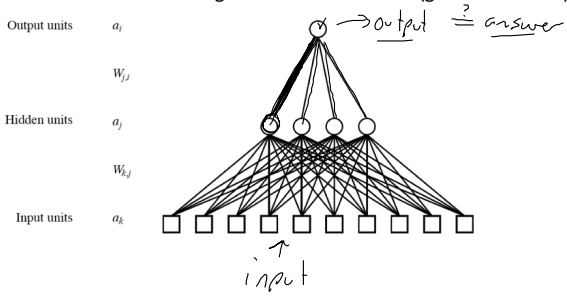
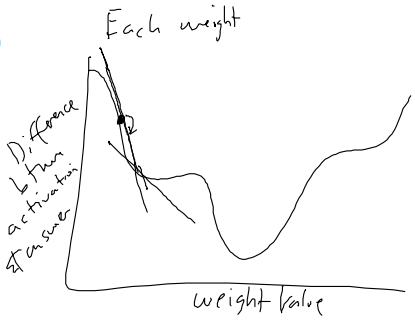
Back Propagation

Friday, November 11, 2016 9:38 AM

Multilayer network learning

- Back-propagation of error
  - Each node is responsible for some fraction of the total error based on strength of connections
  - Update weights based on the amount of error each node is responsible for
  - Search for set of weights that minimize error (gradient descent)





loss function

$$loss(w) = \sum_k (y_k - a_k)^2$$

answer we wanted — activation we got

Back propagation

- Search for a set of weights that reduces the error of the output nodes
- Hidden nodes:
  - Each hidden node j is responsible for some of the error in each of the output nodes
  - The greater the weight, the more of the error the hidden node is responsible for
  - The more it should change
- Gradient Descent

$$\frac{\partial}{\partial w} loss(w) = \frac{\partial}{\partial w} \sum_k (y_k - a_k)^2$$

$$= \sum_k \frac{\partial}{\partial w} (y_k - a_k)^2$$

$$= \sum_k 2 (y_k - a_k) \frac{\partial}{\partial w} (y_k - a_k)$$

$$= \sum_k -2 (y_k - a_k) \frac{\partial}{\partial w} a_k \quad \leftarrow g(in_k)$$

$$= \sum_k -2 (y_k - a_k) \frac{\partial}{\partial w} g(in_k)$$

$$= \sum_k -2 (y_k - a_k) g'(in_k) \frac{\partial}{\partial w} in_k$$

$$= \sum_k -2 \{(y_k - a_k) g'(in_k)\} \frac{\partial}{\partial w} \left(\sum_j w_{jk} a_j\right)$$

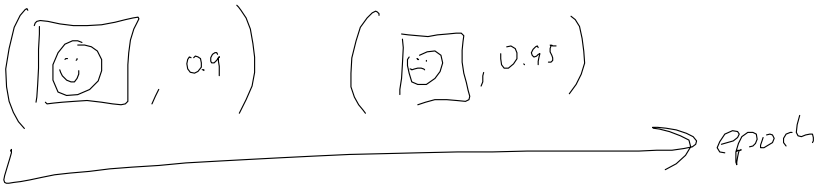
delta improvement — Next level down

Back propagation

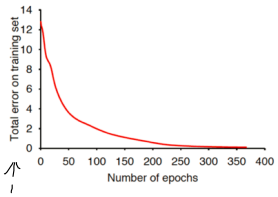
1. Initialize weights in network to small random numbers
2. Given an example (x, y), run the network
3. Propagate backwards

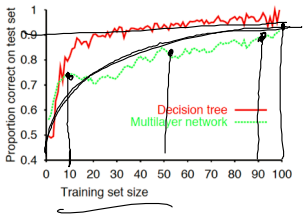
For each node j in output layer do:
$\Delta_j = g'(in_j) \times (y_j - a_j)$

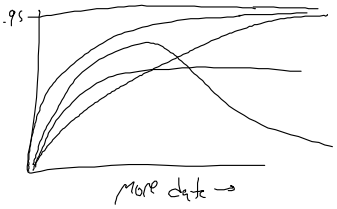
For each layer l from L-1 to 1 do:
For each node i in layer l do:
$\Delta_i = g'(in_i) \sum_j w_{i,j} \Delta_j$
For each weight $w_{i,j}$ in network do:



- Error decreases to zero – converges to a perfect fit on training data
- May need to manually tweak network structure to get perfectly optimal







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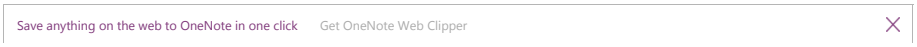
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