Human Awareness to Interface Errors Improves HCI Performance

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A. Biasiucci[1,3], R. Chavarriaga[1], K. Förster[2], D. Roggen[2], G. Tröster[2], J. del R. Millán[1]

cnbi
Defitech Foundation Chair in Non-invasive Brain-machine Interface

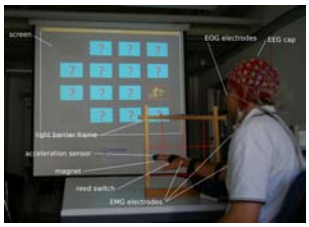
Introduction

We explore the use of brain activity in scenarios of Human-Computer Interaction. Specifically, we aim at the detection of EEG correlates of error awareness to dynamically adapt a Human activity recognition system. We design a Human Computer Interaction experiment which consists in:

- a memory game controlled by a Human Activity Recognition System
- an EEG - Error Potential (ErrP) detection System

We use EEG signal processing to recognize error related potentials (ErrP) on single trial basis.
ErrP are emitted when a human observes an unexpected behaviour in a system: we propose and evaluate performance improvements provided by the ErrP detection system as a "teacher" for the on-line adaptation of a user centered activity recognition system.
The gesture recognition system becomes self-aware of its performance, and can self-improve through re-occurring detection of ErrP signals.

The EEG - Human Computer Interaction Experiment



Experimental setup, including EEG/EMG acquisition system, Light-frame gesture detector and accelerator sensors.

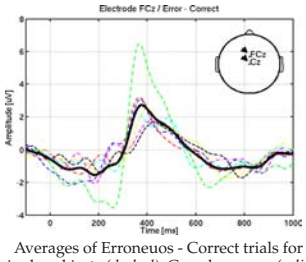
- Subjects are asked to play a memory game controlled through spatial arm movements.
- Actual card selection was achieved through a light frame decoding hand movements. Card flipping was controlled through an inductive sensor on the hand.
- We recorded EEG, EMG of biceps, deltoid and wrist, EOG and hand acceleration.
- In each session we randomly artificially induced between 5% and 33% of gesture recognition errors to elicit ErrP.
- 18'000+ gesture instances recorded on 7 subjects playing 14 memory games each one.

Hand Sensors

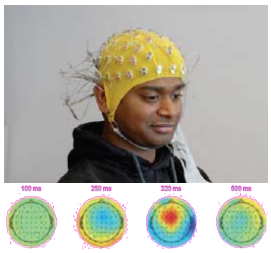
Subject wearing the full set of sensors

EEG - Error Related Potentials (ErrP)

- Stereotypical electrophysiological signals appear as a response to erroneous actions or unexpected action outcomes.
- These signals reflect conscious error processing, post-error adjustment of response strategies, and reward-based adaptive behavior.
- Research has shown that it is possible to recognize EEG error-related signals on single trials above random levels.



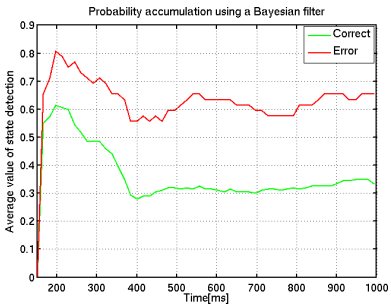
Averages of Erroneuos - Correct trials for single subjects *(dashed)*, Grand average *(solid)* and most discriminant electrodes *(right corner)*



Topographic representation and time dynamics of EEG error-related signals.

Classification based on Bayesian Filtering

- Considering the two possible states of time signals, the filter accumulates probabilities of single trials belonging to one of these two over time.



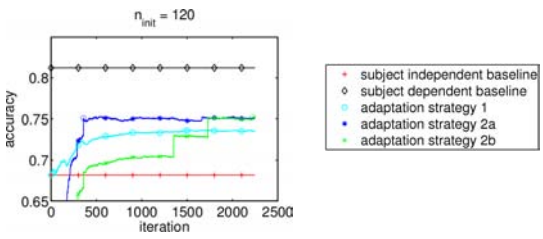
Average value of the state detection for correct *(state=0)* and erroneous *(state=1)* trials.

	Subjects							Average
	I	II	III	IV	V	VI	VII	
Correct	48.50	71.89	73.75	59.11	75.36	65.57	63.96	65.44
Error	74.06	56.30	60.82	63.74	57.91	65.97	58.48	62.46

Sensitivity and specificity for the seven subjects using Leave-One-Fold-Out Cross Validation.

Brain as a teacher for user adaptation

- Accuracy of user independent gesture recognition improves by 3.29% based on actual EEG data recorded during the experiment (the theoretical upper boundary of improvement is 9.58%).
- The achieved recognition rates of ErrPs allow us to integrate this signal for on-line adaptation of complex systems. An online version of the present experiment is currently on development,



Acknowledgments

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[2] Wearable Computing Lab, ETH Zürich
[3] Department of Informatics, Systems and Telematics (DIST), University of Genova
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