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Answer 2 (a)

(i) x_t : Input at time t ; S_t = Hidden state at time t;

$S_t = \tanh(W_{xh} x_t + W_{hh} S_{t-1})$

$\hat{O}_t$: output at time t;

$\hat{O}_t = \text{softmax}(W_{ho} S_t)$

(ii) Let O_t be correct output at time t.

If lr is the learning rate, $\otimes$ → outer product.

$W_{xho} = W_{ho} - lr\,(\hat{O}_t - O_t) \otimes S_t$

Let $p_t = [W_{ho}^T \cdot (\hat{O}_t - O_t)] \circ (1 - S_t^2)$

$p_{t-1} = [W_{ho}^T \cdot p_t] \circ (1 - S_{t-1}^2)$

$p_{t-2} = [W_{ho}^T \cdot p_{t-1}] \circ (1 - S_{t-2}^2)$

$\circ$ → element wise multiplication.

S_t^2 → Element wise Squaring.

Update Rules for W_{xh}, W_{hh}

$W_{xh} = W_{xh} - (p_t \otimes x_t + p_{t-1} \otimes x_{t-1} + p_{t-2} \otimes x_{t-2} \cdots + p_k \otimes x_k) \cdot lr$

$W_{hh} = W_{hh} - (p_t \otimes S_{t-1} + p_{t-1} \otimes S_{t-2} + p_{t-2} \otimes S_{t-3} + \cdots + p_k \otimes S_{k-1}) \cdot lr$