Internship and PhD thesis proposal
Tensorial approaches for causal discovery

Scientific context

Causality and more generally eXplainable AI (XAI) is one of the hot current topics of the AI scientific community, with many applications in medicine, material sciences, environment, marketing…

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We invite for applications for a PhD thesis position within the **CAUSALI-T-AI** project of PEPR IA project funded by the ANR (2023-2029) about tensorial approaches for causal discovery (more details below). The thesis will take place in the Simul Research Group of Centre de Recherche en Automatique de Nancy. International scientific collaborations with Canada, Japan and Germany can also be planned. We have strong connections with Elina Robeva's research group in British Columbia (Canada) , Joscha Diehl's research group in Greifswald University (Germany) and N. Siugara group in JAMSTEC (Japan)

Applications (cv +motivation letter+references) should be sent before Dec 15 to

R. Borsoi : ricardo.borsoi@univ-lorraine.fr
M. Clausel : marianne.clause@univ-lorraine.fr
K. Usevich : konstantin.usevich@univ-lorraine.fr

Subject

Causal discovery is a problem of finding causal (directional) relationships between random variables, and is a challenging problem. A particular difficulty is the presence of latent (unobserved) variables. The methods we consider in this topic, use the higher-order statistics (for example, cumulants or moments) to perform these tasks. Many of those methods rely on the non-Gaussianity assumption.

Some potential tracks for this research project:
1) Methods based on cumulants for models with multidirected edges (algorithm for a particular case: [Liu, Robeva, Wang, 2020] , theoretical foundation: [Robeva, Seby, 2020])
2) Structural equation models with latent variables viewed as mixtures of independent component analysis models [Shimizu, 2007], and also [Liu et al., 2021] for linear dependencies.
3) Advanced topic: methods based on the signature tensors for causal discovery in time series [Chevyrev, Kormilitzin, 2016].

Bibliography

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Liu, Anqi, et al. "Disentangling observed causal effects from latent confounders using method of moments." *arXiv preprint arXiv:2101.06614* (2021).

Robeva, Elina, and Jean-Baptiste Seby. "Multi-trek separation in linear structural equation models." *SIAM Journal on Applied Algebra and Geometry* 5.2 (2021): 278-303.

Shimizu, Shohei, and Aapo Hyvärinen. "Discovery of linear non-Gaussian acyclic models in the presence of latent classes." *International Conference on Neural Information Processing*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2007.