

Deep Learning Basics

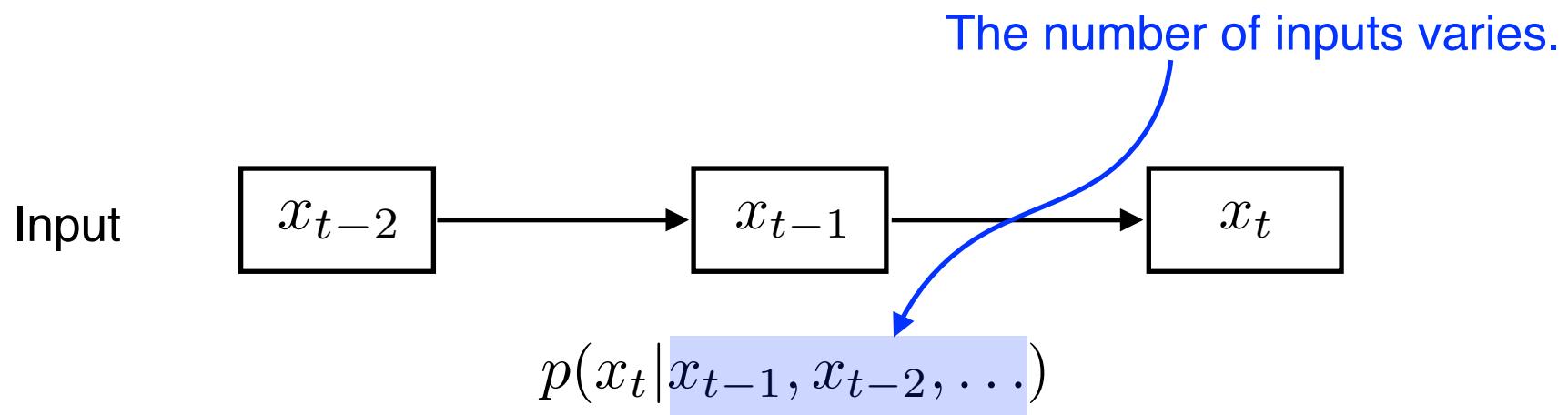
Lecture7 : Recurrent Neural Networks

최성준 (고려대학교 인공지능학과)

