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# Recurrent Neural Networks

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LSTM (long short  
term memory) unit

# GRU and LSTM

## GRU

$$\underline{\tilde{c}^{<t>}} = \tanh(W_c[\underline{\Gamma_r} * \underline{c^{<t-1>}}, x^{<t>}] + b_c)$$

$$\underline{\Gamma_u} = \sigma(W_u[\underline{c^{<t-1>}}, x^{<t>}] + b_u)$$

$$\underline{\Gamma_r} = \sigma(W_r[\underline{c^{<t-1>}}, x^{<t>}] + b_r)$$

$$\underline{c^{<t>}} = \underline{\Gamma_u} * \underline{\tilde{c}^{<t>}} + \underline{(1 - \Gamma_u)} * \underline{c^{<t-1>}}$$

$\underline{a^{<t>}} = \underline{c^{<t>}}$

$\uparrow$   
 $\Gamma_f$

## LSTM

$$\underline{\tilde{c}^{<t>}} = \tanh(W_c[a^{<t-1>}, x^{<t>}] + b_c)$$

(update)  $\Gamma_u = \sigma(W_u[a^{<t-1>}, x^{<t>}] + b_u)$

(forget)  $\Gamma_f = \sigma(W_f[a^{<t-1>}, x^{<t>}] + b_f)$

(output)  $\Gamma_o = \sigma(W_o[a^{<t-1>}, x^{<t>}] + b_o)$

$$\underline{c^{<t>}} = \underline{\Gamma_u} * \underline{\tilde{c}^{<t>}} + \underline{\Gamma_f} * \underline{c^{<t-1>}}$$

$$\underline{a^{<t>}} = \underline{\Gamma_o} * \underline{c^{<t>}}$$

# LSTM in pictures

$$\tilde{c}^{<t>} = \tanh(W_c[a^{<t-1>}, x^{<t>}] + b_c)$$

$$\Gamma_u = \sigma(W_u[a^{<t-1>}, x^{<t>}] + b_u)$$

$$\Gamma_f = \sigma(W_f[a^{<t-1>}, x^{<t>}] + b_f)$$

$$\Gamma_o = \sigma(W_o[a^{<t-1>}, x^{<t>}] + b_o)$$

$$c^{<t>} = \Gamma_u * \tilde{c}^{<t>} + \Gamma_f * c^{<t-1>}$$

$$a^{<t>} = \Gamma_o * c^{<t>}$$

peephole  
connection

