Recurrent neural networks

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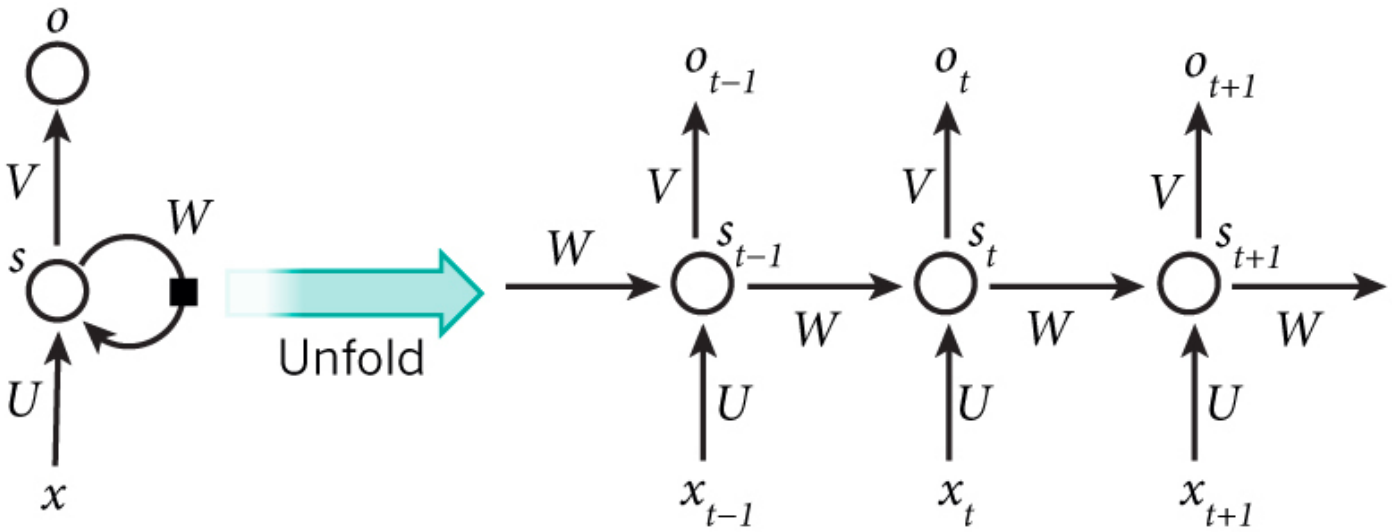
Basic and unfolded structure

