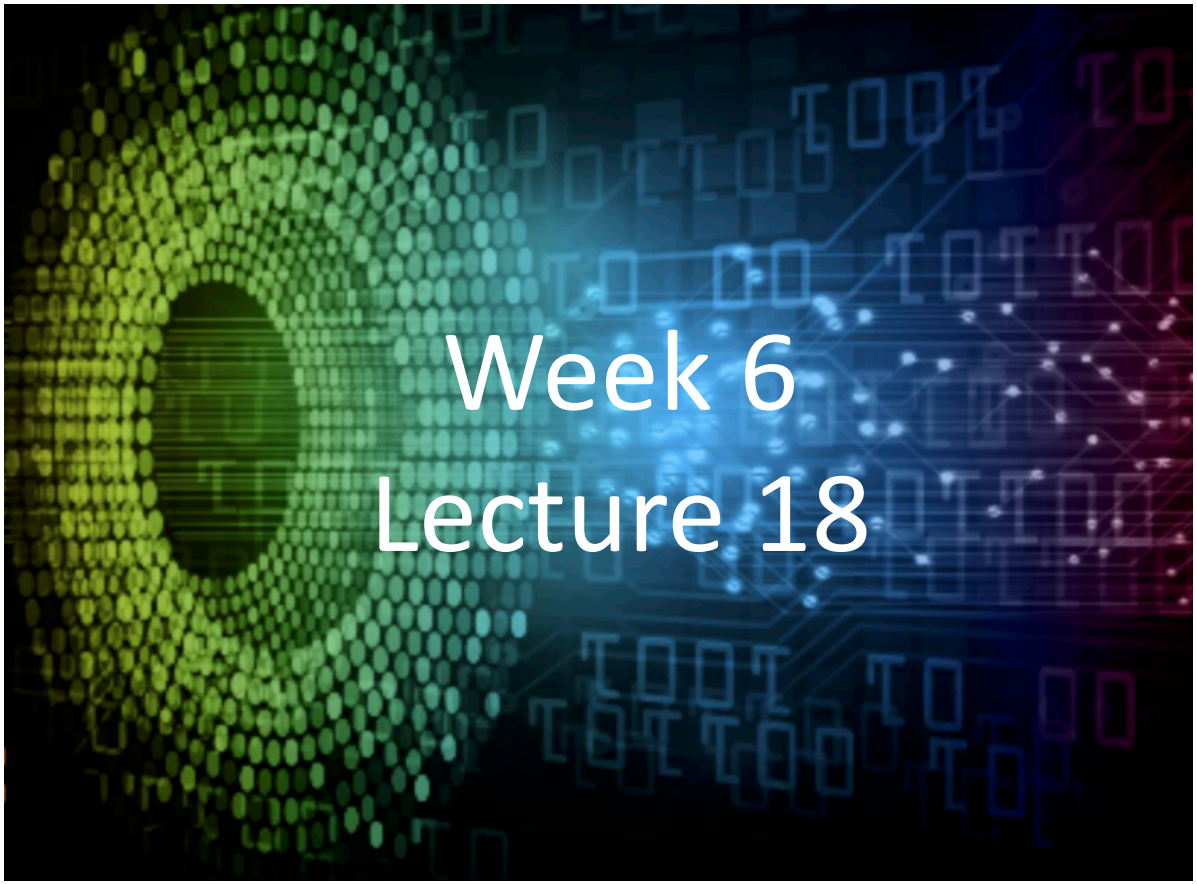
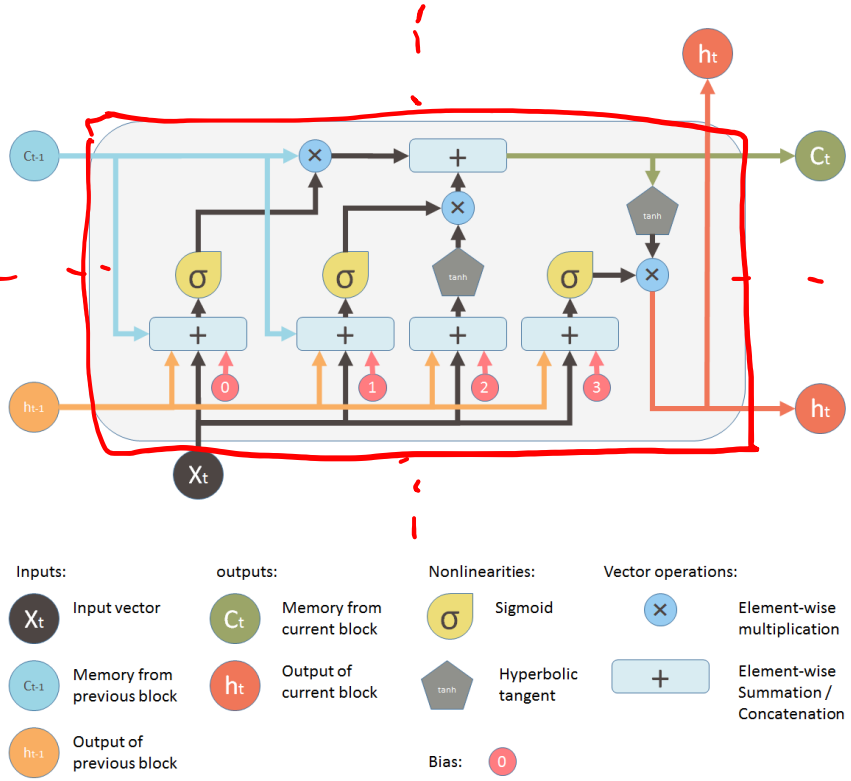
Introduction to Deep Learning
Applications and Theory



ECE 596 / AMATH 563

Previous Lecture: Recurrent Neural Networks (RNNs)

- Diminishing/ Exploding Gradients
- Gated RNNs
  - GRU
  - LSTM



This Lecture: Architectures of RNN Blocks

- Bi-Directional RNN
- Deep RNN
- Encoder / Decoder RNN
- Sequence to Sequence
- Attention

