



**HAL**  
open science

# IMAGING OF MUSCULOSKELETAL TISSUES BY ULTRASONIC TOMOGRAPHY - Prospects for children limb imaging

Elise Doveri, Luis Espinosa, Vadim Monteiller, Régine Guillermin, Laurent Sabatier, Vincent Long, Philippe Lasaygues

► **To cite this version:**

Elise Doveri, Luis Espinosa, Vadim Monteiller, Régine Guillermin, Laurent Sabatier, et al.. IMAGING OF MUSCULOSKELETAL TISSUES BY ULTRASONIC TOMOGRAPHY - Prospects for children limb imaging. CMBBE 2023, 18th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering, May 2023, Paris, France. hal-04544853

**HAL Id: hal-04544853**

**<https://hal.science/hal-04544853>**

Submitted on 13 Apr 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



## IMAGING OF MUSCULOSKELETAL TISSUES BY ULTRASONIC TOMOGRAPHY - PROSPECTS FOR CHILDREN LIMB IMAGING

Elise Doveri (1), Luis Espinosa (2), Vadim Monteiller (1), Régine Guillermin (1), Laurent Sabatier (1), Vincent Long (1), Cécile Baron (3), Philippe Lasaygues (1)

1. Aix Marseille Univ, CNRS, Centrale Marseille, LMA UMR 7031, Marseille, France

2. Univ. Toulouse 3 - Paul Sabatier, Institut Clément Ader, Tarbes, France

3. Aix Marseille Univ, CNRS, Centrale Marseille, IRPHE UMR 7342, Marseille, France

### 1. Introduction

B-mode ultrasound (US) has long been a first-line examination for the diagnosis of many musculoskeletal diseases in children [1]. The other modalities, such as X-ray or magnetic resonance imaging, are associated with inconveniences that are constraining for pediatric applications. Because the large acoustic impedance contrast between echogenic bony structures, and the adjoining soft tissues, US can only see the outer surface of bony structures, and not what lies within. In that context, the ultrasound computed tomography (USCT), with an adapted filtering and signal processing algorithm [2], allows to visualize with a good resolution ( $\lambda/10$ ) and contrast, the different morphologies of small organs (skin, muscles, tendons, nerves, vessels, fat and bony structures). But the method fails to provide quantitative images.

### 2. Materials and Methods

In this work, a new nonlinear approach to USCT is proposed using the full waveform inversion (FWI) algorithm [3], [4], based on a full numerical modeling of the wave propagation in the media, and on the minimization of the difference between recorded and simulated waveforms based on the iterative resolution of the inverse problem. The method requires only one set of recorded signals.

A USCT prototype has been developed, consisting of a crown (300 mm) of 8 1MHz-transducers distributed every 45°. A wavelet-based coded excitation method (WCE) has been adapted to this device [5] allowing to map the inter- or centro-diaphyseal areas, and thus reducing the low-pass filtering effect influencing the contrast-to-noise (CNR).

### 3. Results

Experiments were conducted on a newborn arm phantom containing blood vessels, single and

joined bones (Fig. 1), and on a chicken drumstick with skin, different muscles, fat, tendons, nerves, tibia and fibula (Fig. 2).

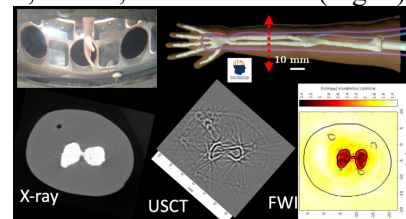


Figure 1: X-ray, linear and non-linear USCT of a newborn arm phantom (True Phantom™, CA).

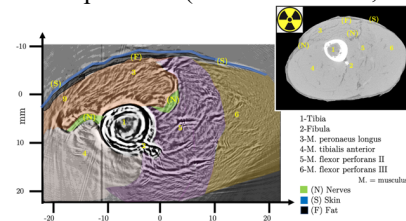


Figure 2: USCT of a chicken drumstick

### 4. Discussion and Conclusions

The algorithm for CNR and gain calculation is detailed in [2] and [4]. The performance of the method is presented in the following table.

Target	CNR	Gain (%)
Arm	1.3 (1.1)	1784
Chicken	1.1 (1)	175

Table 1: Control-to-noise ratio (average and standard deviation) and gain (%) of the USCT of musculoskeletal tissues

### 5. References

- [1] J. F. Griffith, 2nd Edition. Salt Lake City: Amirsys Publishing, 2019.
- [2] E. Doveri et al., *Appl. Sci.*, vol. 11, no. 20, p. 9368, 2021.
- [3] S. Bernard et al., *Phys. Med. Biol.*, vol. 62, no. 17, pp. 7011–7035, 2017.
- [4] L. Espinosa et al. *Ultrason. Imaging*, vol. 43, no. 2, pp. 88–99, 2021.
- [5] M. Loosvelt and P. Lasaygues, *Ultrasonics*, vol. 51, no. 3, pp. 325–339, 2011.

### Acknowledgements:

Centre de Calcul Intensif d'Aix-Marseille is acknowledged for granting access to its high-performance computing resources.