

Clinical neuroengineering: engineering principles applied to clinical neuroscience

Group leader: Prof. dr. ir. N.M. Maurits (applied mathematics)

Members of the research theme

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Dr. J.W. Elting (clinical neurophysiology)

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(Former) Students:

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Summary

By using engineering, mathematical and computational techniques in an interdisciplinary team, we try to optimally apply newly available technologies to further our understanding of neuro(patho)physiology and improve the quality of diagnosis, prognosis and follow-up for individual patients suffering from neurological disorders. In the past few years, we have made important progress in applying multichannel EEG and simultaneous EEG-fMRI and EMG-fMRI recordings to answer clinical neurological and fundamental neuroscience questions.

Introduction

In the hospital of the 21st century technological developments often precede clinical applications. Although we have access to many advanced techniques, often we do not (yet) know how to use them optimally to improve our understanding of pathophysiology, patient diagnosis, follow-up of disease progression and prognosis. Clinical neuroengineering tries to solve these problems for neurology and neuroscience by using engineering, mathematical and computational approaches in an interdisciplinary setting. Our group, with people from various backgrounds, focuses on finding answers to the above questions for some of these new techniques, in particular multichannel electroencephalography (EEG) and simultaneous EEG-fMRI and electromyography (EMG)-fMRI recordings. The research

within this theme is executed both at the UMCG department of Clinical Neurophysiology and at the BCN-NiC.

Main methodology

To derive clinically useful measures from multichannel EEG recordings, we have applied visualization and quantitative EEG techniques in their broadest sense. In a typical engineering way, our solutions are always driven by the clinical or neuroscientific question at hand. So far, we have applied a wide range of techniques such as spectral analysis (to assess frequency content), coherence analysis (to assess functional connectivity), source localization (to find and use generator models for the EEG) and statistical correlation techniques to derive simple and clinically useful measures from 128-channel EEG data. Some details are given in the project descriptions of Michael ten Caat and Wilma van de Wassenberg.

So far, to integrate EEG and fMRI results, we have mainly used the most straightforward approach, i.e. correlating variations in spectral power in specific EEG frequency bands with BOLD variations. This technique was applied to study generators of the alpha rhythm, but also in preliminary sleep studies. Also, we have used simultaneously acquired behavioral and EEG measures to distinguish groups for further fMRI analysis. The methodologies used to develop, validate and apply simultaneous EMG-fMRI recordings are described in more detail in the project of Fleur van Rootselaar.

Main results

By using source localization techniques we could condense the total amount of data of a 128-channel oddball ('P300') recording in only a few numbers: the activity of one or two dipole sources in the brain. This allowed to better distinguish P300 results in patients from those in healthy subjects: the sensitivity of the P300 event-related potential for prognosis in patients with mild to moderate head injury was significantly improved.

Our results in improving the clinical sensitivity of multichannel somatosensory evoked potentials (SEPs), in applying visualization techniques to help analyze the huge amounts of data obtained from 128-channel EEG recordings and in developing and applying simultaneous EMG-fMRI recordings are described in more detail in the projects of Wilma van de Wassenberg, Michael ten Caat and Fleur van Rootselaar, respectively.

Future prospects

In the past few years, we have only touched upon the potential applications of some of the powerful techniques available to clinical and fundamental neuroscience researchers. Moreover, multichannel EEG, simultaneous EEG-fMRI and simultaneous EMG-fMRI are just a few of the recently developed techniques that will continue to prove their relevance for fundamental neuroscience and clinical neurology in the

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coming years. Other technological improvements e.g., in the fields of ultrasound imaging and magnetic stimulation, will equally have a large impact on our knowledge of the (mal)functioning of the central and peripheral nervous system in the near future. Further technical developments in e.g. wireless communication and miniaturization will further expand diagnostic possibilities, such that the above techniques will become even more relevant for individual patients visiting the hospital of the future.

Publications

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3. J.W. Elting, J. van der Naalt, T.W. van Weerden, J. De Keyser, N.M. Maurits
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9. A.F. van Rootselaar, R. Renken, B.M. de Jong, J.M. Hoogduin, M.A.J. Tijssen, N.M. Maurits
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11. W.J.G. van de Wassenberg, J.H. van der Hoeven, K.L. Leenders, N.M. Maurits
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Grants

2008	2 MSc projects Technical Medicine	€ 72.000,-	PI
2008	BCN-BRAIN bursary	€ 81.373,-	PI
2008	Joint Forces Network Grant	€ 9.800,-	co-investigator
2008	Internationalization grant BCN	€ 1.300,-	PI
2008	Partnership Programme in Science	€ 2.068,-	PI
2007	Investment grant BrainProducts GmbH	€ 33.500,-	PI
2006	Internationalization grant BCN	€ 6.100,-	PI
2006	MS Research Pilot project	€ 43.110,-	co-investigator
2005	Internationalization grant BCN	€ 2.000,-	PI
2005	Innovationfund UMCG	€ 37.000,-	co-investigator