LSTM

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

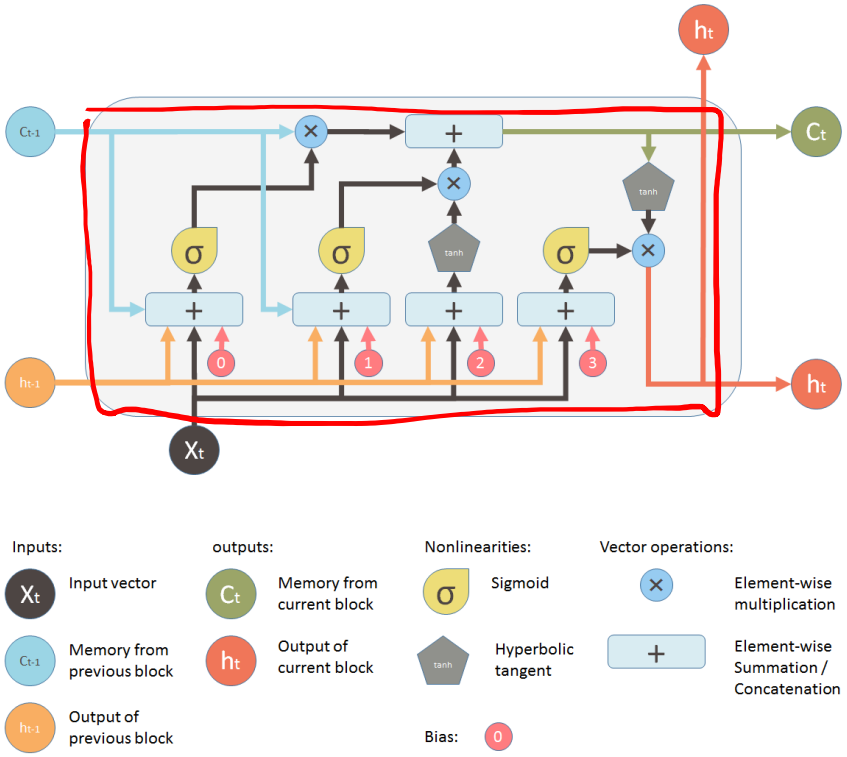
$$\Gamma_u = \sigma(W_u[a^{<t-1>}; x^{<t>}] + b_u)$$

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

$$\Gamma_o = \sigma(W_o[a^{<t-1>}; x^{<t>}] + b_0)$$

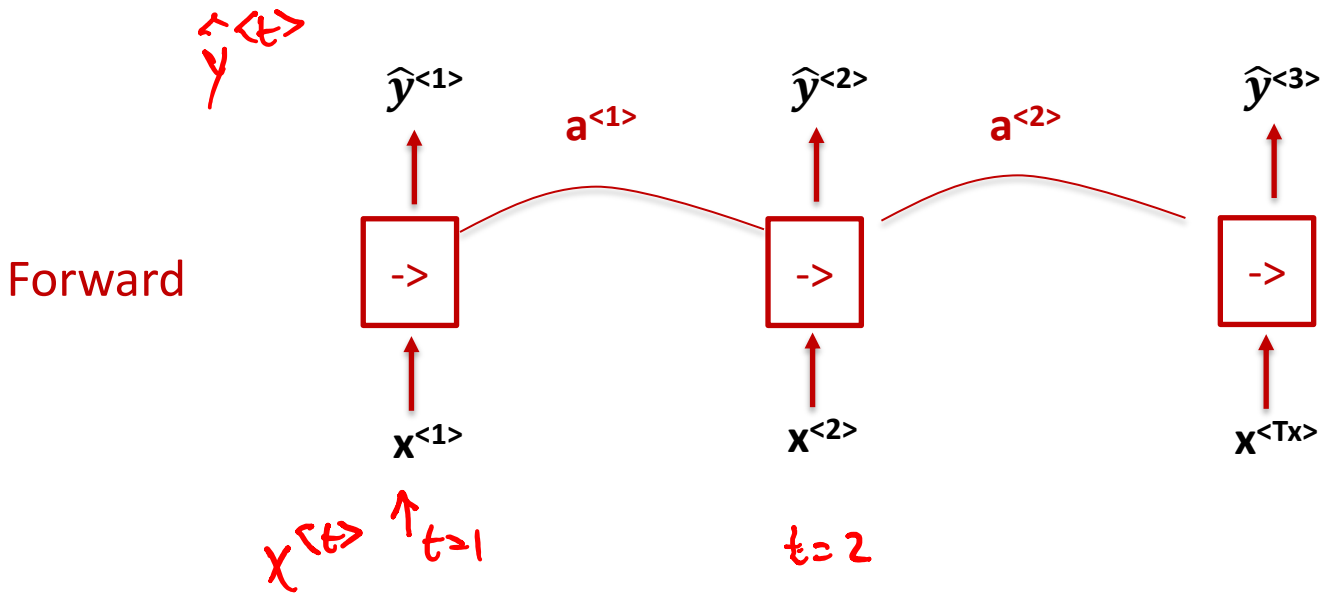
$$c^{<t>} = \Gamma_u \tilde{c}^{<t>} + \Gamma_f c^{<t-1>}$$

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



Hochreiter, S., & Schmidhuber, J. (1997). Long short-term memory. *Neural computation*, *9*(8), 1735-1780.

