanied by a 10 kHz amplitude modulated (AM/ASK) signal which provides data for setting the configuration of the stimulating electrodes. A DC power supply is obtained by the rectification of the incoming RF signal. The receiver on the secondary side extracts four bits of data for each pixel from the incoming RF signal and provides filtering, demodulation, and amplification. The extracted data is interpreted by the electrode signal driver which finally generates appropriate currents for the stimulating electrodes in terms of magnitude, pulse width, and frequency.

D. Ceramic Thin Film Microdetectors

Figure 5: A schematic diagram of the retina — a light-sensitive layer that covers 65% of the interior surface of the eye

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These ceramic micro-detectors are invented by The Space Vacuum Epitaxy Center(SVEC) is a NASA- sponsored Commercial Space Center (CSC) at the University of Houston. SVEC’s ceramic detectors do not share the same problems with the silicon detectors in toxicity to the human body and unfavourable reactions with fluids in the eye. Tests on the ceramic detectors for biocompatibility, and they are totally stable. In other words, the detector does not deteriorate and neither does the eye.

These detectors are thin films, grown atom-by-atom and layer-by-layer on a background substrate — a technique called epitaxy.” Well-ordered, ‘ epitaxally-grown’ films have [the best] optical properties”, said Dr. Alex Ignatiev, a professor at the University of Houston.

WORKING:

How Does The System Helps to See ?

Let’s take an example with viewing a flower. “ First, light from the flower enters the video camera. (Keep in mind that camera technology is already pretty good at adjusting contrast and other types of image enhancement.) The video camera then sends the image of the flower to the wallet-sized computer for complex processing. The processor then wirelessly sends its image of the flower to an infrared LED-LCD screen mounted on the goggles. The transparent goggles reflect an infrared image into the eye and onto the retinal chip.

Just as a person with normal vision cannot see the infrared signal coming out of a TV remote control, this infrared flower image is also invisible to normal photoreceptors. But for those sporting retinal implants, the infrared flower electrically stimulates the implant’s array of photodiodes.

Figure 6

CONSTRUCTIONAL VIEW OF BIONIC EYE:

Scientists at the University of California, Berkeley, have given “ blind” nerve cells the ability to detect light, paving the way for an innovative therapy that could restore sight to those who have lost it through disease. A team lead by neurobiologist Richard H. Kramer, UC Berkeley professor of molecular and cell biology, and Dirk Trauner, assistant professor of chemistry, inserted a light-activated switch into brain cells normally insensitive to light, enabling the researchers to turn the cells on with green light and turn them off with ultraviolet light.

Potassium channels normally open in response to a voltage difference between the inside and outside of a nerve cell, letting potassium ions (K+) flow out to equalize the voltage and turn the cell off. This channel has been broken, then re-engineered to open when hit with ultraviolet light and close when hit with green light. The opening and closing is achieved with a molecule that kinks and unkinks in response to different wavelengths of light. This photoswitch can be used to selectively silence nerve cells or to give the gift of “ sight” to normally sightless organisms or cells. This trick could potentially help those who have lost the light-sensitive rods and cones in their eyes because of nerve damage or diseases such as retinitis pigmentosa or age-related macular degeneration. In these cases, the photoreceptor cells are dead, but other nerve cells downstream of the photoreceptors are still alive. In particular, retinal ganglion cells, which are the third cell in the path from photoreceptor to brain, could take

over some of the functions of the photoreceptors if they could be genetically engineered to respond to light

How well electrodes would work depends on the density of the electrode array and how well you can marry the electrodes with the neural elements underneath. This approach is not a mere chip on the retina — it may allow to cover the entire retina with light sensitive cells. If each nerve responds individually, one could do a very fine scan of the retinal field and create much, much better spatial resolution.

Current, admittedly early attempts at restoring sight with electrodes in the retinal ganglion cells, whose axons bundle together to form the optic nerve entering the brain, allow the patient to see little more than patches of light and dark, Kramer noted. Trauner, Kramer and their team designed a way to re-engineer the potassium channel to respond to light rather than voltage. To create this man-made channel and insert it into living cells, they took a two-step approach. First, they mutated the gene for the ion channel — using as their starting material the potassium channel found in fruit flies — so that, when expressed in a cell, the channel is broken and always stays open. They also added an extra molecule — the amino acid cysteine — to the channel protein so that, once the protein gets in place in the cell membrane, this molecule dangles off the outer surface of the cell like a fish hook. They then inserted the mutated potassium channel gene into cells from the hippocampus of a rat — cells that are found inside the brain and never see the light of day. To achieve this in their cell culture experiment, they flooded the culture with the mutated gene inside a circular piece of DNA called a plasmid, which cells readily take up. They checked to see how many of the hippocampus cells took up the gene by also washing the cells with a plasmid containing a gene for green fluorescent protein, which glows green when hit with UV light. Cells taking up one plasmid usually take up other plasmids, and nearly all the cells glowed green. The second step was to wash the cells with a chemically synthesized switch that gloms onto the cysteine hook. The photoswitch — an azobenzene compound — was built like a drain plug

on a rigid tether, so that when the end of the tether binds to cysteine, the plug fits snugly into the potassium channel.

The chemical was also designed to be sensitive to light — when hit with long-wavelength ultraviolet light (390 nanometer wavelength), the tether kinks and shortens, pulling the plug and letting potassium out of the cell. Green light (500 nanometer wavelength), on the other hand, makes the

chemical tether straight again, replugging the channel pore. They refer to the altered channel as a synthetic photoisomerizable azobenzene-regulated K(SPARK) channel, where K is the chemical signal for potassium .

IMPLANTATION INTO THE EYES

As the detector is so small to handle, the arrays are attached to a polymer film one millimeter by one millimeter in size. A couple of weeks after insertion into an eyeball, the polymer film will simply dissolve leaving only the array behind. The new bionic eyes will surely be promising to the blind.

Figure 7

Advantages:

Although the device will not be able to restore the eye sight of the entire blind community, researches are certain that many people will benefit from the technology. For instance, age-related macular generation is the leading cause of blindness in the industrialized world, with about 2 million Americans suffering from the condition. The new technology will hopefully assist people suffering from this condition, and individuals suffering from retinitis pigmentosa (a genetic condition), but will not help glaucoma patients.

The researchers note the device has some limitations, and it will not restore perfect vision. However, they are sure it will give people the advantage of having a general sense of their surroundings. Hopefully, the technology may enable people

to recognize faces and facial expressions. “ The thing is to significantly improve the quality of life for blind patients,” said Joseph Rizzo of the Massachusetts Eye and Ear Infirmary. The arrays are stacked in a hexagonal structure mimicking the arrangement ofrods and cones they are designed to replace. The natural layout of the detectors solves another problem that plagued earlier silicon research: blockage of nutrient flow to the eye as the ceramic detector.

CONCLUSION:

Blindness need not be a thing that we must regard as a condition of “ suffering.” The suffering part of it is ultimately a matter of personal choice as is true when faced with any challenge. While most blind people would probably rather see than not, at the same time many would not regard their circumstances as “ suffering.” They see and live blindness from a “ gain” perspective, not a “ loss” perspective. That is the only way they can find and own their power. The purpose of fighting blindness isn’t so much to combat it as an affliction, but to bring a positive light to the situation of blindness. That is the” new light called bionic eye”. Blindness may be eradicated in a few instances but more realistically and importantly, the afflictive nature of blindness can and should be addressed in positive, respectful ways.