The Data Acquisition Method of the Sussex MK4 EIM System

XiaolinZhang[1], Wei Wang[2] and Chris Chatwin[1]
[1]University of Sussex, Brighton, UK, xz68@sussex.ac.uk
[2]Micro Image UK Ltd, UK, w97wang@yahoo.co.uk

Abstract: The Sussex MK4 electrical impedance mammography (EIM) is an EIT system dedicated to breast cancer detection. The novel electrode configuration with its data acquisition method has significantly enhances the system performance by improving the signal-to-noise ratio (SNR).

1 Introduction

The Sussex MK4 EIM system is a 3D imaging system for breast cancer detection. It permits visualization of the inner structure of the breast by measuring its impedance distribution. The Sussex MK4 is equipped with a planar electrode array. The appearance of the system is a bed with a measurement tank in an appropriate position (Fig. 1a). The diameter of the tank is 18cm. The maximum depth of the tank is 5cm. The planar electrode array is fixed at the bottom of the tank and it is adjustable in the vertical direction. During examination, a patient can lie still in the prone position with a breast in the saline filled tank. This system uses current excitation (1mA peak to peak) and voltage measurement covering frequency from 10kHz to 5MHz. The measurement circuits consist of a switching network, low noise amplifiers and 14-bit ADCs sampling at 100MS/s, the maximum voltage input range is 5V peak to peak[1].

2 Methods

There are 85 electrodes deployed in a hexagonal pattern (Fig. **1**b). The distance between any adjacent electrodes is 17mm. The current excitation and voltage measurements are only focused and achieved in a small hexagonal area (Fig. 1c). In each hexagonal measurement area, there are a maximum of 3 excitation events at 0° , 60° and 120°, (Fig. 2) and in each excitation, there are maximum of 12 voltage measurements, which are collected strictly parallel to the driving pair. With this special type of electrode configuration method, there are 123 excitation events corresponding to 1416 measurements. In all the figures of this paper,the yellow dots indicate the excitation pair; the blue dots connected by red arrows indicate measuring pairs [2] in one excitation.

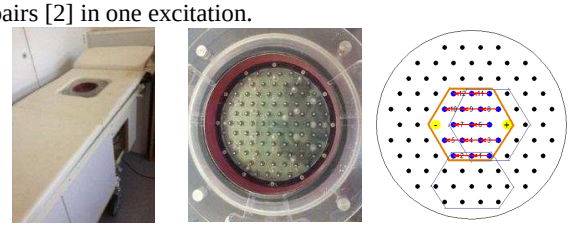

Fig. 1. Sussex MK4 EIM system and planar electrodes. (a) MK4 EIM system. (b) the planer electrodes. (c)the electrode drive and receive hexagon pattern.

The advance of this data acquisition method is gaining the strongest measurements for each excitation to guarantee a much smaller dynamic range (DYR) between the maximum and the minimum measurements in each excitation. Compared with the traditional DAS system in EIT with large DYR, it has achieved a much better overall SNR . Here we provide an example shown in Fig. 3 based on the planner electrode array of the MK4. We name the 12 measurements within the hexagonal measurement area as the inner measurements (IMs) (Fig. 3 (a)) and the 14 additional measurements outside the hexagonal measurement area as the outer measurements (OMs) (Fig. 3 (b)). Fig.4 displays the total 26 measurements shown in Fig**. 3**, which are simulated for a 4.5 cm height of saline with a conductivity of 0.5 mS/cm in the tank. We find that the DYR of the IMs is about 10 times smaller than that of all the 26 measurements including both the IMs and the OMs. Therefore for a 60dB SNR DAS system, the IMs based MK4 data acquisition method has successfully avoided the additional 20dB SNR lost compared with the IMs and OMs based data acquisition method, for a fixed programmable gain amplification (PGA) system.

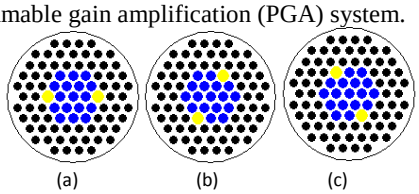

Fig. 2. Three current excitations in a hexagonal area.

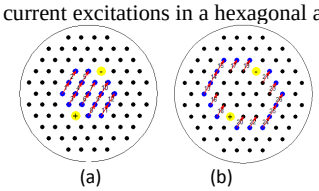

Fig. 3. Measurement pairs.(a) shows the measurements within the hexagonal measurement (IMs) area (b) shows the measurements outside the hexagonal measurement (OMs) area.

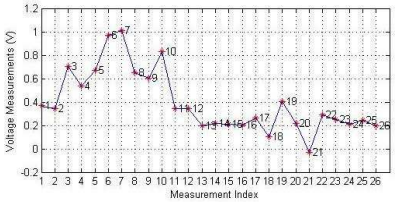

Fig. 4. The voltage measurements corresponding to Fig. 3.

3 Conclusions

The novel hexagonal electrode arrangement and data acquisition method ensures up to 1416 independent measurements with high SNR by effective reducing the DYN without losing the signal in range of interest (ROI) .

References

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