The MIRAGE91 Brain-Computer Interface

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Introduction

MIRAGE91 (Motor Imagery Racing Graz established 1991) is the name of the official Brain-Computer Interface (BCI) Racing Team at Graz University of Technology. Our BCI is based on the (self-paced) Graz-BCI [1, 2]. It captures brain activity by electroencephalography (EEG) and utilizes changes in oscillatory components caused by four different mental tasks to generate control signals.

Methods

We measure EEG with 32 active Ag/AgCl electrodes and two 16-channel biosignal amplifiers. A standard laptop hosts all necessary software and also sends the control commands via network to the Cybathlon Brain Runners game. Our custom made TOBI SignalServer handles data acquisition from the amplifiers and provides an interface to Matlab/Simulink, where signal processing is performed [3]. First we filter EEG in alpha and beta bands separately. Then, we normalize channels to their resting variance to reduce the influence of high variance channels. Resting variance is estimated from a prior resting measurement. After that, we perform spatial filtering with common spatial patterns (CSP) in a one class vs. one class manner and use four filters per CSP model [4]. Then we calculate logarithmic band power over one-second sliding windows and use an analytical shrinkage regularized linear discriminant analysis (sLDA) to calculate class probabilities [5]. If the class probability of one of the four classes exceeds a threshold for a certain time, we send a command to the game. Commands are blocked if the amplitude at AFza or the inverse filtering error exceeds a certain threshold. Figure 1 panel A shows our pilot with the MIRAGE91 BCI during playing the BRAINRUNNERS game. Figure 1 panel B gives an overview on the signal processing of the MIRAGE91 BCI.

Results

Median run times of our motor impaired pilot decline over sessions. The best run time was 112 seconds at 5 trials per class (in total 20 trials per run). At 4 trials per class (16 trials per run) the best time achieved was 106 s. Figure 2 shows the run times over sessions.

