Spiking model of the head direction cell system for orientation estimation

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In mammals, navigation and spatial learning rely on building an internal representation of the environment using both idiothetic (self-motion) cues and allothetic (external) cues, such as vestibular [1] and visual landmark [2] information. Heading is represented by Head Direction cells which are active when the animals head faces a preferred direction.

Visual landmarks have been shown to control the head direction signal in cue rotation studies [2], with longer experience of cues resulting in stronger rotations indicating confidence in a cues association with a heading is important for overriding the idiothetic estimation, which is liable to become less accurate overtime.

Head direction has been previously modelled as a ring attractor with gaussian connectivity between HD cells [3], and as an excitatory population connected to two inhibitory populations that drive activity around the ring (representing the reciprocal connections between two brain regions know to generate the head direction signal) [4].

We propose a spike-based ring attractor model, build using the NEST simulator, composed of an excitatory population and inhibitory population, with two additional rings providing angular velocity (idiothetic) input, and additional cells for associating landmark information with HD cells to correct for drift in the estimation.

The aim of this work is to understand how uncertainty in the animals heading is represented in the brain and explore how allothetic cues can be used to correct drift in a model of the head direction system primarily driven by idiothetic cues.

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