Sequential Model

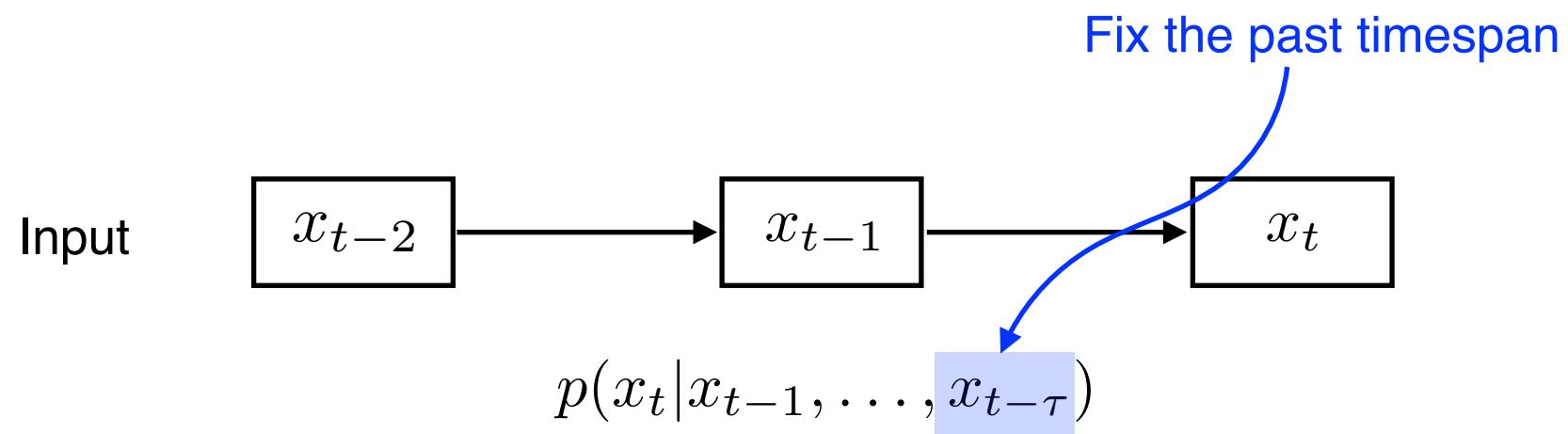
Sequential Model

- Naive sequence model



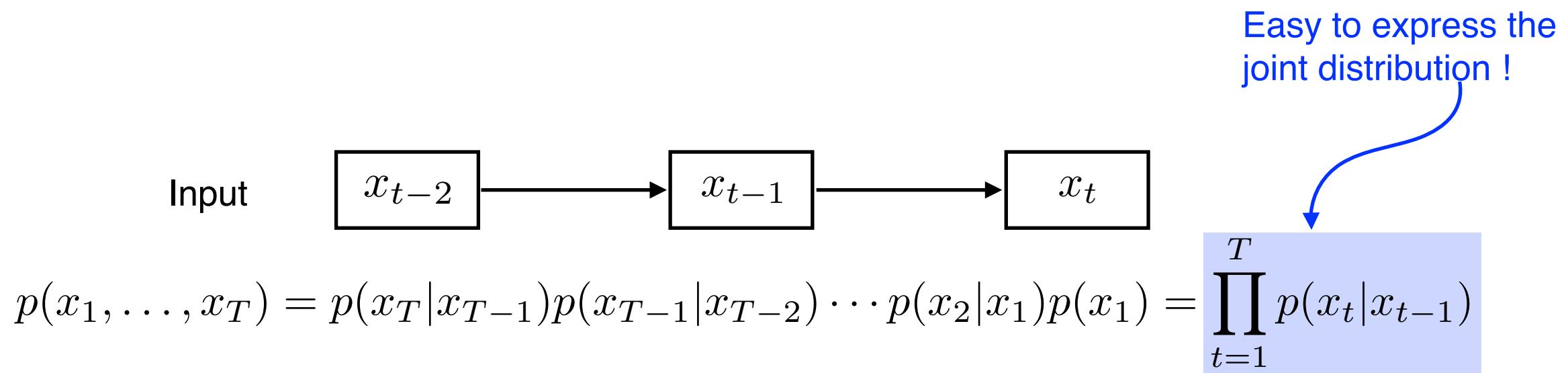