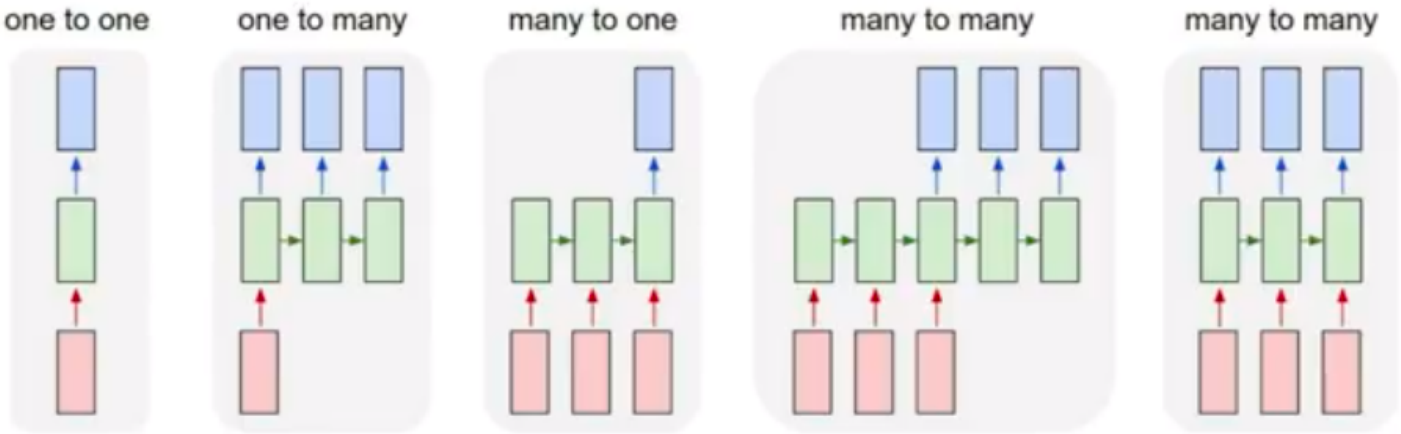


Why do we need RNNs?

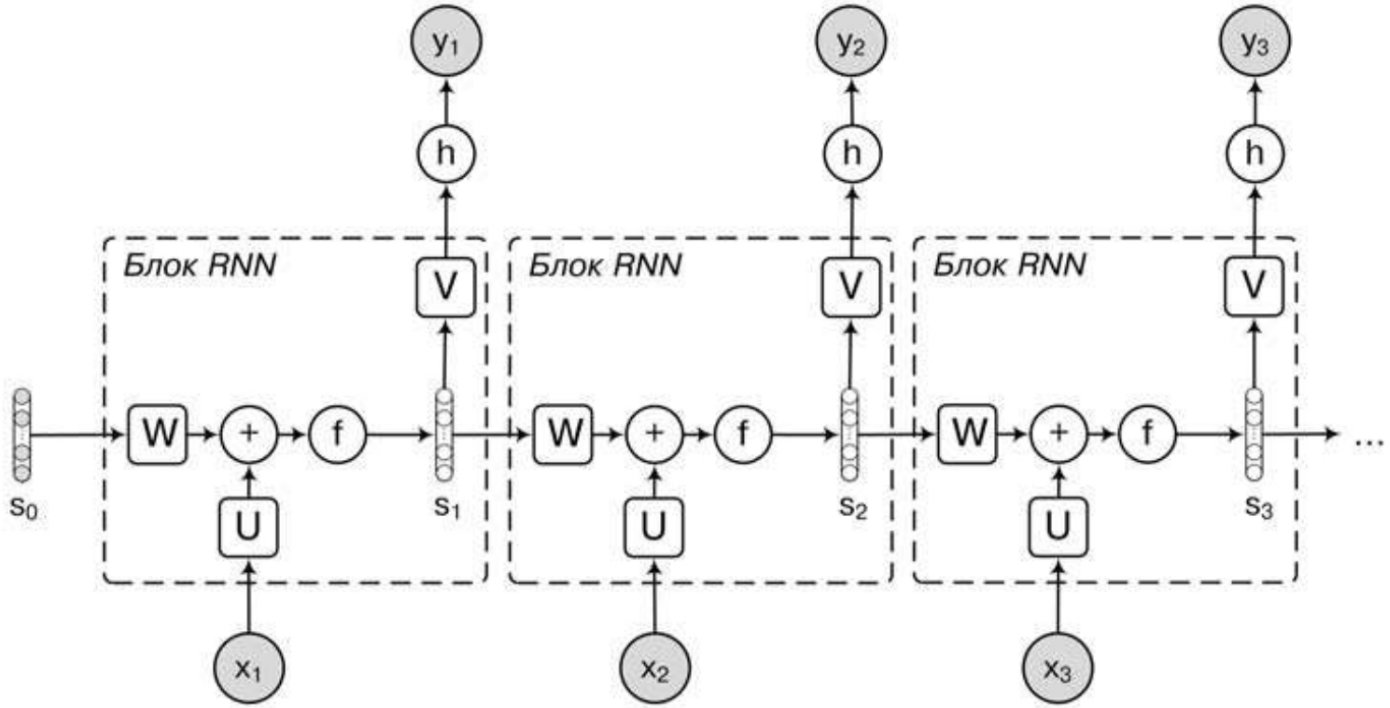
1. Language Modelling and Generating Text
2. Machine Translation
3. Speech Recognition
4. Generating Image Descriptions
5. Video Tagging
6. Emotion Detection

... and a lot of other applications.

