An Eye for the Blind: The Brainport Vision Device

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***Abstract*— A new device has been developed by the scientist which helps blind people to see. This device has a shape of electric lollipop and captures images using a ting camera. The images are converted into tingles on tongue and send to the brain. The brain then converts these tingles into images. This device is also known as a tasting device because it can taste and sense objects. This device is based on the idea of sensory substitution, the process in which if one part of brain is damaged then the part of brain that would normally control the damaged part learns to perform some other function. Within few hours of training this device can help visually impaired people to recognize high-contrast objects, their locations and some aspects of perspective and depth. The device is still in investigation and has not been launched commercially but the results obtained after testing the device on blind people were astonishing and have indicated that there is a huge scope of application for this technology in future. The present paper deals with an opportunity for blind community to interact with the vision of the world through innovative development of electronics and computer engineering.**

Keywords –Brainport device, tongue device, sensory substitution, electrotactile stimulation.

I. INTRODUCTION

An electronic device which will allow blind to see the world has been developed by the scientists. The device is called the Brainport vision device. It is manufactured by Wicab, a biomedical engineering company focused on developing and testing the brain port vision device. It helps in perception of visual information using tongue and camera systems used in pair as a substitute for an eye. Visual data is collected from a video camera about 1.5cm in diameter that sites in centre of a pair of sunglasses worn by the user[17].Bypassing the eyes, the data are transmitted to a handheld base unit which has features such as zoom control, light settings, shock intensify level and central processing unit (CPU). The job of this device is to interpret the information that it receives through stimulation device and use it like data from natural sense. Research from prototype devices showed such training is possible, as patients with severe bilateral vestibular loss could, after time, maintain near-normal posture control while sitting and walking, even on uneven surfaces. Thus if proper training is given to patients they can perceive size, shape, location and motion of objects in environment [1].The device uses concept of electro tactile stimulation for sensory substitution[20]. The idea is to communicate non-tactile via electrical stimulation of the sense of touch. In practice, this typically means that "an array of electrodes receiving input from a non- tactile information source (a camera, for instance) applies small, controlled, painless currents (some subjects report it feeling something like soda bubbles) to the skin at precise locations according to an encoded pattern." For a blind person, it means the encoding of the electrical pattern essentially attempts to mimic the input that would normally be received by the non-functioning sense – vision. So patterns of light picked up by a camera to form an image are replacing the perception of the eyes and converted into electrical pulses that represent those patterns of light [18]. In other words, when the encoded pulses are applied to the skin, the skin is actually receiving image data which would be then sent to the brain in the forms of impulse. Under normal circumstances, the parietal lobe in the brain receives touch information, while the occipital lobe receives vision information [19]. When the nerve fibers forward the image-encoded touch signals to the parietal lobe, "the electric field thus generated in subcutaneous tissue directly excites the afferent nerve fibers responsible for touch sensations". Within the system, arrays of electrodes can be used to communicate non-touch information through pathways to the brain normally used for the touch related impulses. The breakthrough of the Brainport technology is to use the tongue as the substitute sensory channel [11].

Through this paper we would like to make the reader aware of this brilliant technology and broaden his/her perspective on this device; for our goal is to plant the seed of curiosity in the reader so that he/she is compelled to think.

II. RELATED WORKS

On April 3,2009 a portable vision device was presented at the 40th anniversary celebration for the National Eye Institute (NEI), part of the National Institutes of Health (NIH).The vision device is based on technology invented at the University of Wisconsin-Madison and is being developed by Wicab Inc., based in Middleton, Wis. This event featured the showing of BLINDSIGHT - the award winning documentary film featuring Erik Weihenmayer, a blind mountain climber who embarked on an extraordinary expedition up the north face of Mount Everest, with six blind Tibetan students. Prior to this journey, Erik worked with NEI-supported scientists in the development of Brainport device**.** A genetic eye condition known as retinoschisis caused him to be visually impaired at birth and completely blind by age 13. In retinoschisis, tiny cysts form within the eye's delicate retinal tissue, eventually causing its layers to split apart. Neither medication nor surgery can restore sight. But with the help and practicing this device he was at least able to identify the obstacles, objects around him and can also read the signs. Using Brainport, Erik was the first blind man to summit Mount Everest. The technology, developed with NEI research funding and licensed exclusively to Wicab by the UW-Madison's private nonprofit technology transfer organization, the Wisconsin Alumni Research Foundation (WARF), is based upon a principle known as "sensory substitution". The late Paul Bach-y-Rita, the UW-Madison neuroscientist who invented Brainport, famously declared "we see with our brains, not with our eyes." He proposed that visual perception in the brain could be restored using an alternate sensor and input channel, such as a digital camera providing visual signals through the tongue." The National Eye Institute is dedicated to conducting and supporting research related to preserving sight and addressing the needs of people who are blind or have low vision," says Michael D Oberdorfer, program director in the NEI extramural research program.[12] The Brainport device was recently highlighted in the journal *Scientific American* and also featured on Oprah Radio. The scientific and clinical team of The Fox Center led by McGowan Institute faculty members Joel Schuman, MD, Eye and Ear Foundation Professor and chairman of Ophthalmology, and director of the UPMC Eye Center, and Major General (Ret.) Gale Pollock, executive director of The Fox Center, is working with Wicab, Inc. to improve the effectiveness of Brainport. Following this collaborative effort, the device could be approved by the U.S. Food and Drug Administration for market by the end of 2009 at a cost of about $10,000 per machine.

