

Master 2 Research Internship in Performance Bound Estimation using Score-Based Models

Keywords: Performance Bounds, Bayesian Estimation, Score-Based Models, Diffusion Models, Statistical Signal Processing

Location: Gipsa-lab, 11 rue des Mathématiques, Grenoble Campus BP46, F-38402 Saint-Martin-d'Hères, France

Supervisor: Dr. Lorena Leon, Assistant Professor at Université Grenoble Alpes, lorena.leon@gipsa-lab.fr

Duration: 3-6 months

Start Date: February/March 2026 (no later than May 2026)

Research Environment:

The internship will take place at Gipsa-lab (gipsa-lab.grenoble-inp.fr), located on the Grenoble INP-UGA campus. The selected intern will join the GAIA research group (gaia-gipsa.cnrs.fr), working closely with PhD students and permanent researchers in an interdisciplinary environment combining signal processing, statistics, and machine learning.

Subject:

The Cramér–Rao bound (CRB) is a fundamental tool for assessing estimation performance in various fields such as signal processing, medical imaging, and radar systems. Its derivation relies on the computation of the Fisher Information Matrix (FIM), which depends on the score function of the statistical model. However, in realistic scenarios involving non-Gaussian noise, model mismatch, or complex (non-conjugate) priors, obtaining analytical expressions for the FIM often becomes intractable.

Recent advances in data-driven statistical modeling have enabled the estimation of performance bounds even when explicit likelihoods or priors are unavailable. Methods such as normalizing flows and score-matching-based generative models make it possible to empirically approximate complex probability distributions and compute Fisher information directly from data. These approaches generalize traditional performance bounds to cases where classical analytical derivations are not feasible.

This internship will focus on estimating performance bounds using score-based generative models, with the objective of exploring how such models can be employed to estimate or approximate theoretical lower bounds—including the Cramér–Rao and Bayesian Cramér–Rao bounds—in complex inverse or parameter estimation problems.

A potential application will involve the performance analysis of structure-factor model-based scatterer estimation using the Cramér–Rao bound, in collaboration with Pauline Muleki-Seya from the CREATIS Laboratory (Lyon, France).

Student Profile:

- Master's or engineering student in Applied Mathematics, Computer Science, Signal Processing or a related field.
- Strong programming skills in Python and/or MATLAB.
- Solid background in statistics and probability.
- Familiarity with score-based models, flow machine models, diffusion models, or related probabilistic learning algorithms is a plus.
- Fluent in English or French (spoken).

How to Apply:

Please send your CV, a cover letter, and your master or engineering school transcripts to:
lorena.leon@gipsa-lab.fr

Références:

- [1] L. Leon, H. Wendt and J.-Y. Tournet, "Bounds for the estimation of matrix-valued parameters of a Gaussian random process", *Signal Processing*, vol. 211, 2023., doi: 10.1016/j.sigpro.2023.109106
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- [3] E. Scope Crafts, X. Zhang and B. Zhao, "Bayesian Cramér-Rao Bound Estimation With Score-Based Models," in *IEEE Transactions on Information Theory*, vol. 71, no. 3, pp. 2007-2027, March 2025, doi: 0.1109/TIT.2024.3447552
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- [5] H. V. Habi, H. Messer and Y. Bresler, "A Generative Cramér-Rao Bound on Frequency Estimation with Learned Measurement Distribution," *2022 IEEE 12th Sensor Array and Multichannel Signal Processing Workshop (SAM)*, Trondheim, Norway, 2022, pp. 176-180, doi: 10.1109/SAM53842.2022.9827830
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