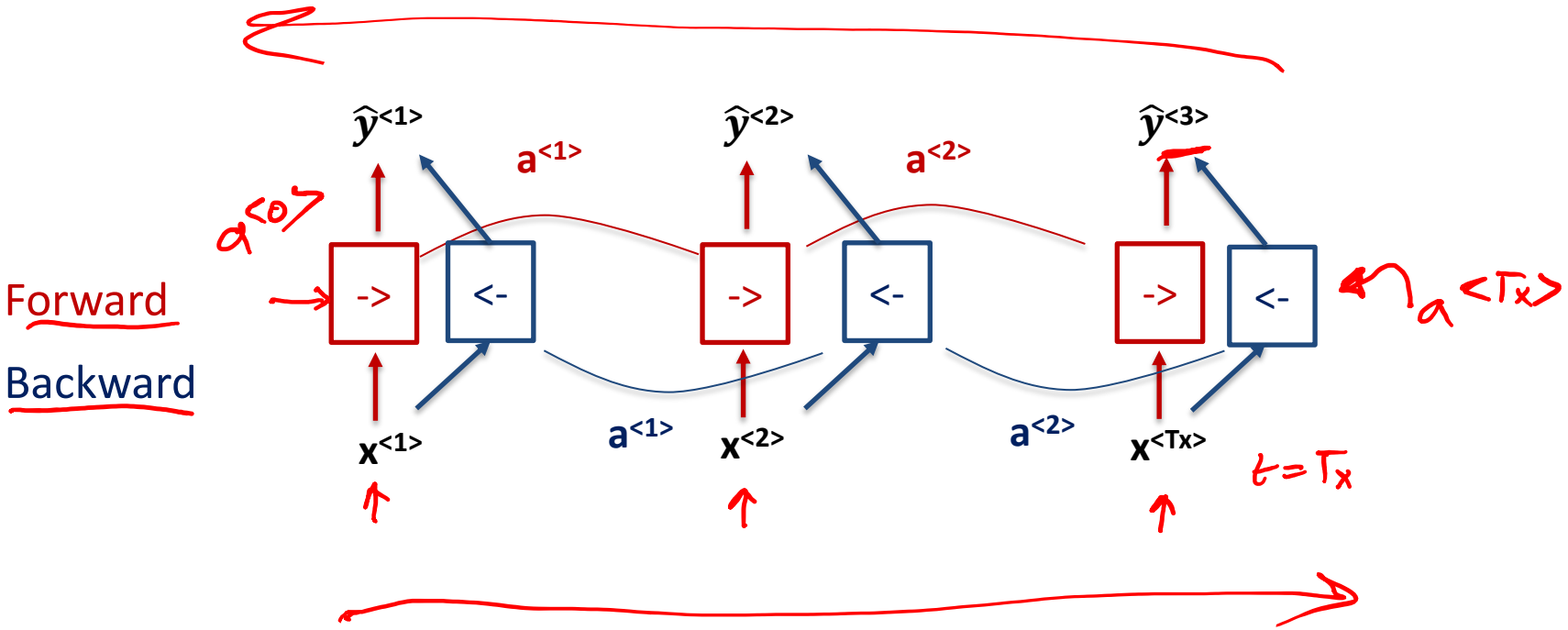
Bi-Directional RNN



He said, Tesla is a unit of magnetic field strength

He said, Tesla is an electric automotive and sustainable energy company

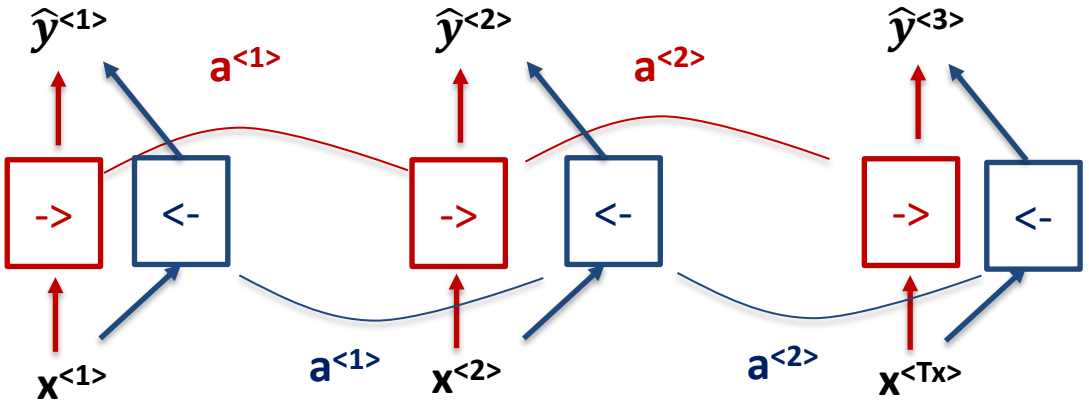
Bi-Directional RNN



