Design of a Prototype for Vision Prosthesis

V. Bhujanga Rao, NIAS I I Sc. Campus, Bangalore, India
P. Seetharamaiah, Dept. of CSSE Andhra University, Visakhapatnam, India
Nukapeyi Sharmili, Gayatri vidya Parishad College of Engineering for Women, Visakhapatnam, India

ABSTRACT

This article describes how the field of vision prostheses is currently being developed around the world to restore useful vision for people suffering from retinal degenerative diseases. The vision prosthesis system (VPS) maps visual images to electrical pulses and stimulates the surviving healthy parts in the retina of the eye, i.e. ganglion cells, using electric pulses applied through an electrode array. The retinal neurons send visual information to the brain. This article presents the design of a prototype vision prosthesis system which converts images/video into biphasic electric stimulation pulses for the excitation of electrodes simulated by an LED array. The proposed prototype laboratory model has been developed for the design of flexible high-resolution 1024-electrode VPS, using an embedded computer-based efficient control algorithm for better visual prediction. The prototype design for the VPS is verified visually through a video display on an LCD/LED array. The experimental results of VPS are enumerated for the test objects, such as, palm, human face and large font characters. The results were found to be satisfactory.

KEYWORDS

BWIP, Electrical Stimulation, Electrode Driver, H Bridge, RIRS, Vision Prosthesis

1. INTRODUCTION

Vision prosthesis restores vision to the blind patients suffering from incurable retinal degenerative diseases such as Retinitis Pigmentosa (RP) and Age-Related Macular Degeneration (AMD) (Banarji, Gurunadh, Patyal, Ahluwalia, Vats and Bhaduria, 2009; Kelly et al., 2009; Weiland, Liu, and Humayun, 2005; Tran, Yang, Bai, Ng, Halpern, Grayden, Skafidas, and Mareels, 2009; Tran, Skafidas, Yang, Bai, Fu, Ng, Halpern, and Mareels, 2011; Ganesan, Stacey, Meffin, Lichter, Greferath, Fletcher, and Prawer, 2010; Chen, Lo, Yang, Weiland, Humayun, and Liu, 2013; Wang, Wang, Tang, and Liu, 2012; Matteucci, Paul, Byrnes-Preston, Chen, Lovell, and Suaning, 2011; Fink, Wolfgang, You, and Tarbell, 2010; Noorsal, Sooksood, Xu, Hornig, Becker, and Ortmanns, 2012; Zhou, David, Dorn, and Greenberg, 2013; Microcontrollers Datasheet, n.d.; Liu and Humayun, 2004; Greenwald, Horsager, Humayun, Greenberg, McMahon, and Fine, 2009; Omni Vision, n.d.; Zou, Yuexian, Shi, Jin, and YaliZheng, 2009). AMD and RP cause dysfunction of the photoreceptors, resulting in blindness, but their retinal ganglion communication) cells were still intact. Several distinct vision prosthesis approaches (i.e. Cortex, Optic nerve and Retinal) have been developed over the years. Retinal prostheses can be divided into two categories: epi-retinal and sub-retinal, depending on where in the retina the device is implanted and they aimed to stimulate the inner retina by bypassing damaged photoreceptors. Of these approaches, majority of the researchers are concentrating on epiretinal prosthesis in surgical and technical point of view. Epiretinal approach is advantageous over subretinal approach in aspect of

DOI: 10.4018/IJBCE.2018070101

Copyright © 2018, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.
surgery and sufficient space to place electronic components, separation of the electronics, software control and possibility of upgrades without surgery.

At present, there are two epiretinal prosthetic projects such as Second sight’s 60 electrode Argus II (FDA 2013, CE 2011) and Pixium vision’s 150 electrode Iris II (CE 2016) have obtained marketing approval for use in the United States and European countries (www.pixium-vision.com, n.d.). In addition to these two projects, a similar epiretinal prosthesis system developed by researchers at Bionic Vision Australia are promising more excitable possibilities. Currently, Second Sight’s Argus II is the only one received the CE Mark and FDA approval for use in the United States and Europe (Sohmyung et al., 2016).

