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Abstract

Bio-Impedance Analysis of Human Upper Limbs Based on Transient Simulation Using the Finite Element Method †

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Abstract: Introduction: Upper-limb loss results in significant functional impairment and a reduced quality of life. A human–machine interface (HMI) using surface electromyography (sEMG) establishes a link between the user and a hand prosthesis to recognize hand gestures and motions. Bio-impedance analysis (BIA) is a non-invasive way of assessing body composition and is adapted for hand motion interpretation with promising results. However, an optimized BIA recording strategy has not yet been achieved due to various parameters (e.g., the large scale of the neuromodulator settings and variations in the tissue dielectric properties). This paper investigates the impact of the dielectric properties of the tissue layers on the bio-impedance variation based on different simulation frequency spectra using the transient modeling method. The model can provide helpful insight into the effect of dielectric properties on the impedance variation of the upper limbs, which is otherwise challenging to investigate in practical studies. **Method:** The 3D realistic human upper arm model was developed based on the image data set. The dielectric properties of each tissue layer were attained based on each frequency level and the time-based current pulse was applied. The electrical potential variation for each frequency level was recorded to calculate impedance variation based on the applied current level. The unseen current distribution across the upper arm's fat, muscle, and bone layers under the skin was also simulated to aid in selecting the most responsive area for BIA towards an optimal simulation frequency level. The results were obtained based on 10 Hz, 1 kHz, 10 kHz, 100 kHz, 500 kHz, and 1 MHz levels. **Results:** The results show that the frequency-based dielectric properties of the tissue layer have a significant impact on impedance variation. **Conclusion:** In this study, a 3D bio-computational model of the human arm was developed to investigate the impact of dielectric properties on impedance. The results of the study may provide helpful insight into an optimized BIA recording strategy.

Keywords: bio-impedance analysis; human-machine interface; transient finite element; upper-arm model; volume conductor

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