

# Population Vector Navigation

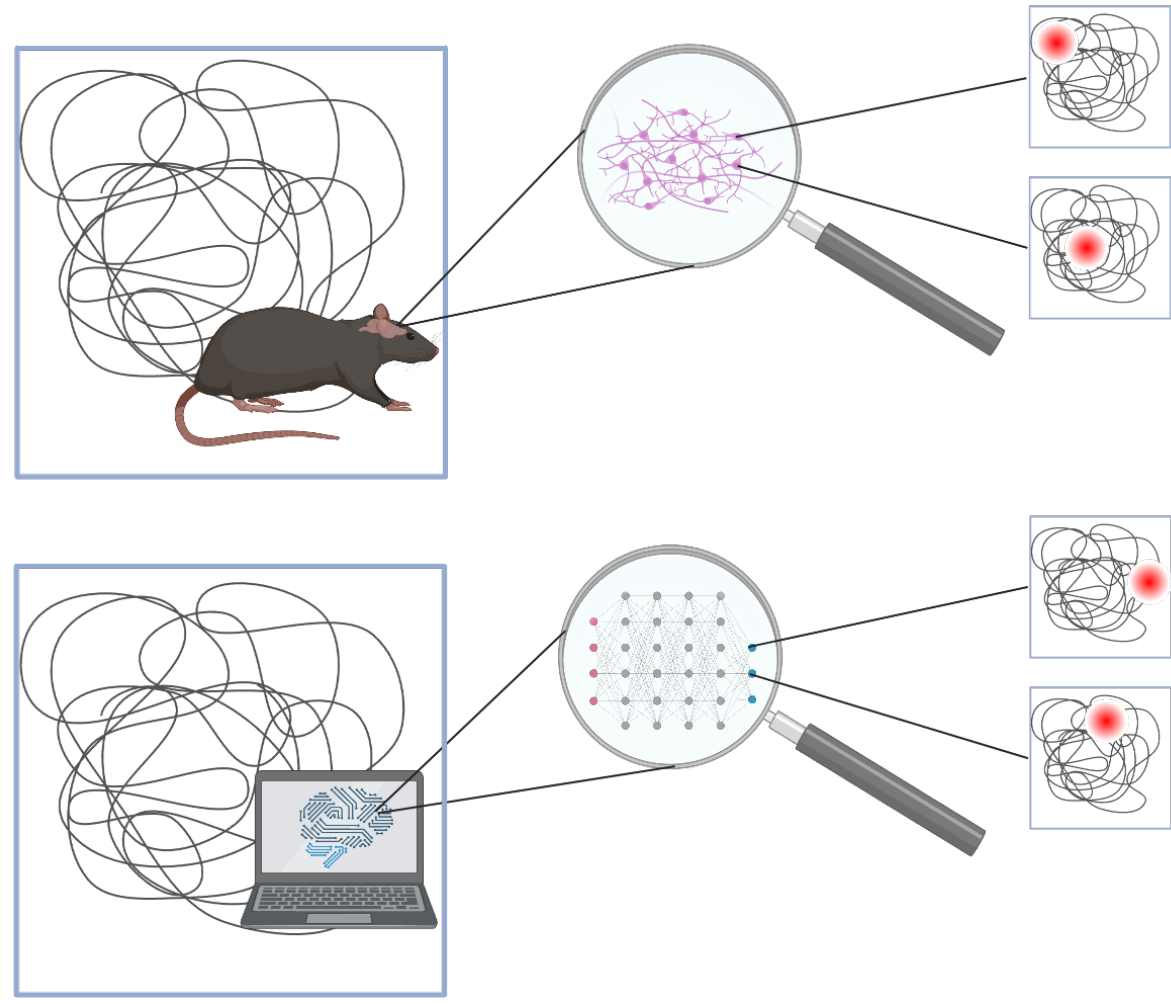
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## Summary:

