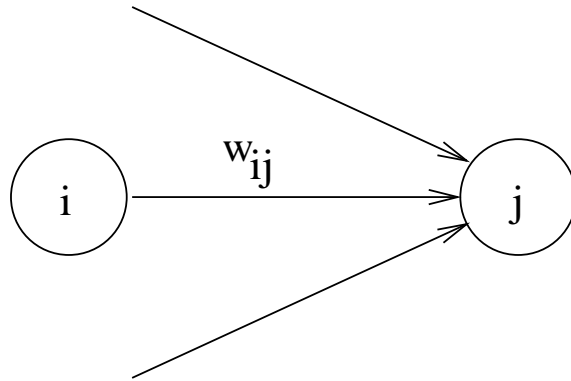


Hebb's Rule (1949)



If unit i repeatedly participates in the firing of unit j then the weight from i to j increases.

problems: saturation, lack of specificity

partial solution: decay

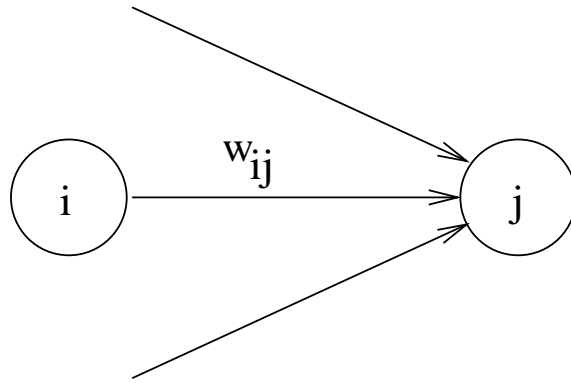
anti-hebbian learning (Stent, 1973):

The weight from i to j decreases if unit j fires, but unit i does not.

another variant:

The weight from i to j decreases if unit i fires, but unit j does not.

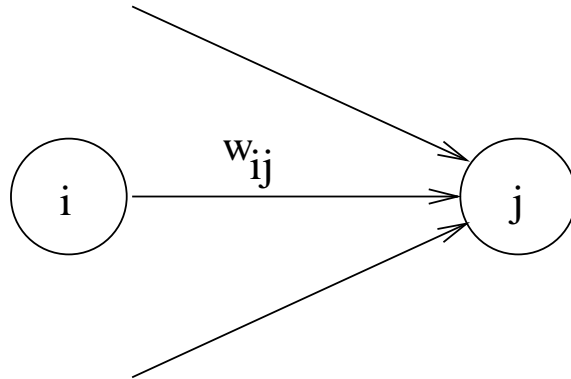
A possible interpretation of Hebb's rule



How often when unit j was firing, was unit i also firing?

$$w_{ij} = \frac{\text{the number of times both } i \text{ and } j \text{ fire}}{\text{the number of times } j \text{ fires}}$$

BCM rule (Bienenstock, Cooper, and Munro, 1982)



$$o_j = net_j = \sum_i w_{ij} \cdot o_i$$

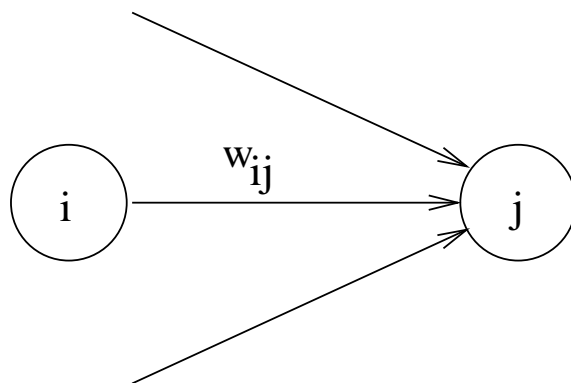
$$\Delta w_{ij}(t) = \Phi(o_j(t)) \cdot o_i(t) - \epsilon \cdot w_{ij}(t)$$

Φ is a scalar function such that:

$$sign(\Phi(o_j(t))) = sign(o_j(t) - \theta_M)$$

weight vector is driven in the direction of the input vector if the output is large (above θ_M), or opposite to the direction of the input vector if the output is small (below θ_M).

BCM rule ...variable threshold, θ_M



$$o_j = net_j = \sum_i w_{ij} \cdot o_i$$

$$\Delta w_{ij}(t) = \Phi(o_j(t), \bar{o}_j(t)) \cdot o_i(t) - \epsilon \cdot w_{ij}(t)$$

Φ is now a function of $o_j(t)$ as well as $\bar{o}_j(t)$, the *average* output.

as before

$$sign(\Phi(o_j(t)), \bar{o}_j(t)) = sign(o_j(t) - \theta_M)$$

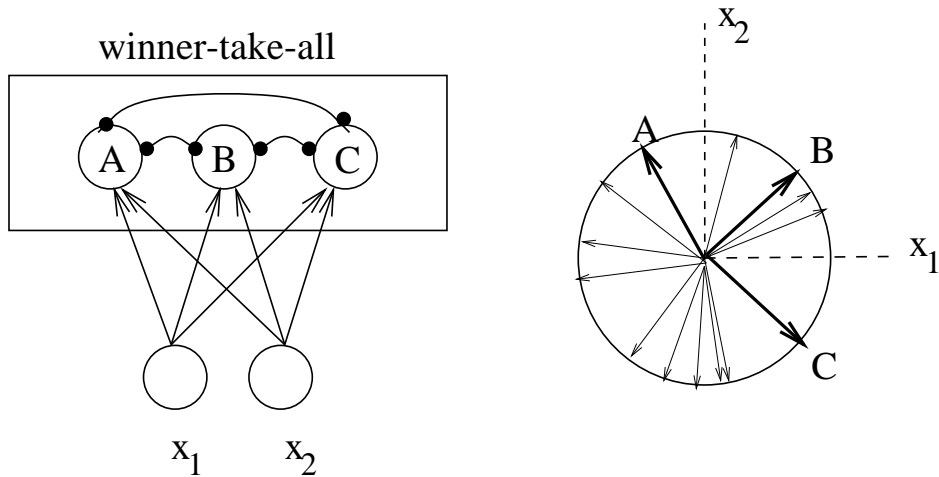
but

$$\theta_M(t) = \left(\frac{\bar{o}_j(t)}{c} \right)^p \cdot \bar{o}_j(t)$$

$$\Phi(0, \bar{o}_j) = 0 \text{ for all } \bar{o}_j$$

where c and p are constants

Competitive Learning



Output of a node = input vector \bullet weight vector

If weight and input vectors are normalized

output = $\cos \alpha$ where α is the angle between the weight and input vectors

Learning algorithm:

1. Present an input pattern to the net
2. Identify the node with the highest response
3. Rotate its weight vector toward the input vector.
4. Repeat

(Spatial competition, cf. temporal competition of BCM)