Robotics and Embedded Systems

Human Brain Project

Master/Bachelor Thesis - Semester Project

Biologically Plausible Spatial Navigation (NeuralSLAM)

Background

Human brain has a tremendous capability to find out a way in an environment, which requires to integrate information about location, direction and traveling distances. Simultaneous localization and mapping (SLAM) [1], as an artificial approach, has been greatly investigated and implemented in the domain of robotics and autonomous driving, with the rapid developments of sensors, algorithms, and the enhanced computing capability of deep neural networks. In recent years, great progress has been made in understanding the intricacies of the spatial navigation system situated in the hippocampus and entorhinal cortex in human brains, which is fundamentally different from conventional SLAM technologies. The main discoveries of those key components in human brain, such as grid cells (GCs) [2], place cells (PCs) [3], and head direction cells (HDCs) [4], have also been regarded as crucial steps to understand the navigation systems in brain and won Nobel Prize and other great honors. Together with the brain-inspired spiking neural networks (SNNs), we would like to develop a biological plausible approach to solve spatial navigation tasks on the basis of the iteration of dedicated models of HDCs, GCs, and PCs via dendritic computation.

Your Tasks

In this thesis, you will learn state-of-the-art knowledge of SNNs and NeuralSLAM. Then you will develop more advanced algorithms or application scenarios to solve similar tasks. To be specific:

1. You will first learn basic knowledge of SNNs and our preliminary work of NeuralSLAM. You will be offered with brain models, simulation environments, and source codes for our current solution.
2. You will widely read state-of-the-art publications and design your own algorithms for further improving the performances on the basis of our current solution.
3. You will either run simulations or conduct prototype experiments to demonstrate your novel solutions.

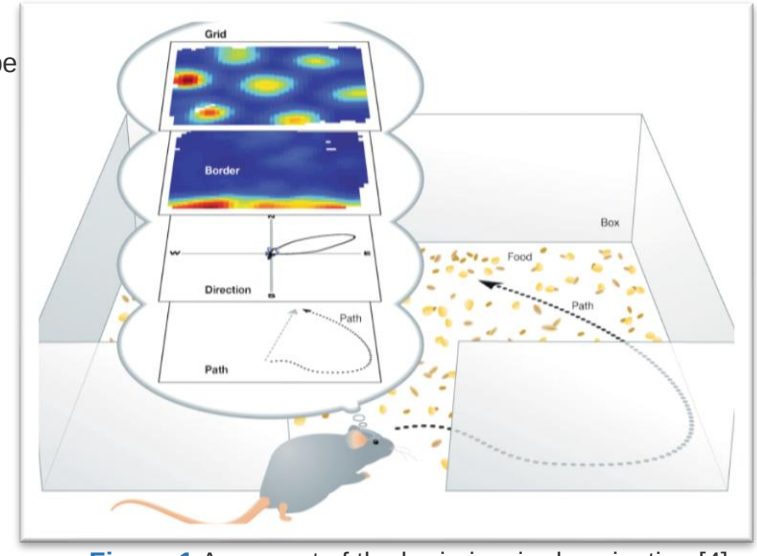

Figure 1 A concept of the brain-inspired navigation [4]

Requirement

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

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[1] *Taketomi, Takafumi, Hideaki Uchiyama, and Sei Ikeda. "Visual SLAM algorithms: a survey from 2010 to 2016." IPSJ Transactions on Computer Vision and Applications 9.1 (2017): 16.*
[2] *Hasselmo, Michael E. "Grid cell mechanisms and function: contributions of entorhinal persistent spiking and phase resetting." Hippocampus 18.12 (2008): 1213-1229.*
[3] *Bostock, Elizabeth, Robert U. Muller, and John L. Kubie. "Experience ‐dependent modifications of hippocampal place cell firing." Hippocampus 1.2 (1991): 193-205.*
[4] *Corneil, Dane S., and Wulfram Gerstner. "Attractor network dynamics enable preplay and rapid path planning in maze–like environments." Advances in neural information processing systems. 2015.*
[5] *Moser, May-Britt, and Edvard I Moser. "Crystals of the brain." EMBO molecular medicine vol. 3,2 (2011): 69-71. doi:10.1002/emmm.201000118*