Brainport Vision Technology

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Abstract – *According to the World Health Organization (WHO) there are 285 million people in the world are visually impaired. Out of them 39 million people are completely blind and 246 million people have low vision. In this modern world science has reached to a point where nothing is impossible. Science has made a great progress in the field biotechnology.*
We have hearing aid for the hearing impaired person, robotic arm for the paralyzed person. We all know that an eye is the very important part of our body. But unfortunately blind people cannot see this beautiful world. So isn't there a device through which blind person can see this world? Yes. Scientist have developed such device and the name of that device is Brainport Vision Device. This device is also known as a tasting device because it can taste and sense objects. This device is based on the idea of electrotactile stimulation for 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. 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.

Key Words: Brainport Vision Device, Tongue Device, Electrotactile Stimulation for sensory substitution.

1. INTRODUCTION

1.1 Introduction

A blind woman sits in a chair holding a video camera focused on a scientist sitting in front of her shown in figure1. She has a device in her mouth, touching her tongue, and there are wires running from that device to the video camera. The woman has been blind since birth and doesn't really know what a rubber ball looks like, but the scientist is holding one. And when he suddenly rolls it in her direction, she puts out a hand to stop it. The blind woman saw the ball through her tongue. Well, not exactly through her tongue, but the device in her mouth sent visual input through her tongue in much the same way that seeing individuals receive visual input through the eyes. In both cases, the initial sensory input mechanism the tongue or the eyes sends the visual data to the brain, where that data is processed and interpreted to form images. Braille is a typical example of sensory substitution in this case, you're using one sense, touch, to take in information normally intended for another sense, vision. Electrotactile stimulation is a higher-tech method of receiving somewhat similar (although more surprising) results, and it's based on the idea that the brain can interpret sensory information even if it's not provided via the natural channel.

Fig -1: Blind woman with Brain Port Device

An electric lollipop that allows the blind to 'see' using their tongue has been developed by scientists. The machine is called the Brain Port vision device and is manufactured by Wicab, a biomedical engineering company based in Middleton, Wis. It relies on sensory substitution, the process in which if one sense is damaged, the part of the brain that would normally control that sense can learn to perform another function. 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. With Brain Port, the device being developed by neuroscientists at Middleton, Wisc.–based Wicab, Inc. (a company co-founded by the late Back-y-Rita), and visual data are collected through a small digital video camera about 1.5 centimeters in diameter that sits in the center of a pair of sunglasses worn by the user. Bypassing the eyes, the data are transmitted to a handheld base unit, which is a little larger than a cell phone. 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. "Part of the challenge of Brain Port is to train the brain to interpret the information it receives through the stimulation device and use it like data from a 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. Most of us are familiar with the augmentation or substitution of one sense for another. Eyeglasses are a typical example of sensory augmentation. Braille is a typical example of sensory substitution in this case, you're using one sense, touch, to take in information normally intended for another sense, vision. Electrotactile stimulation is a higher-tech method of receiving somewhat similar (although more surprising) results, and it's based on the idea that the brain can interpret sensory information even if it's not provided via the "natural" channel.

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. 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. The brain appears to be flexible when it comes to interpreting sensory input. You can train it to read input from, say, the tactile channel, as visual or balance information, and to act on it accordingly. In JS Online's "Device may be new pathway to the brain," University of Wisconsin biomedical engineer and Brainport technology co-inventor Mitch Tyler states, "It's a great mystery as to how that process takes place, but the brain can do it if you give it the right information."

1.2 Concepts of electrotactile stimulation

The concepts at work behind electrotactile stimulation for sensory substitution are complex, and the mechanics of implementation are no less so. The idea is to communicate non- tactile information 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. The encoding of the electrical pattern essentially attempts to mimic the input that would normally be received by the non-functioning sense. So patterns of light picked up by a camera to form an image, replacing the perception of the eyes, are converted into electrical pulses that represent those patterns of light. When the encoded pulses are applied to the skin, the skin is actually receiving image data. According to Dr. Kurt Kaczmarek, BrainPort technology co- inventor and Senior Scientist with the University of Wisconsin Department of Orthopedics and Rehabilitation Medicine, what happens next is that "the electric field thus generated in subcutaneous tissue directly excites the afferent nerve fibers responsible for normal, mechanical touch sensations." Those nerve fibers forward their image-encoded touch signals to the tactile-sensory area of the cerebral cortex, the parietal lobe. The structure of brain is shown in figure 2.

