Tests for Electrical Impedance Tomography

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Electrical impedance tomography (EIT) is a non-invasive imaging technique that displays the spatial distribution of the conductivity of a body from surface measurements. Several different EIT devices are available from academic and commercial suppliers. Although some groups have proposed performance analysis methods as well as phantoms, a robust, standardized, and automated test system for EIT systems is still missing. This prevents fair comparisons between systems, easy and extensive testing and rapid product development iteration cycle.

Materials and Methods

The performances of EIT devices are tested on a cylindrical tank filled with a water-based NaCl solution. It is equipped with a total of 32 electrodes. A dedicated circuit, the contact impedance module, can be connected between each tank electrode and the corresponding EIT device electrode. This circuit is able to generate 9 different contact impedance scenarios for each of the 32 electrodes. In order to achieve precise and reproducible measurements while minimizing human error, we use an industrial robotic 6-axis arm to place test objects at different positions inside the tank.The complete test system is driven by PC software, which defines object placement, contact impedance scenarios and EIT data acquisition schemes. Various image quality indexes – positioning error (PE), area error (AE) and shape deformity (SD) – are used to compare different current injection patterns and image reconstruction parameters.

Results

Current injection patterns using small-angled injection pairs (i.e., electrodes close to each other) show a poor performance. On the other hand, large current injection angles lead to high errors. Good performance with lowest total errors is found at angle 56°, 79° and 101°. Figure 2 is used as an illustration of one positioning error map.

Discussion

The main advantage of the developed test system lays in the complete automation. This enables long and fastidious experimental protocols to be followed and repeated each time modifications are made to an EIT system. Thus the quality of the delivered images can be accurately analyzed. Moreover, it can also be used to optimize the measurement and image reconstruction strategy based on the measurement of the image quality indexes PE, AE and SD.

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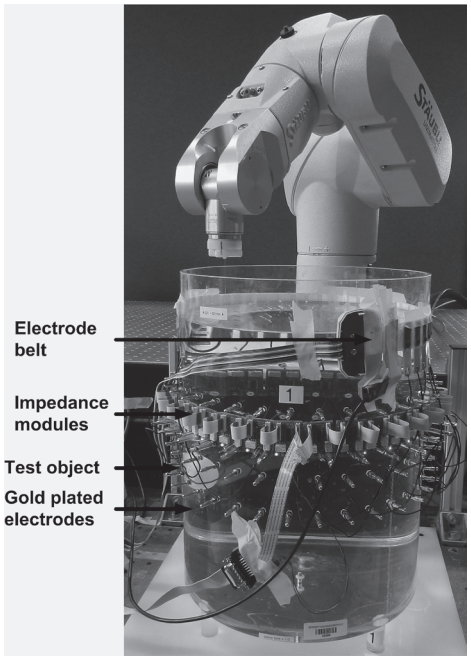

Fig. 1. Overview of the test system including an EIT electrode belt, a robot and a contact impedance module.

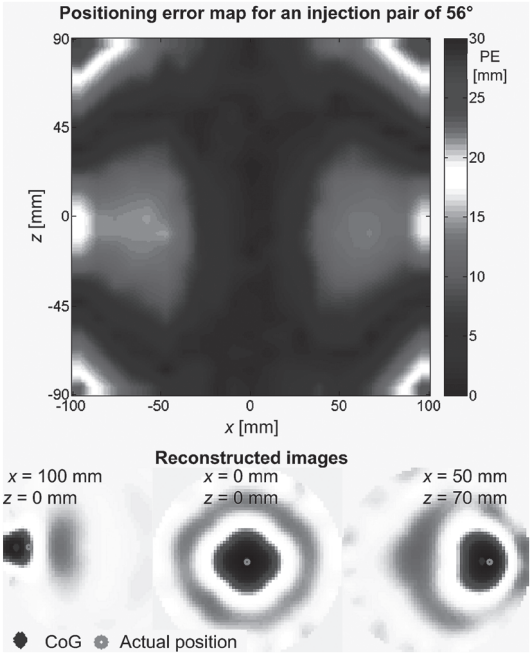

Fig. 2. Upper part: positioning error map.Lower part: Reconstructed images for a non-conductive test object.