Recent advances in EEG-based neuroergonomics for Human-Computer Interaction

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Human-Computer Interfaces (HCI) are increasingly ubiquitous in multiple applications including industrial design, education, art or entertainment. As such, HCI could be used by very different users, with very different skills and needs. This thus requires user-centered design approaches and appropriate evaluation methods to maximize User eXperience (UX). Existing evaluation methods include behavioral studies, testbeds, questionnaires and inquiries, among others. While useful, such methods suffer from several limitations as they can be either ambiguous, lack real-time recordings, or disrupt the interaction. Neuroergonomics can be an adequate tool to complement traditional evaluation methods. Notably, Electroencephalography (EEG)-based evaluation of UX has the potential to address the limitations above, by providing objective, real-time and non-disruptive metrics of the ergonomics quality of a given HCI (Frey 2014). In this abstract, we present an overview of our recent works in that direction. In particular, we show how we can process EEG signals in order to derive metrics characterizing 1) how the user perceive the HCI display (HCI output) and 2) how the user interacts with the HCI (HCI input).
First, at the output level, we conducted some experiments to study the visual comfort experienced by users of stereoscopic displays (e.g., 3D TV). We showed them several objects presented at different stereoscopic depths in front or behind the screen while recording their EEG signals. Some of these depths were voluntarily uncomfortable (either too close or too far from the eyes). By analyzing Event Related Potentials (ERP) following a stereoscopic object appearance using advanced EEG signal processing techniques, we showed we could discriminate, in a single trial (i.e., in 1s of signal), ERP corresponding to comfortable displays versus ERP corresponding to uncomfortable ones (Frey 2016a).
Second, we asked our users to perform different cognitive tasks involving different levels of cognitive workload (i.e., mental efforts), while recording their EEG signals. Here as well, by using signal processing and suitable machine learning, we could discriminate low mental workload from high mental workload in short windows (2s of signal) of EEG (Mühl 2014). By refining these algorithms we showed we could then discriminate mental efforts in complex interaction tasks, notably during 3D object manipulation tasks (Wobrock 2015), as well as during navigation tasks In a video game (Frey 2016b). We also showed we could use such methods to compare the mental workload induced by different interaction devices or techniques.
Overall, these recent results suggest that EEG can be used as an objective and complementary evaluation technique to characterize and assess different HCI. This thus opens the door to a new generation of HCI, designed by exploiting EEG-based neuroergonomics.

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