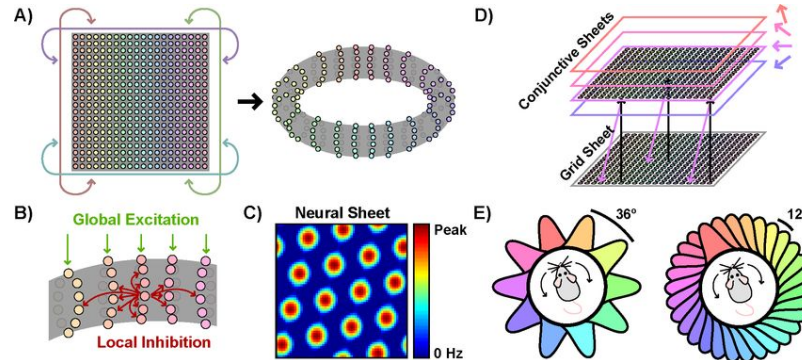


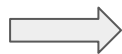
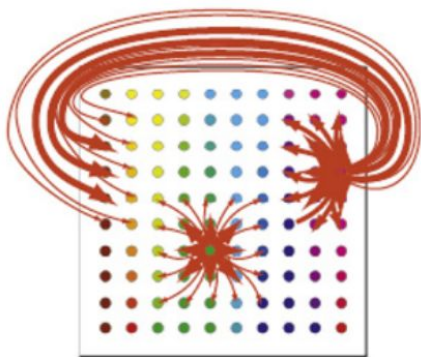
# Continuous Attractor Network and Grid Cells

All Over the Place



# Introduction

- What is a Continuous Attractor Network ?
- Grid fields from CANs

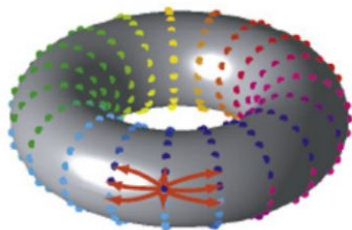
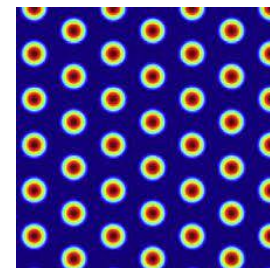
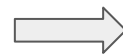
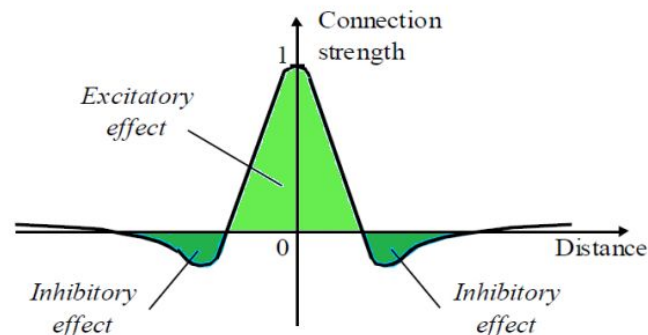


$$\tau \frac{ds_i}{dt} + s_i = f \left[ \sum_j W_{ij} s_j + B_i \right]$$

$$W_{ij} = W_0(\mathbf{x}_i - \mathbf{x}_j - l\hat{\mathbf{e}}_{\theta_j})$$

$$W_0(\mathbf{x}) = \mathbf{a} e^{-\gamma|\mathbf{x}|^2} - \mathbf{e}^{-\beta|\mathbf{x}|^2}$$

$$B_i = A(x_i)(1 + \alpha \hat{\mathbf{e}}_{\theta_i} \cdot \mathbf{v})$$



# Motivation

Accurate Path Integration in Continuous Attractor Network Models of Grid Cells.

