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Research Paper

ARTIFICIAL VISION USING EMBEDDED SYSTEM

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'When you are in the dark even your shadow evades you', this might sound cliché but its true in the case of millions who cannot see. Injuries or genetic defects may cause blindness at any stage of life and this is really unfortunate. This paper looks at an adept way to overcome this adverse glitch in humans and visionise the blind. Since vision depends mainly on nervous system, it would mean trying to heal or change the nervous system. It would be better to say -"we see with our brains than with our eyes". The sole principle used to visionise a blind is – "DECEIVING OUR BRAINS" using embedded systems and mems technology. Miraculous innovations occur when two branches of science merge and in this case medical and engineering sciences come together with such methods to evade blindness. The credential part of this paper focuses on these methods, a) Microchips. b) Nano tube implant. c) Digital artificial vision. d) Ocular prosthetics. e) Braille type writer. Revolution in miniaturization, nanotechnology, image processing etc has paved way for vision. Blindness at any stage can be averted. Adaptability of humans made implantations flexible using embedded and mems technique 'A thousand points of light' no longer a metaphor'

INTRODUCTION

Genetic defects or injury may cause blindness at any time during the life of a person. The visually impaired are the most unfortunate people bearing darkness throughout their life. A blind mans quench for vision has made destinated science to tour its journey. Since vision depends mainly on nervous system, it would mean trying to heal or change the nervous system. It would be better to tell -"we see with our brains than with our eyes". The sole principle used to visionise a blind is **–"DECEIVING OUR BRAINS".**

Evolution in miniaturization, nanotechnology, image processing etc has paved way for vision. Blindness at any stage can be averted. Adaptability of humans made implantations flexible. The credential part of this paper focuses on five different methods available as on now for the noble cause of vision.

a) Microchips.
b) Nano tube implant.
c) Digital artificial vision.
d) Ocular prosthetics.
e) Braille type writer.

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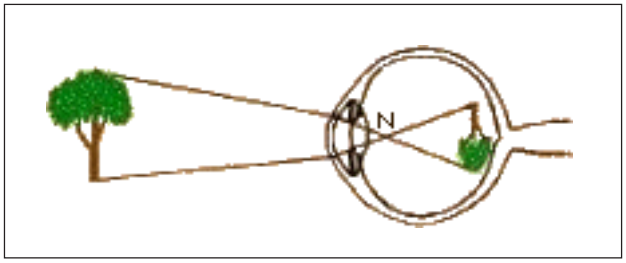
Our advancements have surpassed human brains in accuracy. The novel idea is "With these method the brain should not feel the difference whether the signal came from a natural, healthy or from our implant retina." A key note on future scope is also discussed in this paper.

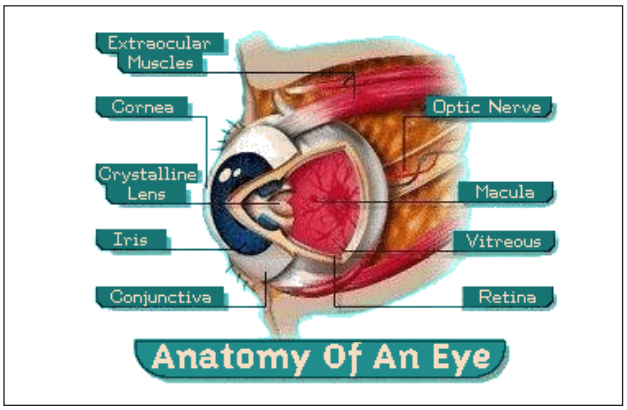
Striving to eliminate the word **"BLIND"** from our vocabulary.

Human Visual System

Prosthetics are artificial substitutions to the organs of the body which are disabled. Neurons of the human visual system exhibit electrical properties. Cornea (dome), pupil (center of iris), crystalline lens (inverted), vitreous retina (into electrical pulses), optic nerves and occipital lobe constitute basic parts of eye.



Neurons send and receive electro-chemical signals to and from the brain up to 200mph.The chemicals like sodium and potassium cause an electrical signal in the neurons. When a neuron is not sending a signal, it is "at rest", then the inside of the neuron is negative with respect to outside. The resting membrane of the neuron is about -70mv. When the depolarization reaches about -55mv the neuron then fire an action potential (signal). This is the threshold level. When the action potential is fired we start to visualize.