Sequential Model

- Autoregressive model



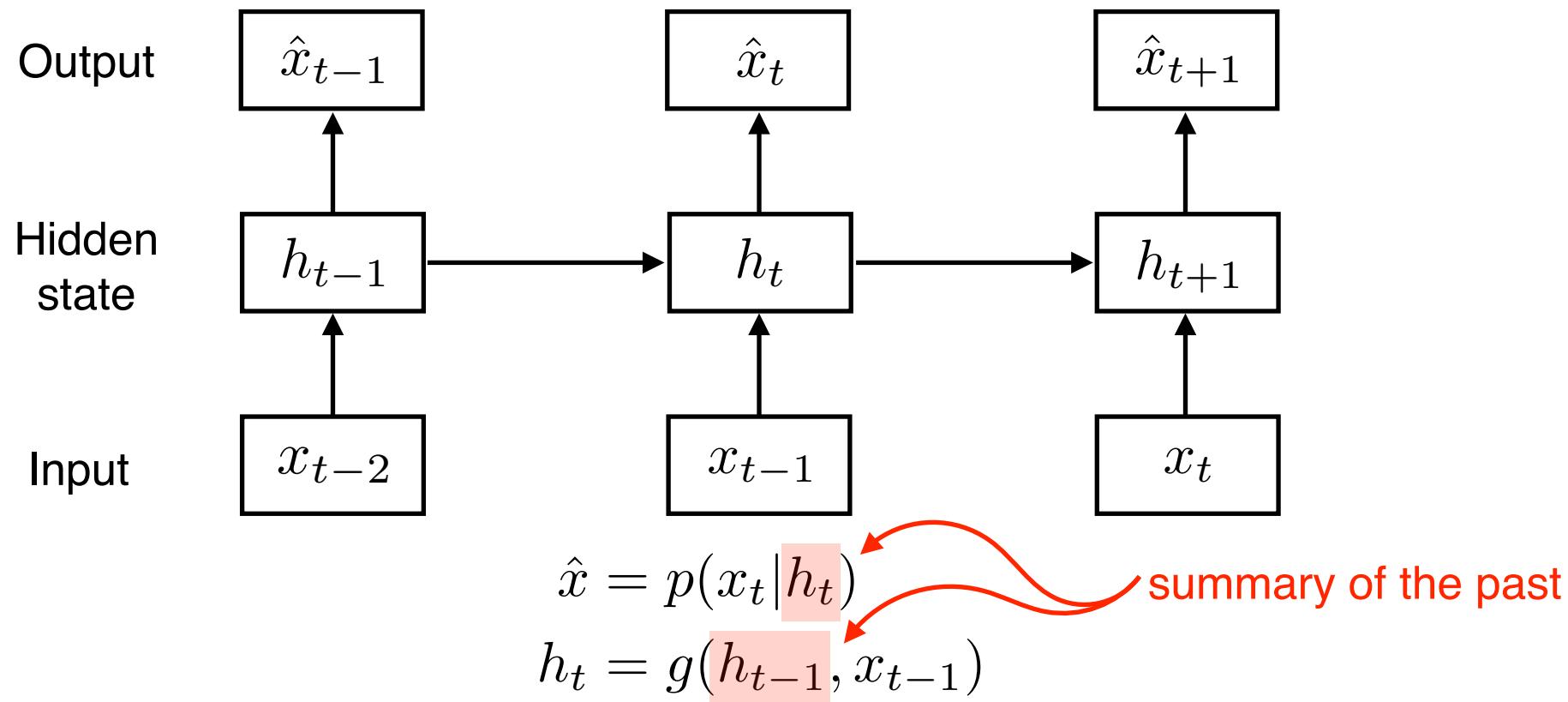
Sequential Model

- Markov model (first-order autoregressive model)



