3iA Côte d'Azur
Interdisciplinary Institute for Artificial Intelligence

Postdoctoral research topic

- Title of the proposed topic:
  Change-point detection for dynamic structured data
  Application to smart city monitoring
- 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:

Change-point detection (CPD) is a fundamental problem in statistics and machine learning, focusing on identifying abrupt shifts in the properties of data over time. These shifts, commonly referred to as change-points, indicate transitions in the underlying distribution or dynamics of a system, which may arise due to external events or internal structural changes. The objective of CPD is to pinpoint when these changes occur and, in some cases, to characterize the nature of the shifts. CPD has a wide range of applications in domains focused on monitoring and securing complex systems, including mobility, manufacturing, communication, economics, and environmental science. These domains often rely on real-time analyses and adaptive decision-making to effectively address evolving conditions.
A growing number of these applications are generating dynamic structured, high-dimensional data with non-trivial and intricate geometric properties. These data often exhibit complex relationships and dependencies that go beyond Euclidean spaces, necessitating sophisticated techniques for analysis and interpretation. Prominent examples include time sequences on groups and manifolds, time sequences of graphs, and graph signals.

The objectives –The project aims to develop unsupervised online CPD algorithms for dynamic structured data, with a particular focus on time sequences of graphs, graph signals, and time sequences on groups and manifolds. Special emphasis will be placed on non-parametric

frameworks, as they impose minimal, if any, assumptions about the underlying data distribution, making them more effective for detecting a wide range of changes.
The CPD algorithms will be designed for computational efficiency, ensuring scalability to large-scale datasets, and their performance will be analyzed.

The project will explore applications in smart city monitoring, an area where the team has established expertise. In particular, this research work will build on breakthrough technology developed by the research team through the SequoIA startup initiative, currently in its pre-maturation phase. SequoIA focuses on urban monitoring using Distributed Acoustic Sensing, a technique that repurposes existing telecom optical fibers as continuous, high-resolution seismo-acoustic sensors. This passive and infrastructure-free sensing paradigm enables the capture of acoustic scenes over distances exceeding 100 km, with meter-level spatial resolution and millisecond-scale temporal precision. However, the real-time processing of these high-dimensional, structured data streams of approximately 10 MB/s presents a significant challenge, requiring advanced algorithms capable of handling complex spatio-temporal and geometric dependencies beyond the Euclidean domain.