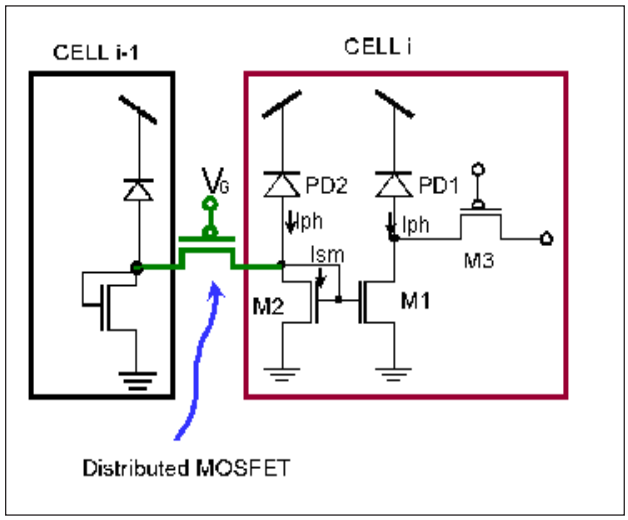
Retinal "Transducer"

An equivalent circuit of a retina is realized using

- A distributed MOSFET
- Three MOSFETs
- Two Photo Diodes
- Two Current Mirrors

The functions of Photoreceptors, Bipolar Cells and Horizontal cells are implemented by this circuit.

1) Digital Artificial Vision: When a person is born blind, inwardly his optic nerve would not function properly. We cannot use any retinal stimulation methods.



The artificial vision system consists of a miniature camera mounted on eyeglasses and ultrasonic range finder, 1 frame grabber, 1 microcomputer, 1 stimulus generation module, 2 implanted electrode arrays.

DESCRIPTION OF DIFFERENT PARTS OF AVS

Microcomputer

This microcomputer consists of two parts

a) Sub-notebook computer

- The new sub-notebook computer employs a 233 MHz processor, 32 MB of RAM, 4 GB hard disk, LCD screen and keyboard.
- Interfaces with camera.
- Important areas of computing are Magnification in software (C, C++).

b) Micro Controller

- Simulation delivered to each electrode typically consists of a train of six pulses delivered at 30 Hz to produce each frame of the image at a speed of 8 frames per second.

IMAGE PROCESSIG (EDGE DETECTION)

- Edge detection through SOBEL filters is the most common approach
- The gradient vectors of SOBEL filter are Gx and Gy.
- The masks used to implement these two equations are called Sobel operators

Gx=(Z3 + 2Z8 + Z9) - (Z1 + 2Z2 + Z3)

Gy=(Z3 + 2Z6 + Z9) - (Z1 + 2Z4 + Z7)

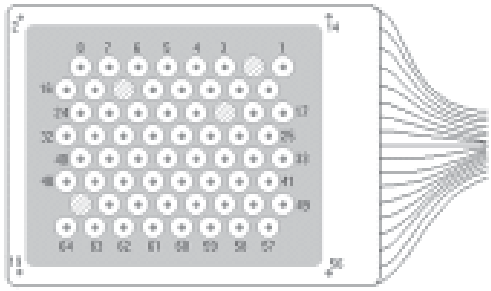
0	1	2
-1	0	1
2	-1	0

MICROCONTROLLER

- Controls the simulating electrodes
- Simulation delivered to each electrode typically consists of a train of six pulses delivered at 30 Hz to produce each frame of the image at a speed of 8 frames per second

Electrode Implantation

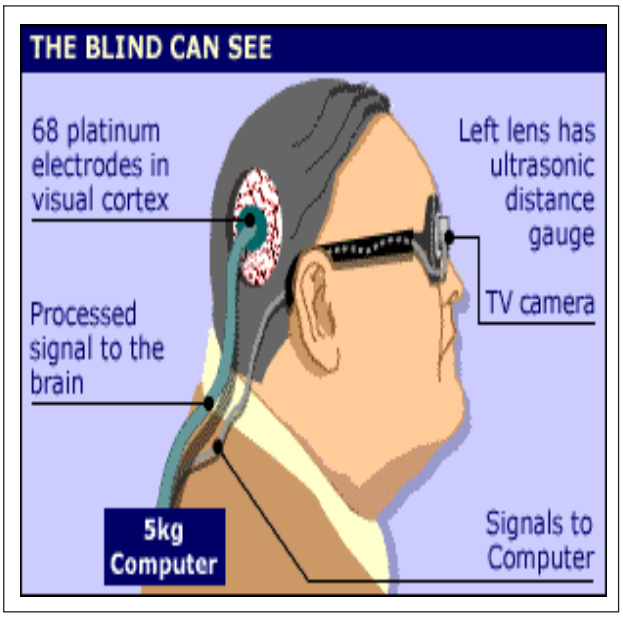
- Electrode implantation is one of the most critical job in this artificial vision system.
- The first step done in this electrode implantation is perforating a platinum foil ground plant with a hexagonal array of 5 mm diameter holes on 3 mm centers on the skull at the right occipital lobe.



