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Designing Stochastic Non-Invasively Applied DC Pulses to Suppress Tremors in Multiple Sclerosis by Computational Modeling

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Abstract : Tremors occur in 60% of the patients who have Multiple Sclerosis (MS), the most common demyelinating disease that affects the central and peripheral nervous system, and are the primary cause of disability in young adults. While pharmacological agents provide minimal benefits, surgical interventions like Deep Brain Stimulation and Thalamotomy are riddled with dangerous complications which make non-invasive electrical stimulation an appealing treatment of choice for dealing with tremors. Hence, we hypothesized that if the non-invasive electrical stimulation parameters (mainly frequency) can be computed by mathematically modeling the nerve fibre to take into consideration the minutest details of the axon morphologies, tremors due to demyelination can be optimally alleviated. In this computational study, we have modeled the random demyelination pattern in a nerve fibre that typically manifests in MS using the High-Density Hodgkin-Huxley model with suitable modifications to account for the myelin. The internode of the nerve fibre in our model could have up to ten demyelinated regions each having random length and myelin thickness. The arrival time of action potentials traveling the demyelinated and the normally myelinated nerve fibre between two fixed points in space was noted, and its relationship with the nerve fibre radius ranging from 5μm to 12μm was analyzed. It was interesting to note that there were no overlaps between the arrival time for action potentials traversing the demyelinated and normally myelinated nerve fibres even when a single internode of the nerve fibre was demyelinated. The study gave us an opportunity to design DC pulses whose frequency of application would be a function of the random demyelination pattern to block only the delayed tremor-causing action potentials. The DC pulses could be delivered to the peripheral nervous system non-invasively by an electrode bracelet that would suppress any shakiness beyond it thus paving the way for wearable neuro-rehabilitative technologies.

Keywords : demyelination, Hodgkin-Huxley model, non-invasive electrical stimulation, tremor
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