Dynamic Electrical Impedance Tomography for Neonate Lung Function Monitoring using Linear Kalman Filter

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Abstract - Electrical Impedance Tomography (EIT) for medical imaging has the potential to replace the conventional medical imaging techniques such as magnetic resonance imaging (MRI), X-ray and computed tomography (CT). Compared with the other medical imaging modalities, EIT has the advantages of being a radiation-free imaging technique, inexpensive, and portable. These advantages gave EIT the surplus to be used in real-time monitoring of neonates lung function. Compared to static imaging reconstruction, the difference imaging reconstruction methods are well known in producing higher quality images that take into account the rapid changes that occurs within the biological tissues, a property that is vital in monitoring the state of patients. The data obtained from neonates can be noisy and linear Kalman filters could provide a useful method for reconstruction these image. We present a comparison of a Kalman filter method with other techniques

Keywords- Electrical Impedance Tomography, Kalman filters, reconstruction algorithm.

1. Introduction

Electrical Impedance Tomography (EIT) is a non-invasive imaging modality, which has great potential for monitoring of lung function of pre-term and unsedated neonates [1][2]. This paper focuses on the development of a Kalman filter method for the reconstruction of neonate images. Kalman filter for single frequency EIT time difference or dynamic image reconstruction may enhance the image spatio-temporal resolution in real-time monitoring. In the field of EIT, a number of research groups [3][4] have applied Kalman filter on measurements that was obtained from adults and phantom tank experiments. Applying Kalman filter on neonates’ measurements that is collected in real-time is a different issue due to the facts that neonates’ data are highly contaminated by noise. Even though the results obtained from applying Kalman filter on adults are promising, these results cannot guarantee that the images reconstructed from neonates’ measurements are clinically satisfying. In this paper we investigate and evaluate the use of linear Kalman filter as an inverse solver for dynamic image reconstruction of neonate lung function. The results obtained from applying Kalman filter on the neonates’ lung data are compared to the results obtained from using both, the Newton-Gauss and total variation algorithms.

2. Method

Real time data was acquired using an EIT instrument, which is using an adjacent current protocol and one ring of 16 electrodes that are attached to a healthy neonate’s thorax. The collected data is then loaded into MATLAB-EIDORS environment where the forward and the inverse models were constructed, and then the three algorithms, namely Kalman, Gauss-Newton and total variation were applied to reconstruct the lung images. We have intensively used codes from EIDORS to solve the reconstruction problem [5]. For the forward model the thorax mesh consists of 2304 elements with electrodes placed on the mesh circumference in the same order as they were attached to the subject, see Figure1. The solution of the forward model is fed to the image reconstruction algorithms; from which the images shown in the results section are obtained.

Figure1. Thorax FEM [5]
3. Results
Comparing the images produced from the three algorithms, preliminary results showed that the Kalman inverse solver has the potential to produce improved images reconstructed from real clinical neonate data. In the figures the red color indicates highly conductive lung regions and the blue color indicates lower conductive lung regions.

![Figure 2. Gauss-Newton Reconstruction](image1)
![Figure 3. Total variation Reconstruction](image2)
![Figure 4. Kalman Reconstruction](image3)
![Figure 5. Neonate Thorax FEM](image4)

4. Conclusion and Future Work
Preliminary results showed that Kalman method has the potential to produce improved images from real clinical neonate data. However, these results are not as optimum as expected, one of reasons that may have led to this un-optimality, is that the boundary shape used in the reconstruction process does not take into account the deformation of the neonates thorax shape. Our goal is the development of nonlinear Kalman filtering techniques for multi-frequency EIT for neonate lung function monitoring, but with the improved neonates’ thorax FEM (4187 elements) model that is depicted in Figure 5.

5. References