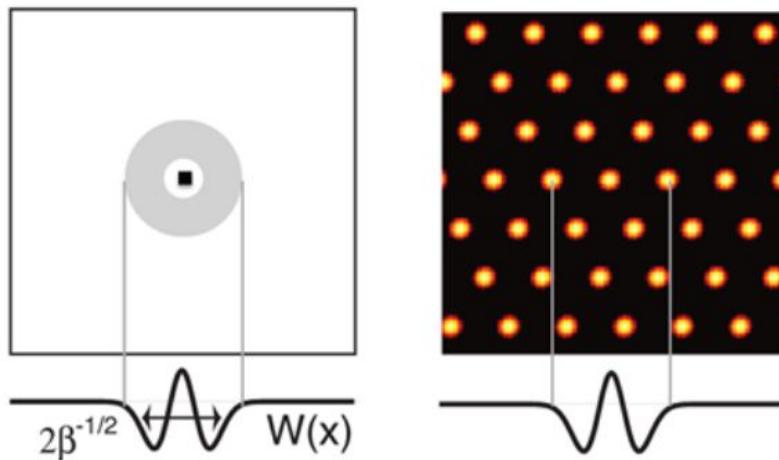
Original model paper: Yoram Burak and Ila R. Fiete (DOI:  
<https://doi.org/10.1371/journal.pcbi.1000291>)

Resonating neurons stabilize heterogeneous grid-cell networks, Mittal and Narayan

- How might grid cells connect to give rise to hexagonal grids.
- An attempt to understand how path integration is done by grid cells.
- How various factors such as synaptic weights, velocity and the extent of inhibition changes the attractor network.

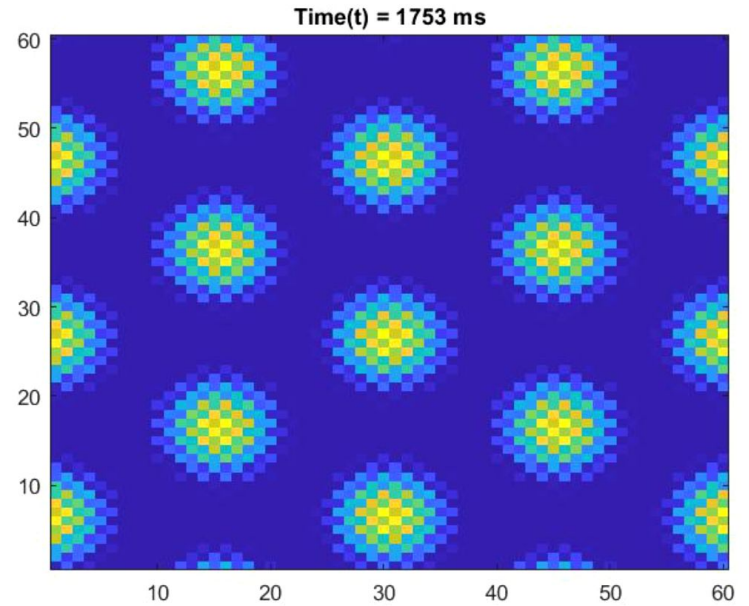
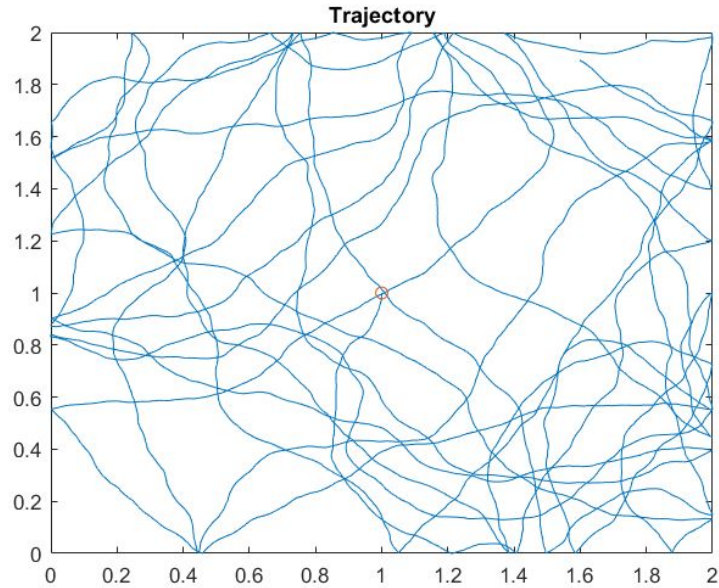
# Parameters Changed

- The velocity gain (Alpha).
- The periodicity of the population (Lambda).
- The extent of the inhibitory region (Gamma).



