UNIVERSITÉ CÔTE D'AZUR | 3iA Côte d'Azur Interdisciplinary Institute for Artificial Intelligence

PHD thesis proposal

Deadline: end June 2023

Passive imaging of the subsurface along transportation infrastructures using distributed acoustic sensing and machine learning

Project partners:
SNCF company, BRGM, TelecomParis, Université Grenoble Alpes, Université Côte d'Azur

Abstract:
A key aspect in the development of sustainable smart cities is to leverage the existing information and communication infrastructure for developing new sensing strategies. In that framework, Telecom-Distributed Acoustic Sensing (DAS) is a recent breakthrough which has shown it is possible to use existing telecommunication fiber optic already deployed in cities for recording the passive seismic vibrations at high frequency in space and time, over large distance and over long-time span. The objective of the thesis is to evaluate how we can use DAS data and Machine Learning (ML) techniques to image and monitor the subsurface along transportation infrastructures.

Indeed, DAS comes with new challenges in handling the various types of recorded seismic signals that impede the application of usual data processing workflows. DAS produces data in the order of 1Tb daily, and requires the use of effective processing methods capable of recognizing multiple acoustic signatures simultaneously, under low signal-to-noise ratio conditions. Over the last decade, machine learning methods have been successfully applied to tackle geophysical problems and assist in laborious tasks such as earthquake detection, and phase arrival picking. Recent studies have explored leveraging ML approaches for analysis and processing of DAS ambient seismic noise recordings. In the majority of these studies, the objective is event detection and classification, and the feature of interest is the seismic signal generated by vehicles or persons travelling past the array. In (van den Ende et al., 2022), the authors propose a self-supervised deep learning approach that deconvolves the characteristic car impulse response from the DAS data. In (Liu et al., 2020), the authors introduce a ML approach for vehicle detection, classification and estimation. In (Jakkampudi et al., 2020), they develop a convolutional neural network to detect footstep signals in ambient seismic recordings from urban DAS arrays. In a similar approach, (Huot and Biondi, 2018) use a convolutional neural network to detect car- generated seismic signals. The study in (Dumont et al., 2020) focuses in the identification and quantification of the useful seismic waves embedded within the seismic signal generated by the vehicles. In (van den Ende et al., 2021), the authors explore a deep learning blind denoising method that optimally leverages spatio-temporal density of DAS recordings to separate earthquake signals from the spatially incoherent background noise.

All these works anticipate the development of ML as a central tool for processing and monitoring seismic DAS signals. Indeed, ML techniques can handle very large volumes of data, and enable fast and efficient processing and interpretation of DAS data in comparison with classic approaches. The goal of the thesis is to develop a ML framework for processing DAS data and performing subsequent seismic noise analysis that will serve as input for passive imaging and monitoring the near-surface geomechanical properties beneath transportation infrastructures.

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