

## Blackboard 2.3 : numerical differentiation

calculate  $E \rightarrow$  calculate output  $\rightarrow$  forward pass

evaluate:	at output	hidden <sup>(2)</sup>	hidden <sup>(2)</sup>		
$X_i^{(n)} = g(a_i^{(n)})$	$m^{(3)}$	$+$	$m^{(2)}$	$+$	$m^{(1)}$
$a_i^{(n)} = \sum_j w_{ij}^{(n)} X_j^{(n-1)}$	$m^{(3)} \cdot m^{(2)}$	$+$	$m^{(2)} \cdot m^{(1)}$	$+$	$m^{(1)} \cdot (N+1)$
	<u>all weights <math>n</math></u>				

update one weight (perturbation  $+\epsilon$ )

$$2(n + m)$$

$\uparrow$  all neurons

update all weights :  $O(n^2)$