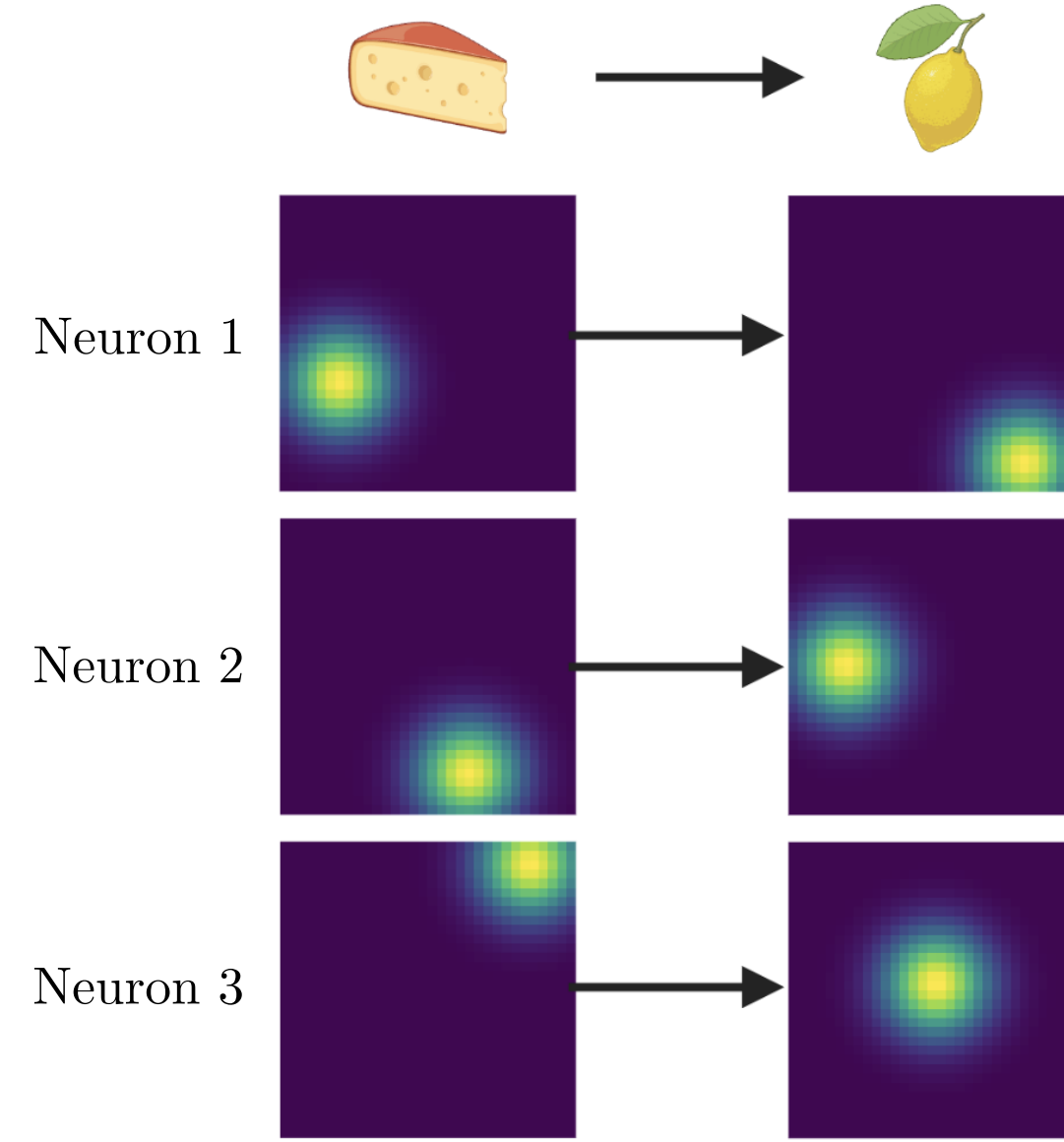
We train a feedforward to minimize the similarity between population vectors at different simulated locations and contexts. We also train a recurrent neural network to distinguish locations while path integrating along simulated trajectories. The feedforward network learns spatial representations similar to biological place cells, and remaps between contexts. The recurrent neural network learns to path integrate, and its spatial representations are similar to biological place and band cells.