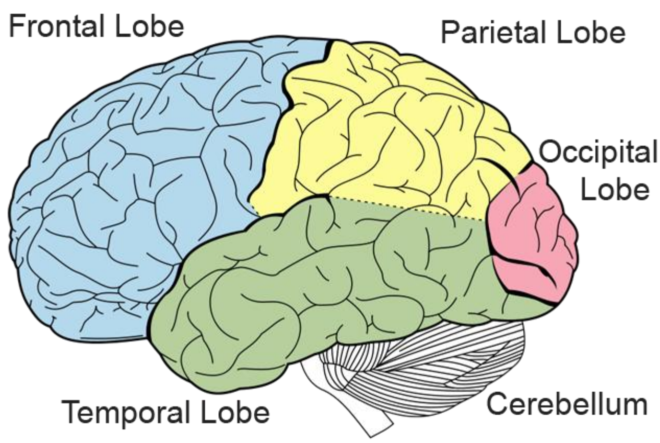

Fig -2: Structure of Brain

Within this system, arrays of electrodes can be used to communicate non-touch information through pathways to the brain normally used for touch-related impulses. It's a fairly popular area of study right now, and researchers are looking at endless ways to utilize the apparent willingness of the brain to adapt to cross-sensory input. Scientists are studying how to use electrotactile stimulation to provide sensory information to the vision impaired, the hearing impaired, the balance impaired and those who have lost the sense of touch in certain skin areas due to nerve damage. One particularly fascinating aspect of the research focuses on how to quantify certain sensory information in terms of electrical parameters -- in other words, how to convey "tactile red" using the characteristics of electricity.

This is a field of scientific study that has been around for nearly a century, but it has picked up steam in the last few decades. The miniaturization of electronics and increasingly powerful computers have made this type of system a marketable reality instead of just a really impressive laboratory demonstration. Enter Brainport, a device that uses electrotactile stimulation to transmit non-tactile sensory information to the brain. Brainport uses the tongue as a substitute sensory channel.

2. NEED AND HISTORY

2.1 Need

According to the Global data recorded in 2010 by the World Health Organization (WHO), there have been 285 million visually-impaired people, 90% of whom live in developing countries. The Vietnam Institute of Ophthalmology (VNIO) reported that in 2007 up to 380,000 people are blind whereas 1.6 billion persons have vision problems. The number showing a high percentage of visually impaired people, which results from lack of trained professionals, limited resources and spatial spread of care.

Loss of sight is associated with independence loss due to the low perception of the environment. This problem leads to difficulties to take part in daily life and hinders the mobility of the visually-impaired people. For the last few decades, various types of aid devices and systems have been manufactured to provide blind users means of navigation, learning or getting to know the environment. Some of the systems which can detect obstacles on the path are White Cane, Mowat Sensor and Sonic guide while the others can help to globally navigate such as Talking Map, SWAN or GPS System. However, the above systems are not capable of doing both tasks simultaneously. To overcome the drawbacks of the mentioned single-purpose aided devices, applied the mobile robot technology into an assistive system called Guide Robot Dog. However, the system is rather bulky and requires users to act as an operator. So there is need to develop single autonomous device which is more efficient than the all above devices.

2.2 History

Brain Port is a technology sold by Wicab Inc. whereby sensory information can be sent to one's brain via a signal from the Brain Port (and its associated sensor) that terminates in an electrode array which sits atop the tongue. It was initially developed by Paul-Bach-y-Rita as an aid to people's sense of balance, particularly of stroke victims. Bach-y-Rita founded Wicab in 1998.

