Karlsruhe Institute of Technology

Intelligent ISAS
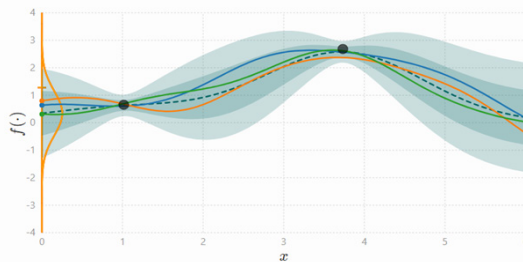Sensor-Actuator-Systems

Gaussian Mixture-Based Filtering using Joint-Space Models

Bachelor/Master Thesis

Figure : Visualization for a Gaussian Process (https://www.infinitecuriosity.org/vizgp/)

Nonlinear state estimation in stochastic dynamical systems remains challenging when using classical linear or unimodal Gaussian filtering techniques, as these approaches often fail to accurately capture nonlinear uncertainty propagation.

Here at ISAS, significant research has been conducted in the area of Gaussian-assumed state estimation. Building upon this work, this thesis investigates a mixture-based filtering framework that represents the system belief as a **Gaussian Mixture Model (GMM)** rather than a single Gaussian density.

To better capture nonlinear relationships between system states and measurements, the system is modeled in a joint state-measurement space using **Gaussian Processes (GPs)** (See Figure). As a possible extension, **Neural networks** may also be explored as an alternative data-driven approach for modeling this joint space.

Samples drawn from the prior Gaussian mixture are propagated through the learned joint-space model to obtain a transformed density, which is then approximated again as a Gaussian mixture for recursive filtering. Sampling from the Gaussian mixtures is performed using the **Projected Cumulative Distribution (PCD)** method.

What to do

- Literature review on nonlinear state estimation
- Joint-space modeling using GPs / Neural Networks
- Recursive density propagation
- Integration into a filtering framework
- Evaluation against existing approaches

Requirements:
Background in computer science, mathematics, electrical engineering, mechatronics, or related fields. Interest in probabilistic modeling and nonlinear estimation 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 or German

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