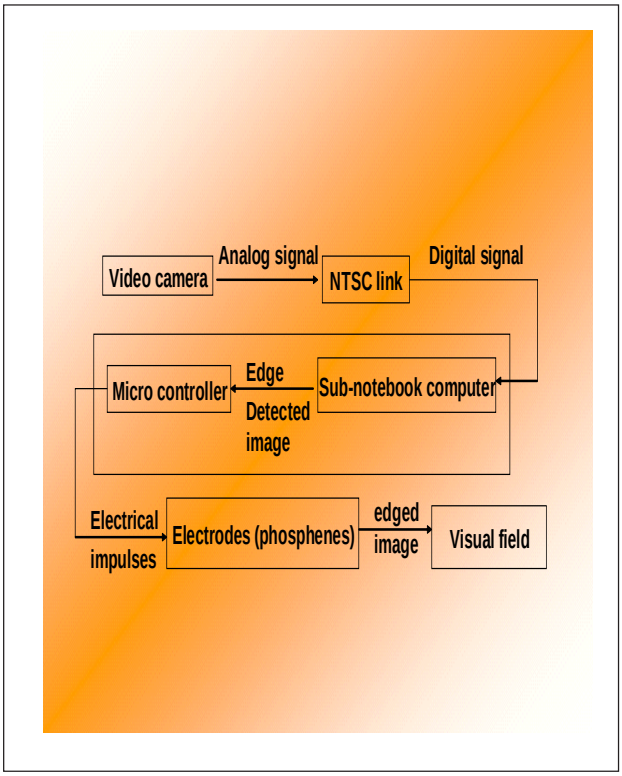
2	-1	0
-1	0	1
0	1	2

- 68 flat platinum electrodes of 1mm
- diameter are pierced from the center of the holes on the platinum foil ground plant into the nucleus of neurons of the occipital lobe
- Each electrode is connected by a separate Teflon insulated wire to a connector contained in the pedestal.
- A group of wires from the belt mounted signal processor are connected to the connector mated to the pedestal. The groups of
- Wires pass the electrical impulses which are generated by the processor with respect to the image being seen by the video camera.

  When the electrode is stimulated by the processor by sending an electrical impulse, the electrode produces 1-4 closely spaced phosphenes (light spots seen by visual field).
- By sending the electrical impulses in different combinations and permutations the phosphense can be created in a regular fashion describing the image.

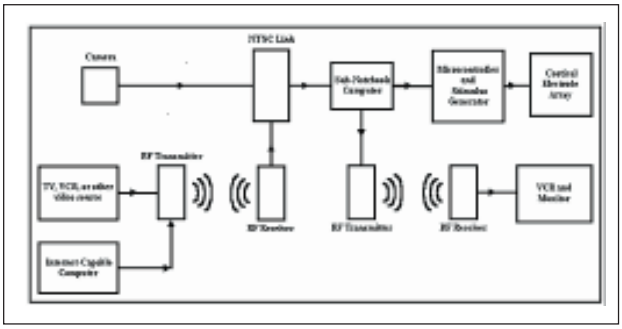


PROCESS AND THE IMAGE CREATED IN THE VISION FIELD OF A BLIND HUMAN



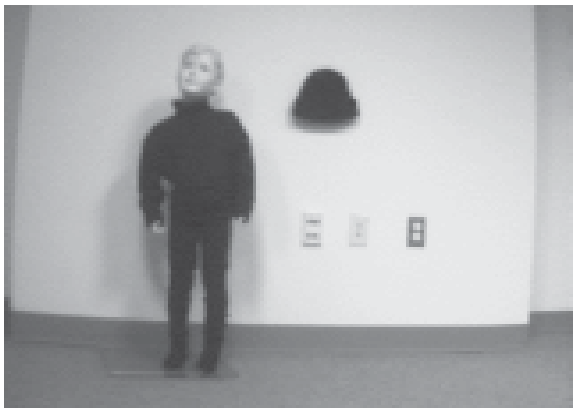
BLOCK DIAGRAM

The original image seen by the camera and phosphene image seen by the visual field in the brain of the blind human are as shown.