The Brain Port vision device was developed by the late Dr. Paul Bach-y-Rita, a University of Wisconsin-Madison neuroscientist. The technology is covered by patents held by the Wisconsin Alumni Research Foundation ("WARF") and is exclusively licensed to Wicab. The Brain Port vision device is currently an investigational device and is not available for sale. Wicab Inc. is pursuing additional funding to support FDA clearance and commercialization.

The machine is called the Brain Port vision device and is manufactured by Wicab; a biomedical engineering company based in Middleton, the device being developed by neuroscientists at Middleton, Wisc.–based Wicab, Inc. (a company co-founded by the late Backy-Rita), the brain port device will be introduced in 2006. Brain Port collects visual data using a tiny, glasses-mounted video camera, translating images into electrical patterns on the surface of the tongue.

After a few hours of training, some users have described the experience as resembling a low-resolution version of the vision they once had. In addition, neuroimaging research suggests that for blind individuals, visual regions of the brain are activated while using the Brain Port vision device. Ultimately, the experience is uniquely individual. However, the resulting perception does not need to "feel" like eye-based vision in order to provide assistive benefit.

The Brain Port vision device is an investigational non-surgical assistive visual prosthetic device that translates information from a digital video camera to your tongue, through gentle electrical stimulation.

2.3 Research Work

The brain is capable of major reorganization of function at all ages, and for many years following brain damage. It is also capable of adapting to substitute sensory information following sensory loss (blindness; tactile loss in Leprosy; damaged vestibular system due to ototoxicity, or general balance deficit as result of stroke or brain trauma), providing a suitable human-machine interface is used (reviewed in Bach-y-Rita, 1995; in press). One such interface is the tongue Brain Port interface (Bach-y-Rita, et al 1998; Tyler, et al, 2003). Sensory substitution allows studies of the mechanisms of late brain plasticity, in addition to offering the possibility of practical solutions for persons with major sensory loss. It also offers the opportunity to study brain imaging correlates of the perceptual learning with the substitute system, such as PET scan studies demonstrating that the visual cortex of congenitally blind persons reveals activity after a few hours of vision substitution training; (Ptito, et al, 2005). In this report tactile vision substitution (TVSS) will be briefly reviewed, followed by a more extensive discussion of electro tactile vestibular substitution. (ETVSS) which will include a personal report by a subject. Some mechanisms related to the therapeutic effects will be presented, followed by a brief presentation of another area of therapeutic applications of late brain plasticity.

The Tongue Display Unit (TDU) is the first prototype of the technology that has evolved into today's Brain Port vision device. The current investigational prototype works best for individuals who are blind and have no better than light perception. Since we do not stimulate the eye or optic nerve, our technology has the potential to work across a wide range of visual impairments. We are actively developing device modifications to address the needs for those with low vision such as macular degeneration.

The brain is capable of major reorganization even many years after an injury, with appropriate rehabilitation. The highly plastic brain responds best when the therapy is motivating and has a benefit that is recognized by the patient. The major objective of this study was to estimate feasibility and efficacy of an electro-tactile vestibular substitution system (ETVSS) in aiding recovery of posture control in patients with bilateral vestibular loss (BVL) during sitting and standing. Subjects used the Brain Port balance device for a period from3 to 5 days.

Other than normal use of tongue for tasting food, eating, talking there are also many other uses. One of them is for sensing of light. It is called as tasting because it can taste the light and sense the objects. It is this property which is used in brain port device.

3. WORKING TECHNOLOGY

3.1 System Architecture

As introduced in the Introduction part, the Tongue Display Unit (TDU) which is based on the patent of Professor Bach-y-Rita is the prototype which is applied into our TVSS system. Because the device is stimulated with the tongue, not the eye or optic nerve, it can work with non-disabled people and also those with visual impairments. However, the system will be developed to address the needs for the purpose of small dimension and wireless communication which have never been done. The block diagram of Brain port device is shown in figure 3.