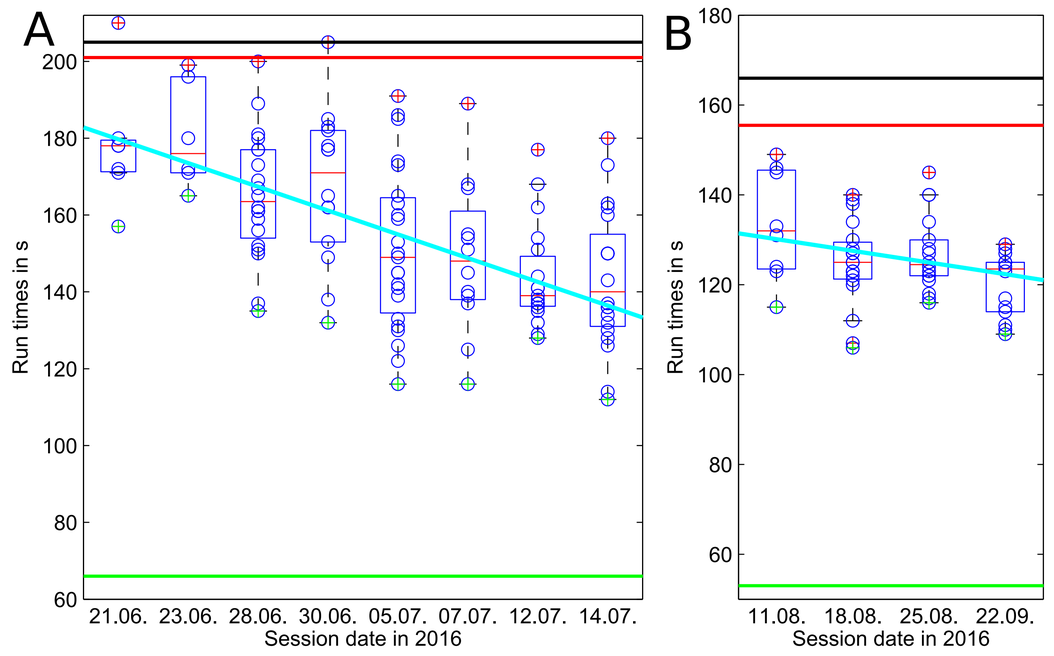

Figure 2: Run times evolution over training sessions from June to September 2016. Black line indicates run time without input (205 s / 166 s). Red line indicates median run time with random input (201 s / 155.5 s). Green line indicates best possible runtime (66 s / 53 s). Cyan line indicates the linear trend of median run times over sessions. Panel A run times are with 5 trials per class and without computer controlled competitors. Panel B run times are with 4 trials per class and with computer controlled competitors.

Discussion

Lessons learned from designing our system will influence future BCI system design in terms of robust signal processing at low trials-to-features ratios and BCI personalization.

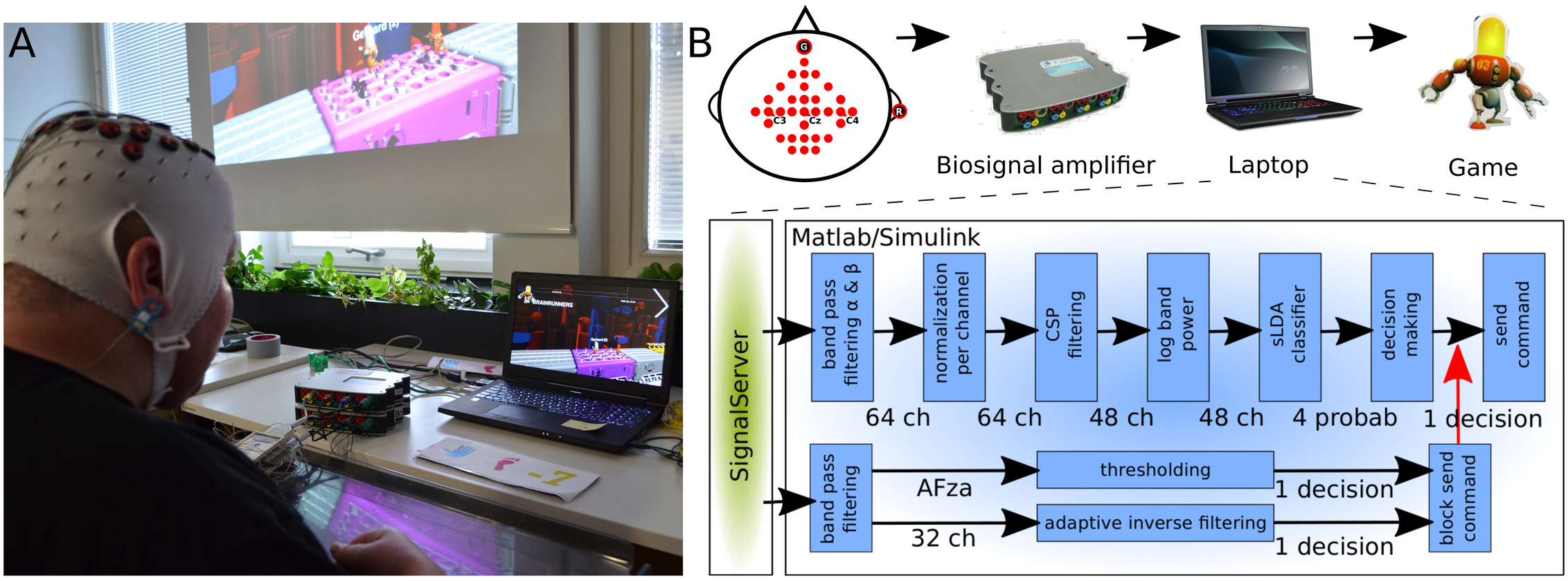

Figure 1: MIRAGE91 brain-computer interface. Panel A shows our Pilot using the MIRAGE91 BCI. Panel B shows the MIRAGE91 BCI signal processing scheme.

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Acknowledgments

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