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Initial design of an AAC device with non-invasive BCI, adaptive language modeling and Rapid Serial Visual Presentation (RSVP)

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Background and Objective

We are designing a portable communication device that relies on a non-invasive BCI with optimized language modeling for literate individuals who are functionally locked-in. We use single trial P3 detection for binary selection of single characters in a rapid serial visual presentation (RSVP).

Our RSVP system prototype uses an N-gram character-based language model, which is an (N-1)-order Markov process, to order symbols in real-time. Letters and characters appear sequentially using the order specified by the language model, the output of which is based on the string of previously detected symbols. A subset of the symbols is repeated at the end of a given sequence based on (1) a limited number of symbols having a high, but sub-threshold, posterior probability and (2) a flag from the vigilance detector indicating that the specified letter was likely not attended. In this paper, we present preliminary results for target classification in such an RSVP paradigm.

Methods

We use a quadcore laptop, each core operating at 2.53GHz. The software uses Labview (National Instruments, Austin, TX), executing functions written in Matlab (Mathworks, Natick, MA) and C, exploiting multicore capabilities. EEG and trigger data are acquired using g.USBamp (Guger Technologies, Austria), a 24-bit, 16-channel biosignal amplifier sampled at 256Hz through a USB2.0 connection. Rapid and accurate stimulus presentation capabilities of the Psychophysics Toolbox v3 (PTB-3; http://psychtoolbox.org) are utilized by presenting a string of symbols on the subject screen in synchrony with the vertical retrace of the 60Hz, LCD monitor using OpenGL commands embedded in PTB-3, while EEG activity is monitored on the administrator screen. For this report, 30 symbols (26 letters and 4 editing characters) appear one at a time using a serial visual presentation paradigm. Synchronization of the different processes is guaranteed by having each process record timestamps from the same high-precision 64-bit hardware counter, which updates at the processor rate.

For data collection, one able-bodied, literate adult matched visually presented symbols to ones that appeared in the series. Rare target letters and common non-target letters (white symbols on black background) and rare non-targets (different color) were presented for 500 ms each, with 80 ms black inter-stimulus intervals. Recording was done from 19 10-20 system scalp locations and non-cerebral activity including EOG. To detect symbol selection intent, we used a Support

Vector Machine classifier which attempts to detect the P3b event-related potentials from single-trial data.

Results

Using a Gaussian kernel SVM to assess 10-fold averaged AUC, results were targets vs. non-targets (common and rare non-targets), AUC=0.9891; target vs. common non-targets, AUC=0.9874; and rare non-target vs. common non-targets, AUC=0.9874.

Discussion and Conclusions

Our initial experiment indicates that there might not be statistically significant differences in BCIs based on P3a or P3b phases. The artifact removal process is continuously trained in a supervised fashion. The classifier is initialized using training data previously recorded from the user and is updated periodically using decision feedback. In the future, we will incorporate a vigilance detector, based on the number of eye blinks and the instantaneous power of alpha waves. Unique design of the RSVP system will be discussed.

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