To date, research on retinal prosthesis have focused primarily on clinical trials on human body with limited electrodes and fail to meet the engineering challenges in retinal prosthesis. The main challenge in epiretinal prosthesis is not to get neuronal signal to brain but to elicit the better visual percepts for blind to do his basic vision tasks (Zou, et al., 2009; Sharmili, Ramaiah, and Swamyndhan, 2011; Sharmili, Ramaiah, 2015; www.pixium-vision.com, n.d.; Noda, takehara, Sasagawa, Tokuda and Ohta, 2016).

One of the Vision prosthesis approach i.e. Epiretinal prosthesis has the potential to restore partial vision in blind patients as it bypasses the defective photoreceptors and electrically stimulating the healthy layers of the retina (i.e. ganglion cells) (Banarji, et al., 2009; Kelly, et al.; 2009; Weiland et al., 2005; Tran et al., 2009; Tran et al., 2011; Ganesan et al., 2010; Chen et al., 2013; Wang et al., 2012; Matteucci et al., 2011; Fink et al., 2010; Noorsal et al., 2012; Zhou et al., 2013; Microcontroller Datasheet, n.d.; Liu et al., 2004; Greenwald et al., 2009; Omni Vision n.d.; Zou et al., 2009). Epi-retinal prosthesis is an electrical device that maps visual images to electrical pulses and stimulates the surviving healthy parts in the retina i.e. ganglion cells using electric pulses applied through an electrode array.

The Epiretinal prosthesis system shown in figure1 is composed of two units: one is extraocular, which means the device is placed outside the eye and intraocular, which is placed inside the eye. The two units are connected by a RF based transcutaneous wireless link, allowing the intraocular unit to derive both power and a data signal from the external unit. At the extraocular unit, Body Worn Image Processor (BWIP) captures the real-time video picture or image using a digital camera, processes the captured image into custom pattern of electrical signals and transmits the processed signals to intraocular unit Retinal through wireless telemetric inductive link. Upon reception of the signals through wireless link, the Retinal Implantable Receiver Stimulator (RIRS) in intraocular unit stimulates the ganglion cells with an electrodes array implanted on the surface of retina.

In the last few years various techniques have been proposed for signal processing software to perform image processing and extrapolate salient information from a video stream for visual prosthesis (Noorsal et al., 2012; Zhou, et al., 2013; Microcontrollers Datasheet, n.d.). Some of recent Researchers used the embedded processors for developing epi-retinal prosthesis. Fink et al. (2013) proposed a much lighter (8g) device which ran at a higher clock speed (600 MHz), resulting in an image reduction in resolution to 160x120 pixels in order to achieve a satisfactory frame rate. In this case the powerful CPU (Verdex-Proclass Gumstix microcomputer consists of mother boards related to ARM®-based platform and processor is Verdex pro XLP6) was mostly underutilized, yielding a load of just 10%. Tsai et al. (2012) reported an image processing device capable of sampling a USB Camera at a resolution of 176 x 144 at 30fps, but requiring a Digital Signal Processor to perform the image processing. Kelly et al. are using Texas Instruments MSP430-F2013 microcontroller using 125 KHz RFID for power source and 15MHz carrier supported PWM channels to dispatch optic data by wireless.

The 60 electrode Argus II retinal system captures the visual information using camera, then processes it and converts it into a brightness map in real time by the video processing unit. The brightness values wirelessly sent to internal stimulator where these values are converted into stimulation current amplitudes for 60 individual electrodes. The system is controlled by software to
Related Content

Studies on Gymnemic Acids Nanoparticulate Formulations Against Diabetes Mellitus
[www.igi-global.com/article/studies-on-gymnemic-acids-nanoparticulate-formulations-against-diabetes-mellitus/86047?camid=4v1a](www.igi-global.com/article/studies-on-gymnemic-acids-nanoparticulate-formulations-against-diabetes-mellitus/86047?camid=4v1a)

Pitfalls and Successes of a Web-Based Wellness Program
[www.igi-global.com/chapter/pitfalls-successes-web-based-wellness/19930?camid=4v1a](www.igi-global.com/chapter/pitfalls-successes-web-based-wellness/19930?camid=4v1a)
Classification of Breast Thermograms Using Statistical Moments and Entropy Features with Probabilistic Neural Networks


Data Mining Medical Information: Should Artificial Neural Networks be Used to Analyse Trauma Audit Data?


[www.igi-global.com/chapter/data-mining-medical-information/26368?camid=4v1a](www.igi-global.com/chapter/data-mining-medical-information/26368?camid=4v1a)