2) Braille Type Writer

- Used majorly for deaf –blind, whose only mode of communication remains as sense of touch.
- A miniature glass is mounted as above.

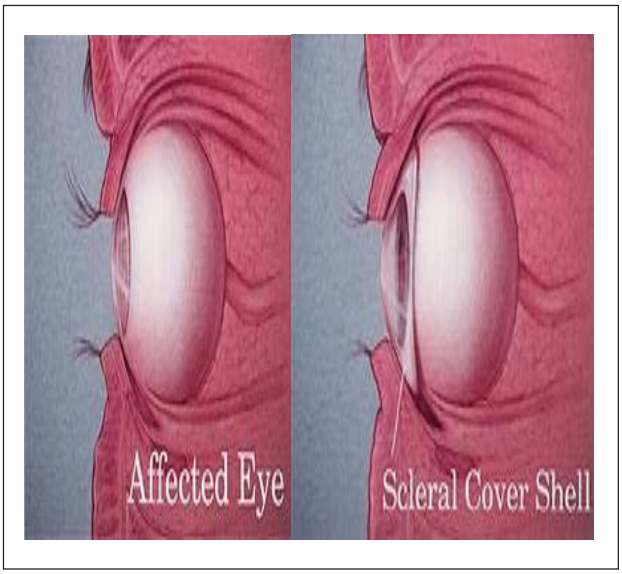


- Using a signal processor synchronized signals are converted to pricking pulses, which is sensed on a pad interfaced on the stomach or hand of blind.
- Braille is a system of reading and writing using raised dots in cells of six that represents alphabets, pictures, obstacles etc.
- Braille is written on heavy paper using either a slate and stylus, or a braille-writing machine (brailler)
- The deaf-blind has to undergo training for about 6 months to one year as per his capability to grab.

3) Ocular Prosthesis (False Eye)

- Traumatic accidents and treatment of ocular and orbital cancers, blind and painful eyes, and other diseases sometimes lead to the need for reconstruction of the orbit (eye socket). Also orbital implant called (enucleation).

- The false eye is designed after taking moldings of the patient's orbital tissues and eyelids, such that, the prosthesis fits nicely and comfortably.
- The BIONIC EYE implants are of porous polyethylene, (Medpor), and of aluminum oxide, (Bioceramic) or hydroxyapatite, kryolite glass or acrylic materials.
- After implant they allow blood vessels to grow in them.
- Usually there is a significant build-up of salt and protein deposits on the eye in one year's time. Polishing removes these potentially irritating deposits.
- Artificial drops are added to desilt eye.
- After orbital implant, it is difficult for the casual observer to distinguish the natural eye from the implant.
- Currently cameras of 100*100 pixels have been implemented.



4) Nanotubes and Nanobatteries

Nano Vision Chip System

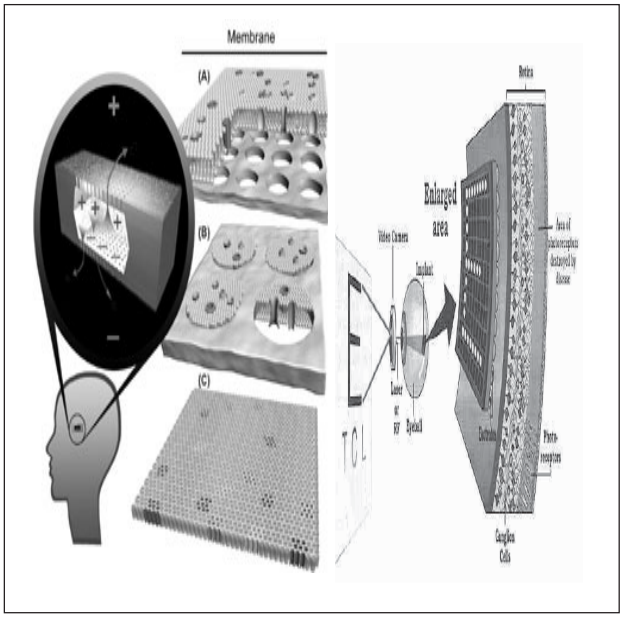
- Age related retinal diseases like macular dysfunction, retinitis pigmentosa can be averted using nano tubes.
- Normally, when light rays or images are focused by the lens of the eye onto the retina, light-sensitive cells called “rods” and “cones” convert the light into electrical impulses that travel to the brain and are interpreted as images of the world around us. “[The retina] actually does some of the image processing, and then sends this information to the brain, and so we see.
- The Nano Vision Chip System consists of

1. A low Power CMOS camera mounted on a spectacle.
2. A Image processing device
3. Transmission device
4. Signal conditioner
5. Electrode array

Implant of Nanobattery in or Near Eye

- CNT at Nano scale reduces background noise, magnifies signal and provides desired redundance.
- Zinc oxide nano wires are used here to transfer the signal from the signal conditioner to the CNT array.
- Nano batteries have long shelf life, predicted to last for 15-20 years.

