History of experimental work

* Types of cells and who first recorded them
* Major observations in behaviour of the cell type
* Major modelling attempts
  + Including problems

My interpretation of how we can model the HD/grid cell system

Hd cells modelled as a ring attractor network

Currently

* Connections between HD cells have a gaussian weight profile which is countered by continuous inhibition from a layer of ‘intenerurons’ leading to a stable bump of activit on the ring.
* In order to track HD of the robot, odometry data from the robot containing the measured angle is used to generate spiking input to the network. Large changes in angular velocity equate to higher firing rates.
* In order to convey this change to the HD network two underlying populations of cells ‘conjunctive cells’ drive the activity bump either clockwise or anticlockwise around the ring. Cell in the clockwise population are disinhibited by a specific HD cell and project an excitatory connection to a HD cell one position clockwise around the ring. HD cells have inhibitory connections to all other conjunctive cells

This current arrangement allows for continuous tracking of HD around the network to a fairly good accuracy

However this arrangement requires many synaptic connections between neurons

It may be possible to implement an excitatory-inhibitory network to produce an attractor bump as used in grid cell network below.

The gris cell network uses a continuous current to keep cells at an elevated excitability which maintains the bump

* This activay has been successfully synchronised with a theta pattern

This may also allow for coincident input to the conjunctive layer to produce spikes instead of using disihibition

-> alternatively a way of keeping only the cells at the position of the bump in an elevated excitable state would be preferable…. More thought can go towards this

Grid cell network

Tried the mexican hat type approach which is an excitatory inhibitory network but then settled on the approach my Matt Nolans group in edinburgh

They implemented the network ijn BRIAN and showed various behaviours consistent with experimental results including theta entrainment and even gamma bursting activity

Excitatory cells (stellate or grid cells) project to interneurons which are inhibitory cells with gaussian connectivity and inhibitory cells project back to the excitatory cells with a ring like pattern implemented by shifting the gaussian weight profile

-> find the eucledian distance between two cells on the neural sheets

Distance is always the same regardless of

The cartesian coordinates are normalised to the size of the sheet and so are always between 0 and 1

\*\*\* could it be I have gone wrong in this normalisation????????? If normalised incorrectly the weights could be biad more towards one direction??

* However this should have been caught by having a quare sheet of neurons rather than and rectangular sheet

At the edges of the sheet the twisted torus topology described by Guanella et al is implemented

For a regular torus

If smaller distances can be produced by subtracting or adding the 1 from either the x or y direction (equivalent to the width or height of the sheet) then this wrapped distance is used instead

For a twisted torus the cells are treated as if they are arranged in a triangular pattern and the distance in modified by in the y dimention

My intentions are to have sheets of conjunctive grid cells which contain fewer cells than the main excitatory population. Similar to the HD conjunctive layers each conjunctive layer will have sparse, biased connections to the grid cell sheet in the direction of its associated HD cell. Coincident input from the grid cell sheet and the HD circuit would lead to movement of the bump around the grid cell sheet

* These cells will have hexagonally patterned firing files like grid cells, but also have a preferred firing direction

Need to keep in mind our purpose

* Biologically inspired and following the biology as much as possible
* However the intention is not to contruibut potential mechanisms but to use what we do know to produce a method of tracking self motion which can be implemented using neuromorphic hardware and using in conjunction with the predictive coding network for the purpose of robot navigaiton