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Real-Time Neuroimaging for Rehabilitation of Stroke Patients

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Abstract : Rehabilitation of stroke patients is dominated by classical physiotherapy. Nowadays, a field of research is the application of neurofeedback techniques in order to help stroke patients to get rid of their motor impairments. Especially, if a certain limb is completely paralyzed, neurofeedback is often the last option to cure the patient. Certain exercises, like the imagination of the impaired motor function, have to be performed to stimulate the neuroplasticity of the brain, such that in the neighboring parts of the injured cortex the corresponding activity takes place. During the exercises, it is very important to keep the motivation of the patient at a high level. For this reason, the missing natural feedback due to a movement of the effected limb may be replaced by a synthetic feedback based on the motor-related brain function. To generate such a synthetic feedback a system is needed which measures, detects, localizes and visualizes the motor related µ-rhythm. Fast therapeutic success can only be achieved if the feedback features high specificity, comes in real-time and without large delay. We describe such an approach that offers a 3D visualization of µ-rhythms in real time with a delay of 500ms. This is accomplished by combining smart EEG preprocessing in the frequency domain with source localization techniques. The algorithm first selects the EEG channel featuring the most prominent rhythm in the alpha frequency band from a so-called motor channel set (C4, CZ, C3; CP6, CP4, CP2, CP1, CP3, CP5). If the amplitude in the alpha frequency band of this certain electrode exceeds a threshold, a µ-rhythm is detected. To prevent detection of a mixture of posterior alpha activity and µ-activity, the amplitudes in the alpha band outside the motor channel set are not allowed to be in the same range as the main channel. The EEG signal of the main channel is used as template for calculating the spatial distribution of the µ - rhythm over all electrodes. This spatial distribution is the input for a inverse method which provides the 3D distribution of the µ - activity within the brain which is visualized in 3D as color coded activity map. This approach mitigates the influence of lid artifacts on the localization performance. The first results of several healthy subjects show that the system is capable of detecting and localizing the rarely appearing µ-rhythm. In most cases the results match with findings from visual EEG analysis. Frequent eye-lid artifacts have no influence on the system performance. Furthermore, the system will be able to run in real-time. Due to the design of the frequency transformation the processing delay is 500ms. First results are promising and we plan to extend the test data set to further evaluate the performance of the system. The relevance of the system with respect to the therapy of stroke patients has to be shown in studies with real patients after CE certification of the system. This work was performed within the project ‘LiveSolo’ funded by the Austrian Research Promotion Agency (FFG) (project number: 853263).

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