The NVCS working can be studied as two parts – Intraocular and Extra ocular.



Extra Ocular (Outside the *Eye)*

The Images are received by the CMOS camera

The microprocessor based image processor processes the images thus received. The processing may be either digital image processing or neural based image processing.

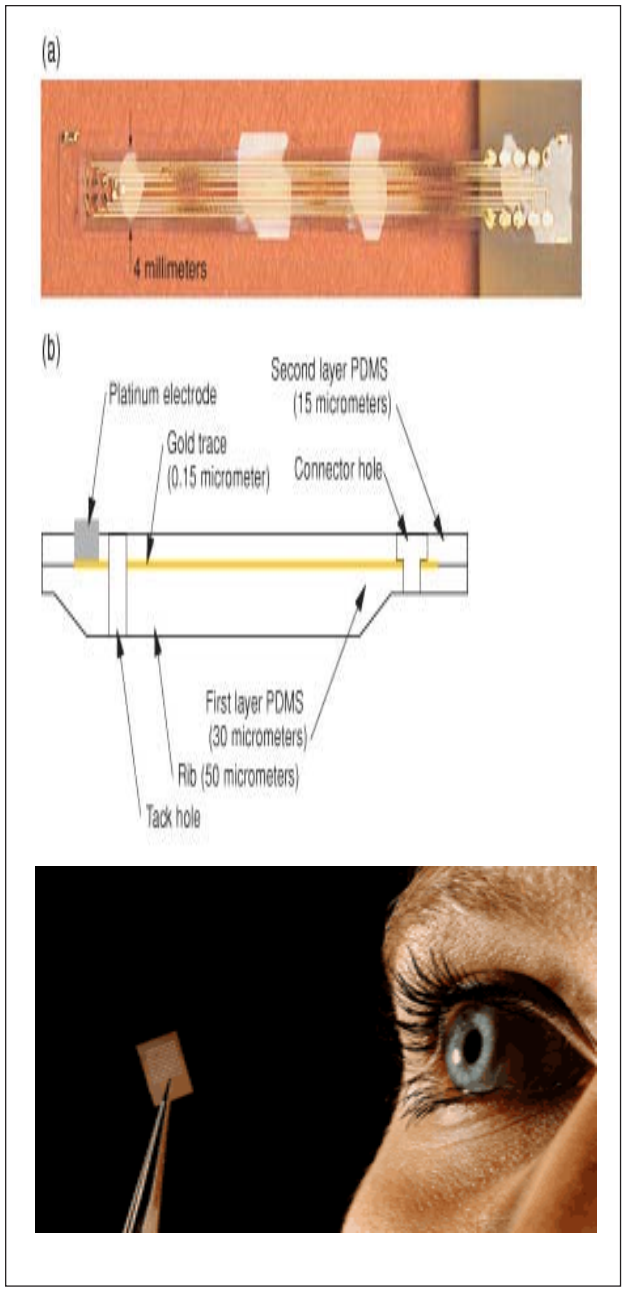
The signal so obtained is PWM encoded and modulated using ASKS.

5) MEMS

(MEMS-) based adaptive optics phoropter.

When light enters the eye, nearly 127 million rods and cones, which are the photoreceptors in the retina, initiate a series of electrical signals so rapid that the images the eye receives appear to be continuously updated in a seamless process. A breakdown in this light-conversion process can lead to vision impairment or loss of sight. A new optical device, called the Micro Electro Mechanical Systems– (MEMS-) based adaptive optics phoropter (MAOP), will greatly improve this process. It allows clinicians to integrate a computer-calculated measurement of eyesight with a patient's response to the target image. Patients can immediately see how objects will look—and the clinician can adjust the prescription—before they are fitted for contacts or undergo surgery. As a result, patients will experience better vision correction outcomes, especially with custom contact lenses or laser refractive surgery. A microelectrode array developed for a retinal prosthesis device. The electrodes are embedded in silicone-based substrate polydimethylsiloxane (PDMS). PDMS is a promising material for the microelectrode array, providing flexibility, robustness, and biocompatibility for long-term implantation.

