Brain-Computer Interface
for Controlling a Robot

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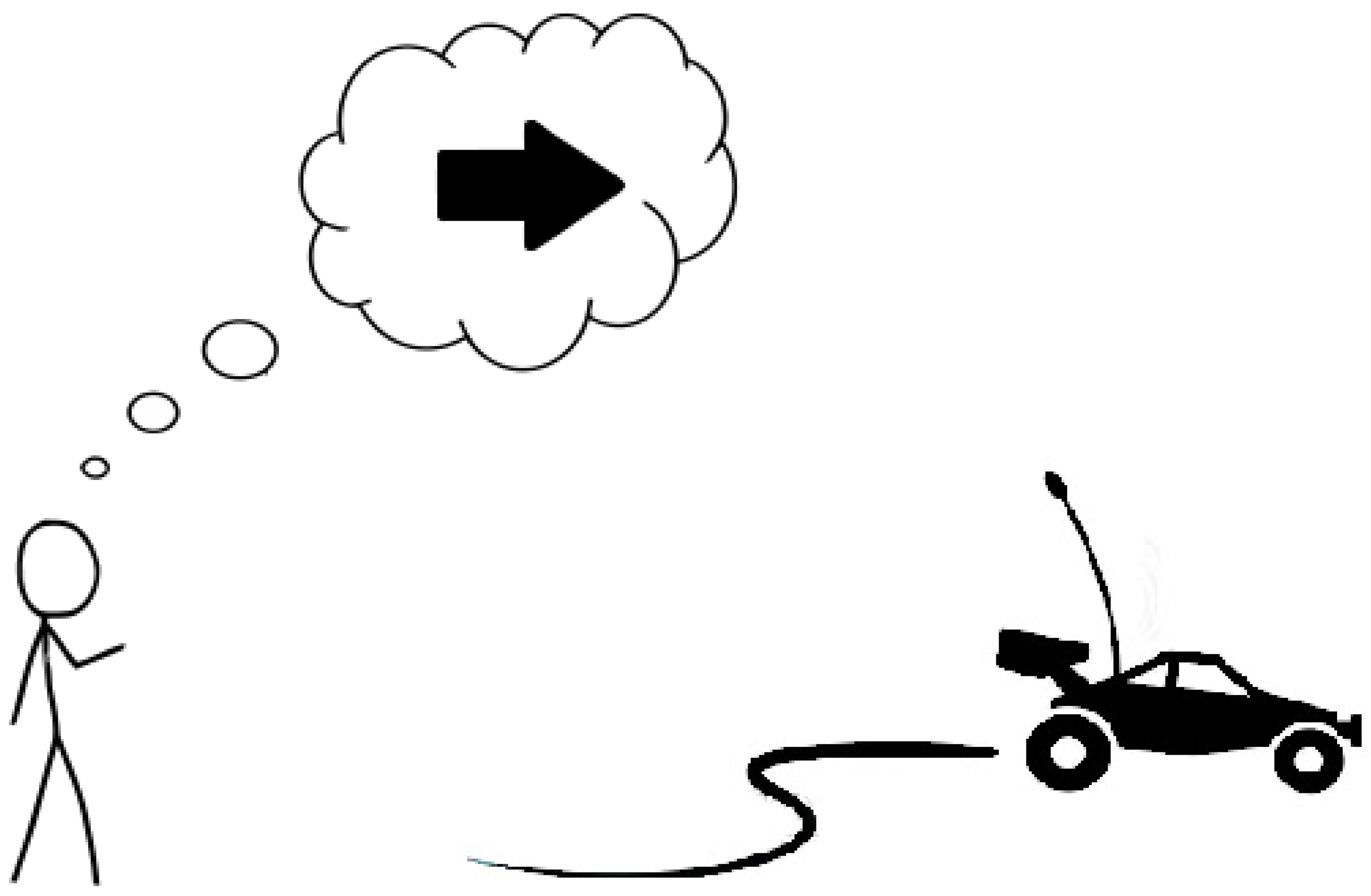
BRAIN ACTIVITY TO ROBOT COMMANDS



In this project a direct communication channel between the brain and a robot or, in other words, a brain-computer interface (BCI) was implemented. The application translates brain activity into commands for a robot and it can be used to control a robot just by looking at certain regions on computer screen without pressing any buttons. Severely disabled people could use such application to control an electric wheelchair or other devices.

