INVERSE PROBLEMS ON ELECTRICAL BIOIMPEDANCE

Hyeuknam KWON

College of Science & Technology, Yonsei University, Wonju, KOREA

Hyeuknam KWON, hyeuknamkwon@yonsei.ac.kr

ABSTRACT

There are various inverse problems on electrical bioimpedance with many applications. One of interesting area is electrical impedance tomography (EIT) which aims to visualize electrical admittivity (conductivity and relative permittivity) distribution inside conducting objects. In this study, I present a static EIT technique which evaluates abdominal obesity by estimating the thickness of subcutaneous fat (SF). EIT has a fundamental draw-back for static admittivity imaging because of the illposeness from forward modelling errors such as those associated with uncertainties in boundary geometry and electrode positions. To reduce the effect of boundary geometry errors in imaging abdominal fat, we develop a depth-based reconstruction method that uses a specially chosen current pattern which enable us to alleviate ill-posedness. The performance of the method is demonstrated by numerical simulations with a humanlike domain.

The electrical impedance myography (EIM) is a relatively new technique to assess neuromuscular disorders (NMD). Although the application of EIM using surface electrodes (sEIM) has been adopted by the neurology community in recent years to evaluate NMD status, sEIM's sensitivity as a biomarker of skeletal muscle condition is impacted by SF tissue. We develop a method that is able to remove the contribution of SF from sEIM data. The method we developed is called model component analysis (MCA), because idea can be understood analogous to independent component analysis (ICA) and principal component analysis (PCA). All methods are validated with numerical simulations and human experiments. Simulations demonstrate that MCA is the most accurate method (99.2%) at separating the impedivity of SF and muscle tissues followed by ICA (51.4%) and PCA (38.5%). Experimental results from sEIM data measured on the triceps brachii of patients are consistent with muscle grayscale level values obtained using ultrasound imaging. Therefore, MCA can be used to separate the impedivity of SF and muscle tissues from sEIM data, thus increasing the sensitivity to detect changes in the muscle.

The last topic is rigorous analysis on the measurement of the permittivity of two-dimensional anisotropic biological tissues such as skeletal muscle. Measuring the dielectric properties of anisotropic biological tissues is of great importance to apply successfully new physical approaches to medicine. However, the existing electrical impedance approach for measuring in-situ these properties has limitations that restrict its practical use. Unlike the current approach, new methods presented here model the angular dependence of tissues' impedance as measured with 4-electrode technique. The methods are validated with numerical simulations and experimental data from ex-vivo ovine skeletal muscle tissues. The experimental results show improvement in accuracy as compared to the previous approach. The methods multipolar needles bring closer the application of needle electrical impedance to patients with neuromuscular diseases.