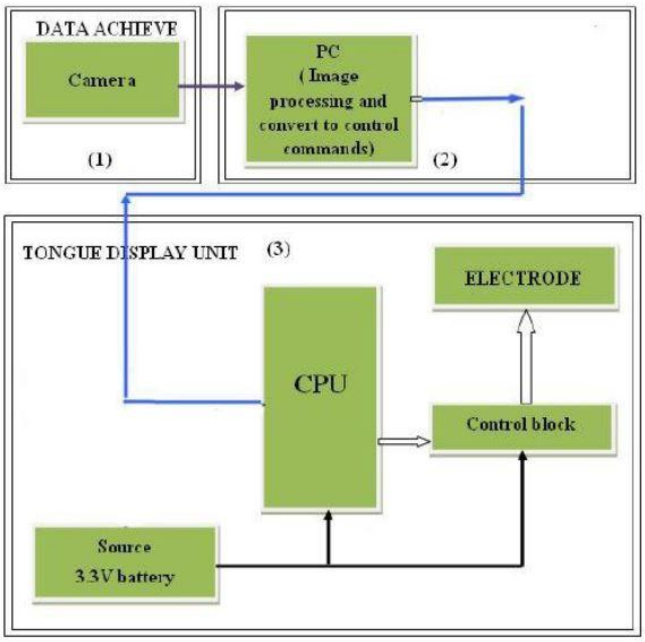

Fig -3: Architecture of Brain Port Device

This system is consist of three parts:

A. Data acquisition

User can wear a pair of sun-glasses which includes a camera capturing images from the environment. The video output is sent to the Host system.

B. Host system

The computer translates output from camera into a pattern of command and then sending wirelessly to the TDU.

C. TDU

Central Processing Unit (CPU) converts the command to electronic pulses that will be sent to an array of electrodes placed in contact with the tongue. The TDU contains five functioning blocks: a battery providing energy to all the components, a CPU processing the command signal into an encoded signal, a control block processing the encoded signal to pulse to be sent to the electrodes and the wireless module that receives the wireless signal from the camera. An array of electrodes is around 2.5 meters square that stimulates the receptor cells on the surface of the tongue to the brain, i.e., tactile or touch receptors on the tongue send impulses to the somatosensory cortex in response to stimulation.

3.2 Parts of Brainport Device

The Brain Port device consists of an Intra Oral Device (IOD) and a Controller. The IOD contains an embedded accelerometer and an electrode array. The electrode array rests on the anterior surface of the patient's tongue and the accelerometer is used to measure head/body position. Using these measurements, a stimulus pattern is generated on the electrode array reflecting the head/body position. The patient feels the pattern as electro tactile stimulation on the tongue. For example, if a patient leans to the left, the stimulus moves to the left side of the patient's tongue; a forward lean moves the stimulus to the front of the tongue. During training, patients are instructed to focus on the stimulus and to adjust their body position to keep the stimulus centered on their tongue. The Controller provides user controls for power, stimulation intensity, and re-centering the stimulus on the

electrode array.

Fig -4: Brain Port Device *(Picture Courtesy: Wicab Inc)*

Subjects were assessed at baseline and at pre-determined points during the study as determined by the individual investigators. Subjects did not use the Brain Port device during the assessments. Each clinical site did not necessarily administer all assessments, resulting in a smaller number of subjects for individual measurements.

Various parts of device are as follow:

3.2.1 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.

3.2.2 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.

3.2.3 Accelerometer

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 electro tactile stimulation of the tongue. Sensitive nerve fibres on the tongue respond to electrodes to enable a rapid transfer of electrical information.

3.2.4 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.

3.2.5 CPU, 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 pulse replacing the function of the retina. It will be a rechargeable battery.

3.2.6 Power Button

It is used for start and stop the device.

3.3 Working of Brainport Device

3.3.1 Design of the TED Device

In order to verify the performance of a new form of the electrodes as well as the impact of electrical signals from such electrodes, a demonstrator of the TED will be fabricated and verified.

a) Matrix of electrodes

The array of electrodes is composed of 33 electrode pins. In the center of each pin, a hole is made to connect with the bottom layer to plays a role as the negative terminal. Each via has diameter of 0.1mm. Outside the hole of each pin, a copper circle of 2 mm diameter is connected to the positive terminal. These pins are arranged on a round grid with 1mm inter electrode spacing. The total dimension of the grid is a circle of 4 cm diameter.

b) Control circuit for electrodes

To specify and control the stimulus waveform, pattern and trial events, a control circuit needs to be made. In the future, it will be minimized to place inside an orthodontic retainer. This circuit is desired to generate low current (the mean current for tongue subjects was 1.62 mA, the source battery has low voltage in order not cause high leakage current and consume little power. The block diagram of this circuit can be depicted in Figure 5.

