

# *E9 205 Machine Learning for Signal Processing*

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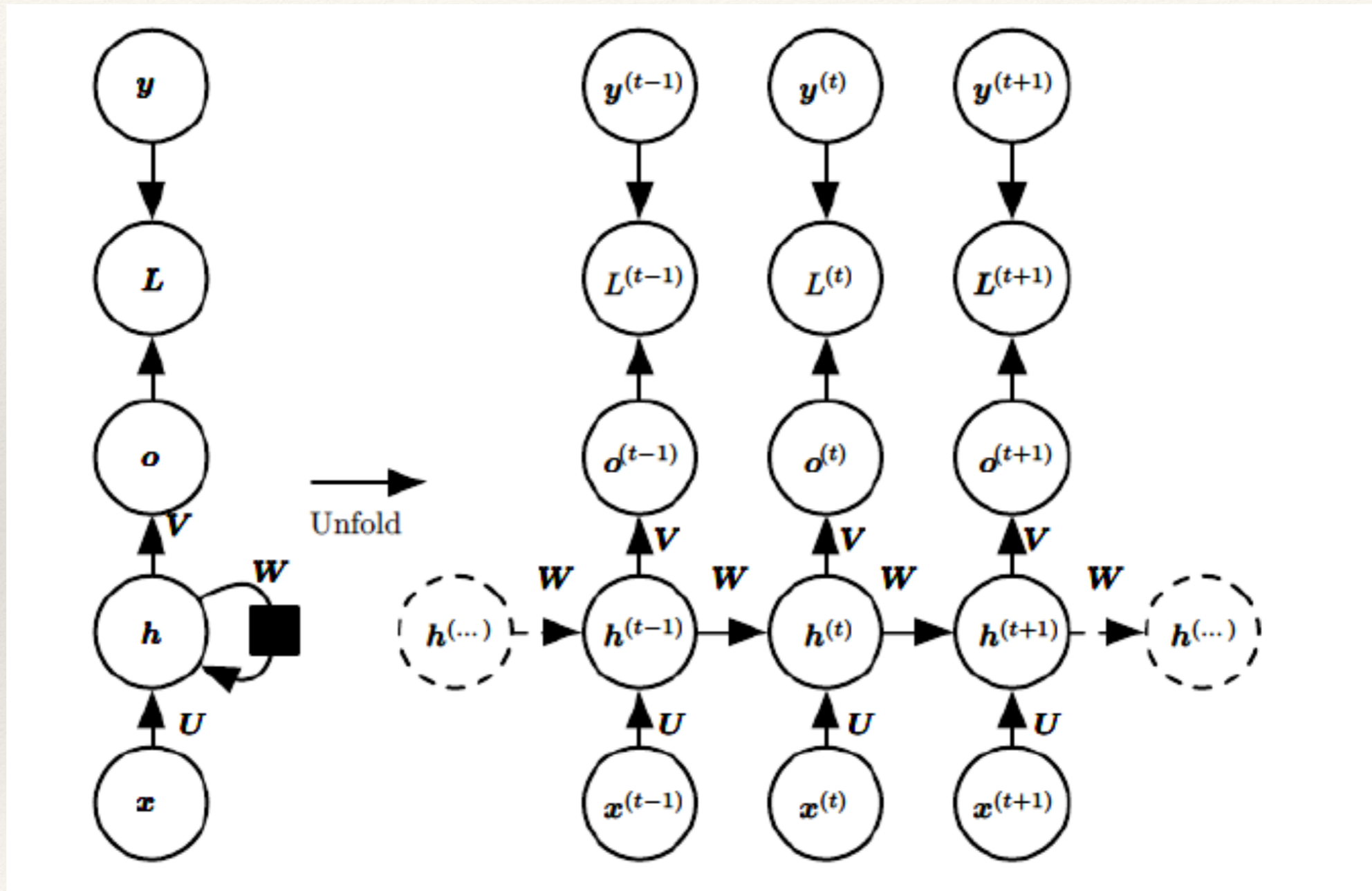
**Convolutional and Recurrent  
Networks**