Bi-Directional RNN

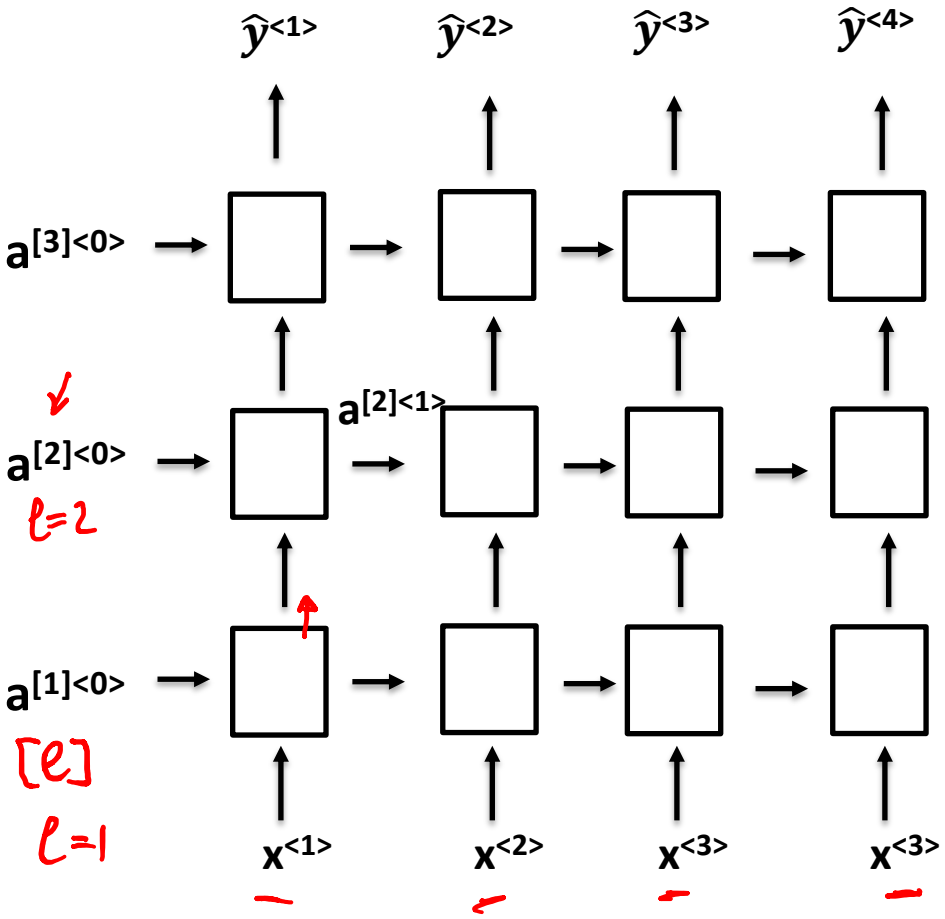
Forward

Backward

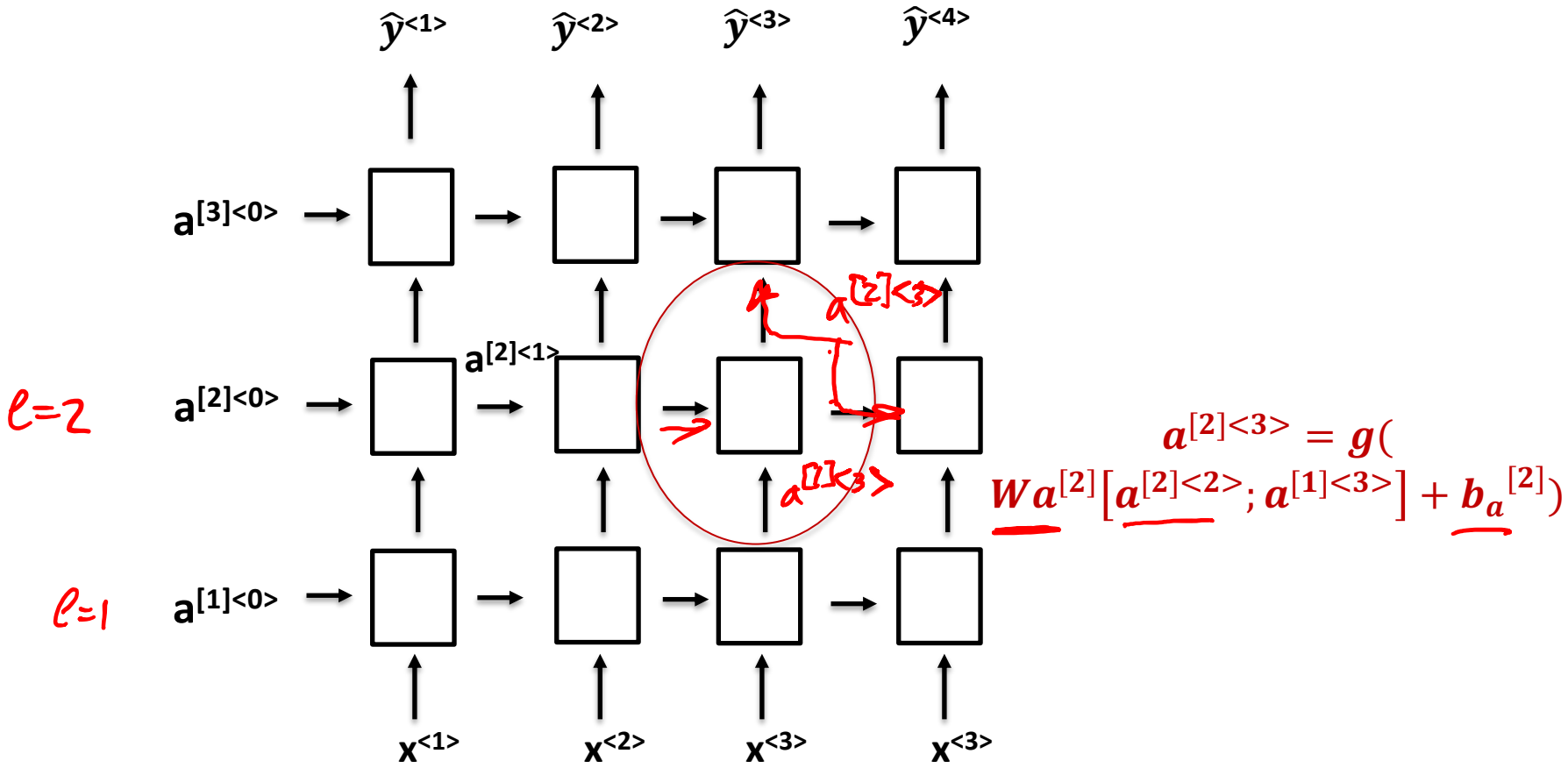


$$\hat{y}^{<t>} = g(Wy\,[a^{F<t>}; a^{B<t>}] + by)$$

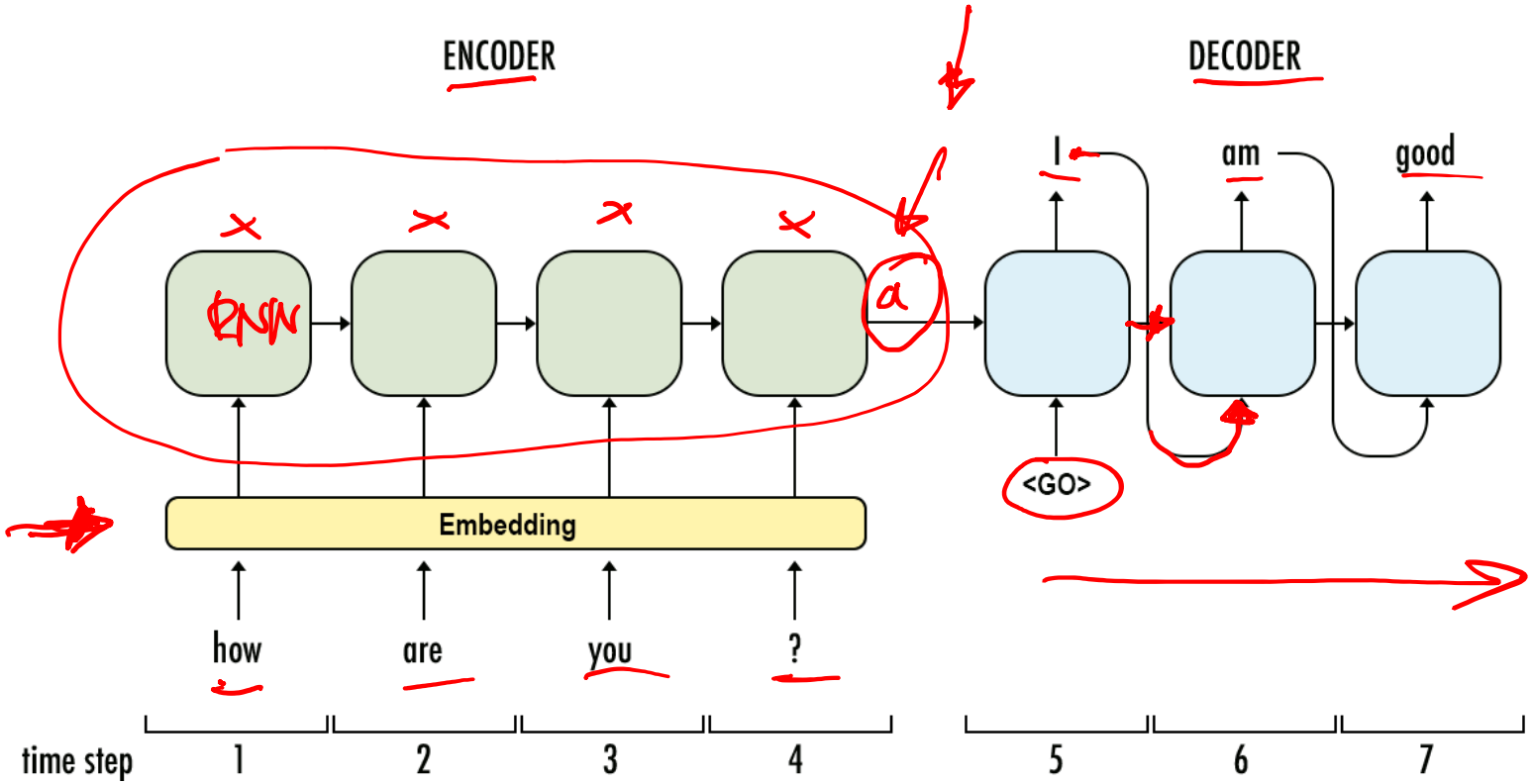
Deep RNN