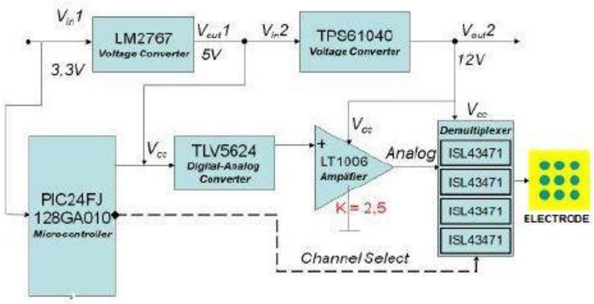

Fig -5: Schematic diagram of the TED device

In Figure 5, the central element is the microcontroller which produces the stimulation signals to the right electrodes on the dorsal part of the tongue. The whole device is powered by a 3.3V Lithium battery which has small output current. As the purpose is to test the electrode impact on the tongue, only the matrix of electrode is placed inside the mouth, the other parts is fabricated in a separate circuit to prevent severe problem in case of leakage. However, in the future, mounting the whole device within the mouth is the final goal. This can be done by packaging the circuit inside an orthodontic retainer since the groups of Vuillerme has ever made. In the following part, detailed descriptions of each block in the schematic diagram in Figure 5 will be indicated. The names of all electronic components were indicated specifically.

1. Source (power supply)

A Lithium battery with diameter of 20mm and height of 3.2mm is used, which supplies a voltage of 3.3V and a current of 135 mA.

2. Voltage Converter Circuits

This design is specifically for future use. According to Robineau et al, the range of stimulus voltage is 5-15V. But when we connected directly the electrode to the voltage generator and applied different voltage, the tongue started to have clear feeling at 3V and, at 10V, the tongue started to hurt. Hence, in our circuit, for safety reason, the voltage range was reduced to from 3V to 10V. Since the battery supply 3V power, voltage converters need to be used. In addition, for more flexible voltage modification, a DAC (Digital Analog Converter) was used. Normally the DAC needs 5V power supply. As a result, two voltage converters are necessary for the circuit, one for 5V conversion and the other for 12V conversion. The schematic diagrams of the DAC and amplifier is shown in Figure 6.

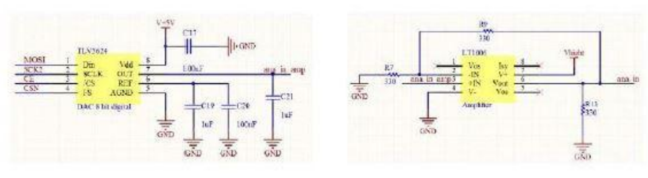

Fig -6: Schematic diagrams of: a) DAC block and b) Amplifier block

The IC (Integrated Circuit) LM2767 of Texas Instruments was to increase the 3V battery to 5V and TPS61040 of Texas Instruments was to rise from 5V to 12V. Both of them are low power IC. The detailed schematic diagram can be easily found in the datasheet of these two ICs. Besides these two converters, in order to modify the voltage, a DAC must be used in combination with an amplifier. The DAC TLV5624 is an 8íbit DAC which has 28 levels of voltage; therefore, there will be 256 voltages in the range from 3V to 12V. It is rather sufficient for choosing a suitable stimulation voltage. The gain of the amplifier is 2.5 because from 12V/5V=2.5. The single amplifier LT1006 consumed small power compared to many other ones.

