

**Master 2 internship proposal - 2023/2024 (5 to 6 months):
Exploring Extensions of Spiked Tensor Models through Random Matrix Theory:
Applications in Machine Learning**

Keywords: machine learning, random matrix theory, tensor decomposition, and high-dimensional statistics.

Context: In unsupervised learning, many high-dimensional machine learning problems involve recovering low-rank structures from noisy tensors [9]. However, assessing the practical performance of tensor-based methods on large random tensors can be challenging. To address this issue and establish a theoretical framework for analyzing these methods, significant progress has been made in the literature by examining low-rank spiked tensor models as the dimensions of tensors tend to infinity [4, 8]. This regime naturally arises in the context of big data, enabling the study of high-dimensional random tensors by leveraging the concentration of measure phenomenon. Recently, researchers have employed tools from random matrix theory [1, 3] to investigate estimation problems in spiked random tensors, shedding light on the performance of various machine learning techniques applied to tensor-structured data [5, 10].

Objectives: The primary objective of this internship is to explore extensions of the spiked tensor model using the random matrix theory approach and investigate their applications in machine learning. The specific tasks assigned to the candidate will be tailored to their profile, spanning from abstract theoretical work involving mathematical analysis of these models to a more experimental approach that includes conducting numerical simulations and interpreting the results. The overarching goal is to develop a comprehensive theoretical framework and innovative methods based on the analysis, accompanied by the publication of research papers and the development of Python libraries to implement the derived outcomes.

Supervision and scientific environment: The internship will be jointly supervised by:

[Mohamed El Amine Seddik](#), a Senior Researcher at the Technology Innovation Institute in Abu Dhabi, UAE, brings expertise in random matrix/tensor theory and machine learning.

[Merouane Debbah](#), a Full Professor at Khalifa University in Abu Dhabi, UAE, and director of the 6G center, is an expert in machine learning, random matrix theory, and game theory with applications to 5G/6G networks.

The intern will have the opportunity to work in a stimulating environment, as the internship will be hosted by both the [Technology Innovation Institute](#) and [Khalifa University](#) in Abu Dhabi, UAE. This arrangement provides access to a scientifically rich atmosphere and encourages exchange and interaction with members of both research institutions. With their wide expertise in machine learning, high-dimensional statistics, and signal processing, these institutions offer numerous opportunities for collaboration and knowledge sharing during the internship.

Candidate profile: We are looking for a highly motivated candidate with a solid background in probability, statistics, machine learning, and optimization. Proficiency in Python or similar scientific programming languages is essential. The ideal candidate should possess strong mathematical and analytical skills, with a solid foundation in linear algebra, probability theory, and optimization. Familiarity with machine learning concepts and algorithms would be advantageous. Excellent communication and technical writing skills are required, as well as the ability to work both independently and collaboratively in a research setting. Prior experience with research projects or internships is preferred but not mandatory. The candidate should have a genuine passion for exploring theoretical concepts in random matrix/tensor theory and their applications in machine learning.

How to apply?

To apply for the internship, interested candidates are requested to email their application to mohamed.seddik@tii.ae. The application should include a comprehensive CV, a motivation letter highlighting their interest and suitability for the position, and official transcripts from their previous academic institutions.

References:

[1] Seddik, Mohamed El Amine, Maxime Guillaud, and Romain Couillet. "When random tensors meet random matrices." *arXiv preprint arXiv:2112.12348* (2021).

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[3] de Morais Goulart, José Henrique, Romain Couillet, and Pierre Comon. "A random matrix perspective on random tensors." *Journal of Machine Learning Research* 23 (2022): 1-36.

[4] Jagannath, Aukosh, Patrick Lopatto, and Leo Miolane. "Statistical thresholds for tensor PCA." (2020): 1910-1933.

[5] Mohamed El Amine Seddik, Mastane Achab, Henrique Goulard, Merouane Debbah. "A Nested Matrix-Tensor Model for Noisy Multi-view Clustering."

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[8] Richard, Emile, and Andrea Montanari. "A statistical model for tensor PCA." *Advances in neural information processing systems* 27 (2014).

[9] Anandkumar, Animashree, et al. "Tensor decompositions for learning latent variable models." *Journal of machine learning research* 15 (2014): 2773-2832.

[10] Mohamed El Amine Seddik, Malik Tiomoko, Alexis Decurninge, Maxim Panov, Maxime Guillaud, "Learning from Low-Rank Tensor Data: A Random Tensor Theory Perspective."