

Internship project (Master level)
Development of artificial intelligence solutions for nonlinear ultrasonics data
applied to the aging and integrity of biomaterials

Context of the work :

Echodentography based images have been obtained experimentally with an acousto-optic non-contact set-up based on the chirp-coded nonlinear time reversal acoustic concept. The complexity of the tooth internal structure (enamel-dentine interface, cracks between internal tubules) is analysed by adapting the nonlinear elastic wave spectroscopy (NEWS) with the objective of the tomography of damage for odontology applications. The same acousto-mechanical experiment using the mixing of a mechanical loading (conducted at 10 Hz frequency) and an ultrasonic 50 MHz Time Reversal based Nonlinear Elastic Wave Spectroscopy [TR-NEWS](#) probing system has been implemented in order to extract the nonclassical nonlinearity of the skin for cosmetic applications [1]. Deep learning algorithms require many data to produce relevant results. 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 [2,3] are more efficient for remote health monitoring and diagnosing suspects. Thanks to AI algorithms, it is possible to record and process different ultrasonic data, opening the way to easier remote health monitoring of the skin and/or the tooth. The student will use a database of several features recorded in an experimental study carried out in our lab. A full description of the database will be made available and description could be improved using raw data. The goal of this internship is to test different machine learning algorithms and analyse the data to build a model able to classify accurately each aging processes.

Objectives:

- The creation and preparation of databases of signals or images from the two experimental set-up associated to tooth and skin.
- Develop processing methods based on Machine Learning and Deep Learning
- Integrate these methods into different control applications
- Ensure the deployment of the final solution on dedicated TR-NEWS-type systems
- Literature and state of the art with the subject and the development environment.
- Automation of the process of extraction, projection and classification of nonlinear signatures.

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 Biennial Baltic Electronics Conference (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 Conf. Proc., 1433, No. 1, pp. 203-206.

Profil :

The student should have a strong motivation on research domain such as bioengineering, computational simulation and modelling. The intern will have to present good knowledge in programming, and in particular on Javascript, Python (back-end) and COMSOL. Notions in medical image processing and machine learning can allow greater interaction with stakeholders. Finally, skills in learning/classification (Tensorflow, etc.), image processing, and computer vision will be welcome. The student will be welcomed by the U1253 Inserm lbrain scientific landscape, which specializes in topics directly related to multidimensional signal processing. All the tools and data necessary for the completion of the internship will be provided. The internship will include a part of methodological and IT developments, which will be carried out mainly in Python and / or Matlab. 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.

Administration :

Supervisor : Serge Dos Santos, Ass. Professor, Hab. Dir. Rech., INSA Centre Val de Loire, Blois Campus
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Laboratory : lbrain « Imaging and Brain » U1253 Inserm-University of Tours

Team : IBT, "[Imagerie, Biomarqueurs et Thérapie](#)", Thème « Analyse d'Image et Vérité Terrain »

Duration : 6 months from Feb 2022. The monthly gratuity will be paid by INSA Centre Val de Loire (French law) (<https://www.service-public.fr/particuliers/vosdroits/F32131?lang=en>)