Types of RNNs

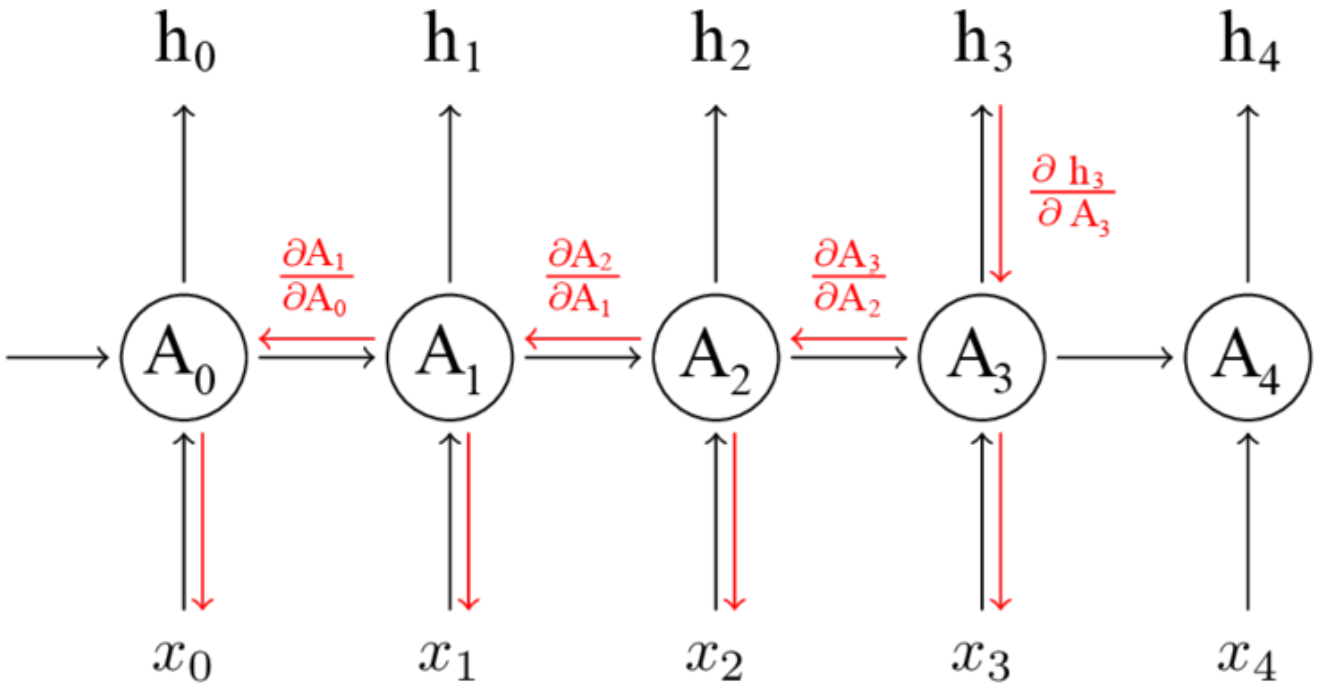


Simple RNN

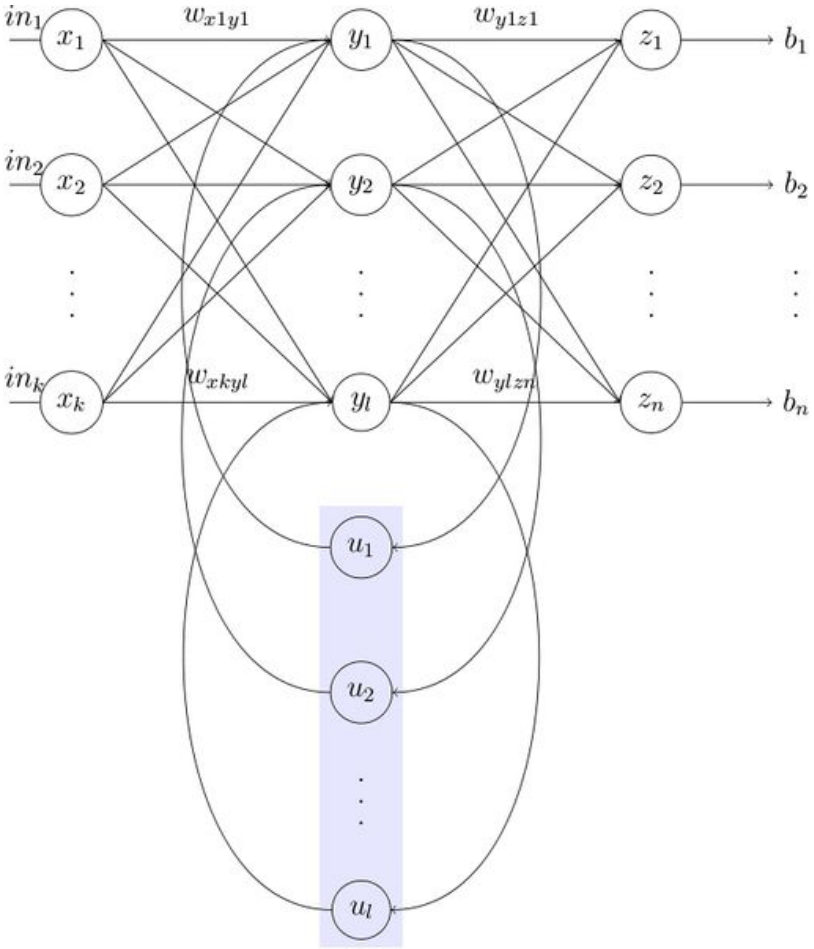


$$a_t = W s_{t-1} + U x_t + b, \qquad s_t = f(a_t),$$
$$o_t = V s_t + b, \qquad y_t = h(o_t).$$

