Calibration framework to tune electrical impedance tomography systems

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Due to the weak signal-to-noise ratio during EIT measurement, finding the right measurement strategy is important in electrical impedance tomography (EIT). In medical applications, additional constraints must be taken into account. For example, the intensity of the current, which is allowed to be introduced into a human body, is limited. Thus the remaining "degrees of freedom" are the current injection strategy (including choice of the type of electrode and size, and selection of injecting pair) and the image reconstruction algorithm.

The goal of this study is to measure objective metrics of image quality in order to select the best EIT device parameters, this may be application specific. For the tests, we used a robotic system (see Fig. 2) to place test objects at different positions inside a cylindrical tank. The tank is sized to represent a simplified human thorax with 90 cm circumference. The test object, a non-conductive ball with a diameter of 45 mm, is placed sequentially on a grid of positions located in the vertical plane (i.e., the ZX-axis). This grid has 21 columns and 21 rows thus a total of 441 measurement points. For each measurement point we evaluated the difference between the known ball position and size, and the same parameters on the reconstructed images. Each image was evaluated using image based criteria such as position precision, position accuracy, measured size and shape deformation. The measurements were taken with a 32-active-electrode-based EIT system from Swisstom AG.

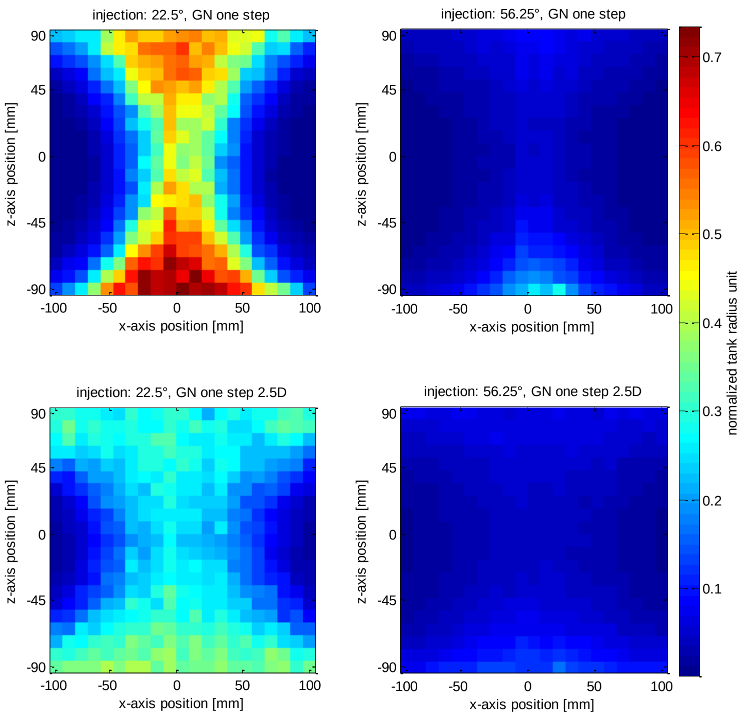

Fig. 1: Position precision maps; position precision is given by the standard deviation of the position of the test object around its mean measured value.

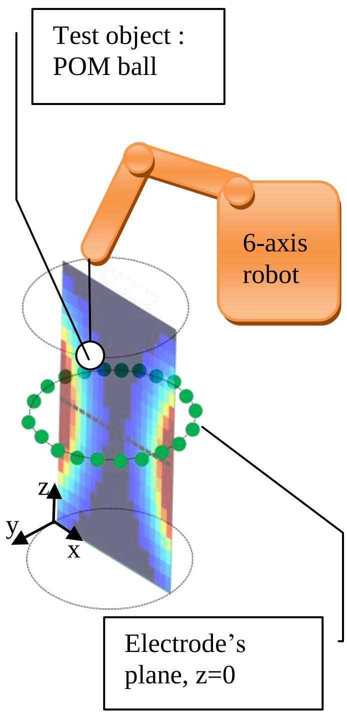

Fig. 2: Experimental set-up

In Figure 1, the EIT system is tuned according to the metric named "position precision" measured in function of the current injection angle and the reconstruction algorithm. We compared position precision between current injection angles of 22.5° (adjacent for 16 electrodes) and 56.25° (4 electrodes between injecting pair) for two different reconstruction methods. In this example, a dramatic improvement was observed when increasing the angle between the injecting pairs, thus the system can be tuned by selecting higher current injection angles. We believe that testing EIT systems using a robust and accurate robotic test system with well-defined test objects and test protocols allows to 1) characterize the EIT system under test, 2) tune its parameters according to the desired output and 3) have high test-retest repeatability of the measurements for the same system.