AI SOlution for Non-DEstructive Ultrasonic Testing of Critical Systems (SONDES)

Theme / Domain / Context
Basic AI and Data Science: high-dimensional statistical learning
Specialized ML and AI: signal, image, vision
Application domain: non-destructive control, ultrasound sensors
Keywords deep learning, multi-modal imaging, weakly supervised learning
Partner laboratories involved: IBISC (UEVE)
total duration of the internship 6 months,
start and end date of the internship from 25/02/01 to 25/09/15

Description Ultrasounds are used for non-destructive testing (NDT) of industrial parts without harming their integrity. This consists of emitting acoustic waves and detecting their interactions with defects present in the part. The re-emitted waves (echo) are then converted, in real time, into a digital image of the fault thus located and characterized.

This internship focuses on the identification by deep neural network of possible defects on fasteners in a critical system. The identification of these defects will be based in particular on several ultrasound measurements (multimodal), carried out *in situ* by the maintenance teams of various partner industrial sites [4]. A promising approach is to first estimate the quality of an acquisition, as many factors can directly lead to poor analysis when it comes to determining the presence or absence of a defect, or render the acquisition uninformative for this task.

Objectives: The (SMART) objectives of this study are as follows:
1 (main): Be able to automatically detect, in an unsupervised way, poor-quality acquisitions
2. Compare results to make them consistent with those of experts.
3. Improve existing models for supervised estimation of acquisition quality.

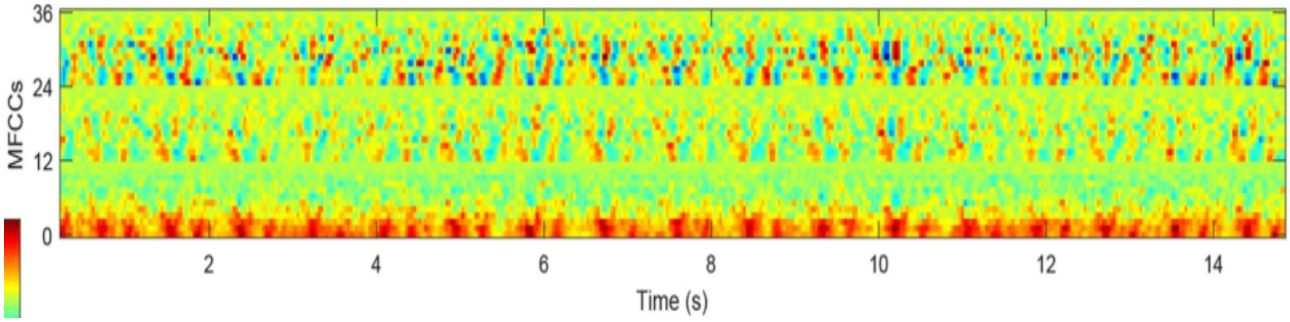

Figure 1 – MFCC time-frequency spectrum

Methodology The networks envisaged *a priori* for this research are deep neural architectures more specifically Vision Transformer (ViT) for supervised classification with, as inputs, several modalities sent at the same time in different directions, forming a multimodal "image" [2] (fig. 1).

Expected results Deep neural networks will be trained to correct pre-existing annotations by identifying suspect annotations. A statistical study of the behavior of model outputs will be carried out in order to obtain a confidence index in the estimation of model outputs.

A data augmentation procedure may be developed to reduce the amount of data to be measured and build a new training database.

Profile and skills required
The recruited person will be in the 3rd year of engineering school or Master. He will be able to understand and develop and/or adapt learning algorithms in an industrial context, index it and use it in an operational system to achieve the mission described above.

Programming skills: Python or C/C++.
A good theoretical knowledge of machine learning and deep learning is required. A practice of Pytorch or Tensorflow would be a plus. The practice of French is not compulsory. His(her) English is fluent. The candidate should be source of proposals. The work will be carried out at the IBISC[1] Laboratory on the Evry campus of the UPSaclay. The project is multidisciplinary, at machine learning, computer science, and medicine interface.

Supervision and scientific and material conditions
The student will be supervised by Thomas Sendra, Vincent Vigneron from the IBISC laboratory (Univ d'Évry, Université Paris-Saclay). All master machine learning, signal and image processing.

Contact: please send marks (Bachelor and Master) to Thomas Sendra and Vincent Vigneron

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Références
[1] Oktay Karakuş, Nantheera Anantrasirichai, Amazigh Aguersif, Stein Silva, Adrian Basarab, and Alin Achim. Detection of line artifacts in lung ultrasound images of covid-19 patients via nonconvex regularization. *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control,* 67(11) :2218–2229, 2020.
[2] Ana Lopez, Ricardo Bacelar, Inês Pires, Telmo G. Santos, José Pedro Sousa, and Luísa Quintino. Non-destructive testing application of radiography and ultrasound for wire and arc additive manufacturing. *Additive Manufacturing,* 21 :298–306, 2018.
[3] Maryam Najafabadi, Flavio Villanustre, Taghi Khoshgoftaar, Naeem Seliya, Randall Wald and Edin Muharemagic. Deep learning applications and challenges in big data analytics. *Journal of Big Data,* 2, 12 2015.
[4] Shangqin Yuan and Xudong Yu. Ultrasonic non-destructive evaluation of selectively laser-sintered polymeric nanocomposites. *Polymer Testing,* 90 :106705, 2020.

[1] IBISC develops multidisciplinary, theoretical, and applied research in the information sciences and engineering field, with a strong orientation towards health applications.