

Pattern Association

Cell Assemblies

1 Association

- Hetero Association
- Auto Association
- Cell Assemblies

2 Recurrent Dynamics

- Attractors
- Storing Memories
- Content Adressable Memory
- Providing Input

1 Association

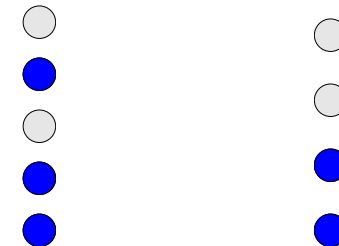
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Association

Mapping from one pattern to another pattern



- Binary patterns (often represented with -1 and 1)
- Threshold units

Example

$$\vec{x}_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \quad \vec{y}_1 = \begin{bmatrix} -1 \\ 1 \\ -1 \end{bmatrix} \quad \vec{x}_2 = \begin{bmatrix} -1 \\ -1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \quad \vec{y}_2 = \begin{bmatrix} -1 \\ -1 \\ 1 \end{bmatrix}$$

Stored using Hebb's rule: $W = \sum_p \vec{y}_p \vec{x}_p^T$

$$W = \begin{bmatrix} 0 & 0 & -2 & 0 & 0 \\ 2 & 2 & 0 & -2 & -2 \\ -2 & -2 & 0 & 2 & 2 \end{bmatrix}$$

- Noisy input may still produce perfect output
- Association in multiple stages is possible
- Patterns are improved at each step

Hetero-Association

Mapping from one pattern to another pattern

Auto-Association

Mapping from one pattern to itself

Neural representation of association chains

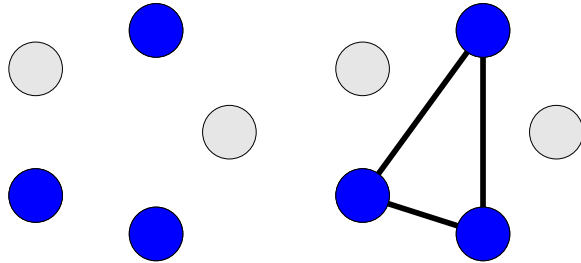
The same neurons can be used for both input and output

- Pattern of currently active neurons — Neural State
- Associations work over time
- Hetero-association — Replacing the current activity pattern with the next one
- Auto-association — Preserving the current activity pattern

Hebbs Cell Assembly Hypothesis

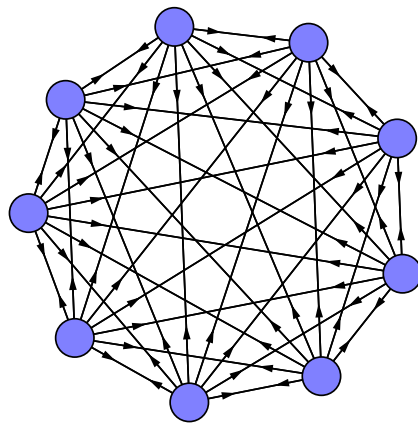
Groups of simultaneously active neurons are the neural correlate of "thoughts"

- Auto-association
- Tied together via excitatory connections



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- Recurrent network
- Dynamical system



What happens over time with a pattern?

Three possibilities

- Converges to a stable pattern — **Fixpoint attractor**
- Cycles over a set of patterns — **Cyclic attractor**
- Never repeats itself — **Chaotic attractor**

Fixpoint Attractors

Model of stable "thoughts"; Cell assemblies

Storing memories — Forming attractors
Hebbs rule works surprisingly well

$$\Delta w_{ji} = \eta \vec{x}_j \vec{x}_i$$

Different ways of providing input:

- Input as the starting condition
- Clamping of nodes with known values

What can it be used for?

- Cleaning up noisy patterns
- Restoring a pattern from a partial pattern
- Resolving rivalry between multiple patterns
- Bi-directional associations
- Multi-modal associations

- Visible and Hidden Units
- Clamping

