Electrical Impedance Spectroscopy imaging of the thigh using current excitation frequencies in the mid-β frequency dispersion range.

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Abstract. Electrical Impedance Tomography (EIT) is a non-invasive imaging technique which consists on placing a number of electrodes (normally 8, 16 or 32) equidistantly around the periphery of the object to be studied. One of the preferred methods for obtaining a projection for image reconstruction uses an alternating current signal injected between a pair of adjacent electrodes and the voltage developed in the periphery is measured using the rest of the electrodes. An image reconstruction algorithm is then used to produce an image or resistivity map of the cross-section. The non-invasive nature of the technique has resulted in numerous biomedical applications reported over the past three decades. However, since EIT is a soft-field sensing technique most of the reported works use current excitation frequencies in the alpha of low-beta frequency dispersion ranges. In particular for breast cancer detection using biompedance information, it has been reported, and generally accepted, that tumors exhibit a significant impedance change in the mid- and high-beta frequency dispersion ranges. Therefore, it is of great interest to increase the current excitation frequency. In addition, it is common to find that the preferred image reconstruction methods are qualitative (i. e. Weigthed Backprojection), to benefit robustness and reconstruction speed, since quantitative methods are iterative, and may fail to converge when noise is present in the measured voltage signals. The authors present an EIT data acquisition system for obtaining data frames using current excitation frequencies from the alpha- to mid-beta frequency dispersion ranges. The equipment generates the current excitation signal by direct digital synthesis that allows current excitation frequency sweeping. Thus, in effect, the equipment is an impedance spectroscopy imaging system. The equipment was used to obtain images of a volunteer's thigh to assess the performance of the equipment. Images were reconstructed using qualitative (Weighted Backprojection) and quantitative (Modified Newton-Raphson) image reconstruction methods, at different frequencies ranging from 200 KHz to 20 MHz. Quantitative images were in agreement with the qualitative images. As frequency is increased it is possible to detect different anatomic features. At low frequencies, the similar conductivity of bone (0.01–0.06 S/m), muscle (0.04–0.14 S/m) and fat (0.02–0.04 S/m) impedes delimiting the internal organ boundaries. As frequency increases, the impedance properties of the different tissues begin to appear. At 20 MHz the reconstructed images show two other regions of higher conductivity consistent with blood flow at the location of the femoral artery and femoral vein and the great saphenous vein, which suggest that the equipment can be used to provide qualitative and quantitative images at the mid-beta frequency dispersion range.

Keywords: Electrical Impedance Tomography, Electrical Impedance Spectroscopy, Biompedance, Digital Signal Processing.