Spellbinder: Interactive Communication through a Brain Computer Interface

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ABSTRACT
The purpose of the Spellbinder project is the development and the testing of a Brain Computer Interface, consisting of a diadem with electrodes to measure electroencephalogram signals, and several interactive computer programs, that allow the user to communicate with others through brainwaves, without using speech, facial expressions or other muscle activities. Spellbinder's primary user group consist of patients suffering from disorders such as Cerebral Palsy, stroke, ALS, MS, Parkinson,… - and that have no other means to communicate with others. Through the BCI they can convey messages, tell a story, express their feelings or play a game with other people.

Categories and Subject Descriptors
H.5.2 **[Information Interfaces and Presentation]**: User Interfaces---*input devices and strategies*

General Terms
Algorithms, Design, Measurement, Experimentation

Keywords
Brain Computer Interface, EEG signals, Interactive Communication

1. INTRODUCTION
A substantial number of adults and children with permanent or temporarily communication problems caused by a loss of linguistic - speech - or motor capacities, experience the extreme frustration of no communication despite, in many cases, intact intellectual functioning. Alternative and Augmentative Communication (AAC) is any method that offers supplementary or alternative systems to speech or writing for these individuals. With AAC they can express thoughts and feelings so that they can begin, resume or continue a productive life. Some people suffer from such severe communication impairments, that pointing or typing in letters or symbols by hand or any other body part is simply impossible. This group of people can solely rely on the gaze of the eye for communication.

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A possible solution for those people is a Brain Computer Interface (BCI) that rely on electroencephalogram (EEG) signals. When the user is looking at a certain item on a computer display, it can be derived from these signals upon which item the user was concentrating. For the interpretation of and the information extraction from the EEG signals, two popular paradigms exist: P300 and SSVEP. The P300 paradigm uses 2 objects, of which one occurs only infrequently, and when the latter is attended, it generates the P300 event-related brain potential in the EEG signal, with a peak amplitude around 300 ms after stimulus onset. The Steady-State Visual Evoked Potential (SSVEP) uses periodically flashed stimuli, with a different frequency for each object. The flashing frequency of the attended object is picked up in the EEG signal. The advantage of P300 compared to SSVEP is that no electrodes have to be placed in the occipital pole – this could be a problem for bedridden patients. It also does not require periodic flashing objects on the screen, which could evoke epileptic reactions. On the other hand, the P300 is a relatively slow paradigm: detection takes 10 to 20 seconds per item. Its use requires a training phase of about 20 minutes, and retraining is needed every time the electrodes are replaced. The SSVEP paradigm offers the advantage of being 5 to 10 times faster, only one once-and-for-all calibration is needed, it requires no training phase, and it relies on a very robust signal, provided that the subject has no disorder in the occipital pole. Recently, a Mind Speller was developed and tested in laboratory conditions which allowed users to spell words letter by letter, purely relying on EEG signals [1-3].

2. PROJECT GOALS
The main goal of the Spellbinder project is to design and develop a new prototype of a Brain Computer Interface, consisting of a diadem containing electrodes to record EEG signals. Three demo applications will be developed and tested by potential users in their natural environment: a spelling tool, an icon-based story telling tool and a multiplayer mini-game. In each case, the user selects and controls items on a computer screen through the BCI. These demo applications will illustrate the feasibility and the possibilities of the technology.

Although there is a wide diversity in the pathology of the potential users, the aim of Spellbinder is to be generic, without requiring any patient-specific modifications on hardware or software. The parameters of the system will be adapted to the patient and fast and easily (re)configured by the intelligent, adaptive software. The chosen paradigms for the EEG signal processing, P300 and SSVEP, imply that user training is limited compared to other technologies. These paradigms also guarantee a robust interpretation of the EEG signals and consequently lead to a reliable system. The diadem will communicate wirelessly with any standard computer running a standard operating system.

The three demo applications are, in increasing degree of complexity:

1. A spelling tool in which the user selects letters on a screen, and this way can spell words letter by letter. To facilitate this, a word completion algorithm will be included to speed up the typing process. Also, text-to-speech conversion will be incorporated in the tool. For these extra functions, existing software will be used .

2. An icon based story telling tool, that allows a user to communicate via symbols. This kind of application is especially useful for language impaired patients (severe autistic disorder and specific language impairment (SLI)) who need a structure to come to storytelling. By selecting icons, images or avatars, the user constructs messages.

3. A multiplayer minigame in which the user has to navigate in a 3D world. The main purpose of this application is to illustrate that an exciting game can be played with a new type of game controller that has a limited bandwidth (the amount of information that can be sent per unit of time is rather small compared to classic game controllers).

A human centered approach will be employed; all stakeholders, including the patients, their relatives and caregivers will be included in the design process, through an iterative procedure including field studies for user and task analysis, conceptual models, prototype development and finally, frequent user testing. Intermediate paper and electronic prototypes of the applications will be evaluated by potential users and their relatives and caregivers via formative and in a later stage summative usability evaluations. Also the final versions of the applications will be tested extensively by these users in their natural environment.

The completion of user analysis and user tests will result in a Style Guide Report containing guidelines for the design of the graphical user interface and related user interaction, applicable to Spellbinder applications. The suggested protocols demand for items that flash at a certain frequency on the screen (between 6Hz and half the screen refresh rate). Parameters such as frequency, contrast, modulation depth, soft vs. hard transitions, placement on the screen and number of alternatives to choose from will be investigated both by physiological and psychophysical tests. This will enable to make a trade-off between the user-friendliness of the interface and the robustness of the signal processing algorithms. These experiments will also reveal the variability among the subjects and result in a list of the most critical parameters that should be adjustable in eventual applications.

3. MOTIVATION FOR PARTICIPATION

We believe that the goals of the Spellbinder project fit well within the scope of the BioS-Play Workshop of the Fun and Games 2010 conference. We will briefly present the current status of the project, thereby focusing on the possibilities of the currently developed hardware and algorithms. At the moment, only a spelling tool has been developed, but as stated before, we would like to design more exciting applications that will open up the world of the patients of the target group and that will allow them to get back in touch with their environment. Since the input device does not allow for quick interaction, nor a high information transfer rate, it will be a challenge to create motivating and enjoyable applications. We hope to learn from other participants who have dealt with similar problems in their past or current projects.

4. REFERENCES

[1] Combaz, A., Manyakov, N., Chumerin, N., Suykens, J. & Van Hulle, M. 2009. Feature Extraction and Classification of EEG Signals for Rapid P300 Mind Spelling. The Eighth International Conference on Machine Learning and Applications 386-391.

[2] Chumerin, N., Manyakov, N., Combaz, A. & Van Hulle, M. 2009. An Application of Feature Selection to On-Line P300 Detection in Brain-Computer Interface. IEEE International Workshop on Machine Learning for Signal Processing a16.

[3] Chumerin, N. et al.2009. P300 Detection Based on Feature Extraction in On-line Brain-Computer Interface. KI 2009: Advances in Artificial Intelligence 339-346