Internship or Thesis

Advanced Control Strategies for Excavator Digging Assistance Functions

BOSCH

Abstract

At Bosch Corporate Research in Renningen, we are working on learning control of hydraulic cylinders for advanced excavator assistance functions, as depicted in fig. 1. Since experienced operators can move along desired trajectories very quickly and with high accuracy, requirements on the assistance functions are also high, so that empirical control strategies cannot fulfill the requirements. Therefore, model-based controllers are needed for an accurate model of the complex and highly nonlinear system behavior. To reduce necessary efforts for the model design, we are using machine learning methods and combine machine specific knowledge with data-based approaches.

Figure 1: Our test vehicle in Renningen with an example trajectory to be followed. More info on https://www.bosch.com/stories/learning-control-for-advanced-excavator-assistance-functions/.

Tasks Description

In this work, we continue our investigations on the trajectory tracking problem for a hydraulic excavator. In the past, Local Model Networks [1] (fig. 2), a special class of machine learning models, showed good potential for learning forward and inverse hydraulic behavior in this application example. The main goal is to develop a controller design strategy (fig. 3) using data-based models obtained with the Local Model Network method and to implement and test it on the real excavator system. The obtained results are compared with existing other learning-based controllers.

The following topics are of interest:

- **Dynamic models:** learning a dynamic model using Local Model Networks and comparing infinite impulse response (IIR) models with finite impulse response models (FIR).
- **Feedforward control design:** automatic generation of feedforward controllers based on Local Model Networks, e.g. based on methods proposed in [2].
- **Online adaptability:** Local Model Networks allow to be updated online, to improve the model accuracy in the areas of interest, and account for system time-varying characteristics.
- **Local Model State Space Networks:** apply latest training strategies for nonlinear state space models [3].

The choice of which direction to follow is left to further discussion, based on the interests and background of the student.

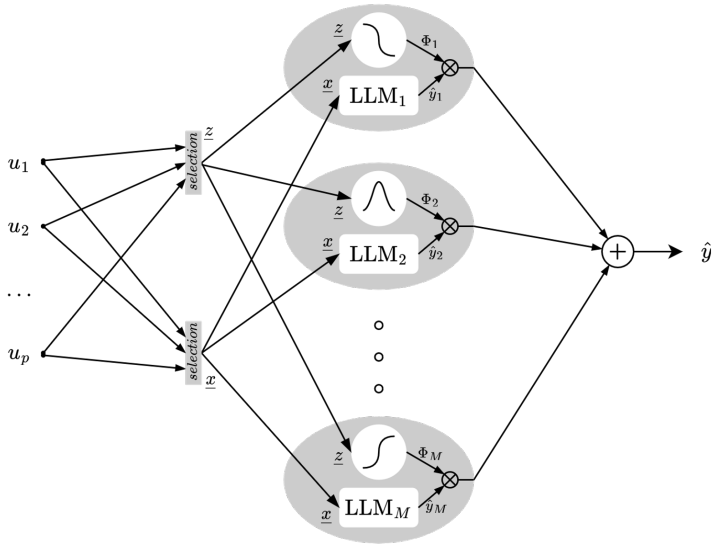

Figure 2: Structure of a Local Model Network

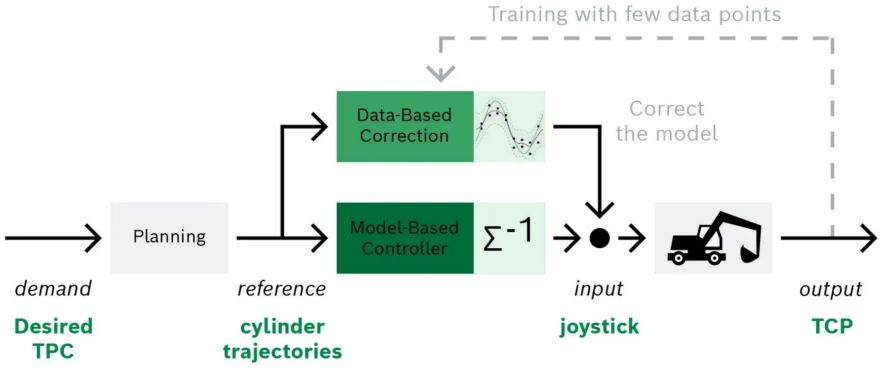

Figure 3: Excavator control scheme

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References

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[2] C. Hametner, S. Jakubek, and N. Euler-Rolle, "Automatic generation of feedforward controllers using dynamic local model networks," *IFAC Proceedings Volumes*, vol. 47, no. 3, pp. 3128–3133, 2014.

[3] M. Schüssler, "Machine learning with nonlinear state space models," *at-Automatisierungstechnik*, vol. 70, no. 11, pp. 1027–1028, 2022.

[4] O. Demir and A. Trachte, "Learning control for advanced excavator assistance functions." https://www.bosch.com/stories/learning-control-for-advanced-excavator-assistance-functions/.