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Electrical impedance tomography simulator

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Abstract: Assessing the performance of electrical impedance tomography (EIT) devices usually requires a phantom for validation, calibration or comparative measurements. To bridge the gap between the typical data obtained in patients wearing a chest belt ventilation- and cardiac- related impedance changes should also be simulated either manually or automatically. In this abstract we describe a novel EIT simulator based on a dynamic controllable resistor mesh.

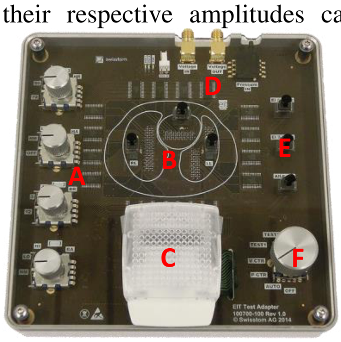
1 Introduction

Electrical impedance tomography is a novel method for monitoring lung and heart providing moving real-time images of function rather than structures. For this purpose, 16 or 32 electrodes are typically placed around the human thorax. Weak alternating currents are applied via two electrodes and the resulting potentials are measured via the remaining electrodes. From the measured voltages, images are calculated which show the distribution of electrical impedance within the body [1]. Intra-thoracic impedance changes with ventilation [2] and within each cardiac cycle [3].

Although some groups have proposed resistor mesh phantoms to test and present EIT devices an EIT simulator allowing the user to dynamically adjust impedance changes is still missing.

2 Methods

Therefore, we developed an EIT simulator consisting of a resistor phantom with 160 resistors, details can be found in [4], [5], a microcontroller (ATmega64), to program various simulation scenarios, a 10 bit digital to analogue converter (MAX5723) and 7 field-effect transistors (IRLL2705) to induce impedance changes. Each field-effect transistor (FET) is located parallel to one of the 160 resistor and induces an impedance change proportional to the applied voltage at its gate. 6 FETs are placed in such a way that they produce impedance changes within the demarcated expected lung contours of the EIT image and one in the heart region. Breath and heart rate as well as their respective amplitudes can be controlled by four knobs. Furthermore, the EIT simulator is equipped with a pressure sensor (MPX5010) to input airway pressures from the ventilator circuit. In this case the FETs can be driven according to the measured pressure signal. Failing electrodes can also be simulated simply by pressing one of the switches, see Figure 1.



A: Control of heart and ventilation
B: resistor mesh phantom
C: Connection to EIT device
D: External signal input
E: Failing electrode control
F: Modus selection control

Figure 1: Components of EIT Simulator

First measurements were performed with the *Swisstom BB*^{2} EIT device. Impedance changes were induced in both, the lung region only and in the lung and heart regions. Power images were generated to describe the impedance distribution while the global impedance curves were plotted to show the signals along the time.

3 Results

Representative sample results are presented in Figure 2. In A the amplitude of only the lung signals can be seen, in B the cardiac related impedance change and the lung signal is shown and C depicts a measurement on a healthy volunteer. D depicts the simulated and measured ventilation and cardiac related impedance changes.

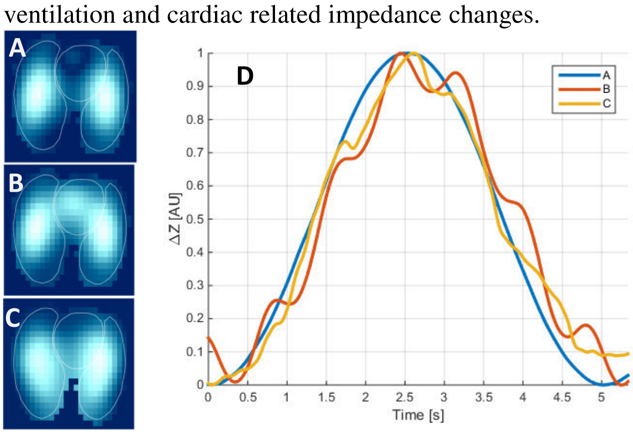


Figure 2: Simulation results: A amplitudes of only the lung signal, B amplitudes of lung and heart signal, C amplitudes of a healthy volunteer, D time signals for case A, B and C.

4 Conclusions

Both, EIT images as well as global impedance curves proved representative of what can be obtained from living beings. Compared to other resistor mesh phantoms our system can also simulate dynamic impedance changes at different anatomy-related locations within the resistor mesh phantom. The novel EIT simulator is used for performance testing, comparative measurements and for demonstration purposes.

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Content: Dr. Stephan Böhm; Concept & Design: Zweizeit Brand Development

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