3. Signal generation

A low cost PIC24FJ128GA010 microcontroller of Microchip Technology was used for the following three functions:

(1) Choosing the stimulation voltage

(2) Choosing the electrode to send signal

(3) Communicating and receiving the command

Consequently it connects to the DAC, to the demultiplexers and wireless module. Using the demultiplexer is to connect the microcontroller to the selected electrode because of the limited number of output pin in the microcontroller. Demultiplexer IC named ISL43741 of Intersils which has two blocks of 1:4 demultiplexer, which results in 8 outputs. This IC is used due to the small dimension and low consumption. The program in the microcontroller receives the information from the wireless module to activate one certain electrode at a time. The selection of the right outputs among 8 outputs from 2 inputs is based on the table of truth in the datasheet of ISL43741.

3.3.2 Working

Following figure 7 shows the working of Brain Port device.

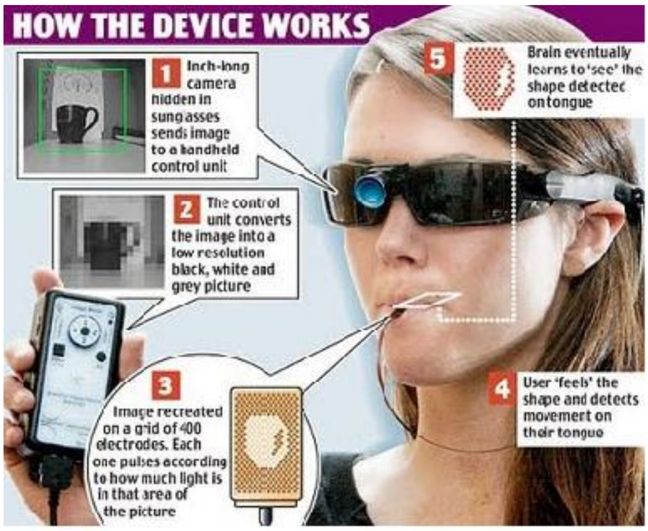

Fig -7: Working of Device

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. Visual data are collected through a small digital video camera. Bypassing the eyes, the data are transmitted to a handheld base unit, which is a little larger than a cell phone. From the CPU, the signals are sent to the tongue via a "lollipop," an electrode array about nine square centimeters that sits directly on the tongue. Densely packed nerves at the tongue surface receive the incoming electrical signals, which feel a little like Pop Rocks or champagne bubbles to the user. These signals from tactile or touch receptors cells are sent to the somatosensory cortex in response to stimulation in the form of pattern impulses. 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.

The Brain Port vision system consists of a postage-stamp-size electrode array for the top surface of the tongue (the tongue array), a base unit, a digital video camera, and a hand- held controller for zoom and contrast inversion. Visual information is collected from the user adjustable head-mounted camera (FOV range 3–90 degrees) and sent to the Brain Port base unit. The base unit translates the visual information into a stimulation pattern that is displayed on the tongue. The tactile image is created by presenting white pixels from the camera as strong stimulation, black pixels as no stimulation, and grey levels as medium levels of stimulation, with the ability to invert contrast when appropriate. Users often report the sensation as pictures are painted on the tongue with Champagne bubbles.

With the current system (arrays containing 100 to 600+ electrodes), study participants have been able to recognize high-contrast objects, their location, movement, and some aspects of perspective and depth. Trained blind participants use information from the tongue display to augment understanding of the environment. Our ongoing research with the Brain Port vision device demonstrates the great potential of tactile vision augmentation and we believe that these findings warrant further exploration. As a result, we are currently working on improvements to the tongue display hardware, software, and usability, and on overall device miniaturization. The system includes the following: A miniature 2-axis accelerometer (Analog Devices ADXL202) was mounted on a low-mass plastic hard hat Anterior-posterior and medial-lateral angular displacement data (derived by double integration of acceleration data) were fed to a previously developed tongue display unit (TDU) that generates a patterned stimulus on a 100 or144-point electro tactile array (10x10 or 12 x 12 matrix of 1.8 mm diameter gold-plated electrodes on 2.3 mm centers) held against the superior, anterior surface of the tongue. Subjects readily perceived both position and motion of a small 'target' stimulus on the tongue display, and interpreted this information to make corrective postural adjustments, causing the target stimulus to become cantered. Thirty nine research subjects used the Brain Port balance device for a period from 3 to 5 days. The subjects included 19 males and 20 females ranging in age from 25 to 78 years, an average age of 55 years. Etiologies of the balance disorders included, but were not limited, to peripheral vestibular disorders, central vestibular disorders, cerebella disorders and mixed etiology. We found two groups of ETVSS effects on BVL subjects: immediate and residual. After a short (15-40 minutes) training procedure all subjects were capable of maintaining vertical posture with closed eyes, and after additional training (30-160 minutes) some were capable of standing with closed eyes on a

