SP121 - Deep Brain Stimulation

TRACK 11: NEUROENGINEERING, NEURAL SYSTEMS

SP121.1 - A 16-bit High-Voltage Digital Charge-Control Electrical Stimulator

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Research on the effects of electrical stimulation, needs an accurate system able to generate any arbitrary waveforms with different frequencies and interphase delays. Some applications such as Deep Brain Stimulation (DBS) turn to smaller electrodes resulting in higher impedances, causing obstacles to deploy the same amount of charge to the tissue. In this paper a 16-bit digital charge-control current stimulator is presented which can produce up to -/+ 35V output swing voltages. Platinum flexible electrodes have been used to compare the performance of the developed with two commercial stimulators.

SP121.2 - A method for side effect analysis based on electric field simulations for intraoperative test stimulation in deep brain stimulation surgery

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Despite an increasing use of deep brain stimulation (DBS) the fundamental mechanisms underlying therapeutic and adverse effects remain largely unknown. The simulations of electric entities are increasingly used to evaluate stimulation effects. So far no group has considered such simulations combined with a side effect analysis of data obtained during intraoperative test stimulations. The aim of the present paper is to introduce a method allowing patient-specific electric field simulations for stimulation amplitudes inducing side effects during DBS-surgery.

Two female patients presenting essential tremor, both bilaterally implanted in the ventral intermediate nucleus (VIM) region (Clermont-Ferrand University Hospital, France) were included in the study. Intraoperative test stimulations were performed on central and posterior trajectories in each hemisphere. At each position, in addition to the evaluation of the therapeutic effects, side effects such as pyramidal symptoms and paresthesia without localization indicator or paresthesia with localization indicated by the patient (in the hand or in the fingers) were noted. The anatomical structures such as VIM and its neighbors were preoperatively manually outlined using the iPlan software (Brainlab, Feldkirchen, Germany) according to spontaneous MRI contrasts [1]. The so identified structures were exported via a specifically designed interface (VVLink, Brainlab, Feldkirchen, Germany). Whenever side effects occurred the inducing stimulation amplitude was chosen for electric field simulations. A finite element method [2] was applied to calculate the electric field distribution. Conductivity values were deduced from the patient's T1 weighted MRI. An isofield level of 0.2V/mm was chosen and the points of the isosurface were exported. They were visualized together with the extracted anatomical structures and the trajectories. The different structures presented inside the volume defined by the isofield level and their appearances were determined. Combinations of structures always appearing together for a specific side effect were identified.

For both patients, eight electric field simulations were performed. A first analysis showed that pyramidal effects appear when parts of the ventro-oral nucleus (VO) and the VIM were present inside the isosurface. The ventrocaudal lateral nucleus (VCL), the ventrocaudal medial nucleus (VCM) and the VIM were among the identified structures in hand paresthesia (VCL, VIM), finger paresthesia (VCL, VCM, VIM) and paresthesia with location not formally identified by the patient (VCM, VIM).

The application of our method to two patients has shown its feasibility. Our results are consistent with anatomical knowledge that stimulation of VCL and VCM induce paraesthesia in the body and the face respectively. Nevertheless, more patient data have to be analysed to draw any conclusions. The present method will allow an optimised data exploration compared to existing methods only taking into account the anatomical position of the center of the measurement electrode.

References

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SP121.3 - Comparison of Three Deep Brain Stimulation Lead Designs under Voltage and Current Modes

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Since the introduction of deep brain stimulation (DBS) the technique has been dominated by Medtronic systems. In recent years, new DBS systems have become available for patients, and some are in clinical trials. The present study aims to evaluate three DBS leads operated in either voltage or current mode. 3D finite element method (FEM) models were built in combination with a neuron model for this purpose. The axon diameter was set to D = 5 μm and simulations performed in both voltage (0.5-5 V) and current (0.5-5 mA) mode. The evaluation was achieved based on the distance from the lead for neural activation and the electric field (EF) extension at 0.1 V/mm. The results showed that the neural activation distance agrees well between the leads with an activation distance difference less than 0.5 mm. The shape of the field at the 0.1 V/mm isopotential surface in 3D is mostly spherical in shape around the activated section of the steering lead.

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