Feasibility of a New Frequency-difference EIT Image Reconstruction Algorithm

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ABSTRACT

Abstract - Frequency-difference Electrical Impedance Tomography (fdEIT) is proposed to deal with technical difficulties of the conventional static EIT imaging caused by unknown boundary geometry, uncertainty in electrode position, and other systematic measurement artifacts. In fdEIT, we inject currents with at least two frequencies and use changes of induced boundary voltages at different frequencies to eliminate unknown common modeling errors. We propose a new fdEIT image reconstruction algorithm and study its feasibility by investigating the sensitivity of a frequency-difference voltage data to a change of a complex conductivity distribution. We numerically test the performance of the proposed fdEIT algorithm through numerical simulations assuming a 16-channel multi-frequency EIT system with a frequency range of 10 Hz to 500 kHz.

INTRODUCTION

In electrical impedance tomography (EIT), we inject currents into an imaging object and measure the boundary voltages. EIT uses these measured boundary voltage data to reconstruct images of the complex conductivity distribution inside the imaging object. Most static EIT imaging methods are based on a minimization technique where the differences between measured and computed voltages is minimized by adjusting the complex conductivity distribution of the model. In order for a static EIT image reconstruction algorithm to be reliable, we should construct an accurate forward model which requires knowledge of the boundary geometry, electrode positions and other sources of systematic artifacts in measured data. However, it is difficult to obtain such information and static EIT imaging is sensitive to these errors.

To overcome these difficulties, we propose Frequency-difference EIT (fdEIT) where we inject currents with at least two different frequencies. Utilizing differences of measured boundary voltages between chosen frequencies, we try to alleviate undesirable effects of modeling errors. By investigating the sensitivity of frequency-difference voltage data to a change in a complex conductivity distribution, we will propose an improved frequency-difference image reconstruction algorithm. We will test its performance through numerical simulations assuming a 16-channel multi-frequency EIT system with a frequency range of 10 Hz to 500 kHz

For image reconstructions of complex conductivity distributions, most previous studies have used real parts of complex voltage data to reconstruct conductivity images and their imaginary parts to reconstruct permittivity images. This traditional approach neglects the interplay of conductivity and permittivity values upon measured complex voltage data. It becomes inappropriate especially for a frequency above 1 kHz, for example, where $\omega\epsilon$ values of biological tissues get bigger to be comparable with their σ values. In this paper, we suggest using weighted frequency differences of complex voltage data together with a complex sensitivity matrix to properly handle the interaction.

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