Experimental verification of a new Pigeon Hole Imaging (PHI) modality

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Extended Abstract: Pigeon Hole Imaging (PHI) is a new and simple imaging modality to give a low resolution electrical impedance image, conceived and developed in our laboratory earlier [1]. This may be used to perform measurements on body organs whose positions are not accurately known, or which moves during measurement. A newer version of PHI has recently been conceived based on a 4 electrode Focused Impedance Method (FIM), which was also developed by our group earlier [2, 3]. In this version of the PHI, many electrodes are arranged in a rectangular or square matrix as shown in the figure 1. Using each of the adjacent 4 electrodes, an FIM measurement is made which gives the respective impedance within the individual matrix position with negligible contribution from the surroundings. Thus all the results, arranged and assigned to respective matrix positions, gives the desired PHI image directly [4]. Because of the inherent 3D sensitivity, large internal body organs may be imaged by placing the electrodes on the chest or on the back of a human thorax.

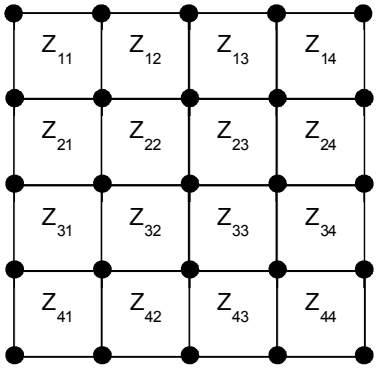

Figure 1: Concept of PHI based on 4 electrode FIM. This shows a 4x4 imaging method.

When a single object extends beyond a single pixel, or when several objects lie in close proximity, some uncertainties occur in the image generation, and the small neighboring sensitivities may have to be considered as well. Some rules have been developed to generate images in such cases to include these effects and necessary software has been developed. Figure 2 shows such an image with four objects in different positions in a 5x5 matrix. It can be seen that adjacent objects along the diagonal can be resolved. However, it may be envisaged that adjacent objects along the horizontal or the vertical will not be resolved.

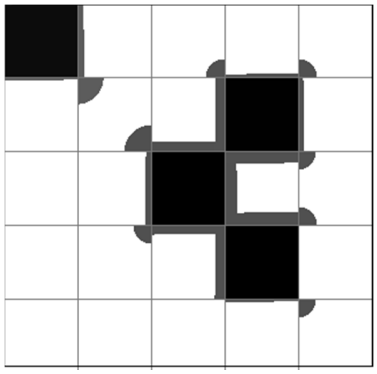

Figure 2: PHI for four objects positioned at different places in a 5x5 PHI.

The above image was obtained using data simulated from experimental FIM values obtained in a single location by placing a single object at various positions in the vicinity in a phantom described below. This was a cubic phantom with dimensions of 30cm×30cm×30cm, made of a transparent 'Perspex' tank with saline inside. Four electrodes (thin square metallic sheets of area 0.5mm^2) were fixed at a central location on the inside of a wall in a square formation with sides of 2cm. Around this central square, 2cm square regions were marked out on the wall to form a 5×5 matrix. An FIM value was obtained with this arrangement, with saline only, which was regarded as the background value. Then an insulated spherical object with a diameter of 2cm was hung in the saline to fall within the central matrix, almost touching the wall with the electrodes, and FIM measurements were taken. Subtraction of the background from this value gave the sensitivity at the focused zone. Sensitivity values were also similarly obtained by moving the object to outer matrix positions, while taking the FIM readings at the centre (without any object in the focused zone). All the above values were then mapped onto a 5×5 matrix with appropriate manipulation to obtain a sensitivity distribution of FIM for a single object placed within the focused zone. For the above arrangement and for the size of the object mentioned, the sensitivities outside the focused zone were very small, less than 10% even for adjacent matrix positions.

For two objects placed at assumed positions within this square matrix, the FIM sensitivity distribution for each was assigned with reference to each of the object positions. Thus each matrix position had two sensitivity values which were algebraically added to obtain a simulated image. This was similarly done for more objects at different matrix positions.

Then two similar insulated spherical objects with 2cm diameter were placed at different positions within the 5×5 matrix and the experimental FIM values using the four electrodes at the central location were measured. These

values were again mapped appropriately to form respective images. The experimentally obtained sensitivity values at the positions of the two objects were then compared with the values predicted by the simulated method described above. The agreement was very good, differences being less than 1.5%. Therefore, PHI appears to be a valid modality for imaging. Being simple and direct in its approach, the image would be reliable and clinically useful. With a frontal plane measurement of the thorax the image would correspond directly to X-Ray images in this plane, making comparisons easier.

References:

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