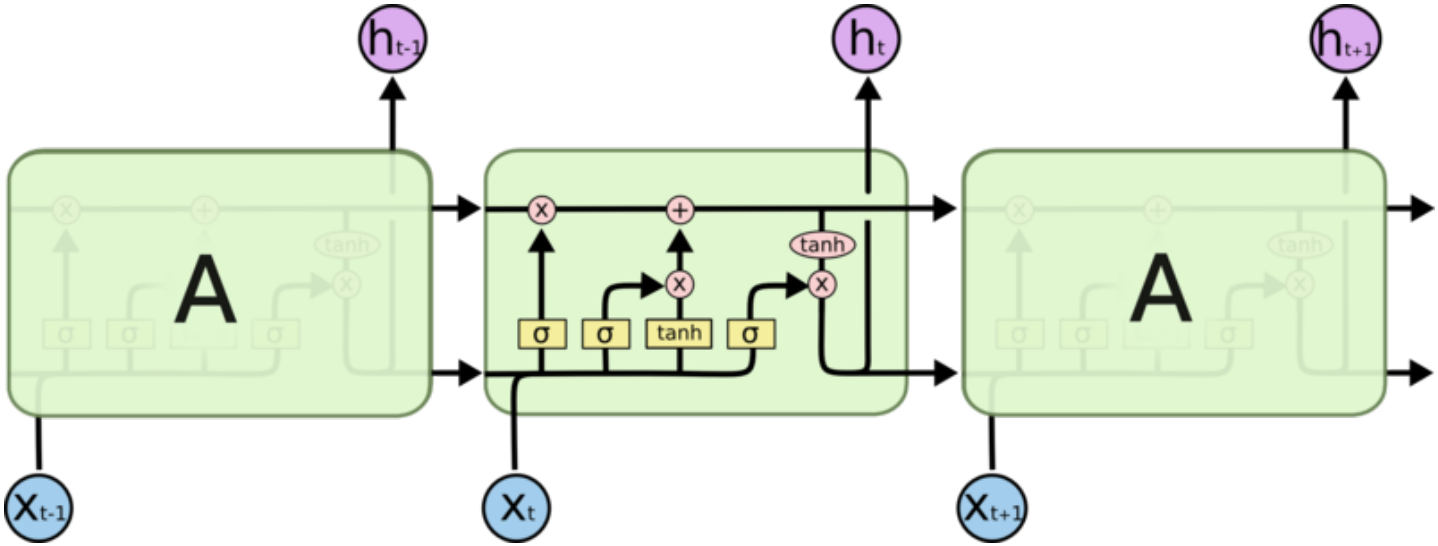
Backpropagation Through Time



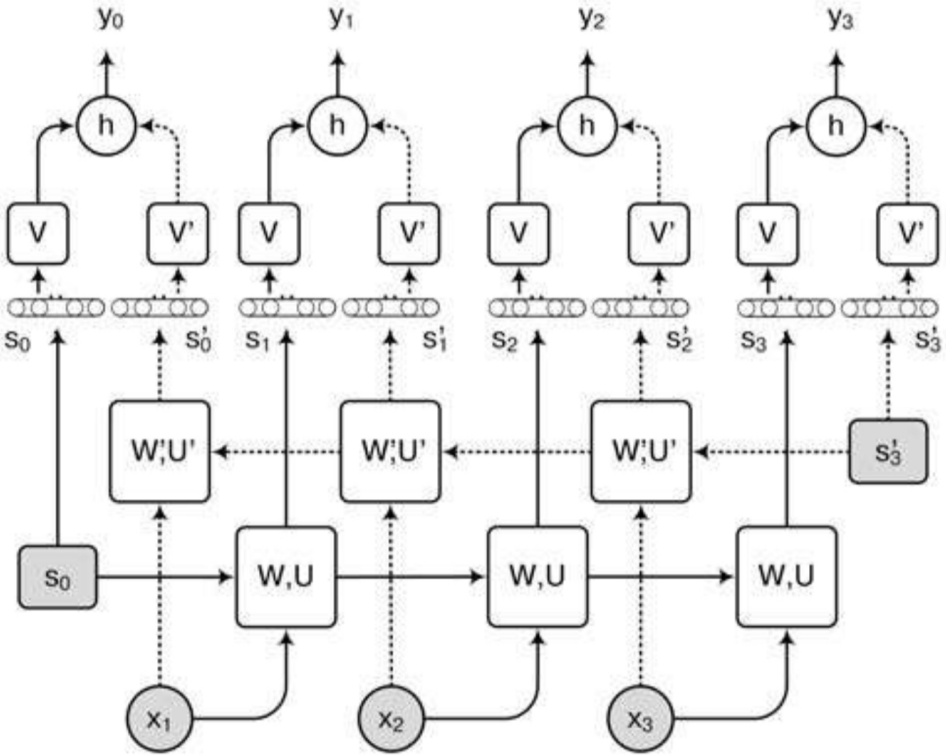
Elman RNN


in_1
x_1
w_{x1y1}
y_1
w_{y1z1}
z_1
b_1
in_2
x_2
y_2
z_2
b_2
in_k
x_k
w_{xkyl}
y_l
w_{ylzn}
z_n
b_n
u_1
u_2
u_l

Long short-term memory (LSTM)



Bidirectional RNN



$$s_t = f(W s_{t-1} + U x_t + b), \qquad s'_t = f(W' s'_{t-1} + U' x_t + b'),$$
$$y_t = h(V s_t + V' s'_t + b).$$