1. Short-term after-effects were observed in sitting subjects after 1-5 minutes of ETVSS Exposure and lasted from 30 sec to 3 minutes, respectively.

2. Long-term after-effects were observed in trained subjects (after an average 5 training sessions) after 20 minutes standing with eyes closed and ETVSS use, with stability lasting from 4 to 12 hours, as measured by standard posture graphic techniques and spectral analysis. Additionally, during that period subjects also experienced dramatic improvement in balance control during walking on uneven or soft surfaces, or even riding a bicycle.

3. Persisting effects were demonstrated in one subject after 40 training sessions and continued for 8 weeks after the last ETVSS session. Evaluation of the results and previous studies suggests that a small amount of surviving vestibular sensory tissue can be reorganized; previous studies suggest that as little as 2 percent of surviving neural tissue in a system can serve as the basis for functional reorganization.

3.3.3 Why device should be placed on Tongue

If we compare tongue with other parts of body well notice that the skin of tongue is more sensitive than any other body part. 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 .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.

4. TRAINING AND TESTING OF BRAIN PORT

This device has been tested on several blind people; one among them is Erik Weihenmayer. 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. And by use of this device he has climbed mountains around the world—the highest peaks, in fact, on every continent.

The figure 8 below demonstrate how information from the video camera is represented on the tongue. Today's prototypes have 400 to 600 points of information on a ~3cm x 3cm tongue display, presented at approximately 30 frames per second, yielding an information rich image stream. Our research suggests that the tongue is capable of resolving much higher resolution information and we are currently working to develop the optimal tongue display hardware and software.

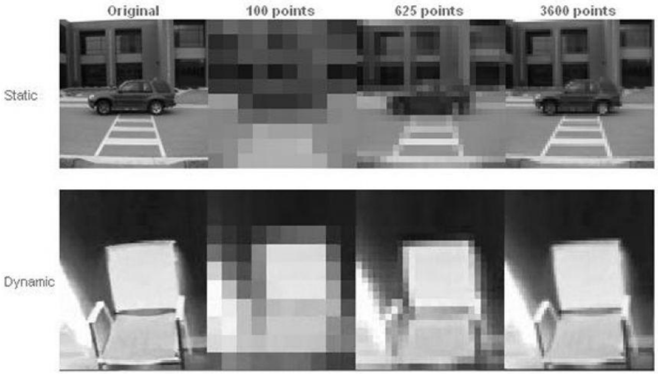

Fig -8: Recovered image from Brain port device

Sonly had between 100- and 1032-point arrays, the low resolution has been sufficient to perform complex perception and "eye"-hand coordination tasks. These have included facial recognition, accurate judgment of speed and direction of a rolling ball with over 95% accuracy in batting a ball as it rolls over a table edge, and complex inspection-assembly tasks. The latter were performed on an electronics company assembly line with a 100-point vibrotactile array clipped to the work-bench against which the blind worker pressed the skin of his abdomen, and through which information from a TV camera substituting for the ocular piece of a dissection microscope was delivered to the human-machine interface (HMI).

4.1 Learning Time

Current research studies involve participation between 2-10 hours. Within minutes of introduction, users may understand where in space stimulation arises (up, down, left and right) and the direction of movement. Within an hour of practice, users can generally identify and reach for nearby objects, and point to an estimate the distance of objects out of reach. With additional training, subjects can identify letters and numbers and can recognize landmark information when using the device in a mobile scenario.