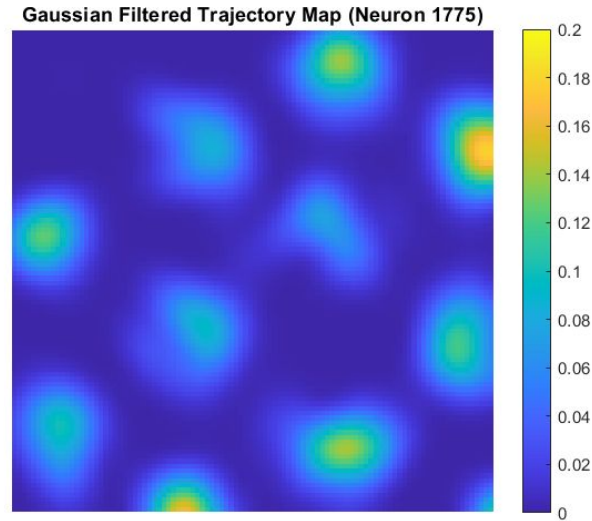
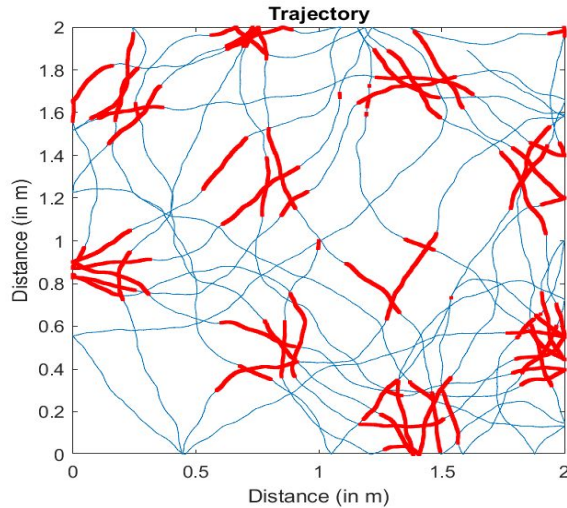
# Implementation