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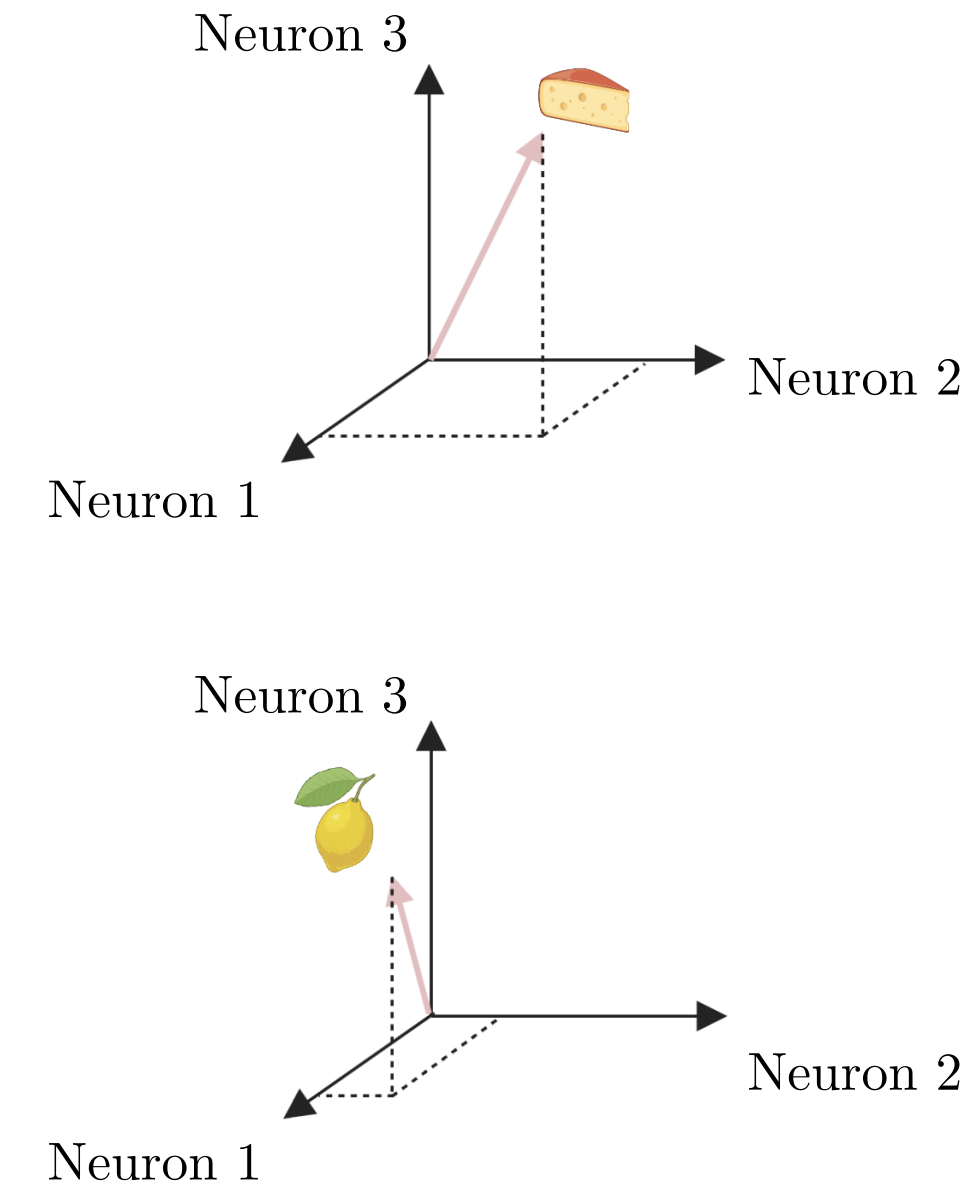
Navigating neural networks learn biologically plausible representations



Biological neurons change their spatial responses when contextual cues change



Information is encoded in population vectors



How *should* population vectors encode position and context?

