Blackboard 6.1

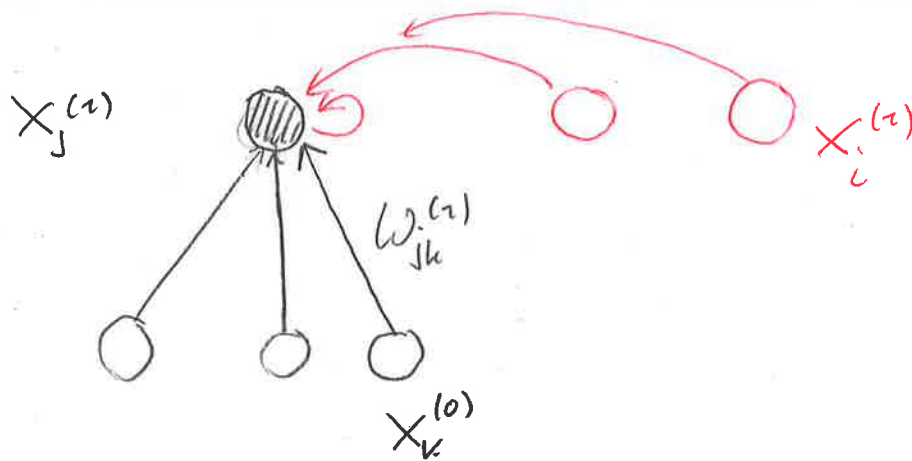## network element / recurrent network

$$x_j^{(1)} = g\left[\sum_k \omega_{jk}^{(1)} \cdot x_k^{(0)} + \sum_i \omega_{ji}^{lat} x_i^{(1)} \right]$$

timing

$$x_j^{(1)}(t) = g\left[\vec{\omega}_j^{(1)T} \cdot \vec{x}(t) + \vec{\omega}_j^{lat T} \cdot \vec{x}^{(1)}(t-1) \right]$$

input $\vec{x}^\mu$ with $\mu = t$

previous

forward pass "same time step"

Blackboard 6.2 : Unfolding in time

Output at time step $t=4$

$$\hat{y}_i(4) = g\left[\sum_j \omega_{ij}^{(2)} x_j^{(1)}(4) \right]$$

(↑ time, ↑time)

$$= g\left[\sum_j \omega_{ij}^{(2)} \cdot g\left[\sum_k \omega_{jk}^{(1)} x_k^{(0)}(4) + \sum_k \omega_{jk}^{lat} x_k^{(1)}(3) \right] \right]$$

(↑ previous time step)

$$= g\left[\sum_j \omega_{ij}^{(2)} \cdot g\left[\sum_k \omega_{jk}^{(1)} x_k^{(0)}(4) + \sum_k \omega_{jk}^{lat} g\left[\sum_\ell \omega_{k\ell}^{(1)} x_k^{(0)}(3) + \sum_\ell \omega_{k\ell}^{lat} x_\ell^{(1)}(2) \right] \right] \right]$$

$$= g\left[\sum_j \omega_{ij}^{(2)} \cdot g\left[\sum_k \omega_{jk}^{(1)} x_k^{(0)}(4) + \sum_k \omega_{jk}^{lat} g\left[\sum_\ell \omega_{k\ell}^{(1)} x_k^{(0)}(3) + \sum_\ell \omega_{k\ell}^{lat} g\left[\sum_m \omega_{\ell m}^{(1)} x_\ell^{(0)}(2) + \sum_m \omega_{\ell m}^{lat} x_\ell^{(1)}(1) \right] \right] \right] \right]$$

input at $t=4$ input at $t=3$ ...at $t=2$

$$g\left[\sum_n \omega_{mn}^{(1)} x_{\ell(1)}^{(0)} + 0 \right]$$

...at $t=1$

assumption: no activity for $t \leq 0$