THE ROBOT

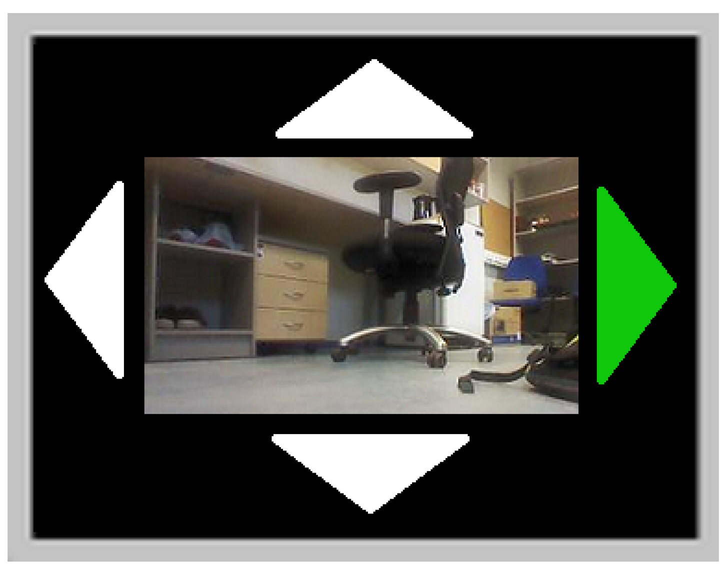
The figure on the right shows a picture of the robot which was used in testing the application. It has five possible commands: go forward, go backward, turn left, turn right and stop. There is also a camera in front of the robot and the stream from the camera can be shown on a computer screen.

RECORDING BRAIN ACTIVITY

The application uses electroencephalography (EEG) device called Emotiv EPOC to record brain activity. The device can be seen in the figure on the right. Emotiv EPOC is inexpensive, portable and easy to use, but when compared to medical-grade device, it can be seen that Emotiv EPOC has significantly lower signal quality.

