Robotics and Embedded Systems

Human Brain Project

Master/Bachelor Thesis - Semester Project

Biologically-inspired Perception for Autonomous Vehicles based on LiDAR Sensor

Background

Autonomous navigation is one of the most challenging tasks for autonomous vehicles, which usually involves many research fields including sensory perception, path planning, decision making, and motion control. Autonomous vehicles utilize sensors and state-of-art algorithms to perceive the world. For the commonly used sensors, Light Detection And Ranging (LiDAR) sensors have been widely used in autonomous robots due to the higher accuracy and robustness compared with cameras [1], which are able to obtain a precise point cloud for the surrounding environment by actively project laser beams to objects.

For autonomous vehicles, precise perception is critical to navigation safety and reliability. With the development of deep representation learning and artificial neural network, deep learning has become a powerful approach and framework to solve autonomous perception problems, such as objection detection, classification, semantic segmentation. However, due to the complexity of the deep artificial neural networks, the training and inference of deep ANN are still computationally expensive and power-consuming, which makes it barely suited to deploy on the power-constrained autonomous vehicles.

In recent years, biologically-inspired algorithms, such as spiking neural networks (SNN), have gained attention which are able to closely mimic animals' behaviors. SNNs implement the natural neural networks based on the temporal synaptic model and are able to make use of the Spike-timing dependent plasticity [4]. Furthermore, spiking neural networks have the potential to deploy on neuromorphic processors which enable the networks to perform computation in a highly efficient way [5]. In this thesis topic, we will focus on developing a spiking neural network to solve the autonomous perception problems with LiDAR.

Your Tasks

In this thesis project, you will learn about LiDAR sensors, perception algorithms, and spiking neural networks for autonomous driving, and also the latest and the most widely-used programming framework of robots. You will be able to develop and deploy your algorithms in both the simulator environment and a real robot platform for different application scenarios. To be specific:

1. You will first learn about basic knowledge of LiDAR and do preliminary literature studies for spiking neural networks and perception algorithms. You will be offered basic ideas, simulation environments, and source codes to get started.
2. You will widely read state-of-the-art publications and implement your own ideas and algorithms to solve the problem and possibly further improve the performances.
3. You will either run simulations or conduct prototype experiments to demonstrate your novel solutions.

Requirement

- High self-motivation and passion on research.
- Six-month working time.
- Python programming experiences.

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Figure 1 Object detection & semantic segmentation

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[2]. Redmon, Joseph, et al. "You only look once: Unified, real-time object detection." Proceedings of the IEEE conference on computer vision and pattern recognition. 2016.
[3]. Long, Jonathan, Evan Shelhamer, and Trevor Darrell. "Fully convolutional networks for semantic segmentation." Proceedings of the IEEE conference on computer vision and pattern recognition. 2015.
[4]. Pfeiffer, Michael, and Thomas Pfeil. "Deep learning with spiking neurons: opportunities and challenges." Frontiers in neuroscience 12 (2018): 774.
[5]. Bouvier, Maxence, et al. "Spiking neural networks hardware implementations and challenges: A survey." ACM Journal on Emerging Technologies in Computing Systems (JETC) 15.2 (2019): 1-35.