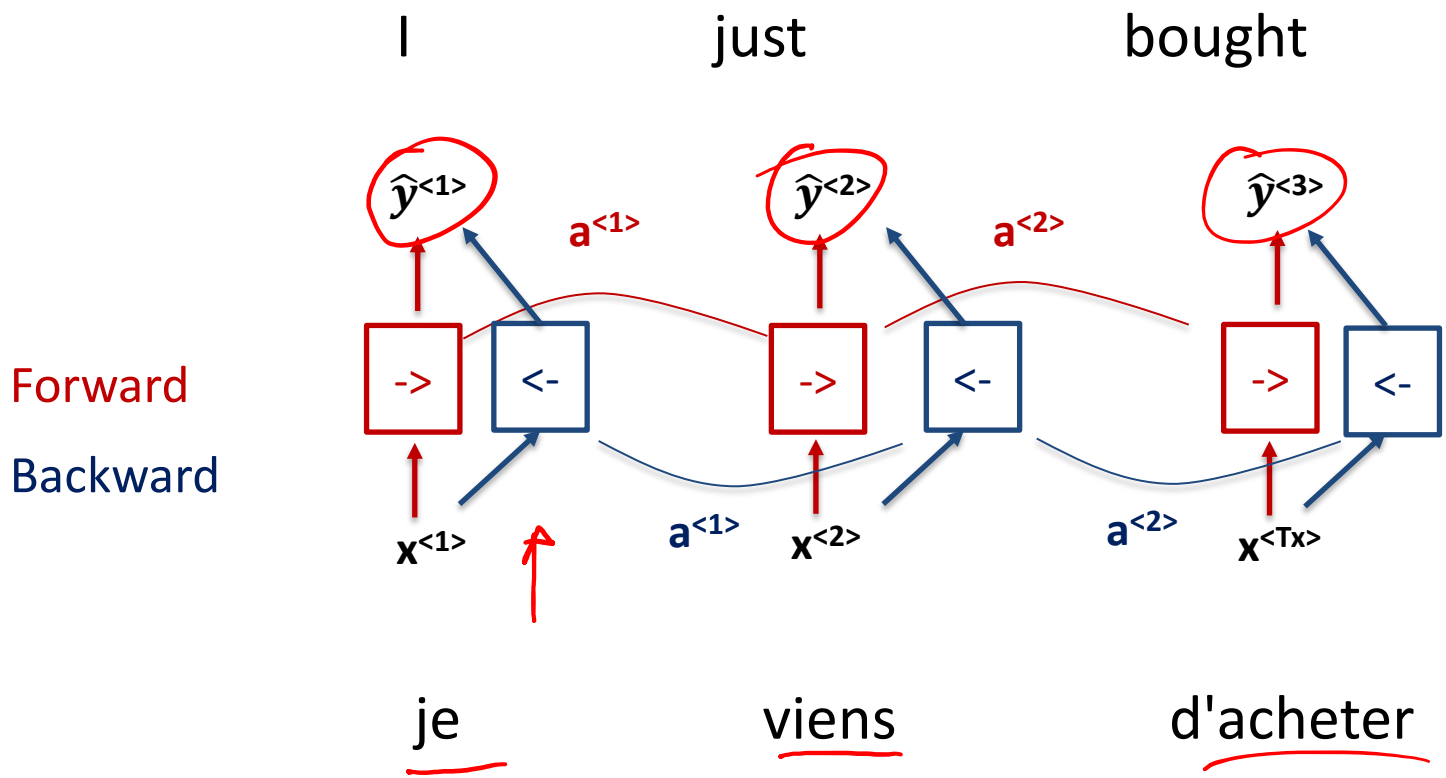
Deep RNN


$\hat{y}^{<1>}$
$\hat{y}^{<2>}$
$\hat{y}^{<3>}$
$\hat{y}^{<4>}$
$a^{[3]<0>}$
$a^{[2]<0>}$
$a^{[2]<1>}$
$a^{[1]<0>}$
$x^{<1>}$
$x^{<2>}$
$x^{<3>}$
$x^{<3>}$
$a^{[2]<3>}$
$a^{[1]<3>}$
$\ell=2$
$\ell=1$
