

Preface

A brain–computer interface is a system that provides a direct connection between human brain activity and computer-based devices. It generates an alternative channel of communication between the human and his/her environment bypassing the normal output pathways. The applications of BCIs are constantly increasing. It includes communication systems, prosthetics control, rehabilitation, robotics, and interaction of healthy people with their environment. Nowadays, one of the main challenges of this technology is to provide practical and suitable applications for patients with partial or complete paralysis caused by severe neuromuscular disorders. SSVEP-based BCIs are becoming robust systems and are achieving high performance; however, the traditional assessment is not suitable for employing paralysis situation because it demands neck, head, or/and eye ball movements.

In order to take advantage of the potential of the SSVEP-BCI, this book introduces and describes a novel approach of setting visual stimuli based on the optical phenomenon of Depth-of-field. The intention is to offer to users the possibility of selecting a SSVEP stimulus by shifting focus of the eye, instead of perform neck, and/or eye ball movements. This approach was inspired in the photography when it was noticed that any object of a scene can be highlighted by adjusting the focus control of the camera; and not necessarily moving the camera. Then, if two visual stimuli are present in the subject field of view, he/she can highlight one of them (e consequently attenuate the other one) by adjusting the eye focusing. The advantage of the human eye is that focusing is a reflex mechanism. This book is the result of the studies and experiments conducted during my Doctoral and Postdoctoral research at the Intelligent Automation Lab of the Federal University of Espirito Santo. Its content aims to contribute with the development of technologies of human–computer interaction in paralysis situation. It starts with a brief definition of light and how it can modulate the brain signals, and ends showing practical applications, such as the control of a telepresence robot.

The book is organized as follows; In Chap. 1, the problem is contextualized and the purpose of the book is established. Also, a hypothesis is formulated. Chapter 2 provides a theoretical background; starting with the definition of the light and ending with the presentation of a command of a brain–computer interface

originated by a light stimulus. Also, a literature review is dealt including recent relevant works that addressed the application of SSVEP-BCI in patients with paralysis. In Chap. 3, the new approach of setting the SSVEP stimuli based on Depth-of-field phenomenon is presented. Concepts related to the optical phenomenon of Depth-of-field are reviewed, such as defocusing and point spread function. Also, physiological aspects such as the accommodation of the eye mechanism and retinal blur model are addressed. Chapter 4 introduces a demodulation method for extracting frequential features in the context of the SSVEP-BCI based on the Depth-of-field. For this aim, the spatial-temporal spectral response caused by a focused stimulus and a non-focused stimulus was studied. Some experiments are conducted by evaluating and comparing the spectral power of focused and non-focused stimuli to verify if the amplitude of the retinal response is higher for the focused one than for the non-focused one. In Chap. 5, experiments conducted for evaluating the detection of commands associated to focusing mechanism are described. The evaluation is conducted in offline mode to find out the possibilities of employing a SSVEP-BCI based on Depth-of-field in practical situations. Conventional BCI performance metrics were employed. Chapter 6 presents and describes online practical applications of the SSVEP-BCI based on Depth-of-field in communication and control. A speller system and a system for controlling a telepresence robot were implemented. Pilots experiments conducted for evaluating each system are described. Finally, vantages and limitations of the proposal and its future directions in patients with paralysis are presented.

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