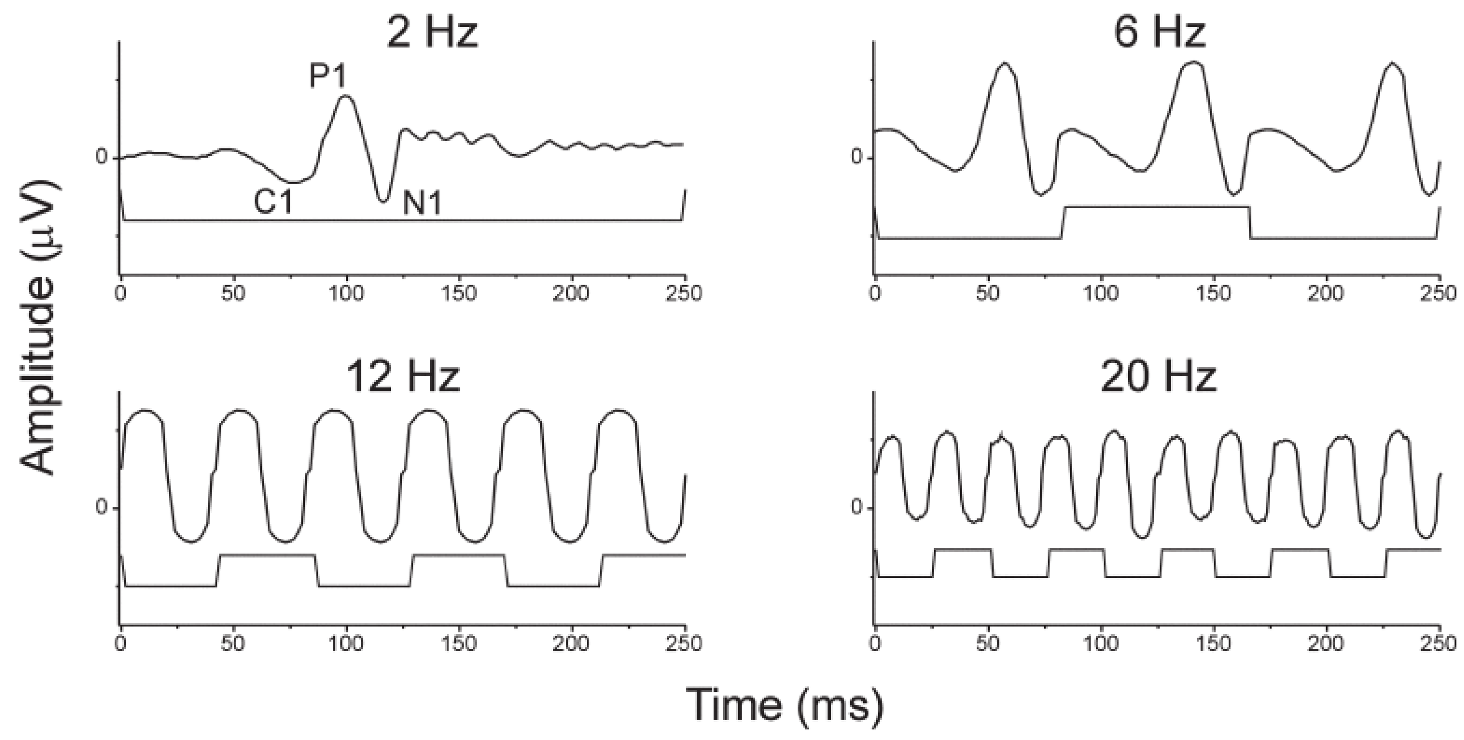
VISUAL STIMULI

The application presents visual stimuli to the user along with the stream from the robot's camera and tries to detect which visual stimulus or target the user is looking at. Each target is blinking with different frequency and each blink elicits a response in the brain called visual evoked potential (VEP).