$a^{[2]<3>} = g(W a^{[2]}[a^{[2]<2>}; a^{[1]<3>}] + b_a{}^{[2]})$

Seq2Seq – Encoder Decoder

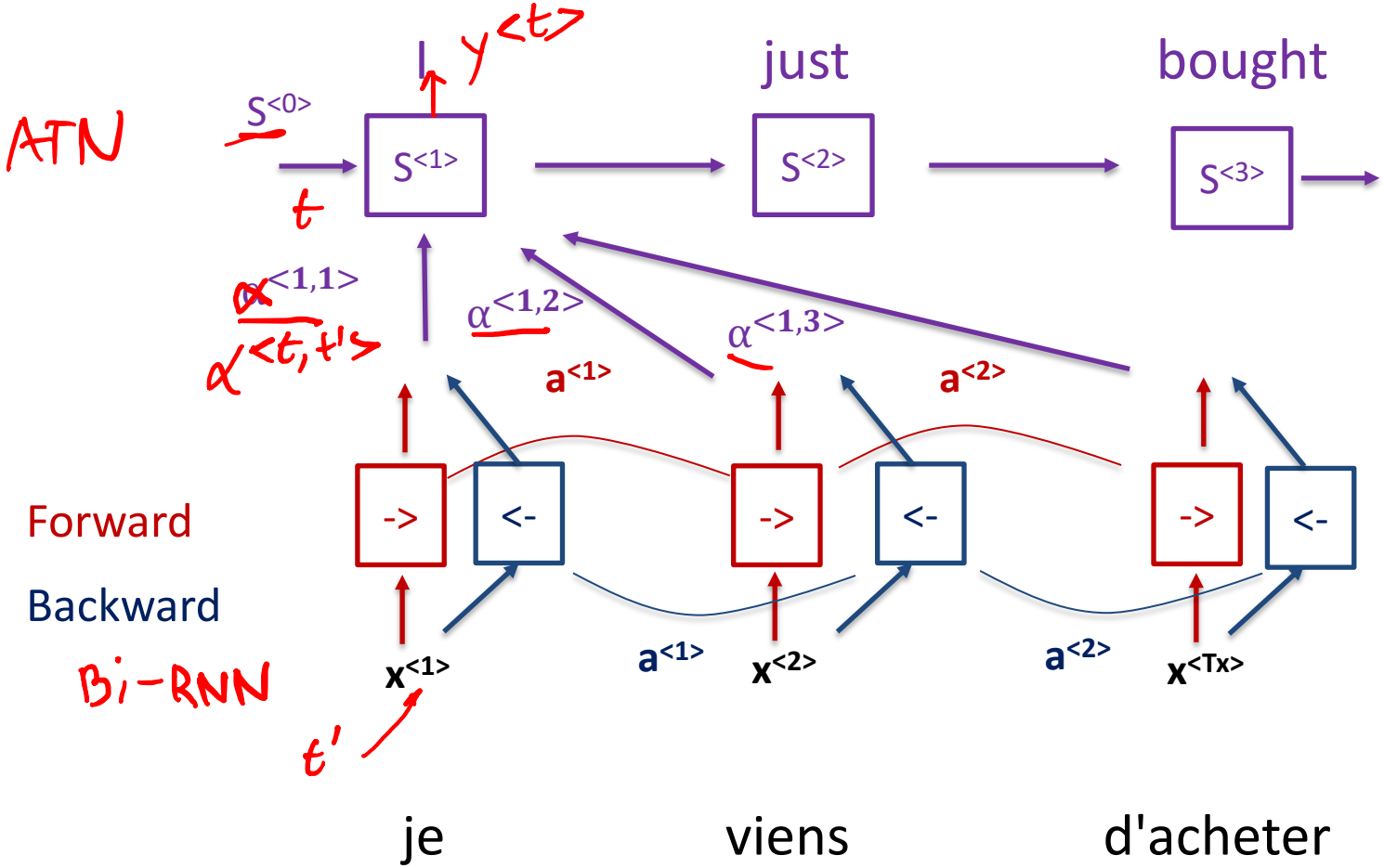


Attention Model



Bahdanau et al. "Neural machine translation by jointly learning to align and translate." (2014).