III. BRAINPORT VISION TECHNOLOGY

A. Motivation

Brainport vision device is a revolutionary new technology enabling a visually impaired person to see with his tongue. This device is an investigational device and its use remains limited by US Federal law to investigational use only. This device is used by people who are between the ages 18 – 79 years and have medical diagnosis of blindness (light perception or no light perception) for at least 6 months. Blindness should not have occurred due to traumic brain surgery or stroke. This technology can make the world come alive for the visually impaired people. Brain Port device does not replace the sense of sight, it adds to other sensory experiences to give users information about the size, shape and location of objects [2].

1) Users can operate it independently with a hand-held controller.

2) A pair of sunglasses wired to an electric "lollipop" helps the visually impaired regain optical sensations via a different pathway Therefore device is like normal sunglasses hence it does not look bad [13].

3) It uses a rechargeable battery like in normal cell phones.

The multiple channels that carry sensory information to the brain, from the eyes, ears and skin, for instance, are set up in a similar manner to perform similar activities [10]. All sensory information sent to the brain is carried by nerve fibers in the form of patterns of impulses, and the impulses end up in the different sensory centers of the brain for interpretation. To substitute one sensory input channel for another, you need to correctly encode the nerve signals for the sensory event and send them to the brain through the alternate channel [14].

B. Proposed Model

The Brainport device consists of a postage-stamp-size electrode array (the tongue array) that is placed on top surface of the tongue, a base unit; a digital video camera and a hand held controller for zoom and contrast inversion. Visual information is collected from uses adjustable head-mounted camera (FOV range 3-90^0) and sent to base unit. The base unit translates the information received into a simulation pattern that is displayed on tongue. Image is created using by presenting white pixels for strong stimulation, black-no, grey-medium level of simulation. Users have reported that the picture formed on tongue is seen as one made up of champagne bubbles. The current system uses arrays containing 100-600+ electrodes. The scientists have been currently working to bring further improvements in the hardware, software and usability of this tongue device [4].

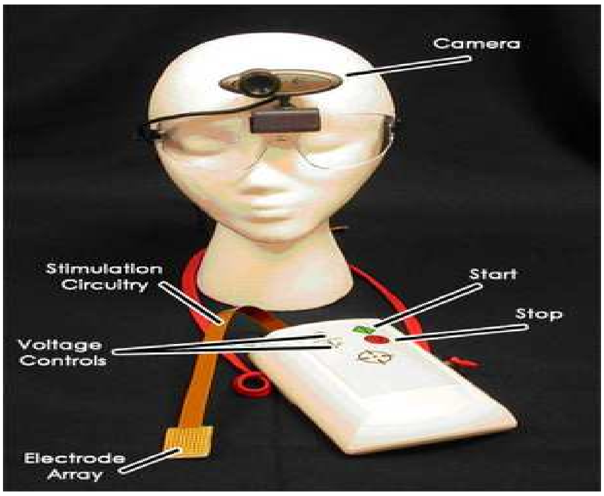

Figure 1.Components of Brainport device

The three main parts of the device as shown in Figure 2 are as follows:

1) Electrode array

The lollipop contains a square grid of 400 electrodes which pulse according to how much light is in that area of the picture. White pixels have a strong pulse while black pixels give no signal. The control unit converts the image into a low resolution black, white and grey picture, which is then recreated as a square grid of 400 electrodes – around the size of a postage stamp – on the lollipop. Each of the electrodes pulses according to how much light is in that area of the picture. It converts pictures into electrical pulses and it is placed on tongue.

