Chair of Automatic Control

FAU

Announcement for Research Project/ Bachelor Thesis

Using Neural Networks with state space models for improved nonlinear Kalman filtering

Motivation

Nonlinear Kalman filtering for state estimation either uses a linearized dynamical system (extended Kalman filter, EKF) or sampling points (unscented Kalman filter, UKF) for the calculation of covariance and the Kalman gain. However, both state-of-the-art methods are model-based and therefore lack accuracy in the case of model mismatch. An interesting alternative is to predict the optimal Kalman gains by means of a neural network [1], which allows model inaccuracies to be corrected and the state estimation to be improved.

Task description

In a first step of this work, several academic nonlinear ODE-based models of different complexity are designed in state space form to generate large realistic data sets with measurement noise. Optimization algorithms can be used to generate the target value of the Kalman gain in every timestep of state estimation. Subsequently, neural networks are designed and trained on the operating data and target values of the Kalman gain to get an improved state estimation. Finally, the nonlinear state estimation methods are compared with each other in terms of performance and robustness.

Requirements

First experiences with Pytorch or Tensorflow and good knowledge of Matlab and Python including solving of ODEs is recommended.

References

[1] G. Revach et al., “KalmanNet: Neural Network Aided Kalman Filtering for Partially Known Dynamics”, IEEE Transactions on Signal Processing, vol. 70, pp. 1532-1547, 2022, doi: 10.1109/tsp.2022.3158588

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