Efficient radar collision detection on neuromorphic hardware

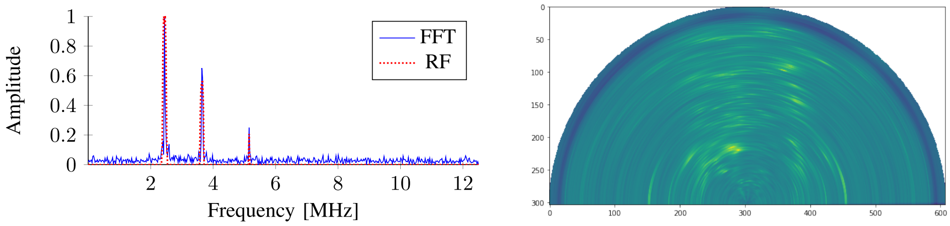

Figure 1: (Left) Comparison between resonate-and-fire neurons and a standard FFT algorithm. [1] **(Right)** Range angle map taken from RaDICal dataset. [3]

Background

In the automotive domain, computational demands are steadily increasing to ensure a safe driving experience (e.g. Advanced Driver Assistance Systems (ADAS)). Especially for electrical vehicles, this is a big drawback since these functionalities reduce the driving range.

The field of neuromorphic computation tries to tackle this task by building brain-inspired algorithms and hardware, that utilize the advantages of the brain; solving high demanding tasks with low power consumption. The brain benefits among others from sparse event based and asynchronous processing. The third generation of Neural Networks, Spiking Neural Networks (SNNs), naturally incorporate these benefits by using dynamic neuron models that transmit information via spikes. In recent years, hardware (e.g. SpiNNaker or Loihi) has been designed to efficiently run SNNs. Combining the latest neurmorphic hardware and algorithms might lead to efficient edge devices that reduce the overall power consumption of electrical vehicles.

Description

The Resonate-and-Fire (RF) neuron [2, 1] are selective for one specific frequency and hence can be used to replicate the output of Fourier Transforms (FT). Usually, the FT is used to extract distance information of targets detected by a radar sensor. The student will work on a SNN architecture containing RF neurons that are explicitly optimized for extracting the distance and angle information from radar data. The neural network should be able to detect targets that are close to the sensor and might cause a collision. The network will be implemented on neuromorphic hardware (SpiNNaker and Loihi 2) and evaluated on real radar data.

During this project the student will be

- working with SNNs and dynamic neuron models, such as RF neurons,
- having access to robots and newest radar sensors,
- recording their own radar dataset with the previously mentioned robots and sensors,
- optimizing SNNs in Python (PyTorch) and
- implementing SNNs on the latest neurmorphic hardware (SpiNNaker and Loihi 2).

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KI-ASIC

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Python, Machine Learning, Radar

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References

[1] Daniel Auge and Etienne Mueller. "Resonate-and-Fire Neurons as Frequency Selective Input Encoders for Spiking Neural Networks". In: ().

[2] Eugene M. Izhikevich. "Resonate-and-fire neurons". In: *Neural Networks* 14.6 (2001), pp. 883–894. ISSN: 0893-6080. DOI: https://doi.org/10.1016/S0893-6080(01)00078-8. URL: https://www.sciencedirect.com/science/article/pii/S0893608001000788.

[3] 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.

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