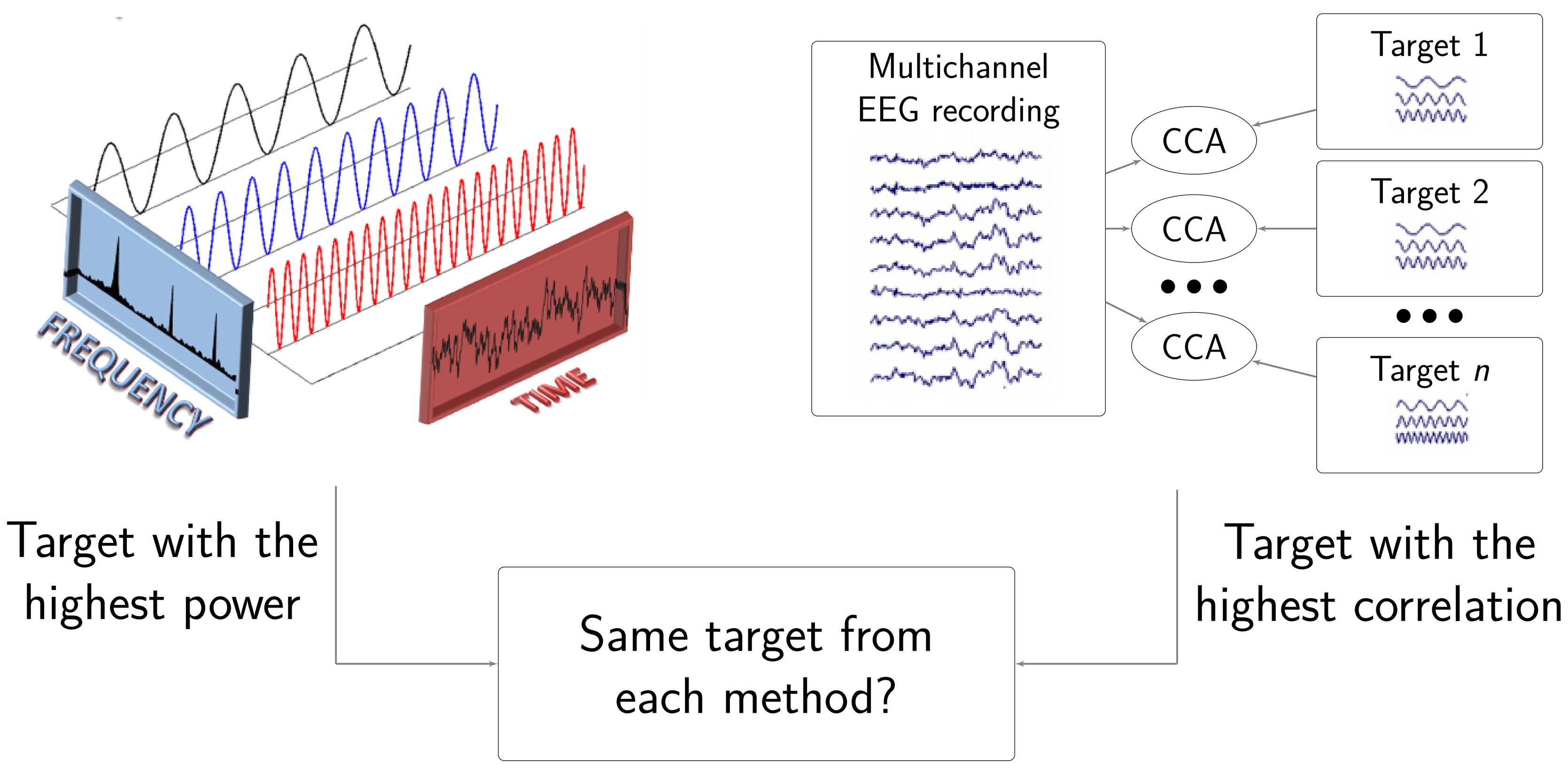
VISUAL EVOKED POTENTIAL (VEP)

The targets are blinking with different frequencies and each blink elicits specific brain response. When user is looking at a target, then the target's blinking frequency can also be detected from the user's brain. The brain's response to different blinking frequencies can be seen in the figure below.



