Karlsruhe Institute of Technology

Department of Informatics
Institute for Anthropomatics und Robotics (IAR)
Chair for Intelligent Sensor-Actuator-Systems (ISAS)
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Intelligent ISAS Sensor-Actuator-Systems

Bachelor/Master Thesis

Conditional Density Estimation using Neural Network-Based Gaussian Process Approximations

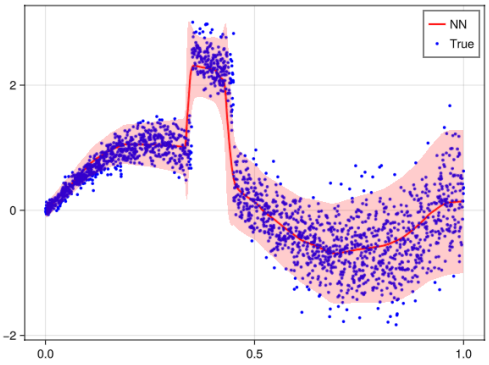

Figure : Neural Network based conditional density estimation

Reliable state estimation in nonlinear stochastic systems requires accurate modeling of conditional relationships between system states and measurements.
While **Gaussian Processes (GPs)** provide a principled probabilistic framework for modeling such dependencies, their computational cost can limit their use in practical filtering applications.
Here at ISAS, significant research has been conducted in Gaussian-assumed state estimation. Building upon this work, this thesis investigates the use of neural networks as a parametric approximation of Gaussian Processes for scalable conditional density estimation.
Most existing neural network approaches in this context primarily focus on learning conditional mean functions, often neglecting the associated uncertainty in the prediction. In contrast, this work aims to explore neural network-based models that are capable of learning full conditional density representations, enabling improved uncertainty-aware modeling for nonlinear estimation tasks.

As one possible research direction, approaches such as **Attentive Neural Processes (ANPs) [1]** may be investigated for capturing complex conditional relationships while maintaining a probabilistic interpretation.
The learned conditional density model can then be integrated into recursive filtering frameworks to better represent nonlinear state-measurement dependencies.

What to do

- Literature review on conditional density estimation
- Study of GP-inspired neural network models
- Implementation of neural network-based density models
- Possible Integration into a state estimation framework
- Evaluation against GP-based approaches

References: [1] Attentive Neural Processes (Kim et al.)

Requirements:
Background in computer science, mathematics, electrical engineering, or related fields. Interest in machine learning and probabilistic modeling is beneficial.

Emphasis:

Theoretical Study	■■■■■
Software Implementation	■■■■■■■
Hardware Implementation	■

We offer:
- excellent support and advice
- highend infrastructure
- contact to industry and research partners

Language:
English

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