MUBI : Multi-Modal Ultrasound Breast Imaging Research Platform

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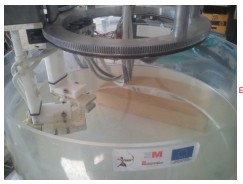
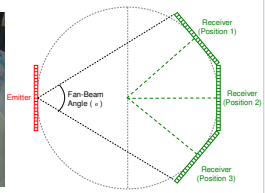
INTRODUCTION

The Multimodal Ultrasound Breast Imaging System (MUBI) is a joint development of the Spanish National Research Council (CISC) and the Complutense University of Madrid (UCM), under the projects ARTEMIS [1] and TOPUS [2]. It is intended to be a flexible platform for multi-modal ultrasound imaging research, mainly oriented to breast diagnosis [3]. Up to now, the following imaging techniques have been implemented:

- **Phased-Array** full angle spatial compound (FASC) [4].
- **Acoustic Radiation Force** Imaging (ARFI) full angle spatial compound [5].
- **Ultrasound Computed Tomography** (USCT) speed of sound and attenuation reconstruction [6].

The system is formed by two arrays that rotate into a water tank, controlled by independent stepper motors. A full parallel ultrasound system is used for excitation and signal acquisition. While only one array can be used as emitter, both of them can act as receivers, allowing pulse-echo and through-transmission operation modes. The system is able to perform emission and reception beamforming in real-time, and also gives access to the individual signals received by each array element). A standard personal computer controls the motors movement and the ultrasound equipment with Matlab scripts.



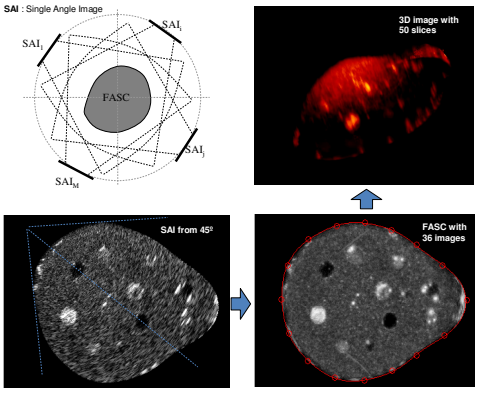


MUBI system (left) picture (right) fan-beam acquisition scheme

System parameters			
Turn Radius	95 mm (50 mm with optional array holders)		
Angle resolution	0.1 º		
Z movement	Manual screw for sample platform movement		
ARRAYS (Prosonic, Korea)			
	Frequency	Elements	Pitch
P2-4/30	3.2 MHz	128	0.22
L3-8/40	5 MHz	128	0.3048
ULTRASOUND EQUIPMENT (Dasel, Spain)			
Nº of channels	128		
Excitation	100 V square pulse (16 bits coded optional)		
Bandwidth	800 kHz to 16 MHz		
Sampling	40 MHz @ 12 bits		
Memory	Up to 4 kSamples per channel		
Beamforming	Dynamic Depth Focusing (DDF)		
Delay resolution	3.125 ns		

REFLECTIVITY IMAGES

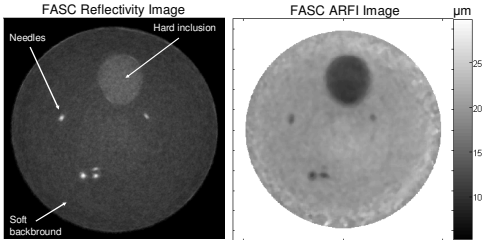
Full Angle Spatial Compound (FASC) of phased-array sector-scan images reduces texture speckle, improves contrast-to-noise ratio (CNR) and reduces direction dependant artifacts like shadows and reverberations. Moving the sample in the vertical direction, a 3D image of the breast can be obtained by slices stacking. An automated algorithm was developed for detecting the breast contour and correcting the beam propagation path before the scan conversion to rectangular coordinates.



Full Angle Spatial Compound of Phased-array images

ARFI IMAGES

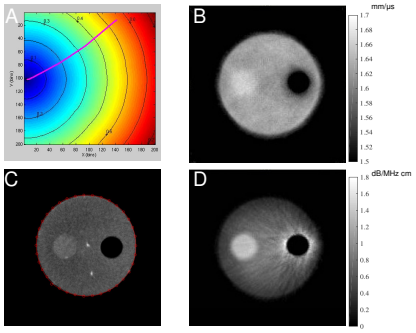
Acoustic Radiation Force Impulse (ARFI) images has the ability of discriminating tissue stiffness, a parameter directly related with cancer malignity. We have developed full angle spatial compound algorithm specific for ARFI images, including depth, angle and focal length equalization of individual displacement images. A peculiarity of this work is that ARFI images are acquired without direct contact between the transducer and the breast, which required to account for the water-path in the radiation force generation procedure.



Full Angle Spatial Compound of ARFI images

USCT IMAGES

Ultrasound computed tomography (USCT) is an emerging imaging technique that provides quantitative information of soft-tissues in-vivo. The most common properties obtained with USCT are the speed of sound, which correlates well with the density of the tissue [6] and the acoustic attenuation coefficient which is far more sensitive to the particular tissue type and it may be used to improve the detectability of malignancies.



A. Bent rays algorithm using FMM [6] B. Sound speed.
C. Reflectivity D. Attenuation

CONCLUSIONS

The MUBI platform has proven to be a flexible experimental tool for research in breast ultrasound. Several imaging modalities have been successfully implemented and tested with tissue mimicking phantoms. Future developments include a second hardware version with a complete ring of 16 arrays, reducing acquisition time by eliminating the circular movement.

Dataset for USCT reconstruction is available at*:

http://ipeusctdb1.ipe.kit.edu/~usct/challenge/?page_id=183

REFERENCES

[1] ARTEMIS project "Advanced Real-TimE Multimodality Medical Imaging", Comunidad de Madrid, S2009/DPI-1802.

[2] TOPUS project "Positron emission and ultrasound tomography", Comunidad de Madrid, S2013/MIT-3024.

[3] J. Camacho, L. Medina, J.F. Cruza, J.M. Moreno, C. Fritsch, "Multimodal ultrasonic imaging for breast cancer detection" Archives of Acoustics, 37-3, 253-260, 2012.

[4] L. Medina, J. Camacho, C. Fritsch, "A characterization of ultrasonic full angle spatial compounding as a possible alternative for breast cancer screening" Archives of Acoustics, 40, 3, 301-310, 2015.

[5] Nuria González-Salido, Luis Medina, Jorge Camacho, "Full angle spatial compound of ARFI images for breast cancer detection", Ultrasonics, 71, 161-171, 2016.

[6] M. Pérez-Liva, J. L. Herraiz, N. González-Salido, L. Medina-Valdés, J. Camacho, C. Fritch, J.M. Udías "Ultrasound Computed Tomography for Quantitative Breast Imaging", Proc. IEEE Global Medical Engineering Physics Exchanges (GMEPE) & Pan American Health Care Exchanges (PAHCE), Madrid, Spain, 4-9 Apr. pp 1-6, 2016.

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