Attention Model



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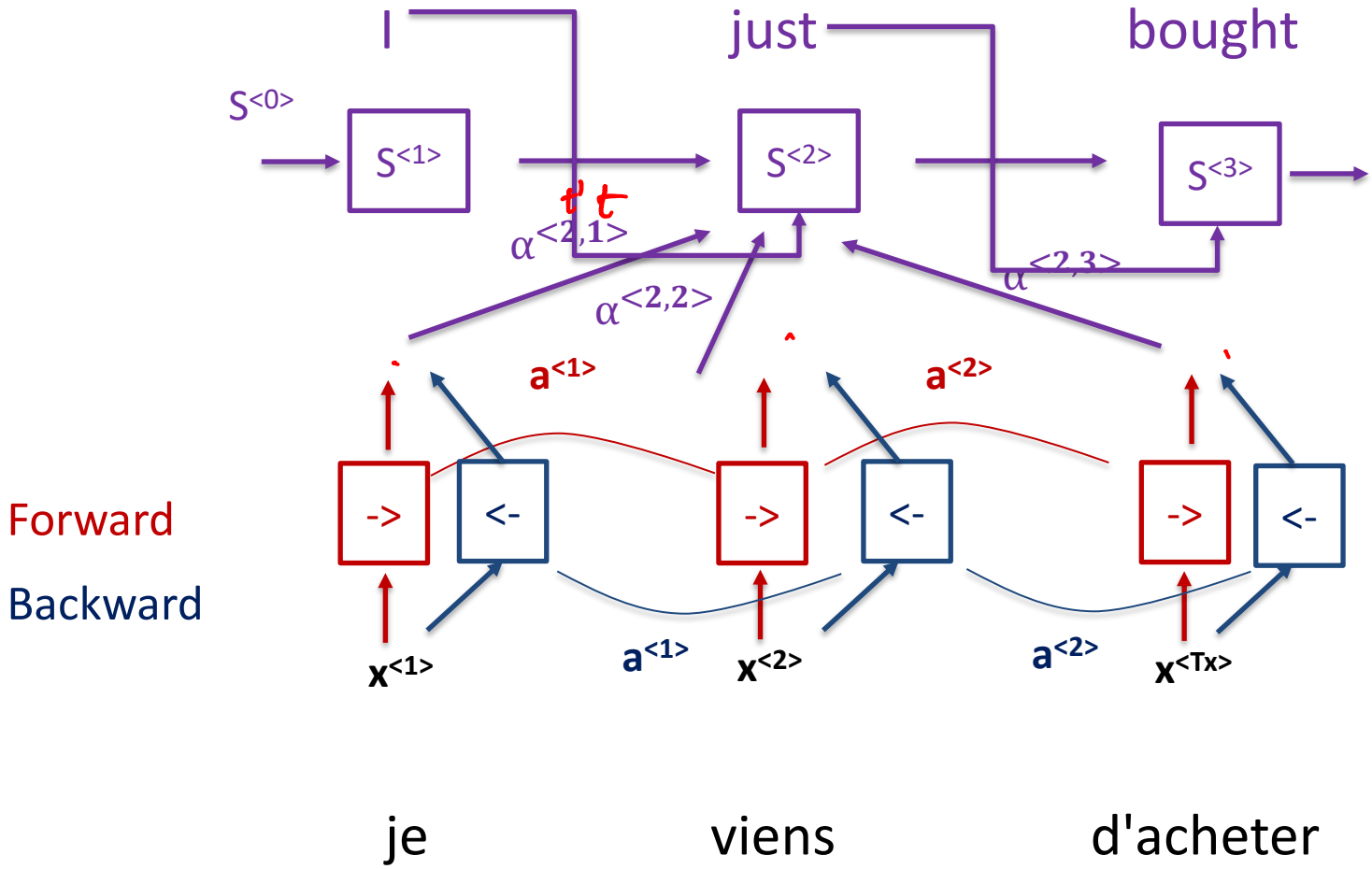
Attention Model



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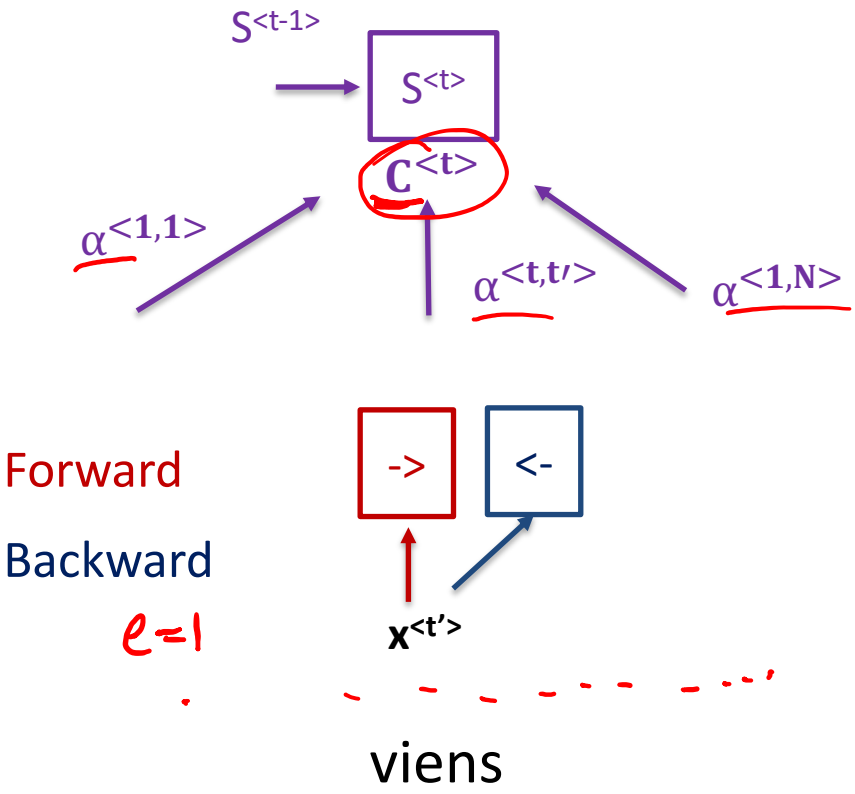
Attention Model