The array will serve as the interface between an electronic imaging system and the eye, providing electrical stimulation normally generated by the photoreceptors that convert visual signals to electrical signals transmitted to the optic nerves**.** The electrode array is embedded in a silicone-based substrate, polydimethyl-siloxane (PDMS).



a) A prototype of polydimethylsiloxane (PDMS) array used in testing. (b) Cross-section of an eight-electrode PDMS device shows conductive lead and electrode metallization contained between two layers of PDMS. Reinforcement ribs facilitate handling of the thin PDMS device. A tack hole is used to pin the device to the retina.

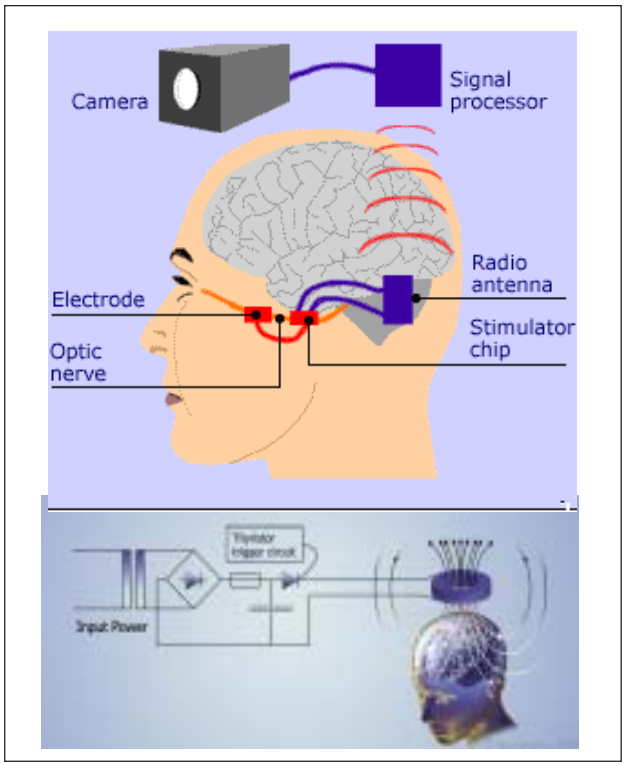
The device is designed to be epiretinal; that is, it will be placed on the surface of the retina inside the eye. The implant will overlap the center of the eye's visual field, which is the area affected in macular degeneration. Once implanted, a small

camera attached to eyeglasses will capture a video signal that will be processed and transmitted inside the eye using a radio-frequency (rf) link. The rf link is composed of an external rf coil that will either be part of the eyeglass apparatus or will rest on the eyeball like a contact lens. Another rf coil inside the eye will pick up the signal and transmit it to electronics that will format the signal for stimulating the electrode array. The power for the circuitry, or microchip system, will be provided inductively through transcutaneous coupling. That is, a coil attached to a battery on the side of the eyeglasses will inductively generate power in a coil parallel to it under the skin

"They won't be able to drive cars, at least in the near future, because instead of millions of pixels, they'll see approximately a thousand."

FUTURE APPLICATIONS

1. As now, only black and white images are seen by this AVS system, research is being carried to visualize colored images by using optical fiber technology.
2. Research is being carried to replace the electrode implantation with ray or wave devices
3. Reduction of electrodes to 4, by operating into optic nerve directly. It involves usage of stimulator chip, radio antenna and signal processor.
4. Electrical signaling, osmotic pumping, and molecular detection.
5. In the future the whole setup (excluding the camera) in NVCS can be nano fabricated on single chip thereby making it more feasible and sophisticated.



CONCLUSION

- This invention is not only the fruit of one branch of science; it involves the participation of different branches of science.
- This concludes every professional relating to a branch of science should have a interesting view towards other branches of science also.
- "Wishing a remarkable progress in the development of this artificial vision system, such that each and every blind person today, is never a blind tommorow."
- Striving to eliminate the word **"BLIND"** from our vocabulary. "A thousand points of light' no longer a metaphor"

THE BEST IS YET TO COME"

India total people 110 crores.. Each day death is 62389.. Each day born is 86853.. In INDIA total blind is 682497…… If each death people donate their eyes, within 10 days, INDIA achieves.. No blind man in the country

"Donate your eyes"

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