# Generating the Trajectory Plots



# Generating the Grid Scores

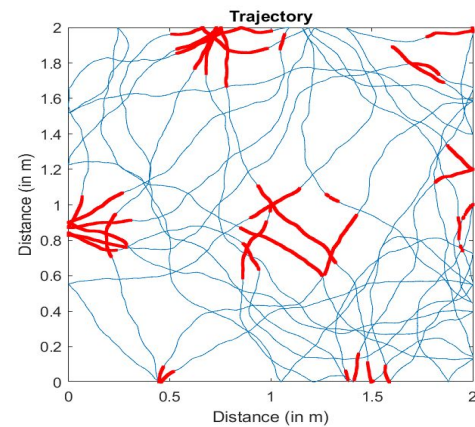
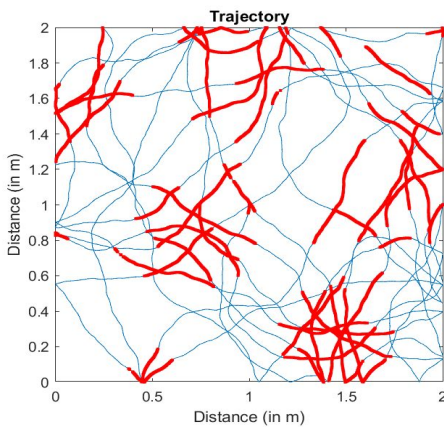
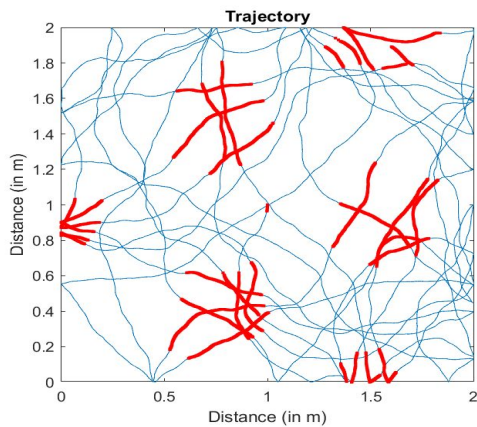
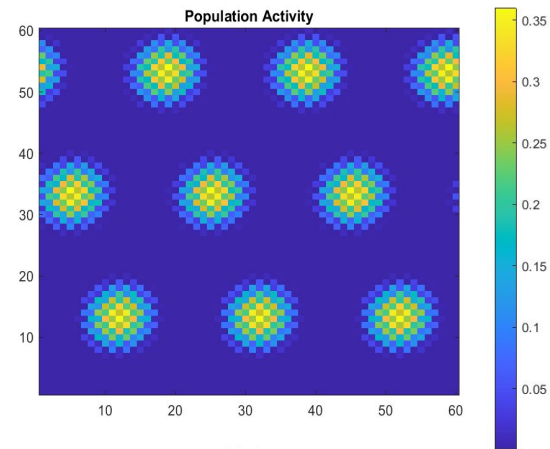
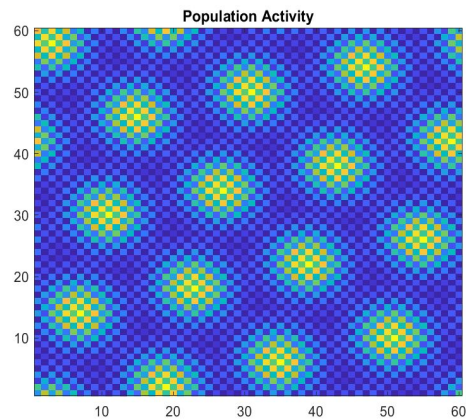
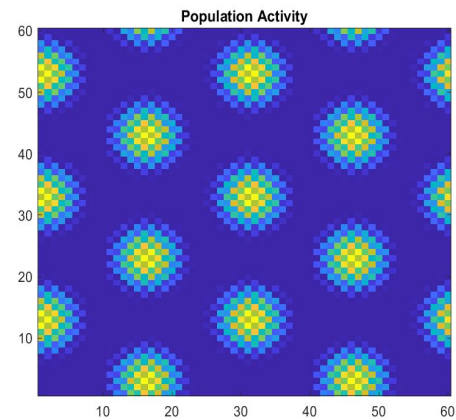
$$\text{Gridness score} = \min(A_{\text{corr}_{60^\circ}}, A_{\text{corr}_{120^\circ}}) - \max(A_{\text{corr}_{30^\circ}}, A_{\text{corr}_{90^\circ}}, A_{\text{corr}_{150^\circ}}).$$



