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Fusion of P300 and Eye Tracker Data for Spelling Using BCI2000

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Introduction: The P300 speller, an EEG-based Brain Computer Interface (BCI) [1] and various eye-trackers [e.g. 2] have been used individually as communication aids for people with ALS. The work presented here explores the efficacy of combining EEG and eye tracker data to improve P300 speller performance.

Material, Methods and Results: In this work, a Bayesian update classifier [3] has been adapted to combine EEG and eye-tracker inputs probabilistically in order to estimate the probability that a character is the target character. Eye tracker data was assumed to be well modeled by a two-dimensional Gaussian distribution centered on the target character, and independence between the EEG and eye tracker probabilities is assumed. The *a priori* variance of this Gaussian distribution can be static or learned during training – both types were considered in this work. To assess the potential benefit of utilizing this type of bimodal system, data will be collected from 20 non-disabled individuals using the updated Bayesian classifier to select characters in real-time. Data collection is currently ongoing, but preliminary results from seven subjects are shown below.

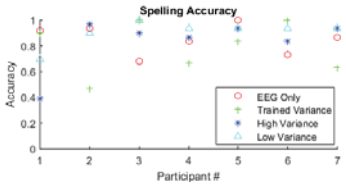

Figure 1. *This figure shows the spelling accuracy given the four different configurations of the Bayesian update classifier.*

Figure 2. *This figure shows the average number of flashes to spell a character given the four different configurations of the Bayesian update classifier.*

Figure 1 shows the spelling accuracy given four different configurations for the Bayesian update classifier: EEG without eye gaze, EEG with eye gaze variance learned during training, and two static eye gaze variances. The trained variance is very low for all participants, so this configuration is almost identical to eye-gaze only. Using only EEG or the trained variance configuration is always the worst performer except in the case of participant 1, showing that the use of the multimodal system provides robustness to the speller. Figure 2 confirms this observation and shows the mean and standard deviation of the spelling accuracy given the four different configurations of the Bayesian update classifier. The results show that given a broad enough gaze variance, the speller performs with higher accuracy and more robustness than using EEG or the trained variance configuration.

Additional offline simulations were performed to consider eye gaze challenges that might occur in the target population. These simulations included the addition of variance and bias to data collected from non-disabled participants as well as random fixations towards incorrect characters. As with the online accuracy, the classifier was robust given a large enough *a priori* variance.

Discussion: The probabilistic combination of EEG and eye tracker data is fairly robust to large variance in gaze fixation. Although promising, results from online testing with the ALS target population will be necessary to assess the true potential for a bimodal spelling system. Even though the Gaussian distribution for non-disabled eye gaze is appropriate, it is possible that a more complex statistical model will need to be used for eye gaze collected from an ALS patient.

Significance: This work shows that combining information from the P300 and eye-gaze data is a promising research avenue.

References

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