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Navigation and the Efficiency of Spatial Coding: Insights from Closed-Loop Simulations

Friday 16 June 2023 13:00 (20 minutes)

Spatial learning is critical for survival and its underlying neuronal mechanisms have been studied extensively. Much is known about the neural representations of space, e.g. place cells(PC) and border cells(BC) in the hippocampus. However, little is known about the functional role in spatial navigation and spatial learning. We extended an existing computational modeling tool-chain to study the functional role of spatial representations using closed-loop simulations of spatial learning.

In our model an artificial agent had to find a hidden goal in an open-field environment. The model network consisted of PCs that tile the environment and BCs that represent its edges powered by NEST[1]. Their activity varies over time and is a function of the 2D location of the agent in the environment. This input was fed to 40 action selection neurons that each represent one direction of movement, distributed homogeneously across 360°. Therefore, the agent was able to move freely in any direction. If the agent enters the reward zone, learning is reinforced by potentiation of feedforward weights in a symmetric STDP learning rule with eligibility trace.

Efficiently encoding spatial information is critical for navigation performance. Parameters of PC, such as their number, field sizes, peak firing rate, and the size of the goal zone, influenced navigation performance. We showed that he overlap index, which measured the degree of overlap between neighboring PCs, showed a nonmonotonic relationship with performance. In contrast, the Fisher information, which describes how informative the PC population is, best accounted for navigation performance in the model[2].

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References

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Topic area

models and applications

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