FEATURE EXTRACTION

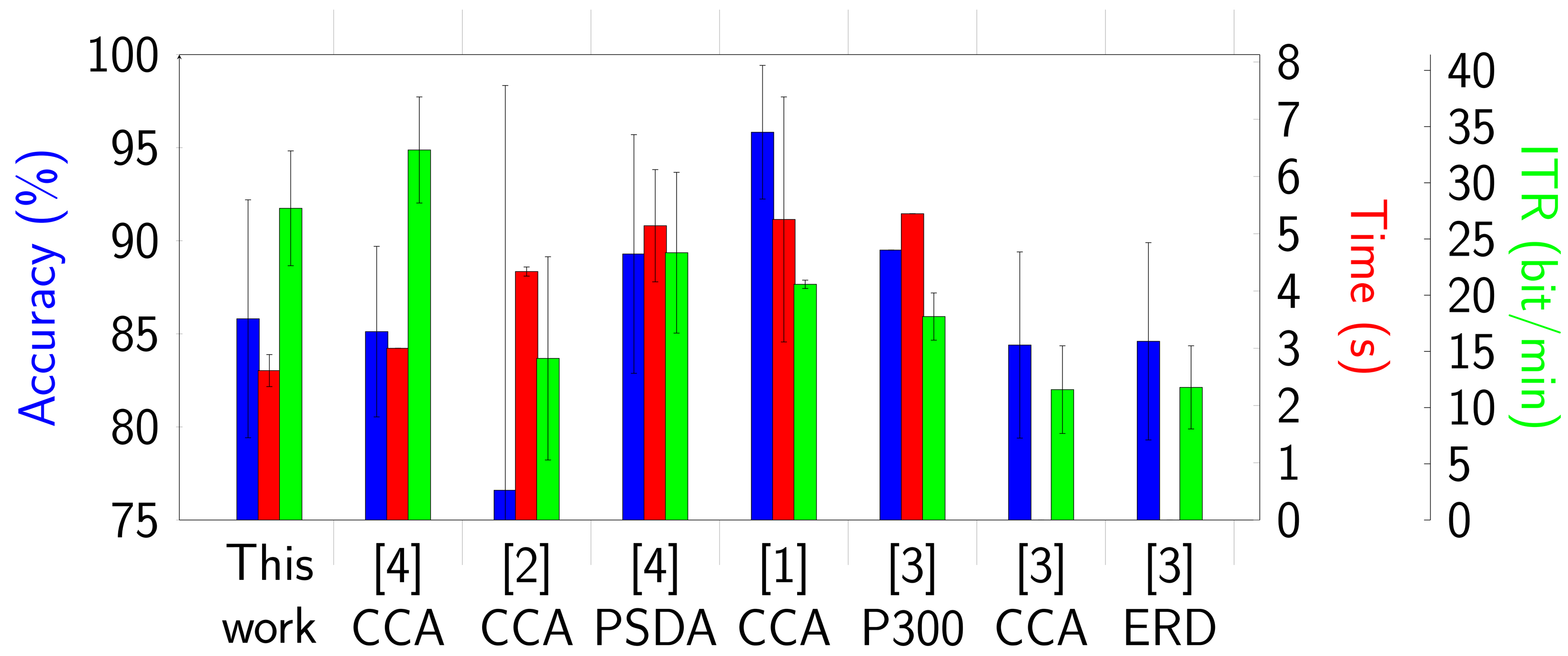
The application uses two methods to detect frequencies in EEG recording or two feature extraction methods. One method is power spectral density analysis (left picture on the figure below), which estimates brain signal's power spectrum and chooses a target whose frequency has the highest power. The other method is canonical correlation analysis, which calculates canonical correlation between the brain signal and reference signals and chooses the target with the highest correlation. Novelty of the application is that previous BCIs have not combined different feature extraction methods and this approach has shown results superior to previous Emotiv EPOC BCIs.



RESULTS AND CONCLUSION

Results of this work compared to previous Emotiv EPOC BCIs can be seen in the table below. Three performance measures were compared: target detection accuracy, target detection time and information transfer rate (ITR).

The method introduced in this work shows good results and maybe one day the application performs well enough to control real-world devices.



[1] Y. Liu, X. Jiang, T. Cao, F. Wan, P. U. Mak, P.-I. Mak, and M. I. Vai. Implementation of SSVEP based BCI with Emotiv EPOC. Virtual Environments Human-Computer Interfaces and Measurement Systems (VECIMS), 2012 IEEE International Conference, pages 34-37, 2012.
[2] Y.-P. Lin, Y. Wang, and T.-P. Jung. Assessing the feasibility of online SSVEP decoding in human walking using a consumer EEG headset. NeuroEngineering and Rehabilitation, 11(119), 2014.
[3] S. J. Bongjae Choi. A low-cost EEG system-based hybrid brain-computer interface for humanoid robot navigation and recognition. PLoS ONE, 8(9), 2013.
[4] F. T. Hvaring and A. H. Ulltveit-Moe. A comparison of visual evoked potential (VEP)-based methods for the low-cost Emotiv EPOC neuroheadset. Master's thesis, Norwegian University of Science and Technology, 2014.
Emotiv EPOC picture: http://www.arts-numeriques.info/emotiv-epoc/
VEP picture: A. Zani, A. M. Proverbio, and M. I. Posner, editors. The Cognitive Electrophysiology of Mind and Brain. Academic Press, San Diego, 2003.
PSDA picture: http://groups.csail.mit.edu/netmit/wordpress/projects/sparse-fourier-transform/
Also used: http://asun.vn/images/category/subcategory/xe-dieu-khien-tu-xa-asun.jpg

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