Modeling of Multi-Scale Spatial Navigation in Complex Environments

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Abstract

Studies suggest that spatial navigation is supported by the multiscale neural system of the hippocampus and associated structures. The dorsal hippocampus (DH) plays a critical role in spatial learning and memory, but most of the supporting experiments have been conducted using simple spatial tasks in small arenas. Such conditions may not have required the integration of spatial representations at different scales along the dorso-ventral axis of the hippocampus, and hence may not have relied on ventral hippocampal (VH) computations.

Our overall hypothesis is that the interactions of spatial maps at multiple scales along the dorso-ventral axis of the hippocampus allows for spatial navigation in large and complex environments. We are developing a biologically-inspired computational model to simulate goal-directed navigation tasks in a large environment with different density of obstacles. The current work will present preliminary results related to this computational model and its evaluation with autonomous robotic systems.

Methods

Animals
- Male brown norway rats, 7-8 months old.
- White males in Dorsal or Ventral Hippocampus

Behavioral Apparatus
- Open field arena 8x8 ft
- Spaced obstacles containing sugar water

Hippocampus inactivation
- Experimental protocol
  - Place Cells (PC)
  - Task Cells (TC)
- Simulation protocol

Hippocampus inactivation
- Male brown norway rats, 7-8 months old.
- Standard cages in Dorsal or Ventral Hippocampus

Small objects
- Large objects

Memory Test: 1.4x (in particular order)
- Object(s): Lego blocks

Model

Multiscale Actor Critic Model

- Striatal Cells (SC)
The actor critic algorithm uses striatal cells as soft states. Each striatal cell is the product of one PIC, one HD cell and one task cell.

- Reinforcement Learning (RL)
State value function using soft striatal cells.

Model (continued)

- Temporal Group
- Control Group

Simulation Experiment Results

- Non-delayed cue
- Delayed cue
- Control group
- Septal group
- Temporal group

Conclusions and future work

Our preliminary study shows that the model displays similar results to the experiments with rats when using small obstacles, ventral and septal groups resulted in reduced performance when compared to controls, but no statistical difference was observed between both groups.

Future studies will further analyze the differences between ventral and septal roles, assessing the advantage of multiscale representation when varying PC size distributions. Also, future studies will assess the role of using wall modulated place cells in the model.

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References