2) Stimulation circuitry

A programming device comprising: a user interface; and a processor that presents a user with an interface for selection of one of a constant current mode or a constant voltage mode via the user interface, receives a selection of one of the modes from the user via the user interface, configures a medical device according to the selected mode, and presents the user with either an interface for selection of a voltage amplitude or an interface for selection of a current amplitude via the user interface based on the selected mode, wherein the processor configures the medical device to measure, using impedance measurement circuitry, an impedance presented to stimulation circuitry of the medical device based on the selected mode, and wherein, when the medical device comprises constant current stimulation circuitry and the user selects the constant voltage mode, the processor configures the medical device to measure, using the impedance measurement circuitry, the presented impedance and adjust a stimulation current amplitude based on the measured impedance to deliver stimulation with a substantially constant voltage amplitude[15].

3) Accelometer

The other side of electrode array is accelerometer. Named Brain Port, and developed by Wicab, Inc, this experimental device uses an accelerometer to provide head and body position information to the brain through electrotactile stimulation of the tongue. Sensitive nerve fibers on the tongue respond to electrodes to enable a rapid transfer of electrical information.

a) Sunglasses and camera

The device is made up of a video camera hidden in a pair of sunglasses, which the user wears. Signals from the camera are sent along a cable to a handheld control unit, about the size of a cell phone, and then to a lollipop-shaped stick, which is placed on the tongue. The inventors claim that blind people using the device, that look like sunglasses attached by cable to a plastic lollipop, blind people can make out shapes and read signs with less than 20 hours training. The Brain Port device collects visual data through a small digital video camera about 1.5 centimeters in diameter that sits in the middle of a pair of sunglasses worn by the user.

b) CPU and Battery

This unit houses such features as zoom control, light settings and shock intensity levels as well as a central processing unit (CPU), which converts the digital signal into electrical pulses—replacing the function of the retina. It will be a rechargeable battery.

c) Power button

It is used for start and stop.

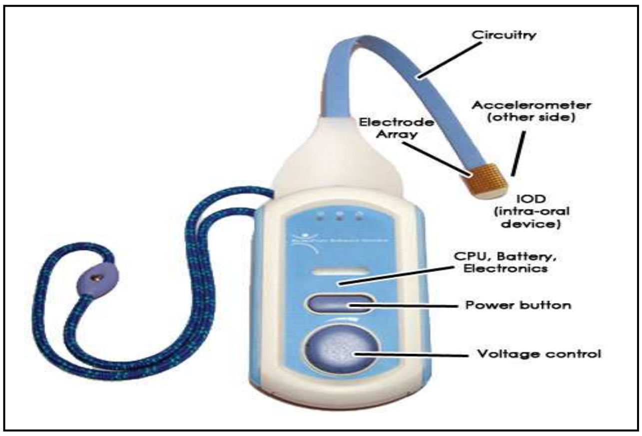

Figure 2. The Brainport device circuitry

C. Working Principle

About two million optic nerves are required to transmit visual signals from the retina—the portion of the eye where light information is decoded or translated into nerve pulses— to the brain's primary visual cortex.[5] The optical information that would normally fall on retina is picked up by the digital camera in digital form. Radio signals are used to send one's and zero's to the CPU for encoding purpose. It uses concept of electrotactile stimulation in which image entering eye does not go to retina instead it get converted into spatio-temporal nerve patterns of impulse along the optic nerve fibers. By analyzing this impulse pattern the brain creates an image. Each set of pixels in camera's light sensor corresponds to electrodes on an array. Then the CPU runs the program which connects camera's electrical information in spatially encoded signal. The encoded signal will represented differences in data of pixel as differences in characteristics of pulse such as frequency, amplitude and duration. The electrode array receives the resulting signal via stimulation circuitry and put it is applied to the tongue [3]. At last, this information from tongue is inspected and used by the brain as if it were coming from eyes. In this way person is able to see the object. Although users initially 'feel' the image on their tongue, with practice the signals activate the 'visual' parts of the brain for some people. In any case, within 15 minutes of using the device, blind people can begin interpreting spatial information via the Brain Port. [6]