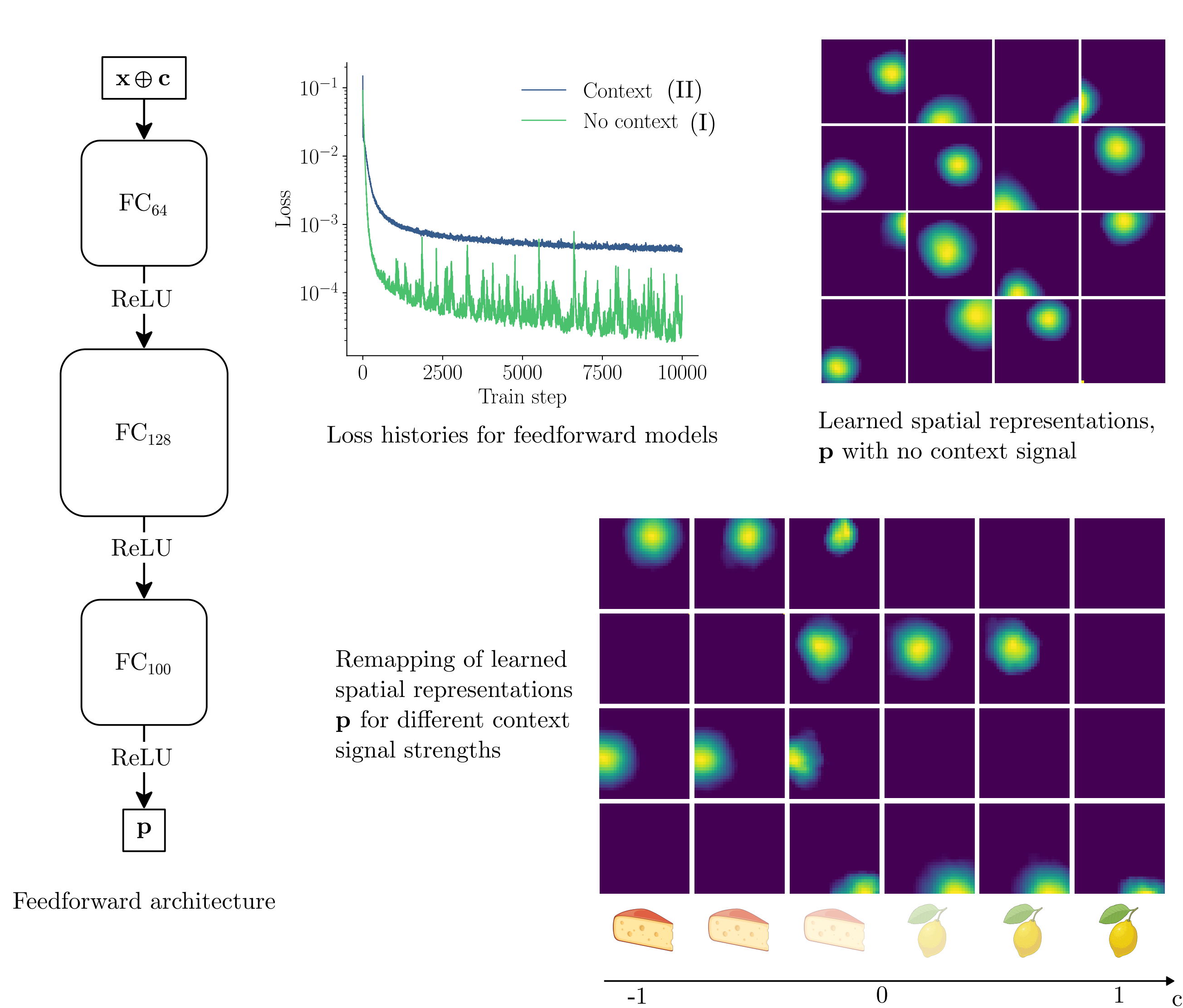
- All positions are uniquely encoded
- Close locations are similar in representation
- Distant locations are dissimilar in representation
- There are no privileged locations in space
- Non-negativity

Find  $\mathbf{p}$  that minimizes

$$\text{(I)} \quad \mathcal{L} = \mathbb{E} \left[ \left( e^{-\frac{0.5}{\sigma^2} |\mathbf{x} - \mathbf{x}'|^2} - \mathbf{p}(\mathbf{x}) \cdot \mathbf{p}(\mathbf{x}') \right)^2 \right]$$
$$\text{(II)} \quad \mathcal{L} = \mathbb{E} \left[ \left( e^{-\frac{0.5}{\sigma^2} |\mathbf{x} - \mathbf{x}'|^2} e^{-\frac{0.5}{\sigma^2} |c - c'|^2} - \mathbf{p}(\mathbf{x}, c) \cdot \mathbf{p}(\mathbf{x}', c') \right)^2 \right]$$

(I): Spatial objective  
(II): Conjunctive spatial and context objective

Feedforward networks learn biologically plausible place cell-like spatial representations and remapping across contexts



A recurrent neural network learns biologically plausible band and place cell-like spatial representations and path integration

