Bayesian Filtering of FMWC radar data with Spiking Neural Networks

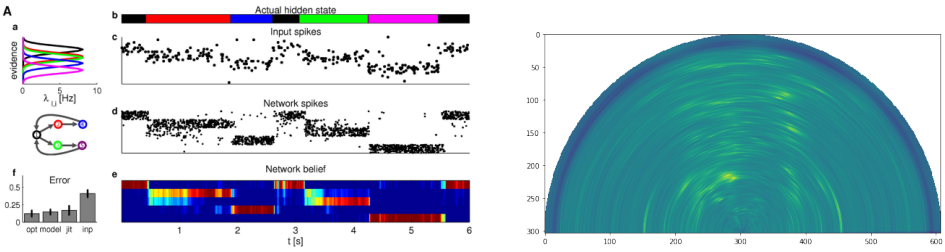

Figure 1: (Left) Particle filtering task with noisy spike input. [3] **(Right)** Range angle map taken from RaDICal dataset. [4]

Background

Our brain performs outstanding signal processing tasks to ensure its survival. It copes with an uncertain environment and noisy sensory information and still manages to make real-time estimates and predictions of its surroundings. It becomes evident that neural circuits employ approximate probabilistic calculations [2], but it is still unclear how these calculations are implemented biologically. Several approaches exist that implement Bayesian filtering algorithms on Spiking Neural Networks [1, 3]. Generally, Bayesian filters estimate an unknown probability density function (PDF) of a variable, typically the signal. This approach can be used to remove the noise from the data, since only the information of the signal is extracted.

The filtering step is crucial for all sensor data. Although lidar sensors and vision systems are still the predominantly used sensors for automotive use cases, radar sensors receive more and more attention, mainly due to their robustness with regards to the weather. In contrast to lidars and cameras, radar sensors are able to detect objects even in problematic weather conditions like snowfall or fog and recent advances in FMCW radars increased the range/angle resolution significantly. Applying filtering algorithms, such as Bayes filters, on the range-angle maps (Figure 1) does not only clean the noisy data, but also allows the tracking of an object by estimating the PDF of its position. Especially in the domain of autonomous and electrical vehicles, efficient real-time filtering algorithms become more important.

Description

Based on works of Bayesian filtering with SNNs [1, 3], the student will work on SNN architectures including new neuron models that are able to perform efficient Bayesian filtering on range-angle maps of FMCW radar data. Here, the student will learn about the fundamentals of Bayesian filtering and probabilistic approaches for signal processing. Finally, benchmarks of the student's approaches will reveal the most promising architecture.

During this project the student will be

- doing an extensive literature research on probabilistic approaches on SNNs,
- starting with toy models to gain some intuition on probabilistic SNNs,
- working with FMCW radar datasets from the automotive domain,
- implementing SNNs in Python (and neural network simulators) and
- extending the work on Bayes filters with SNNs.

Technical University of Munich

Faculty of Informatics

Chair of Robotics, Artificial Intelligence and Embedded Systems

Supervisor:
Prof. Dr.-Ing. Alois Knoll

Advisor:
Nico Reeb, M.Sc.

Research project:
KI-ASIC

Type:
Master Thesis, Guided Research

Research area:
Spiking Neural Networks, Signal Processing

Programming language:
Python

Required skills:
Python, Machine Learning, Signal Processing

Language:
Englisch/German

Date of submission:
24. Februar 2022

For more information please contact us:

Phone:

E-Mail: nico.reeb@tum.de

Internet:
https://www6.in.tum.de/

References

[1] Yonina C. Eldar. "Bayesian Filtering in Spiking Neural Networks: Noise, Adaptation, and Multisensory Integration". In: ().

[2] Konrad P. Körding and Daniel M. Wolpert. "Bayesian integration in sensorimotor learning". In: 427.6971 (), pp. 244–247.

[3] Robert Legenstein and Wolfgang Maass. "Ensembles of Spiking Neurons with Noise Support Optimal Probabilistic Inference in a Dynamically Changing Environment". In: 10.10 (), e1003859.

[4] Teck Yian Lim, Spencer Abraham Markowitz, and Minh Do. *RaDICaL: A Synchronized FMCW Radar, Depth, IMU and RGB Camera Data Dataset with Low-Level FMCW Radar Signals (ROS bag format)*. 2021. DOI: 10.13012/B2IDB-3289560_V1. URL: https://doi.org/10.13012/B2IDB-3289560_V1.

Technical University of Munich

Faculty of Informatics

Chair of Robotics, Artificial Intelligence and Embedded Systems