PhD PROJECT

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Neural networks for the representation of 3D environments

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Scientific background

In their brains, animals form internal representations of objects, body posture or extended spatial environments. From these representations, they perform complex computations like the optimization of spatial trajectories. The brain activities that give rise to these computations are not yet understood and are the subject of very intense research, both experimental and theoretical.

These problems have been explored in simplified 2D environments and have led to the characterization of cells coding for various spatial parameters (place cells, grid cells, head direction cells). However, recently, traces of neural activities have been found to correlate with 3D representations. In bats and mice, for instance, the activity of some neurons depends on the 3D orientation of the head of the animal. During this PhD, we propose to study the possible neural networks that can sustain such representations.

PhD Objectives

3D orientations are elements of the continuous group SO(3), and we will, therefore, explore how neural network can deal with such objects. The student will be able to work along two axes of research:

- **Attractor networks for 3D orientation representations.** The student will study the architecture and dynamics of recurrent neural networks that can sustain representations of 3D orientations. This subject mixes computer simulations of neural networks with analytical analyses of the underlying group structure.
- **Feed-forward networks that extract 3D orientation from visual scenes.** The student will build deep neural networks that extract the 3D orientation information from a series of visual scenes.

Proposed approach

The student will build deep neural networks that extract the 3D orientation information from a series of visual scenes. This subject does not necessarily require knowledge of modern machine learning techniques, but certain ease with programming and Python is highly recommended.
Students will also have the opportunity to work on recently acquired neuronal activities in mice whereby the animal watched rotating objects in 3D.