Master's Thesis

Uncertainty Quantification in Spiking Neural Networks for Data Fusion during Drone Landings

The IABG Innovation Centre is a development incubator for the IABG's portfolio, which includes major trends in digitization, artificial intelligence, robotics, and sensor networks in the mobility and security sectors.

AirSim[1] is an open-source simulator for drones, cars, and more, built on the Unreal Engine and designed as a platform for AI research to experiment with deep learning, computer vision, and reinforcement learning algorithms for autonomous vehicles. AirSim is currently used in the program **safeAI** at the IABG Innovation Center to develop safety and robustness evaluations of AI-based image detection algorithms applied to the vertical landing of flight vehicles. State-of-the-art probabilistic object detection techniques are applied to quantify the uncertainty of image detection outputs.

During landing, an onboard data fusion to fuse sensor signals from an Inertial Measurement Unit (IMU), GPS, magnetometer, and barometric altimeter with a machine learning based image detection of the landing pad together with an online uncertainty quantification is utilized.

Our brain constantly integrates sensor information and estimates the uncertainty to survive in its environment. In the brain, sensory inputs are processed via sparse electrical pulses (spike train) to keep the power consumption low. Spiking Neural Networks (SNNs) utilize this trait and mimic the dynamics of biological neurons. Therefore, uncertainty estimates performed with SNNs are expected to reduce the power consumption and enable us to build fast mobile devices.

The goal of this Master's Thesis is to investigate state-of-the-art machine learning uncertainty quantification methods currently utilized at the IABG Innovation Center for their applicability for SNNs. Detailed efficiency and runtime analyses considering the onboard hardware resources will be carried out.

This Master's Thesis will be jointly supervised by IABG, Technical University of Munich (TUM) Institute of Robotics and Embedded Systems, and Bauhaus Luftfahrt.

[1] https://microsoft.github.io/AirSim/

Your Responsibilities

- Familiarization with the current methodologies utilized at the IABG Innovation Center and the TUM Institute of Robotics and Embedded Systems
- Evaluation of the current state of spiking neural networks (SNNs) and uncertainty quantification methodologies
- Implementation of suitable uncertainty quantification methodologies for SNNs and integration into the existing data fusion framework in AirSim
- Analysis of accuracy (of fused predictions), runtime, and efficiency to compare the existing convolutional neural networks (CNNs) implementation with the SNNs
- Depending on the results and the progress of the thesis, an application on a real drone currently set up at IABG could be possible

Your Profile

- Motivated student of Computer Science, Mathematics, or related engineering disciplines
- Strong programming skills (Python, C++)
- Experience with data science, neural networks, and ideally SNNs
- Interest in open-source software projects and collaborative working using Git version control
- Excellent communication skills in English

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