Master/Bachelor Thesis - Semester Project

Brain-inspired Localization and Mapping based on LiDAR Sensor

Background

Human brains have an excellent capability to find a way out in an environment, which requires brains to integrate information about location and direction, and also to keep a track of the information. In robotics, Simultaneous Localization And Mapping (SLAM) [1], as a big issue of the navigation for artificial intelligence robots, has been deeply studied and implemented in the domain of autonomous navigation with the rapid developments of sensors and algorithms, in which Light Detection And Ranging (LiDAR) sensors have been widely used in autonomous robots for the higher accuracy and robustness compared with cameras [2]. In recent decades, great discoveries have been made in investigating and understanding the spatial navigation system of mammalian brains. The mechanisms, however, are fundamentally different from conventional SLAM technologies. The main discoveries of those key components in mammalian brains, such as the grid cells (GCs) [3], place cells (PCs) [4], and head direction cells (HDCs) [5], have been regarded as crucial component parts to model the navigation system in a brain. There have been several proposed studies utilizing PC and HDC models to develop a SLAM system using a camera sensor [6]. With these biological cues and existing algorithms, we aim to develop a brain-inspired SLAM algorithm utilizing the PC model and HDC model, at the same time taking the advantages of the LiDAR sensors, to perform localization and mapping for a robot platform in different environments.

Your Tasks

In this thesis project, you will learn state-of-the-art knowledge of LiDAR sensor and Neural SLAM for autonomous driving, and also the latest and the most widely-used programing framework of robots. You will develop and deploy advanced algorithms in both the simulator environment and a real robot platform for different application scenarios. To be specific:

1. You will first learn basic knowledge of LiDAR and preliminary studies of Neural SLAM. You will be offered with basic ideas, simulation environments, and source codes for a basic 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 the current solution.
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.
- C++/Python programming experiences.

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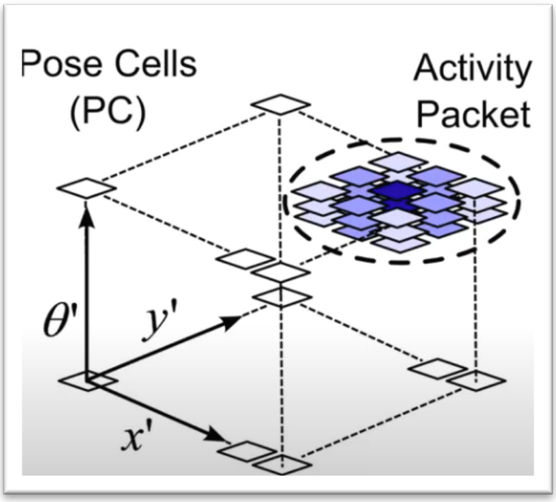

Figure 1 A 3D Attractor Model of Pose Cells [6]

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[2] *J. Zhang and S. Singh, "Loam: Lidar odometry and mapping in real- time." in Robotics: Science and Systems, vol. 2, 2014, p. 9.*
[3] *Hasselmo, Michael E. "Grid cell mechanisms and function: contributions of entorhinal persistent spiking and phase resetting." Hippocampus 18.12 (2008): 1213-1229.*
[4] *Bostock, Elizabeth, Robert U. Muller, and John L. Kubie. "Experience ‐ dependent modifications of hippocampal place cell firing." Hippocampus 1.2 (1991): 193-205.*
[5] *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.*
[6] *Milford, Michael J., Gordon F. Wyeth, and David Prasser. "RatSLAM: a hippocampal model for simultaneous localization and mapping." IEEE International Conference on Robotics and Automation, 2004. Proceedings. ICRA'04. 2004. Vol. 1. IEEE, 2004.*