# Results



# Periodicity of the lattice

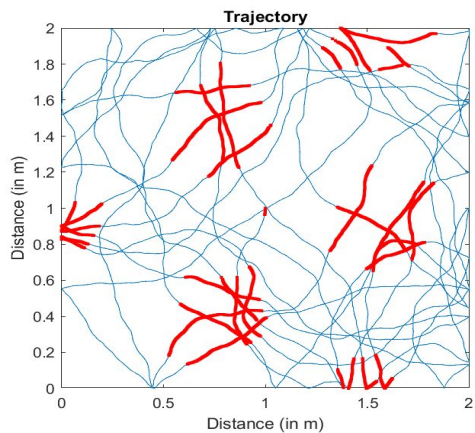
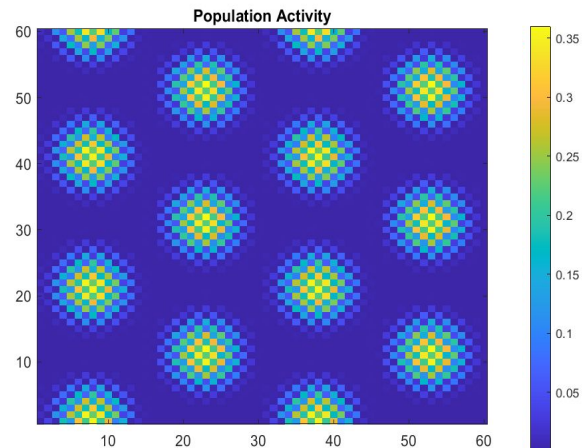
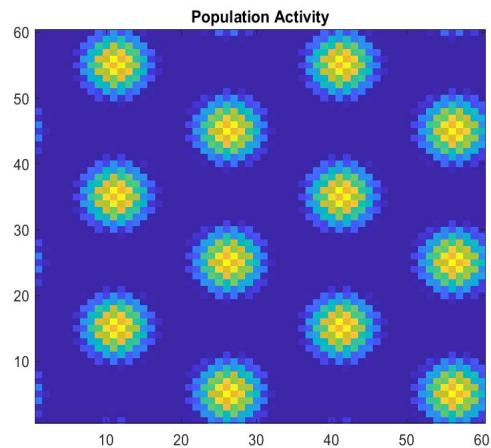
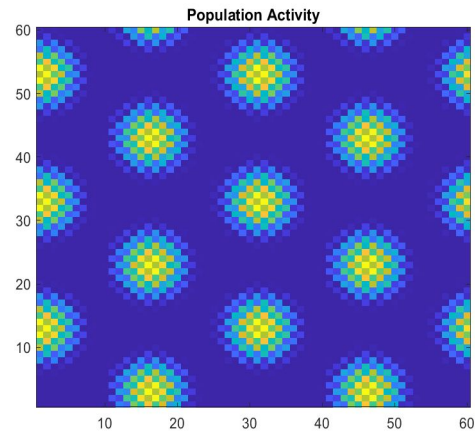


