A phantom based system to evaluate EIT performance

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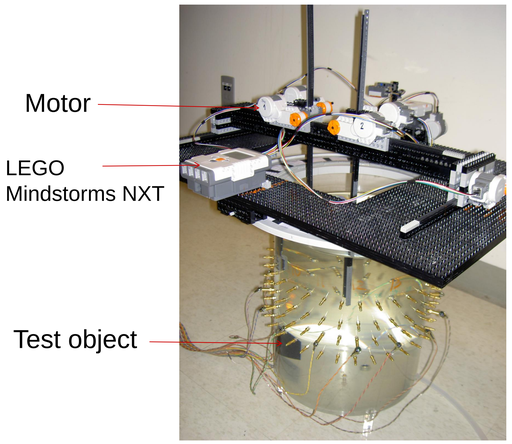
Abstract:

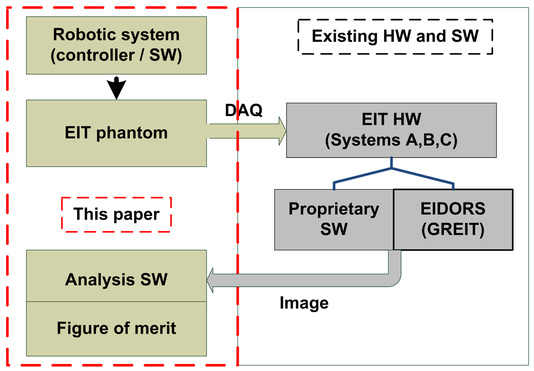
• **Motivation** is to generate stable and accurate phantoms on which EIT systems can be calibrated and tested.

• Q**uantitatively** and **reproducibly** validated EIT system performance.

Robotic EIT system:



Schematic of EIT system:



A phantom test system was constructed using a robot, saline tank phantom, test targets and EIT measurement system. We have carefully calibrated resistive targets.

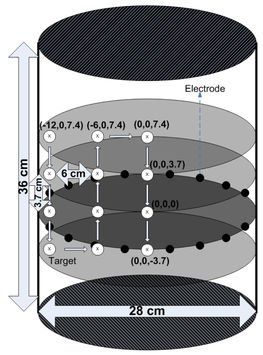
- The **saline phantom:** 14 cm radius and 36 cm height with 4 rows of 32 electrodes.

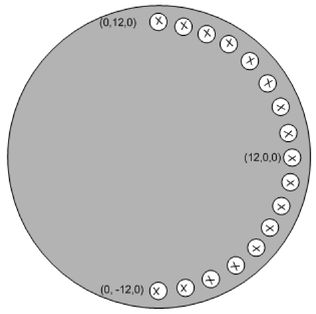
- The **robotic system** was used to position calibrated conductivity targets within the saline solution with sequential object locations precisely controlled by a computer. It was constructed from standard LEGO parts using a LEGO Mindstorms system.

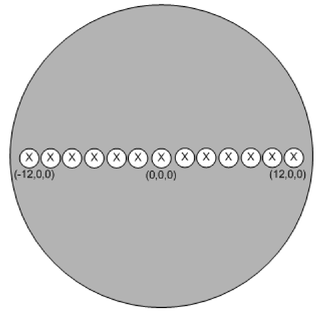
Introduction:

- We proposed a phantom system design based on reproducible procedures with completely characterized and traceable test objects.
- We also present a **methodology** to evaluate the performance of a complete EIT system.
- A **robotic system** was used to reproduce predefined positions of targets in a saline filled tank, and a data analysis system was implemented to evaluate the image reconstruction accuracy and performance.
- **Three EIT hardware systems** were tested and compared.

Three movement protocols:

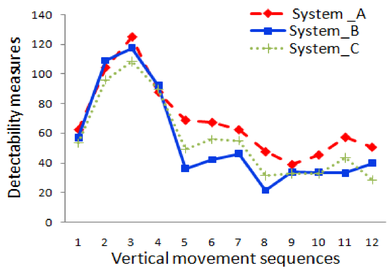


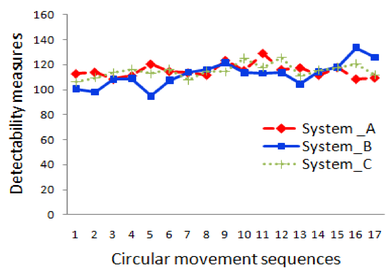


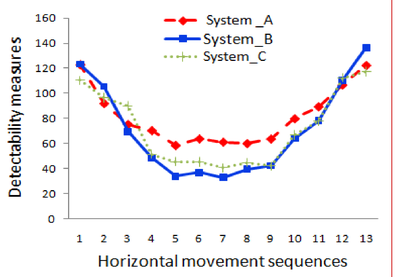


Results (a non-conductive object):

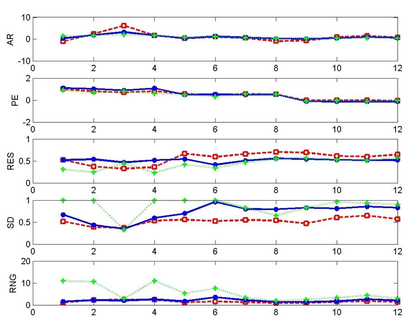
1. Detectability measure:

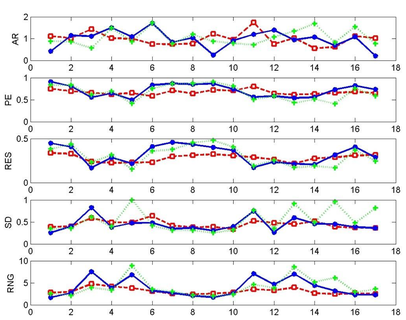


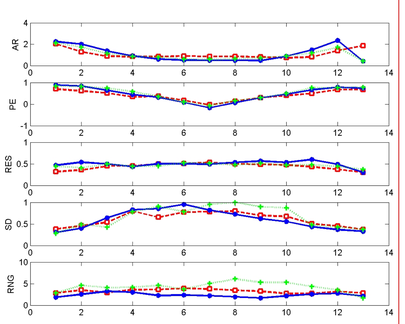




2. GREIT evaluation:







➢ System A - red dashed line; B - blue solid line; C - green dotted line.

➢ AR, PE, RES ,SD are desired to be constant, while PE, RES, RNG, SD to be small for any target position.

➢ All three systems have similar PE for the target with vertical and horizontal movement in different positions, while circular movement of the target produced unstable PE.

Methods:

Figures of merit defined in the GREIT {Adler09}: (i) amplitude response (AR), (ii) position error (PE), (iii) resolution (RES), (iv) shape deformation (SD), (v) non circular and ringing shape (RNG).

A new ***detectability*** measure, *DET*, to measure an index of the probability of detection of a target with a given EIT system,

$$\mathrm{DET} = \frac{\overline{X}_{ROI}}{\sigma_{ROI}}$$

which equals normal (*z*-) score in statistical testing.

- indicate the amplitude of the imaged target region and the signal to noise ratio (SNR).

Discussion:

A reproducible protocol was used to test the performance of three EIT systems.

Typically there is visually little difference in reconstructed images for most target positions with the three EIT systems for non-conductive objects. Thus, comparisons are carried out based on detectability measure and figures of merit on three EIT systems. The reproducible procedures and test phantoms were found to be effective for evaluating the performance of different EIT hardware and image reconstruction systems in terms of detectability measures.

Interestingly, system C behaved differently for conductive targets where conductive object appeared as non-conductive.

References:

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