Offer #2023-05908

PhD Position F/M Inference of causal models for networks from single observations

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

About the research centre or Inria department

The Centre Inria de l'Université de Grenoble groups together almost 600 people in 22 research teams and 7 research support departments.

Staff is present on three campuses in Grenoble, in close collaboration with other research and higher education institutions (Université Grenoble Alpes, CNRS, CEA, INRAE, ...), but also with key economic players in the area.

The Centre Inria de l'Université Grenoble Alpe is active in the fields of high-performance computing, verification and embedded systems, modeling of the environment at multiple levels, and data science and artificial intelligence. The center is a top-level scientific institute with an extensive network of international collaborations in Europe and the rest of the world.

Context

The work will take place at Inria Univ. Grenoble Alpes, Montbonnot, France either with frequent travels to Nokia Bell Labs, Massy, France.

Assignment

Context. Networks such as modern telecommunications networks or distributed embedded systems are permanently monitored to allow identification of failure situations; thousands of new data points reflecting the system state changes are generated every minute. Even if faults are rare events, they can easily propagate driven by local and remote dependencies, which makes it challenging to distinguish causes from effects among the thousands of highly correlated alerts.
A timely automated identification and root cause analysis (RCA) of the origins of performance issues allows executing the most adequate corrective actions and preventing their further propagation. In general, RCA is a hard problem, because it requires a deep knowledge of cause-effect dependencies among many features, physical and logical components the network nodes. In a data driven approach, where most of this knowledge is unavailable a priori, a major difficulty emanates from hidden or unknown variables. Furthermore, even in a fully observable system we are faced with the combinatorial explosion of potential cause-effect dependencies and the difficulty to collect enough information for distinguishing causality from spurious correlations.

Goals. The objective of this project is to develop techniques to infer a causal model that represents the dependencies between components (or nodes) of the network, given a set of event logs and possibly sampled KPI of these components. The vector of event logs can be seen as a single data point, hence in absence of prior knowledge - about, e.g., distributions of events -, well-known statistical inference approaches are not applicable. The PhD candidate will benefit from a large degree of autonomy regarding the evaluation and interpretation of results as well as the tuning of the algorithm.

Main activities

Approach. We will explore the use of non-reversibility to infer direction of causation. The rationale is that the complexity of the "true" causal process is expected to be in a lower class than the complexity of reconstructing a cause by only knowing its effect. This principle has been studied in the literature in statistical settings. However, these results have two shortcomings: they require the probability distributions to be known, or are based on Kolmogorov complexity, which is not computable.

1. To apply complexity-based causal discovery to a single observation or when the distribution is complex or unknown, the first goal of the project is therefore to formalize this principle in a deterministic and decidable setting. Similarly, there is an extensive body of work on process discovery from logs [3], which guesses causal dependencies between events. However, this work does not provide any information about causal dependencies on the level of components.
2. To cope with the complexity of causal discovery, our second goal is to (1) study whether it can be

decomposed, in a multi-variable setting, into local analyses like the decomposition into Markov kernels in a statistical setting, and (2) identify tractable complexity classes that match typical behavior of basic network equipment and services.
3. Our third goal of the project is to study applications of the proposed causal inference to the construction of causal explanations for network failures, and/or the detection of change of behavior in terms of altered causal dependencies.

Skills

Candidates should be pursuing internationally recognized research in ML/AI, information theory, or formal methods, with a strong interest in causal inference and causal reasoning.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

- 1st Year : 2082 euros gross salary monthly
- 2nd & 3rd Year : 2190 euros gross salary monthly

General Information

- **Theme/Domain :** Embedded and Real-time Systems
- **Town/city :** Grenoble
- **Inria Center :** Centre Inria de l'Université Grenoble Alpes
- **Starting date :** 2023-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2023-08-30

Contacts

- **Inria Team :** SPADES
- **PhD Supervisor :**
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About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.