Robotics and Embedded Systems

Human Brain Project

Master/Bachelor Thesis

Image-Goal Navigation in Unstructured Environments via Deep Reinforcement Learning

Background

Navigating toward a visual target in unstructured or partially known environments remains a core challenge in robotics. Traditional navigation methods often rely on accurate maps or structured priors, which are not always available in dynamic real-world settings. In recent years, Deep Reinforcement Learning (DRL) has emerged as a powerful approach for enabling agents to learn complex navigation behaviors directly from high-dimensional sensory inputs such as images, without requiring explicit maps. This project investigates the use of DRL for image-goal navigation, where an agent must reach a target position defined by a reference image, using only egocentric observations and learned policies.

Your Tasks

In this thesis, You will demonstrate a novel DRL-based navigation framework that incorporates visual goal encoding, policy learning, and robust generalization strategies. The learned policy network will be trained and tested in 3D simulated scenarios and robotic platforms that reflect a variety of unstructured environments. To be specific:

1. You will gain foundational and advanced knowledge in DRL, robotic vision, and traditional control methods.
2. You will build upon our existing algorithmic framework to develop and implement novel navigation algorithms.
3. You will have access to available GPU resources to support training.

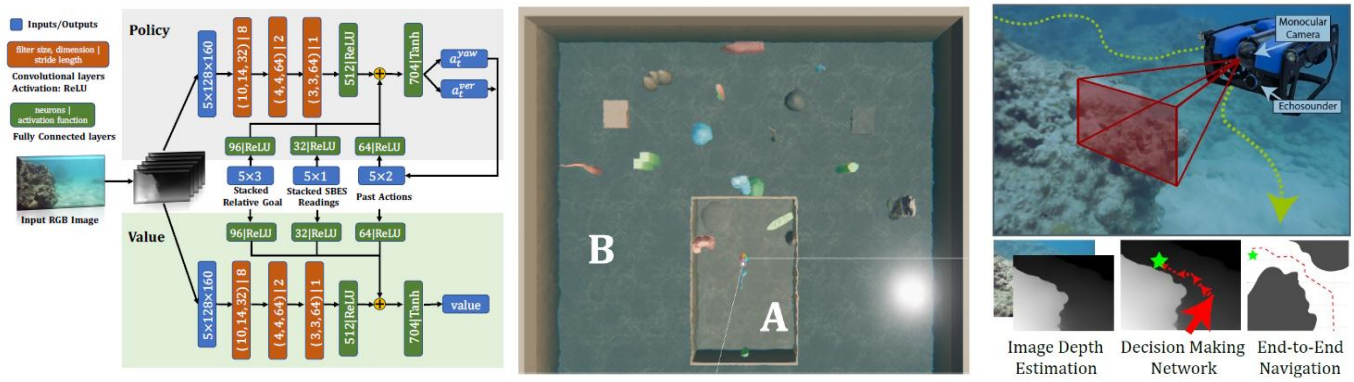

Image-Goal Navigation for Marine Robots via DRL[1]

Requirements

- High self-motivation and passion for research.
- Six months working time.
- Existing knowledge about robotic vision, DRL.

Existing knowledge about ROS and marine robots will be a bonus.

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[1] S Yang, Pengzhi, et al. "Monocular camera and single-beam sonar-based underwater collision-free navigation with domain randomization." The International Symposium of Robotics Research. Cham: Springer Nature Switzerland, 2022.

[2] Yang, Pengzhi, et al. "Learning continuous control policies for information-theoretic active perception." arXiv preprint arXiv:2209.12427 (2022)

[3] .Kumar, Swagat, Hayden Sampson, and Ardhendu Behera. "Benchmarking Deep Reinforcement Learning Algorithms for Vision-based Robotics." arXiv (2022).

[4] Piater, Justus, et al. "Learning visual representations for perception-action systems." The International Journal of Robotics Research 30.3 (2011): 294-307.