Postdoctoral research topic

- Title of the proposed topic:
  Leveraging the spatio-temporal coherence of distributed fiber optic sensing data with Machine Learning methods on Riemannian manifolds
- Research axis of the 3IA: AI FOR SMART AND SECURE TERRITORIES
- **Supervisor (name, affiliation, email): Cédric RICHARD, Lagrange, UCA cedric.richard@unice.fr**
- The laboratory and/or research group: Lagrange Lab, UCA

Apply by sending an email directly to the supervisor.
The application will include:

- Letter of recommendation of the supervisor indicated above
- Curriculum vitæ including the list of the scientific publications
- Motivation letter
- Letter of recommendation of the thesis supervisor

- Description of the topic:

Optical fiber, in addition to being a means of transmitting information, is also a material that is very sensitive to environmental variations. When a laser light pulse travels through an optical fiber, it interacts with tiny impurities in the material, causing optical backscattering. Processing this response provides estimates of the local variations in acoustic pressure along the fiber, over distances ranging from 40 km to 140 km with some systems. This technique, called Distributed Acoustic Sensing (DAS), is currently experiencing growing interest in an increasing number of applications, such as traffic monitoring, structural health monitoring, and natural hazard detection, to name a few. As telecom fibers are ubiquitous in urban environments, DAS represents a breakthrough concept to upgrade existing fiber optic networks to acoustic sensor arrays, becoming a key component for managing smart cities.

Except for a few applications, DAS data are typically processed on a trace-by-trace basis, essentially treating the instrument as a collection of conventional seismometers. Since these processing routines do not leverage the spatio-temporal coherence of DAS data, they do not reach their full potential. Recently, through the use of Riemannian geometry, we proposed a nonparametric framework for change-point detection in manifold-valued data streams [1]. We applied these methods to detect micro-seismic events in borehole and underwater DAS data based on their long-range coherence rather than their energy [2]. Although they achieved superior performance and are built on stochastic Riemannian optimization algorithms, these methods still suffer from limitations in computational complexity.

The post-doctoral fellow will build upon this preliminary work to investigate the development of more efficient online learning algorithms for manifold-valued data streams, with an initial focus on change-point detection, opening the door to new unsupervised data exploration methods. Next, the post-doctoral fellow will consider designing distributed learning algorithms for streaming manifold-valued data. Experiments will be carried out on urban, coastal, and underwater DAS data. The novelty of the application and the relative lack of a framework for processing DAS data should ensure the fast dissemination of this work.

[1] Xiuheng Wang, Ricardo Augusto Borsoi and Cédric Richard. Non-parametric Online Change Point Detection on Riemannian Manifolds. In International Conference on Machine Learning (ICML). PMLR, Vienna, 21-27 July 2024.

[2] Martijn van den Ende, Xiuheng Wang, Ricardo Augusto Borsoi, et al. Leveraging the spatio-temporal coherence of DAS data for detection and classification. In Fibre Optic Sensing in Geosciences, Catania, 16-20 June 2024.