$$C^{<t>} = \sum_{t'} \alpha^{<t,t'>} a^{<t'>}$$

FC

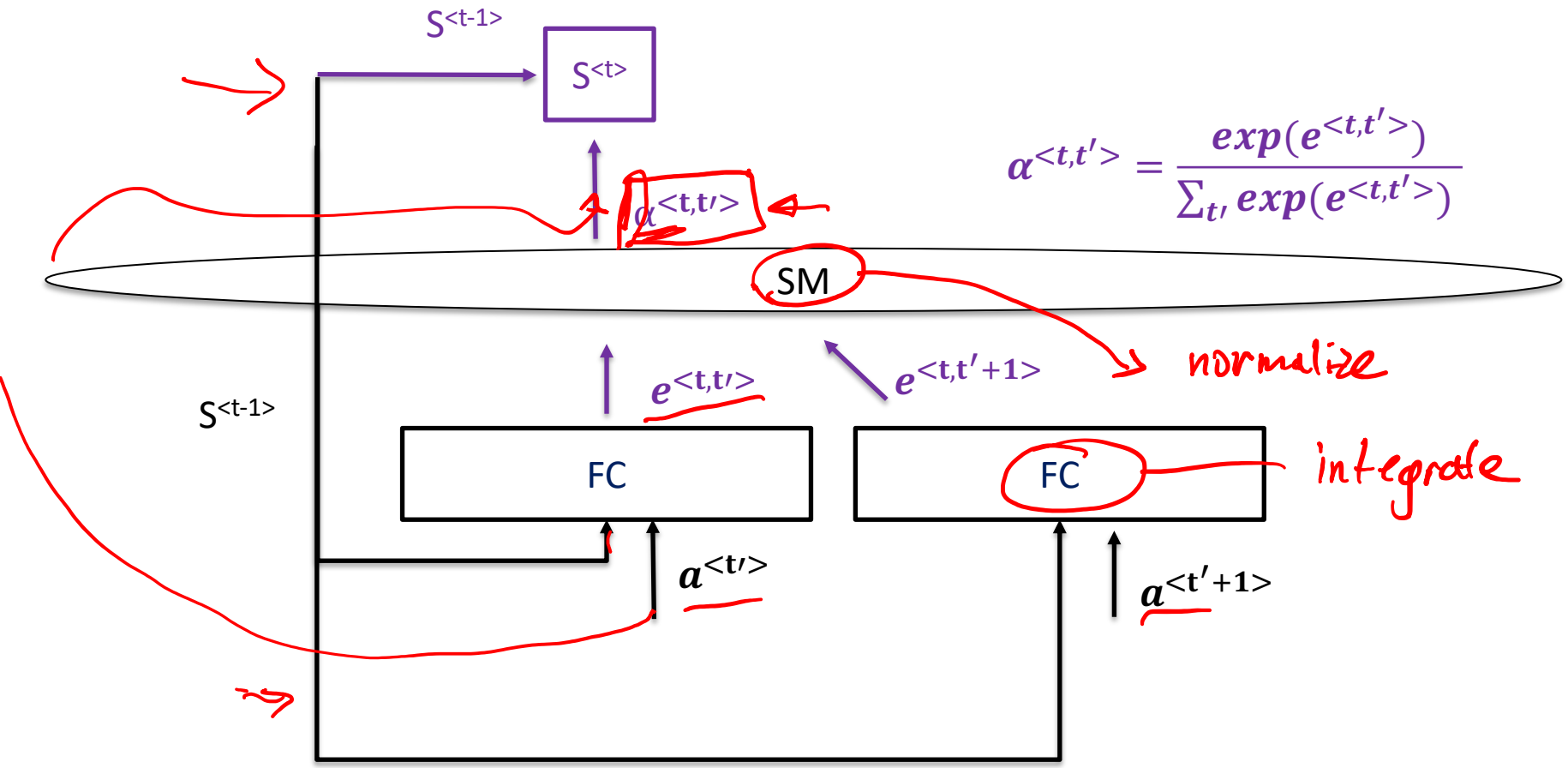
$$\sum_{t'} \alpha^{<t,t'>} = 1$$

SM

$$a^{<t'>} = (a^{<t'>}, a^{<t'>})$$

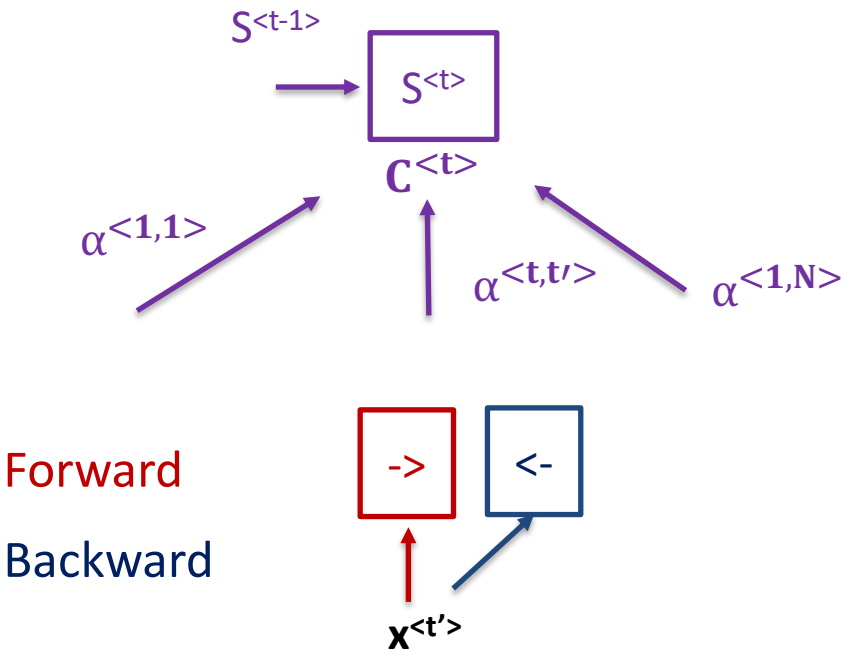
Bahdanau et al. "Neural machine translation by jointly learning to align and translate." (2014).

Attention Model



$$\alpha^{<t,t'>} = \frac{exp(e^{<t,t'>})}{\sum_{t'} exp(e^{<t,t'>})}$$

Attention Model



$$C^{<t>} = \sum_{t'} \alpha^{<t,t'>} a^{<t'>}$$

$$\sum_{t'} \alpha^{<t,t'>} = 1$$

$$a^{<t'>} = (a^{<t'>}, a^{<t'>})$$

Bahdanau et al. "Neural machine translation by jointly learning to align and translate." (2014).