INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES CENTRE VAL DE LOIRE

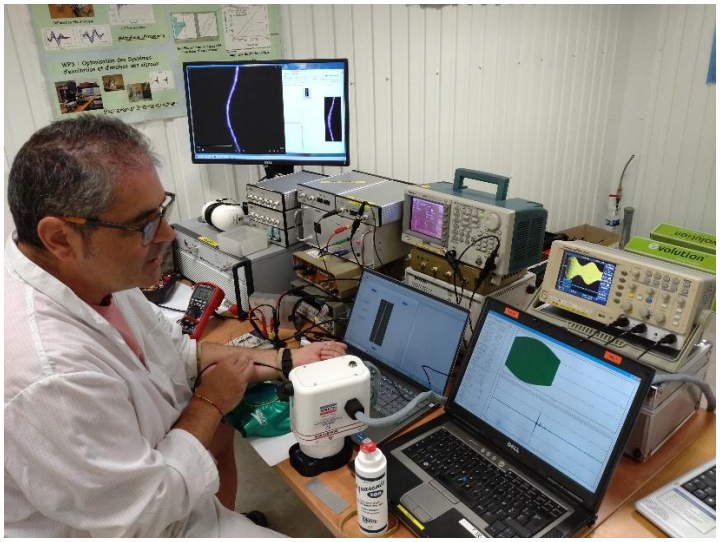
INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

Internship project (Master 2 Level)

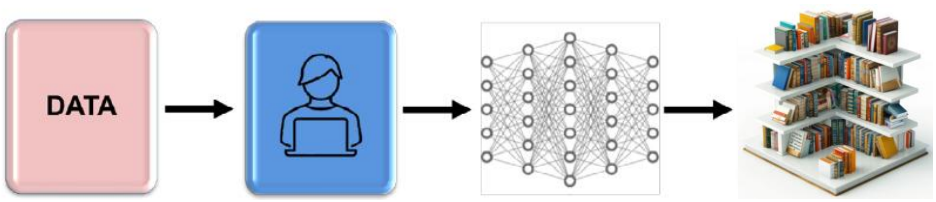
Development and validation of an interoperable annotation framework for nonlinear ultrasonic skin data

Context of the work :

The TR-NEWS ultrasonic platform developed at INSA Centre Val de Loire enables the acquisition of nonlinear ultrasonic signatures from soft biological tissues using advanced excitation schemes such as quaternion-coded signals[1]. These experiments, applied to skin imaging, are designed to quantify nonclassical nonlinearities linked to structural changes in biological tissues.



In the DICA#UP project, a major challenge is the lack of interoperability between heterogeneous ultrasonic datasets and metadata formats (proprietary TR-NEWS descriptors, experimental context, acquisition parameters, etc.) as identified in the project description. This lack of standardization makes it difficult to compare experiments, automate the analysis pipeline, or feed machine learning algorithms.



The present internship focuses on the processing and modelling of nonlinear ultrasonic data, and on the construction of an interoperable annotation dictionary compatible with DICONDE-like structures. The goal is to formalize the signal-processing workflow and enable standardized annotation of advanced ultrasonic experiments on skin.

Experiments to be analysed include:

- nonlinear TR-NEWS excitations based on quaternionic coding,
- calibration procedures using V3 blocks,
- imaging experiments on synthetic and biological skin models, used in cosmetic and bio-engineering applications.

It is therefore necessary to develop tools allowing *(i)* the analysis of the experimental results obtained with the trained models as well as *(ii)* the annotation of the acousto-mechanical metadata and ultrasonic images.

Previous research in the team has shown that automatic classifiers using information-divergence based approaches [1-3] are more efficient for remote health monitoring and diagnosing suspects.

Objectives:

- Signal processing and nonlinear signature extraction from TR-NEWS experiments (time reversal focusing, harmonic content analysis, memory effects, PM-space projection, etc.).
- Identification of relevant acoustomechanical metadata for annotation (experimental context, boundary conditions, excitation type, mechanical loading, acquisition chain).
- Design of an interoperable annotation dictionary (DICA#UP) derived from:
  - TR-NEWS metadata structure,
  - DICONDE-like standards for nondestructive evaluation,
  - Ontological models described in the project's Lot 2 (semantic interoperability)
- Validation of the dictionary by annotating representative calibration and skin experiments
- Implementation of a prototype annotation tool

References :

[1] S. Dos Santos, M. Maslouhi, and K. A. Okoudjou, Recent Advances in Mathematics and Technology (Applied and Numerical Harmonic Analysis), Springer Nature, 2019. https://www.springer.com/gp/book/9783030352011

[2] C. Kozena, V. Kus and S. Dos Santos, "*Hysteresis and memory effects in skin aging using PM space density identification*," 2016 15th IEEE BEC, 2016, pp. 179-182, doi: 10.1109/BEC.2016.7743758 .

[3] Dos Santos, S., Farova, Z., Kus, V., & Prevorovsky, Z. (2012, May). *Echodentography based on nonlinear time reversal tomography: Ultrasonic nonlinear signature identification*. In AIP Conference Proceedings (Vol. 1433, No. 1, pp. 203-206). American Institute of Physics.

Profile :

The student should have a strong motivation on research domain such as bioengineering, computational simulation and modelling. The intern should be proficient in modelling and programming in different languages such as C, Java, Matlab, and Python. In addition to programming skills, knowledge of the basics of image processing is highly desirable. Intern should have good written and verbal communication skills and enjoy working in a multi thematic team. Good English language skills are required.

Starting period : Spring Semester 2025-2026

Supervisors :

- Serge Dos Santos, Associate Professor,
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- Frédérique Biennier, Full Professor,
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The monthly gratuity will be paid according to the French law :
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