Internship project

Improvement of artificial intelligence solutions from nonlinear ultrasonic data

applied to the aging of biomaterials

Context of the work :

Echodentography based images have been obtained experimentally with an acousto-optic noncoupling 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 goal of this internship is to continue the previous work [4,5] and 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 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.

[4] S. Dos Santos, P. Hemmati and S. Furui, "*Memristor based ultrasonic optimized excitations for mesoscopic nonlinear characterization of biomedical tissues*," 2022 18th IEEE Biennial Baltic Electronics Conference (BEC), 2022, doi: 10.1109/BEC56180.2022.9935594.

[5] S. Dos Santos, P. Hemmati and S. Furui, "*Optimization of memristor based ultrasonic transducers for mesoscopic characterization of biomaterials*," 2022 IEEE International Symposium on Applications of Ferroelectrics (ISAF), 2022, doi: 10.1109/ISAF51494.2022.9870130.

Profil :

The student should have a strong motivation on research domain such as bioengineering, computational simulation and modelling. The intern should be proficient in modeling neuron dynamic behavior using MATLAB & Python and skilled at programming in different languages such as C, Java, and Python in order to work with machine learning and image processing techniques. 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.

Adminitration :

Supervisor : Serge Dos Santos, Associate Professor, INSA Centre Val de Loire, serge.dossantos@insa-cvl.fr
Laboratory : Imagerie et Cerveau U1253 Inserm-Université de Tours
Team : IBT, "Imagerie, Biomarqueurs et Thérapie", Thème « Analyse d'Image et Vérité Terrain »
The monthly gratuity will be paid by INSA Centre Val de Loire, according to the French law
(https://www.service-public.fr/particuliers/vosdroits/F32131)