

Public summary of PhD-thesis of Stephan Meesters

PhD-defense date: 29 March 2018

Medical data analysis for minimally invasive treatment of epilepsy

Surgical treatment of epilepsy may be necessary for patients who have seizures that cannot be controlled by anti-epileptic drugs, which entails the removal of the area of the brain that causes the epilepsy. In this PhD research, multi-disciplinary methods have been investigated with the goal of minimizing the negative impact of epilepsy surgery on the patient. This is achieved by identifying the area of the brain that causes seizures, by providing structural information of a brain pathway called the optic radiation to prevent loss of peripheral vision as result of surgery, and by quantifying the structural connectivity of the brain to increase the success of deep brain stimulation.

A major goal in epilepsy research is to achieve minimally invasive treatment of epilepsy by combining the clinical information from 'functional' and 'structural' medical diagnostic equipment. Stereoelectroencephalography (SEEG), a functional modality, uses depth electrodes to measure the electrical activity in deep parts of the brain. Magnetic resonance imaging (MRI), a structural modality, is used to study the presence of brain abnormalities and can furthermore be used to study the 'wiring of the brain' through diffusion-weighted imaging (DWI).

With SEEG it is possible to pinpoint the areas of the brain where seizures originate from by recording electrical activity during seizures. Epilepsy surgery guided by SEEG is not always successful, however, especially if the patient does not exhibit abnormalities in the MRI scan. There is a vast number of spikes that occur in-between seizures, called interictal epileptic discharges (IEDs), which, however, are difficult to interpret due to complex underlying network interactions. In this PhD study, we developed an analysis framework to unravel the network interactions underlying the IEDs and to visualize the probable source of the epilepsy. We conclude that this approach is promising in case of patients with complex epilepsies and is considered a valuable addition to the routine review of SEEG recordings. This has the potential to increase the success rate of epilepsy surgery. Furthermore, it could shorten the time duration of electrode implantation by a week or more, alleviating patient burden and costs to society.

Using DWI, we developed a framework for reliably visualizing the optic radiation (OR), which is the 'brain highway for visual information'. The OR can be reconstructed using diffusion-weighted tractography by generating fiber tracts (streamlines) between the thalamus and the visual cortex. For doctors the measurement of the distance between the temporal pole and the tip of the OR is an important landmark, which can be used during surgery to prevent damage to the OR. However, tractography may generate implausible streamlines, which hinders an accurate measurement. We introduced a method to quantitatively measure the alignment of streamlines and to identify and remove badly aligned streamlines. With this improved OR-reconstruction a better trade-off can be made between the expected reduction of seizures and the damage to vision as a consequence of surgery.

Lastly, we developed a quantitative measure of brain connectivity based on a novel pathfinding algorithm. The developed methodology was evaluated on artificial datasets and was shown to lead to shortest pathways that may be good candidates for blood vessels or neural fibers in the brain. This improved connectivity mapping may lead to a better understanding of the propagation pathways of

brain activity, which, as a result, may improve success of deep brain stimulation for seizure reduction.

Title of PhD-thesis: Functional and structural methods for minimally invasive treatment of epilepsy.

Promotors: prof.dr. Luc Florack (TU Eindhoven), prof.dr. Paul Boon (Academisch Centrum voor Epileptologie Kempenhaeghe, Universitair Ziekenhuis Gent). Copromotor: Pauly Ossenblok

Other main parties involved: Academisch Centrum voor Epileptologie Kempenhaeghe