After a few hours of training, some users have described the experience as resembling a low-resolution version of the vision they once had. In addition, neuroimaging research suggests that for blind individuals, visual regions of the brain are activated while using the Brain Port vision device. Ultimately, the experience is uniquely individual. However, the resulting perception does not need to "feel" like eye-based vision in order to provide assistive benefit.

You can adjust the intensity of the stimulation to your comfort level. Participants have reported that the impulses feel like champagne bubbles effervescing on their tongue.

4.2 Treatment

Subjects received clinic training for 3-5 consecutive days (2 one-hour sessions each day) with the Brain Port balance device. Each training session included up to 9 short (1-5 minute) training sessions, followed by a 20 minute training session, in progressively challenging positions. Subjects continued training at home for two 20-minute sessions each day for the duration of the study.

5. APPLICATIONS AND LIMITATIONS

5.1 Applications

1. One of the applications which has been commercialized is providing vestibular or balance information for people with balance disorders. This is a simple form of sensory substitution, in which the tongue is used to present information from an artificial balance sensor.

2. Another application is providing directional or navigational information for people who operate under central command and control scenarios, such as military and civilian rescue personnel. Providing information via the tongue allows them to fully use their vision and hearing to respond to unforeseen threats or hazards. We have shown in the laboratory that it is possible to navigate a virtual maze (like a simple video game) using only information received on the tongue (i.e., buzz on right side of tongue means turn right, etc.

3. A third, more ambitious application would be providing very crude visual information through the tongue for persons who are completely blind. Our colleague Eliana Sampaio at the Louis Pasteur University in Strasbourg, France has used our tongue stimulator with a small video camera and demonstrated an equivalent visual acuity of about 20-to-830, which is very poor vision, but possibly useful for certain limited activities with enough practice. Wicab, Inc continues to improve this technology with the aim of commercializing it.

4. A fourth application would be providing tactile feedback to the human operators of robots used for various tasks. For example, UW professor Nicola Ferrier is developing a robot controlled by the tongue of persons with quadriplegia which could incorporate touch sensors into its gripper, relaying the touch information back to the user's tongue.

5. Beyond medical applications, scientists have been exploring potential military uses with a grant from the Defense Advanced Research Projects Agency (DARPA). They are looking into underwater applications that could provide the Navy Seals with navigation information and orientation signals in dark, murky water.

6. Brainport may also provide expanded information for military pilots, such as a pulse on the tongue to indicate approaching aircraft or to indicate that they must take immediate action.

7. Race car drivers might use a version of Brainport to train brains for faster reaction times, and gamers might use electrotactile feedback gloves or their controllers to feel what they're doing in a video game.

5.2 Limitations

1. This technology can't be adapted to work on senses the brain doesn't already have. So, the research centre wibac is trying to implement this kind of people also.

2. The Brain Port requires training the brain incrementally using daily practice sessions.

3. When it comes in market its cost is around $10,000 so it cannot be afforded by common people.

4. Occasionally it will produce weak metallic taste sensations, a minor side effect.

6. CONCLUSIONS

Science has always provided mankind with answers and solutions, and science will continue to do so, while simultaneously supplying us with improvements upon previous technologies or new technologies altogether. Today, humanity owes the majority of our commodities, from prosthetic limbs to iPods, to years of scientific research and collaboration between different scientific disciplines. Unfortunately, however much science may have contributed to improving our lives, there is still plenty of headway to be made. We are always looking for areas in which our interdisciplinary strengths can be leveraged to revolutionize areas of science, engineering and technology, and to improve quality of life for millions of people.

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. The brain appears to be flexible when it comes to interpreting sensory input. You can train it to read input from, say, the tactile channel, as visual or balance information, and to act on it accordingly. It's a great mystery as to how that process takes place, but the brain can do it if you give it the right information.

There is a hope that a balance device that uses nerve fibers on the tongue to transmit information about head and body position to the brain can make a serious difference for patients whose sight cannot be replaced. Thus we hope that blind people can also see this colorful world by using this brain port device.

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