Thoughts on Grid cell place cell interactions

* After building an inhibitory-excitatory attractor network model of grid cells driven purely by ground truth position data as current input to up, down, left and right biased conjunctive layers, and finding poor gridiness in the firing patterns of these cells. We noted previous spiking models of grid cell attractor networks relied on ‘place cell’ input to prevent drift.
* It became obvious that within a spiking network, drift is inherent due to the stochastic nature of spikes, inconsistent transfer of current input to spike times dependant on voltage state of the cell and timing of other spiking inputs
* Therefore how can we expect the grid cell network to perform without drift if with consistent input a consistent network behaviour is not observed.
* An additional error minimising input is required
* Place cells could well be providing this correcting input
  + Place fields may be produced as a result of input from several Grid cells from different modules, when the firing fields of all of these grids overlap, the input to the place cell will be greater causing it to fire in one specific location in the environment
  + In biology this may be bolstered or influenced by boundary vector cells etc
  + If when these place cells fire plasticity occurs which associates visual input with this position, firing of this cell will begin to occur when that visual input occurs again
  + Place cells feeding back onto the grid cells which should be active to cause that place cell to fire, provides a method to move the attractor state towards that expected according to the real world input

Exploratory activity

If place cell firing field are first determined by grid cell firing, but reliable grid cell firing relies on place cell input driven by association with visual landmarks. It is important that place cells become associated with correct visual landmarks, rather than errorsome locations

Uncertancy in the system must be minimised regularly, this could be achieve using a repetitive exploration behaviour where the robot travels a short distance to keep uncertainty low then returns to a previously visited position to close the loop. At this point the error is known and can be corrected. Revisiting and reinforcing associations between particular vies and a place cell increases confidence in this landmark which then can be used to close the loop and minimize accumulative error in the grid cell system. As confidence in landmarks increases then the robot can explore further afield and return to a previously visited location once again.

The system does not need to track the location of the robot perfectly, is just gives a good enough estimate.

For example extremely dense place filed packing would produce a very detailed tracking of the movement trajectory

However only dispersed updates to the grid cell network to account for drift are required to produce the regular triangular grid firing fields and provide an estimate of current pose, or be used to plan a route from landmark to landmark

Place field repetition

Place fields have been shown to occur in the same position in parallel compartments, this may occur because the place cell becomes active due to the similarity in visual input in each container

Grid cells have been shown to become uniform across multiple containers with extensive experience - may require le\rning in the strength of connection between place cells and grid cells? Although i am not sure if place cell repetition persist with extensive experience or if small differences between views in each environment would eventually be reflected in the weight between visual input and the PC

It may be the case that grids are entrained to the repeating place field and with time place field repetition decreases and less remapping of the grid field occurs

Including Hd in the visual information to PCs provides a mechanism for discriminating similar views in different locations, this would account for the lack of repetition in the radial environment. It would also allow for multiple views to become associated with a place cell if the subject stays in the same location but rotates their head

Theta activity

Although the concept of theta rhythms is tricky to understand

Cells become entrained to the theta rhythms, but the theta oscillation is due to population synchronicity so what drives what etc etc

Julian sees whisk rate coherence with theta rhythm in the hippocampus

Whisk rate has also been show to change with attention (when encounter an interesting object, whisking frequency increases during exploration)

If then theta frequency increases in line, this may be important for increasing learning (in our case associating visual information with location) - potentially increasing episodic memory formation

If PC activity is entrained to this theta rhythm, error minimisation in the grid cell network would be periodic rather than continuous

Potential pros of theta:

* More memory of interesting places
* Formation of LANDMARKS which are interesting places
* Just generally periodic inputs to grid cell network, which supports having not too many place cells
* Periodic formation of associations between visual information and location
  + Not oversaturated

Whole system is suitable of general location tracking rather than exact position

Predict wher we are then observing (THETA FOR SLAM)