An Active RBSE Framework to Generate Optimal Stimulus Sequences in a BCI for Spelling

Abstract:

A class of brain computer interfaces (BCIs) employs noninvasive recordings of electroencephalography (EEG) signals to enable users with severe speech and motor impairments to interact with their environment and social network. EEG based BCIs for typing popularly utilize event related potentials (ERPs) for inference. Presentation paradigm in current ERP-based letter by letter typing BCIs typically query the user with an arbitrary subset of characters. However, the typing accuracy and speed can potentially be enhanced with more informed subset selection. In this manuscript, we introduce the active recursive Bayesian state estimation (active-RBSE) framework for inference and sequence optimization. Prior to each iteration of presentation, rather than showing a subset of randomly selected characters, this framework optimally selects a subset based on a query function. Selected queries are made adaptively specialized for users during each intent detection. Through a simulation-based study, we assess the effect of active-RBSE on the performance of a language-model assisted typing BCI in terms of typing speed and accuracy. To provide a baseline for comparison, we also utilize standard presentation paradigms namely, row and column matrix presentation paradigm and also random rapid serial visual presentation paradigms. The results show that utilization of active-RBSE can enhance the online performance of the system, both in terms of typing accuracy and speed. Moreover, we conduct online experiments with human participants to study the human-in-the-loop effect on the performance of the proposed framework and the results were consistent with the simulations.