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Early stopping strategies for P300 speller with Bayesian accumulation of Riemannian probabilities

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Introduction: P300-based BCI [1] have been widely investigated; it provides a resourceful ground to build BCI speller applications, as proves the numerous many experimental or commercial frameworks. Most of the P300 speller literature focus on the detection of P300, with the objective to reach single trial classification, while existing frameworks still require several repetitions to yield proper accuracy.

Unlike previous works, Bayesian accumulation of Riemannian probabilities (ASAP) [2] considers the full problem of character classification based on P300 detection, providing an end-to-end machine learning pipeline, from feature extraction at signal level to character selection at user-interface level by Bayesian accumulation. This seamless processing of information from signal to BCI characters outperforms standard methods [2]. However, ASAP does not describe *when* a character could be selected before moving to the next one. This work tests different strategies for early/dynamic stopping.

Material, Methods and Results: Existing literature proposes to increase the confidence of characters solely when they are flashed, following a *maximization of occurrences* (OM). ASAP relies on Bayesian accumulation to update the confidence of each character after each flash. The comparison between Bayesian accumulation and maximization of occurrences is illustrated on Fig. 1-left. We investigate here the role of early stopping to make the most out ASAP model (Fig. 1-right) using Timeflux[1].

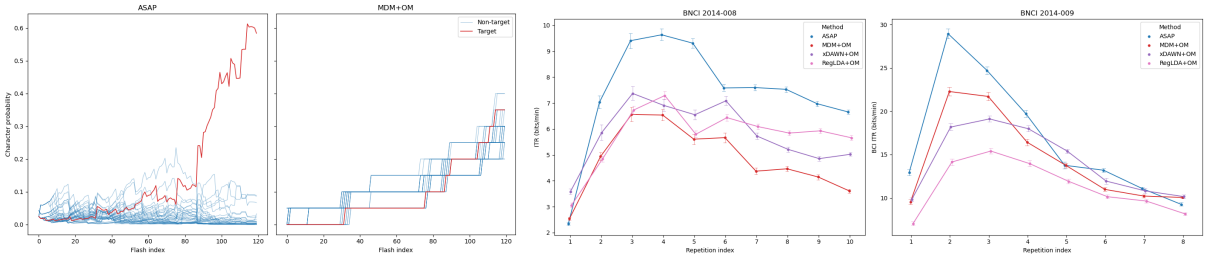

Figure 1: Left: Character probabilities as a function of flash (target character in red, non-target characters in blue) on ASAP (left) and Riemannian Minimum Distance to Mean (MDM+OM, right). Right: BCI ITR (in bits/min) as a function of repetition, for ASAP and state-of-the-art classifiers.

Discussion: Different strategies allow balancing the prediction accuracy with the ITR. ASAP provides a solid ground to investigate the different early stopping strategies, with rich information as the probabilities of all characters are available anytime.

Significance: This work provides a fast P300 BCI, and aims to bridge the gap between published literature on offline dataset and usable interface for empowering people.

References

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[1] `https://github.com/timeflux/demos/tree/main/speller/P300`