SECTOR; Higher Education Institution

LOCATION: France, Grenoble

RESEARCHER PROFILE:

First stage researcher,

INSTITUTION: Univ. Grenoble Alpes, University of Innovation

One of the major research-intensive French universities, Univ. Grenoble Alpes**\(^1\) enjoys an international reputation in many scientific fields, as confirmed by international rankings. It benefits from the implementation of major European instruments (ESRF, ILL, EMBL, IRAM, EMFL\(^2\)). The dynamic ecosystem, grounded on a close interaction between research, education and companies, has earned Grenoble to be ranked as the 5th most innovative city in the world. Surrounded by mountains, the campus benefits from a natural environment and a high quality of life and work environment. With 7000 foreign students and the annual visit of more than 8000 researchers from all over the world, Univ. Grenoble Alps is an internationally engaged university.

A personalized Welcome Center for international students, PhDs and researchers facilitates your arrival and installation.

In 2016, Univ. Grenoble Alpes was labeled «Initiative of Excellence ». This label aims at the emergence of around ten French world class research universities. By joining Univ. Grenoble Alpes, you have the opportunity to conduct world-class research, and to contribute to the social and economic challenges of the 21st century ("sustainable planet and society", "health, well-being and technology", "understanding and supporting innovation: culture, technology, organizations" "Digital technology").

* ESRF (European Synchrotron Radiation Facility), ILL (Institut Laue-Langevin), IRAM (International Institute for Radio Astronomy), EMBL (European Molecular Biology Laboratory), EMFL (European Magnetic Field Laboratory)

Key figures:

- + 50,000 students including 7,000 international students
- 3,700 PhD students, 45% international
- 5,500 faculty members
- 180 different nationalities
- 1st city in France where it feels good to study and 5th city where it feels good to work
- ISSO: International Students & Scholars Office affiliated to EURAXESS

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\(^1\) Univ. Grenoble Alpes
\(^2\)
MANDATORY REFERENCES:

IDEIX PROJECT TITLE: Large Dimensional Statistics for AI
SUBJECT TITLE: Randomized linear algebra for large dimensional data
SCIENTIFIC DEPARTMENT (LABORATORY’S NAME): GIPSA-lab
DOCTORAL SCHOOL’S: EEATS
SUPERVISOR’S NAME: Nicolas Tremblay (co-supervisors Barthelmé, Amblard(HdR)).

SUBJECT DESCRIPTION:

Motivation. Some of the core operations in linear algebra, including inversion, the SVD or the eigendecomposition, scale cubically in the dimension of the input. For large dimensional datasets, this is too slow, and much effort has gone into developing approximate faster methods. One recent direction has been to use Monte Carlo methods that sample the input matrix, and perform all expensive operations on the sample matrix rather than the original input. This class of techniques is called “randomized Linear Algebra” (RLA, [1]). For example, when computing the SVD of a “wide” matrix $A$, an RLA algorithm will sample only a few, well-chosen columns of $A$, and compute the SVD on these columns only. Under certain conditions this leads to a large increase in performance with only a small estimation error on the singular vectors.

We have recently begun to explore another way of performing RLA, one that does not involve sampling the columns or rows of a matrix. Instead, we use links between linear algebra and graph theory. Specifically, we focus on matrices that can be viewed as graph Laplacians. In that case some linear-algebraic properties of the matrix reflect graph-theoretic properties on the corresponding graph, and vice-versa (that’s the basis of spectral methods for finding communities in a graph, for example). Uniform Spanning Trees, and variants thereof, are objects of particular interest in this context. A spanning tree is a tree that connects all nodes in a graph. There can be many spanning trees in a graph, and Wilson’s algorithm is a (fast) way of sampling one of these trees at random. Due to the matrix-tree theorem, there are many deep links between linear algebraic quantities and Uniform Spanning Trees. We have been able to exploit these links to construct a fast estimator of regularised inverse traces [2], i.e. quantities of the form $\text{Tr}(qI + A)^{-1}$.

PhD description. The goal of the PhD is to further this work by estimating other linear-algebraic quantities. We have ways of constructing estimators for the eigenspectrum of a matrix, and ways of solving certain linear systems. The student will investigate the theoretical properties of these estimators, and seek to find efficient implementations. The student will apply the resulting methods to problems in graph signal processing and/or semi-supervised machine learning, where the properties of the underlying graph Laplacian are of great importance.

Organization. The position is held within the GIPSA-lab at the University Grenoble-Alpes, as part of the MIAI chair on “Large Dimensional Statistics for AI” (LargeDATA). The LargeDATA chair develops expertise in large dimensional statistics for AI, notably focusing on random matrix theory, statistical physics and graphs. The PhD position is located at Gipsa-lab. Besides the two co-supervisors, the other people involved in the project are: Pierre-Olivier Amblard (also at Gipsa), Luca Avena (Univ. of Leiden), and Alexandre Gaudilliére (CNRS, Institut de Mathématiques, Marseilles). P-O Amblard has worked on a large variety of estimation problems and has extensive expertise in multivariate and higher-order statistics. L. Avena and A. Gaudilliére are probability specialists, with a growing body of work on the statistical properties and applications of random spanning trees and forests [3].

Profile. The candidate should hold a MSc in statistical signal processing/applied mathematics.

References.
ELIGIBILITY CRITERIA
Applicants must hold a Master's degree (or be about to earn one) or have a university degree equivalent to a European Master's (5-year duration),

Applicants will have to send an application letter in English and attach:
- Their last diploma
- Their CV
- A short presentation of their scientific project (2 to 3 pages max)
- Letters of recommendation are welcome.

Address to send their application:
nicolas.tremblay@gipsa-lab.grenoble-inp.fr
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