**$\lambda = 13$**

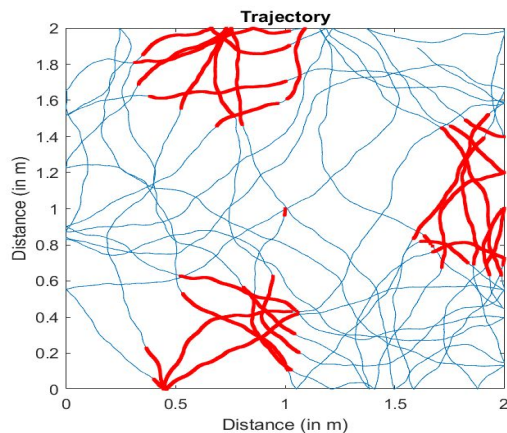
**$\lambda = 11$**

**$\lambda = 15$**

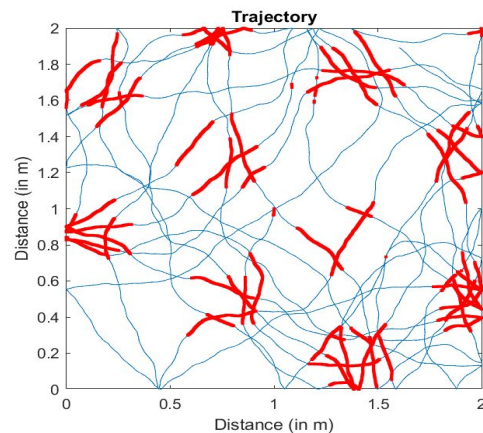
# Velocity gain



**alpha = 45**



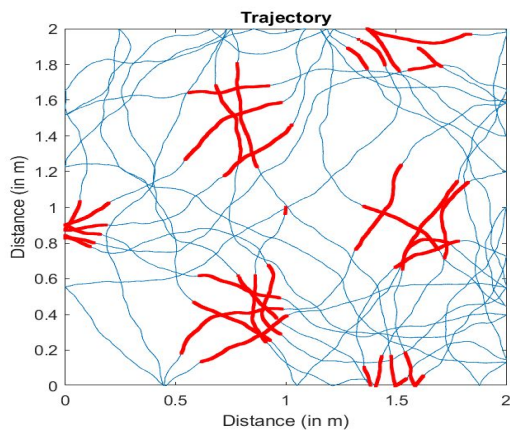
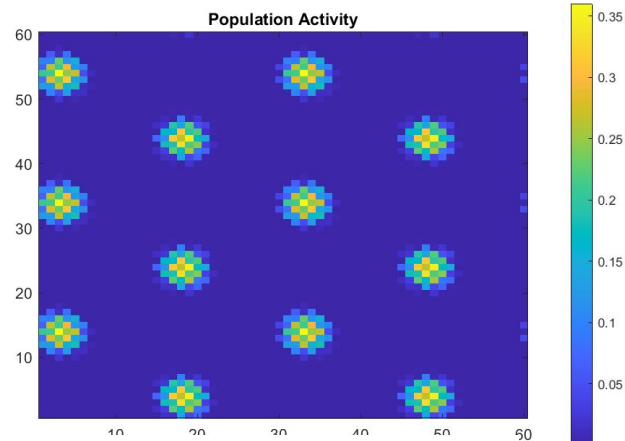
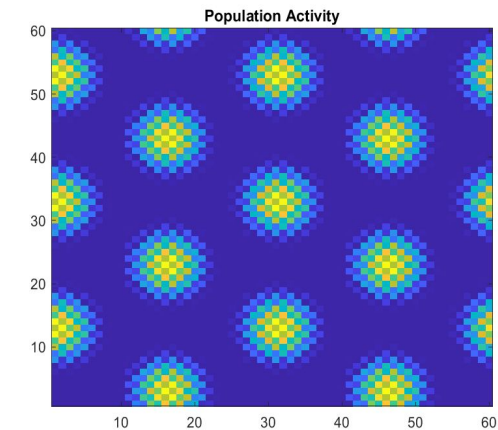
**alpha = 30**



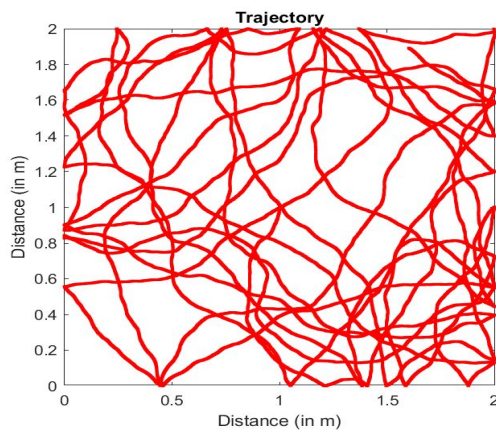
**alpha = 60**



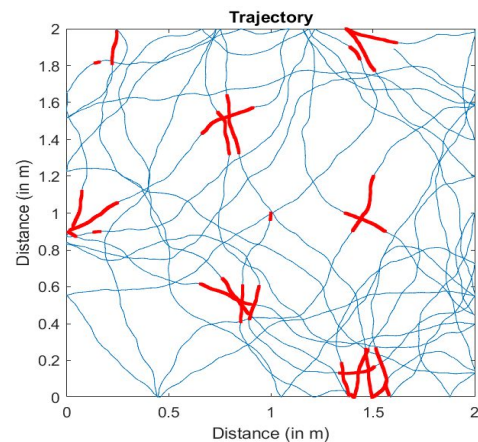
# Extent of inhibition



$\gamma = 1.1 * \beta$



$\gamma = 0.8 * \beta$



$\gamma = 1.5 * \beta$

# Comparing Grid Scores

Alpha	Grid Score
45	0.3530
30	0.2330
60	0.2572

Lambda	Grid Score
13	0.3530
11	0.2076
15	0.1160

Gamma	Grid Score
1.1	0.3530
0.8	-0.0127
1.5	0.3990

# Limitations

- Large number of cells are required for the hexagonal grids to form.
- Simulation Time prevents longer simulations
- Spatial Autocorrelation might not have been done in the most precise way

# Acknowledgement

We would like to thank the TAs for helping us brainstorm and validate our ideas when we were trying to develop a project.

Special thanks to Harshith for helping us gain clarity on the implementation and guiding us.

# Contributions

Conceptualisation: Arkadeep, Mrittika, Nilay

Implementation: Nilay, Kajal, Mrittika

Analysis and Presentation: Arkadeep, Kajal, Mrittika, Nilay

Thank you

