tDCS montage optimization for the treatment of epilepsy using Neurotwins

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Transcranial direct current stimulation (tDCS) has proven to be effective in reducing the seizure frequency in patients with epilepsy. This therapy greatly benefits from designing personalized electrode montages (electrode positions and currents) that target the appropriate areas of the brain. Commonly, a specialized physician selects these areas and this information is used to create a target map on the grey matter surface of the regions to inhibit. Then, a biophysical model of the patient's head together with optimization algorithms are used to find an optimal electrode montage that generates a field distribution as close as possible to the target map. In the framework of the Galvani project, we aim at going a step forward and using personalized Neurotwins to design optimized tDCS montages. A Neurotwin is a mathematical model of the patient's brain comprising physical and physiological models (i.e. a brain network model) personalized through data assimilation techniques. In particular, here we use aMRI, dMRI and SEEG data to produce Neurotwins of epileptic patients. Once personalized, these models can be used to evaluate the fitness of a montage. To do so, we propose a loss function that combines the information from the brain network models (i.e. seizure spread on the brain) and the physical model (i.e. field in certain areas). Using an evolutionary algorithm, we can minimize the loss function and find optimal montages. Our results show that with this approach it is possible to identify the most relevant areas to inhibit beyond those that would be identified by a physician and produce a montage that targets them.