WASP Project Course 2023

Cloud for Control

Background

With the on-going digitalization of industry, control systems will to an increasing degree execute in the cloud in order to enable use of advanced AI features and large compute capacity. One drawback is the dependence on connection reliability, therefore these solutions typically require a local backup controller in case the cloud is disconnected. Determining when and how to handle failovers is non- trivial, and in applications with real-time constraints the switch must occur within limited time. In this project we will use deep anomaly detection algorithms to manage a hybrid control system running in the cloud and at the edge.

Constraints: Location in Lund is needed only for experimental work on the control process, all other activities can be done remotely.

Participants

Industrial partner: Ericsson

Industrial supervisor: Johan Eker, johan.eker@ericsson.com

Academic supervisor: Karl-Erik Årzén, karlerik@control.lth.se, Lund University

Coordinating WARA representative: Johan Eker, johan.eker@ericsson.com

Suggested WASP PhD students: <optional>

Challenges to investigate

- How to design a control system that can dynamically switch between running locally and in the cloud. Proposed process to control is the inverted pendulum or the ball on beam process.
    - This task mostly involves control theory.
- What are the signals and and methods to use for anomaly detection for real-time data for a connected control systems? This includes developing methods for real-time anomaly detection, e.g., detect deviations in timing patterns that may lead to missed deadlines.
    - This task mostly involves machine learning.
- What is the software architecture for fault intolerant cloud based control system?

Depending on the groups size and background, the focus on the above research questions may vary.

Resources

WARA-Ops will provide a compute environment as well as a running 5G network with support for data collection. The physical process to be controlled will be located in the RobotLab at Lund University.

Deliverables

- Fault tolerant controller
    - Proof-of-concept implementation running in the cloud & edge. Should be complete with demonstration of fault injection and fault management.
    - Report describing the control design
- Fault detector
    - Proof-of-concept implementation that processes operations data in real-time with the purpose of detection fault ahead of time.
    - Report describing the design of the anomaly detection.

References

[1] Skarin, P. (2021). Control over the Cloud: Offloading, Elastic Computing, and Predictive Control. Doctoral Thesis. Department of Automatic Control, Lund University.

[2] Gummesson Atroshi, Jacob and Le, Christian (2021), Automatic Log Based Anomaly Detection in Cloud Operations using Machine Learning. Master's Thesis. Department of Automatic Control, Lund University

[3] Stefano Fiori, Luca Abeni, and Tommaso Cucinotta. 2022. RT-kubernetes: containerized real-time cloud computing. In Proceedings of the 37th ACM/SIGAPP Symposium on Applied Computing (SAC '22).

Keywords

Machine Learning
Real-time systems
Cloud computing
Control systems