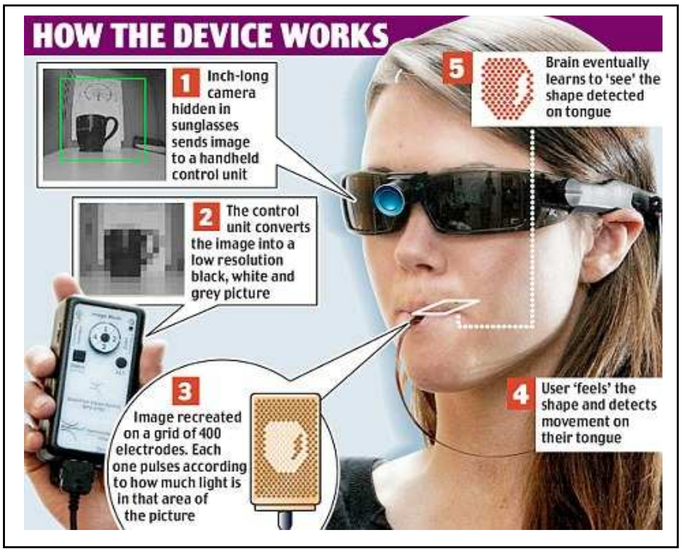

Figure 3. Working of the Brainport device

D. Significance Of Utility Of Tongue In Brainport Technology

If we compare tongue with other parts of body well notice that the skin of tongue is more sensitive than any other body part.[8].Large numbers of nerve fibers are present on the tongue and there is no stratum corneum (outer layer of dead skin cells) on the tongue which would otherwise act as an insulator. To stimulate nerve fibers in tongue we require not if 5-15V which is much less as compared to any other body part [16]. Also saliva in our mouth which surround our tongue acts as an electrolyte and helps to maintain constant flow of current between the electrode and skin tissue. Moreover the area of cerebral cortex which helps to interpret the data from tongue is also larger than any other body part. Thus tongue is the best choice so far [7].

E. Flowchart

1) Camera to CPU

a) Camera captures the image of test symbol and sent to a processor i.e. handled unit about size of cell phone.

b) CPU translates camera output in to a pattern of electronic pulses & sent to electrode array which is held against the tongue.

2) CPU to tongue

a) An array electrode stimulate receptor cells (tactile/touch) on the surface of the tongue with practice in use signals activate visual part of brain.

b) Tongue to brain.

c) These signals from tactile or touch receptors cells are sent to the somatasensory cortex in response to stimulation in the form of pattern impulses.

d) With practice in use signals activate visual part of brain.

e) The images as seen through the Brainport device are as shown in the Figure 4.

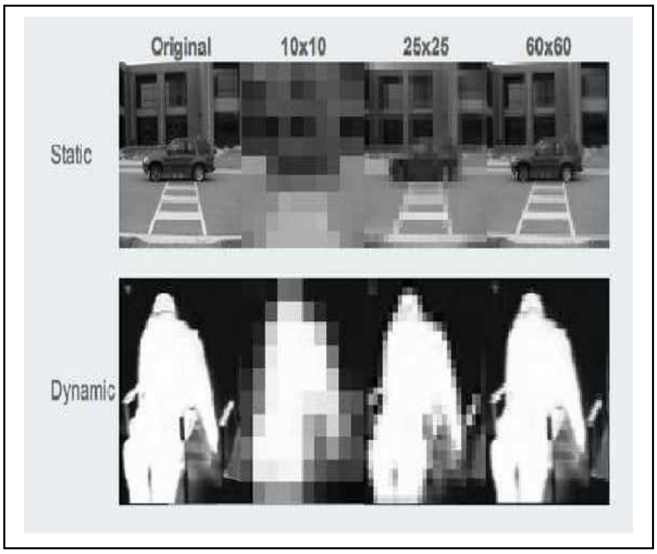

Figure 4. Image as seen through Brainport device

IV. APPLICATIONS

A. Medical

It can be effectively sense the application direction and also provide visual sense of obstacles [9].

B. Military

It can be used to provide expanded information for military pilots, such as a pulse on the tongue to indicate approaching aircraft or assist in taking immediate actions.

C. Robotics Surgery

The surgeon can wear electrotactile gloves to receive tactile from robotic probes inside smel's chest cavity.

D. Car Racing

Racers might use a version of Brainport to train brains for faster reaction time.

E. Video Gaming

Gamers might use electrotactile feedback gloves or their controller to get the feel of gaming experience.

V. CONCLUSION

Even though this is a field of scientific study that has been around for nearly a century it has been picked up in this decade due to various advancements and discovers in electronic and computer devices. Researchers are working towards making this device more user-friendly, economical and smaller in size so that it can be easily used by more number of people across the world. Scientists have claimed that after 20 years we might be seeing a camera with size of grain of rice embedded in people's brain.

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