18-11-2017

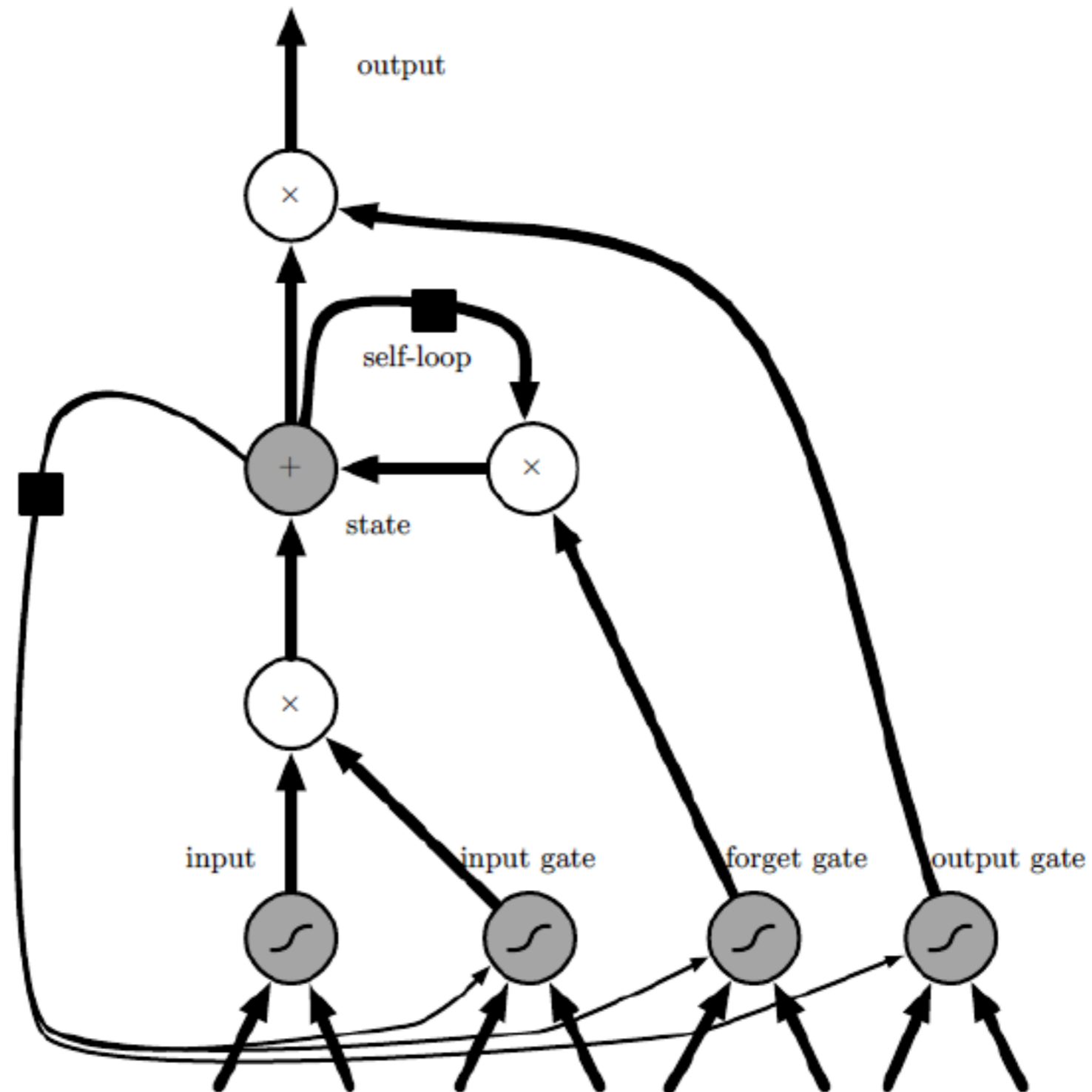
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# Recurrent Networks



# Long Short Term Memory Networks



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# Long Short Term Memory Networks

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$$f_i^{(t)} = \sigma \left( b_i^f + \sum_j U_{i,j}^f x_j^{(t)} + \sum_j W_{i,j}^f h_j^{(t-1)} \right)$$

$$s_i^{(t)} = f_i^{(t)} s_i^{(t-1)} + g_i^{(t)} \sigma \left( b_i + \sum_j U_{i,j} x_j^{(t)} + \sum_j W_{i,j} h_j^{(t-1)} \right)$$

$$g_i^{(t)} = \sigma \left( b_i^g + \sum_j U_{i,j}^g x_j^{(t)} + \sum_j W_{i,j}^g h_j^{(t-1)} \right)$$

$$h_i^{(t)} = \tanh \left( s_i^{(t)} \right) q_i^{(t)}$$

$$q_i^{(t)} = \sigma \left( b_i^o + \sum_j U_{i,j}^o x_j^{(t)} + \sum_j W_{i,j}^o h_j^{(t-1)} \right)$$

# Restricted Boltzmann Machines

**A Symmetrical, Bipartite, Bidirectional Graph with Shared Weights**

