Grid-Like Representations and Hierarchical Reinforcement Learning for Robot Navigation

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INTRODUCTION

There is a growing interest in the development of **autonomous navigation** technologies for application in domestic and urban environments. Recent studies show that geometrically regular representations of space can facilitate flexible navigation strategies. In particular, the periodic firing patterns of **grid-cells**[1] offer a compact brain code for navigation within large spaces. At the same time, machine learning provides a set of computational tools that have proved useful for robot navigation, such as neural networks (NN), reinforcement learning (RL) and deep learning (DL). RL is a computational approach to learning by trial-and-feedback where an agent tries to maximize the total amount of reward it receives when interacting with the environment to achieve a goal[2,3]. This work investigates how to combine grid-like representations and **hierarchical RL**[4,5] for robotic navigation tasks, being inspired by human topological navigation and hierarchies.

OBJECTIVES & TASKS

This dissertation aims to investigate how to combine computational models of grid-cells with hierarchical RL (HRL) for mobile robot navigation (Fig. 1). The work addresses the challenges of space representation using grid-like models, designing the hierarchical structure and the RL algorithm, and transferring the knowledge from the simulation to the real-world. The main tasks to be carried out are the following:

1. **State-of-the-art study on hierarchical RL.** This task aims to provide an up-to-date review of topics such as human spatial representation[6,7] (*e.g.*, place, head direction and grid cells), robot navigation systems using grid-like representations[8,9], recurrent neural networks[10,11] & HRL computational approaches[4,5].
2. **Grid-like representations for robot navigation.** The grid cell network is a Recurrent Neural Network that should learn to path integrate within a square arena and locate goals in dynamic environments.
3. **HRL framework for learning navigation skills.** This task focuses on the specification of the hierarchal structure in which low-level sub-tasks are sequenced at a higher-level and the integration of the grid-cells.
4. **Transfer learning from simulation to physical robot.** This task addresses the transfer of the experience gained in simulation to a real robot, as well as the evaluation of the added-value of grid-like models.
5. **Writing the master dissertation and other detailed documentation.**

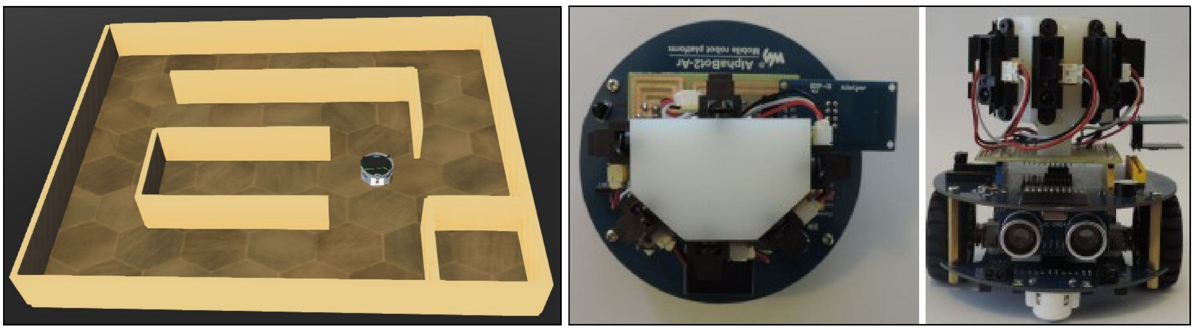

Fig. 1: Simulated robot navigation in a maze-like environment (left) and physical robot equipped with 6 IR-sensors and a ultrasonic sensor (right). Development environment: Linux/ROS/Webots/Python.

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