CentraleSupélec

Pôle Projet
Intelligence Artificielle & ML

Evaluation and improvement of a deep reinforcement learning model for the planning of condition-based maintenance operations in a large-scale industrial system

Description du projet

Qui sommes nous?

Our team is developing research activities for safety and risk analysis of complex engineered systems. Our models are mainly based on stochastic processes and data driven approaches with a strong focus on optimization and uncertainties quantification for decision making in design and operation. We are strongly connected to several industry partners with the chair Risk and Resilience of Complex System. This chair is supported by EDF, SNCF and Orange. This is an arena to define study cases, share knowledge data and experiences, develop methods, implement benchmark and prototypes of tools.

Contexte?

Industrial systems are often complex systems, composed of many items that stochastically degrade over time. In order to maintain a certain level or service and ensure revenues, the optimization of maintenance policies (regarding cost and/or reliability criteria) is of major importance.

In recent years, the development of sensor technologies has enabled industrial systems to be remotely monitored. Such monitoring systems collect data on the degradation state of each components, making it possible to implement condition-based maintenance (CBM) policies. Depending on the context and the monitoring quality, hybrid policies can be considered. They should combine human inspections with sensor-based continuous condition monitoring observations and use the collected information to make more accurate and cost-effective maintenance decisions.

Domaines d’application

Power networks (offshore wind farms), telecom networks (data centers), railway networks (fleet of trains)

Description du projet

Objectifs

A previous research work identified that reinforcement learning (RL) and deep RL (DRL) could be used to solve maintenance planning problems. DRL is particularly suitable to overcome the curse of dimensionality, when the degradation state space is large or when the system is composed of a lot of coupled units for example. However, it also came out from the literature review that RL and DRL have been applied quite recently to maintenance planning and reliability problems, and many problems remain unaddressed within this framework. More precisely, we identified that CBM policies with imperfect monitoring or economic dependencies have not received much attention and very few models tackle it via RL or DRL approaches.

The goal is to model the CBM planning problem of a fleet of items (e.g., an offshore wind farm). The students would focus on implementing a BDQN (Branching Dueling Q-Network) algorithm, which is particularly adapted for taking coordinated maintenance decisions in a large distributed system. A particular attention will be expected on the tuning of the numerous hyperparameters, where we would like to identify good practice and efficient tuning strategies for future researches applying DRL to maintenance problems.

Attendus et livrables du projet

Attendus

- Get familiar with the underlying maintenance problem
- Get familiar with the literature about BDQN algorithm, its strength and limitations
- Implement a first (simplified) provided model; help on the implementation is possible (continuation of a previous project and associated code)
- Hyperparameters tuning and justification for it
- Based on the interest of the students, one additional direction should be explored:

a) Improve the given model / Propose an alternative and potentially better DRL model
b) Propose (and solve) a more realistic model
c) Justify the quality of the obtained solution

Livrables

- Working implementation
- Numerical results on a provided case study to demonstrate the relevance of the approach explored
- Report summarizing the literature used, the proposed model and the numeriacl results obtained. A particular attention is expected on the description of the hyperparameters tuning phase.

Mise en oeuvre

Langage: Python

Outils: Useful librairies, such as PyTorch, TensorFlow, Gym…

A **numerical case study** will be provided. Since we are studying a planning problem, a model of the environment can be used to simulate interactions of the agent with its environment, so no additional data sources are needed.

Client du projet

Laboratoire de Génie Industriel (LGI) de CentraleSupélec
Equipe *Safety & Risks* - Chaire Risque et Résilience des Systèmes Complexes (RRSC)

LGI SAFETY & RISKS
Industrial Engineering Research Department

CentraleSupélec

EDF

SNCF

orange™

Correspondant des élèves