Discarding the Direct Component in Electrical Impedance Tomography

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Abstract: Several studies [1,2] have shown the potential of EIT to estimate cardiovascular parameters. To achieve this goal, EIT devices have to deal with small impedance variations. As a consequence, the high value of the direct component (DC) of the bio-impedance signal becomes an issue in terms of analog to digital converter resolution. With this research, we aim at demonstrating that the DC of the signal can be discarded before digitalization.

1 Introduction

The present research aims at studying the impact of DC signal in EIT difference image reconstruction algorithms, via simulations and actual measurements. An example of a thoracic bio-impedance measurement performed in a human subject is shown and illustrates the high dynamic range required to measure both DC amplitude and cardiogenic impedance variations. The feasibility of DC-free approach has been proven by means of simulated data based on a body-inspired model. These simulations underline the importance of filtering out low frequencies to highlight the cardiogenic signal. The results obtained via simulation have been validated with results obtained on real experimental data. Finally, a discussion describes the encouraging results found during this research.

2 Materials and method

2.1 Actual bio-impedance measurement

In vivo measurement performed in a male subject's thorax shown the very small cardiogenic impedance variation (0.5Ω) compared to the high DC value (155Ω). Such a large dynamic range requires demanding ADC resolution.

2.2 Simulations based on a body-inspired model

EIT simulations with EIDORS software [3] were performed to ensure that DC is not essential for the difference image reconstruction process. For the standard reconstruction process (Figure 1), the homogeneous set of voltages is computed once during the baseline and kept constant throughout the whole recording time. This is the main difference with the novel approach shown in Figure 2. Namely, a high-pass filter is applied in the time dimension to each voltage channel before digitalization and image reconstruction. Consequently, the homogeneous set of voltages becomes the null vector.

Raw simulation data in Figure 3 (left image) shows the result of the standard image reconstruction method. In this example, one can see the high amplitude of the breathing signal compared to cardiogenic signal. High-passed data (right image) shows that it is possible to filter out low frequencies, including DC, before image reconstruction without altering image quality of higher-frequency regions (i.e. cardiogenic signal region). The cutoff frequency of the high-pass filter has been chosen at 0.8Hz. This way, the breathing signal (0.2Hz) and the DC component of each of the voltage channels were filtered out, whereas the cardiogenic signal (1Hz) remained close to its raw value.

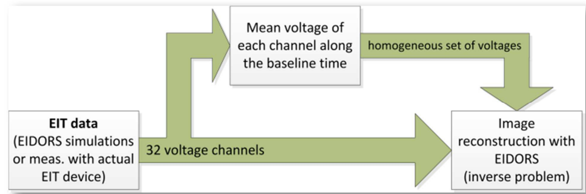

Figure 1: Standard approach for image reconstruction process.

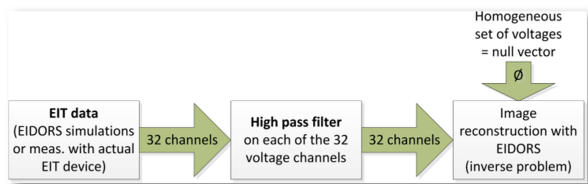

Figure 2: Novel image reconstruction process.

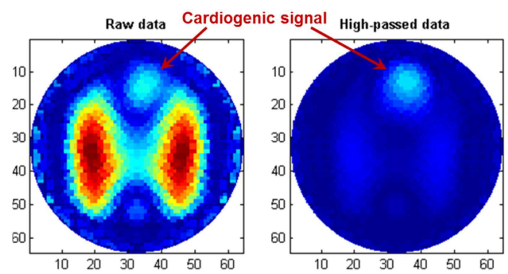

Figure 3: AC Energy of each pixel in the reconstructed image sequence without (left) and with (right) the high-pass filter.

2.3 Actual measurement

Measurements on real data have been performed, concluding that the DC of bio-impedance is not required for EIT difference image reconstruction.

3 Conclusions

In this research, we hypothesized that the zero-frequency component of the EIT voltage signal was not required to reconstruct differential images. Both simulations and actual measurements have corroborated this hypothesis by showing that the amplitude of high frequency signal was not altered whether the DC component was kept or filtered out.

4 References

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