Sequence Models

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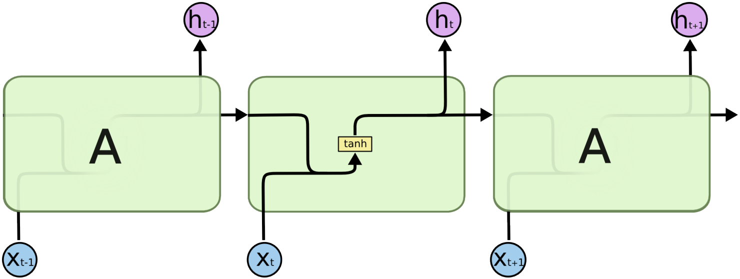
LSTMs

Slides adapted from Christopher Olah

The Model of Laughter and Forgetting

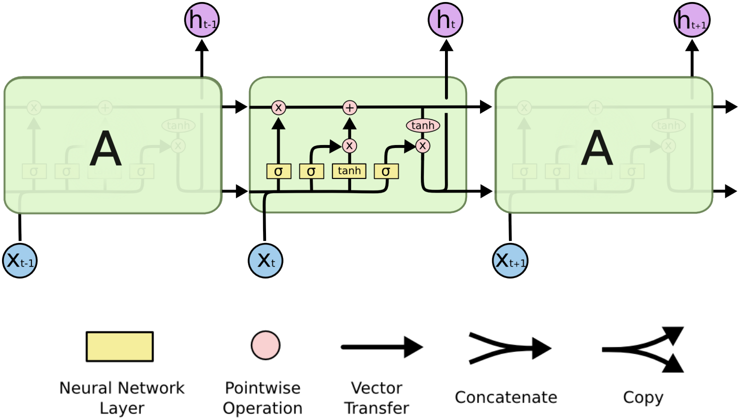
- RNN is great: can remember anything
- RNN stinks: remembers everything
- Sometimes important to forget: LSTM

RNN transforms Input into Hidden

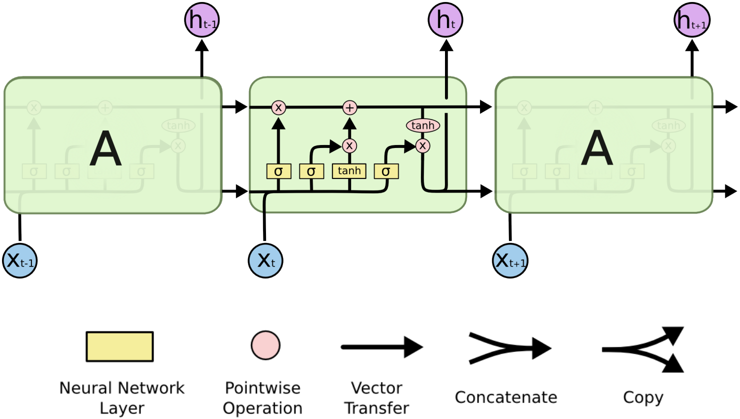


(Can be other nonlinearities)

LSTM has more complicated innards

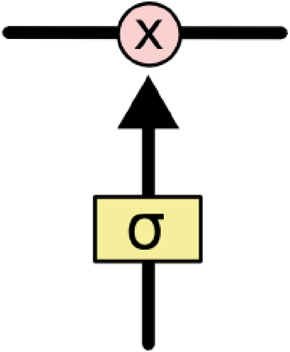


LSTM has more complicated innards



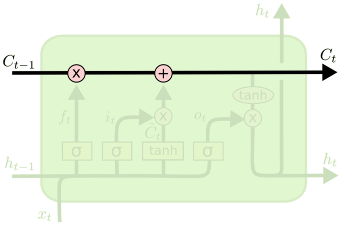
Built on gates!

Gates



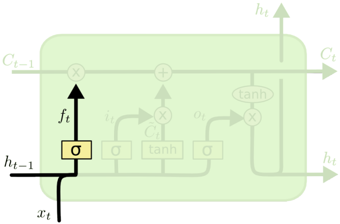
- Multiply vector dimension by value in $[0, 1]$
- Zero means: forget everything
- One means: carry through unchanged
- LSTM has three different gates

Cell State



Can pass through (memory)

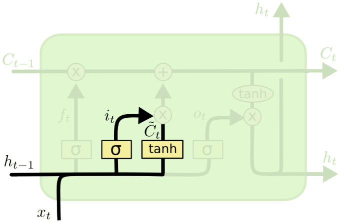
Deciding When to Forget



$$f_t = \sigma\left(W_f \cdot [h_{t-1}, x_t] \; + \; b_f\right)$$

Based on previous hidden state h_{t-1}, can decide to forget past cell state

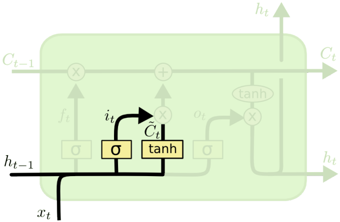
Updating representation



$$i_t = \sigma\left(W_i \cdot [h_{t-1}, x_t] \ + \ b_i\right)$$
$$\tilde{C}_t = \tanh(W_C \cdot [h_{t-1}, x_t] \ + \ b_C)$$

Compute new contribution to cell state based on hidden state h_{t-1} and input x_t

Updating representation



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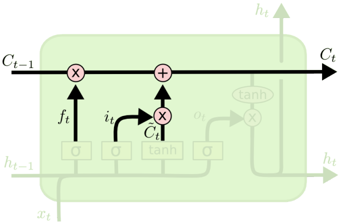
Compute new contribution to cell state based on hidden state h_{t-1} and input x_t. Strength of contribution is i_t

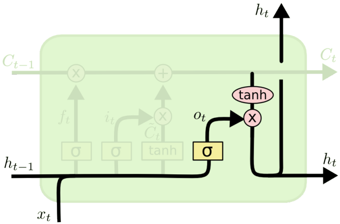
Updating representation



$$C_t = f_t * C_{t-1} + i_t * \tilde{C}_t$$

Interpolate new cell value

Output hidden



$$o_t = \sigma\left(W_o \ [h_{t-1}, x_t] \ + \ b_o\right)$$

$$h_t = o_t * \tanh\left(C_t\right)$$

Hidden layer is function of cell C_t, not h_{t-1}

Why are we still talking about LSTM?

- Historically important
- ELMO: first LLM, used LSTM

Why are we still talking about LSTM?

- Historically important
- ELMO: first LLM, used LSTM
- But not really used much any more…
- So know it exists and how it deals with long-range dependencies at a high level
- **Do not** memorize equations