Fully funded PhD Position: Stochastic Optimization and Reinforcement Learning for the Resilience of Networked Infrastructures against Climate Change

The Industrial Engineering Laboratory (LGI) within the French engineering school CentraleSupélec at the University of Paris Saclay is looking for a doctoral student working on leveraging stochastic optimization and reinforcement learning-based methods for improving the resilience of critical networked infrastructures (NIs) such as electrical power grids and telecommunication networks. This Ph.D. project is funded by a French Agence Nationale de la Recherche (ANR) JCJC grant, which involves several groups within and outside of CentraleSupélec and focuses on developing robust and scalable methodologies for NI resilience. It will be directed by Professor Yiping FANG and hosted by the team Safety and Risk and the industrial chair Risk and Resilience of Complex Systems (RRSC), partnered with three major actors of the French industry: EDF (Power supply provider), Orange (Telecom) and SNCF (Railway).

The Ph.D. candidate will have great opportunities to stay in several other prestigious research institutes or universities in France or abroad, including INRIA Paris, École Normale Supérieure Paris, and the University of Edinburgh Business School (UK) within the framework of the JCJC project. She/he will also have the opportunity to build a rich industrial network by interacting with the three industrial partners at both the top management level and the operational ones.

Research problem statement

NIs (e.g., power grids and telecom networks) constitute the backbone of the functioning of our modern societies. However, the inherent vulnerability stemming from increasing strengths of system complexity, aging, and coupling, intertwined with an increasingly complicated and uncertain exogenous risk landscape, especially due to global climate change, is pushing the systems toward the brink of catastrophic failures. Thus, the concept of resilience, defined as a system's ability to withstand, adapt and recover from disruptions, emerged as a new paradigm in the past decade and has been significantly emphasized by researchers, practitioners, and policymakers.

Resilience is a multiphase concept, and therefore prescriptive models for NI resilience improvement should consider different stages: i) ex-ante including strategic planning and short-run preparation, and ii) ex-post including emergency response and recovery planning. A crucial issue of ex-ante methods for NI resilience improvement is that a decision (of a set of actions, such as system expansions, protections, and upgrading) often must be identified from a large number of alternatives under deep uncertainty of future disruptions. This project will address this problem by proposing robust ex-ante prescriptive methods (e.g., optimization) that integrate all available but ambiguous information about the uncertainty of disruptive climate events.

In addition, ex-post prescriptive models aim at aiding the efforts of NI response and recovery after a disruptive event, e.g., structure reconfiguration in power distribution grids and post-disaster scheduling and routing of repair crews, where effective decisions must be made as rapidly as possible in highly time-critical and dynamic post-disaster environments. Enhancing NI resilience through effective ex-post operations typically requires solving large-scale combinatorial optimization problems, often in stochastic spaces. Current literature mostly resorts to mathematical optimization models which struggle with both uncertainty and the curse of dimensionality, posing a significant challenge to applying them to real-world large-scale NIs. This project will exploit model-free and learning-based approaches such as (deep) reinforcement learning, which have been recognized as a promising framework for solving decision-making problems with high-

dimensional state-action spaces. Challenging issues such as the "domain selection" and "simulation-to-reality" gap will be carefully addressed in the project when devising sample-efficient and effective RL/DeepRL architectures for real-world NI systems.

Keywords: Operations research, stochastic optimization, reinforcement learning, resilience, power systems, telecommunication networks

Job description

You will work within a highly interdisciplinary project, at the intersection of operations research (stochastic and robust optimization), machine learning (reinforcement learning), and engineering, where you will develop novel methods for modeling, optimization under uncertainty, and reinforcement learning for NI resilience. More specifically, you will participate in

(i) Characterizing and accounting for future climate risky events associated with planning and operations of NI systems (focusing on power grids and telecommunication networks);
(ii) Developing cutting-edge (distributionally) robust methods to consider deep uncertainty in ex-ante resilience optimization models;
(iii) Developing cutting-edge reinforcement learning-based methods to solve the ex-post response and recovery planning problems for system resilience improvement.

To this end, you will have access to state-of-the-art computational capabilities, and you will be in contact with leading experts at CentraleSupélec, University of Paris Saclay and internationally.

Your profile

We are looking for a proactive and highly motivated candidate with an MSc degree in a quantitative discipline (such as engineering, computer science, or mathematics) from a recognized University. You have a strong background in quantitative modeling (mathematical programming and optimization, machine learning, and reinforcement learning are an asset), computer programming, and/or power/telecommunication systems. Professional command of English (both written and spoken) is mandatory. Furthermore, you will need to enjoy working in a dynamic and international environment with other doctoral students and postdocs. French is not mandatory but a plus.

How to apply?

We look forward to receiving your application with the following documents compressed in one PDF file and sending it as an attachment to phd.candidate.rrcs@gmail.com with the title "[Your name]-ANR PhD application":

- Curriculum Vitae, max. two pages
- Motivational Letter, max. two pages
- Transcript of academic records (including detail of grades and rankings, where available)
- Two reference letters with contact details

Please note that the position will start as soon as possible and we exclusively accept applications submitted through phd.candidate.rrcs@gmail.com before **01 November 2022**.

Further information about the RRSC team and LGI Laboratory can be found on the website. Questions regarding the position should be directed to Professor Yiping FANG, yiping.fang@centralesupelec.fr (no applications).