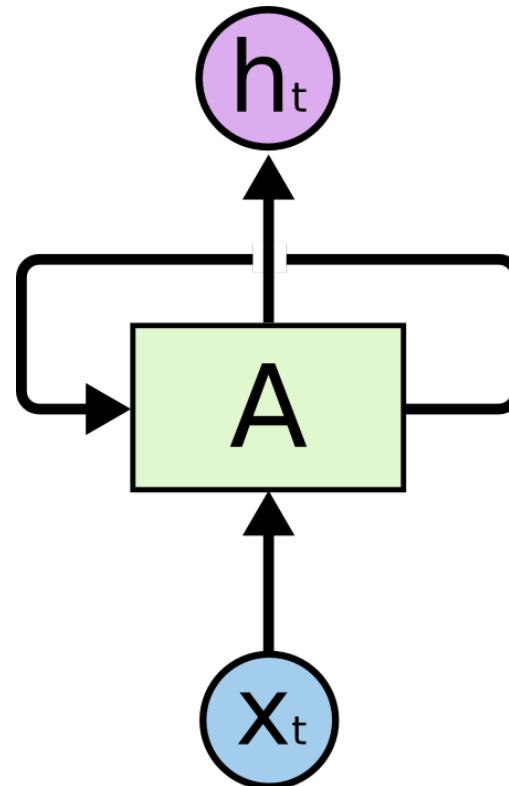
Sequential Model

- Latent autoregressive model



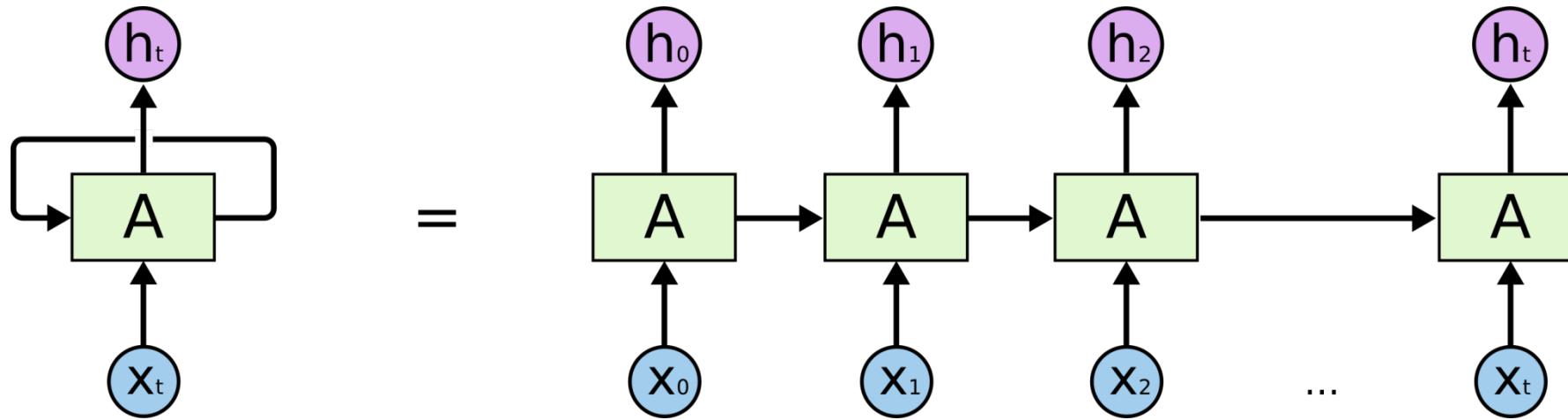
Recurrent Neural Network

Recurrent Neural Network



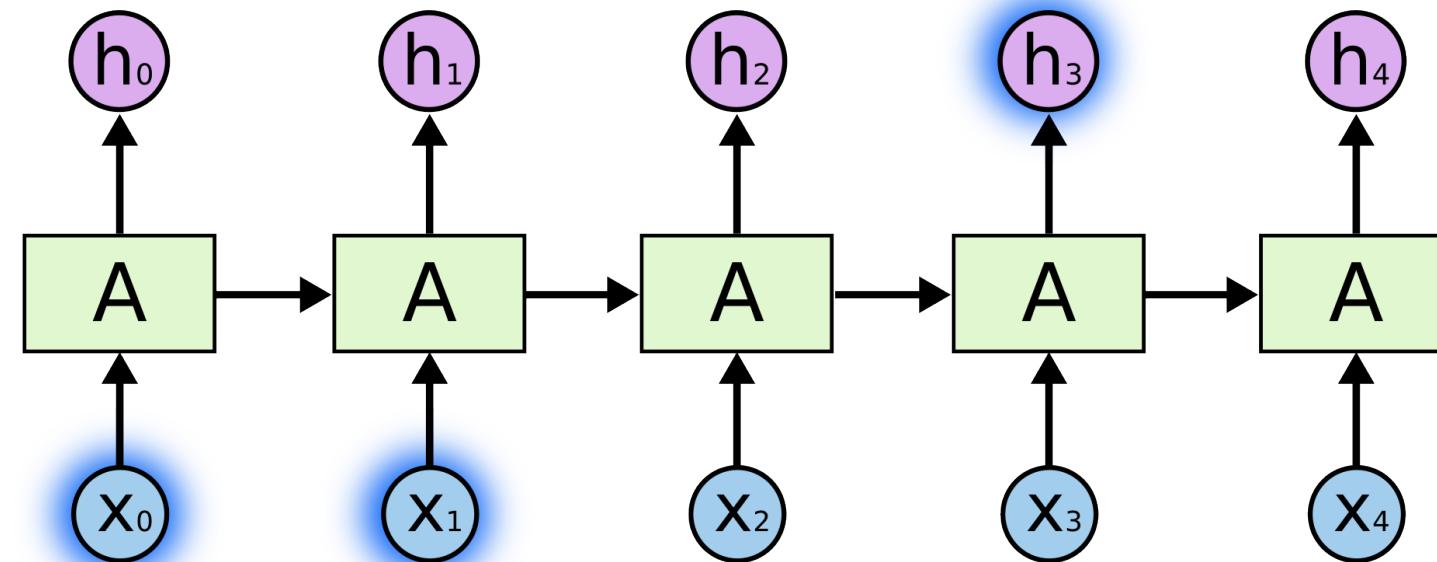
C. Olah

Recurrent Neural Network



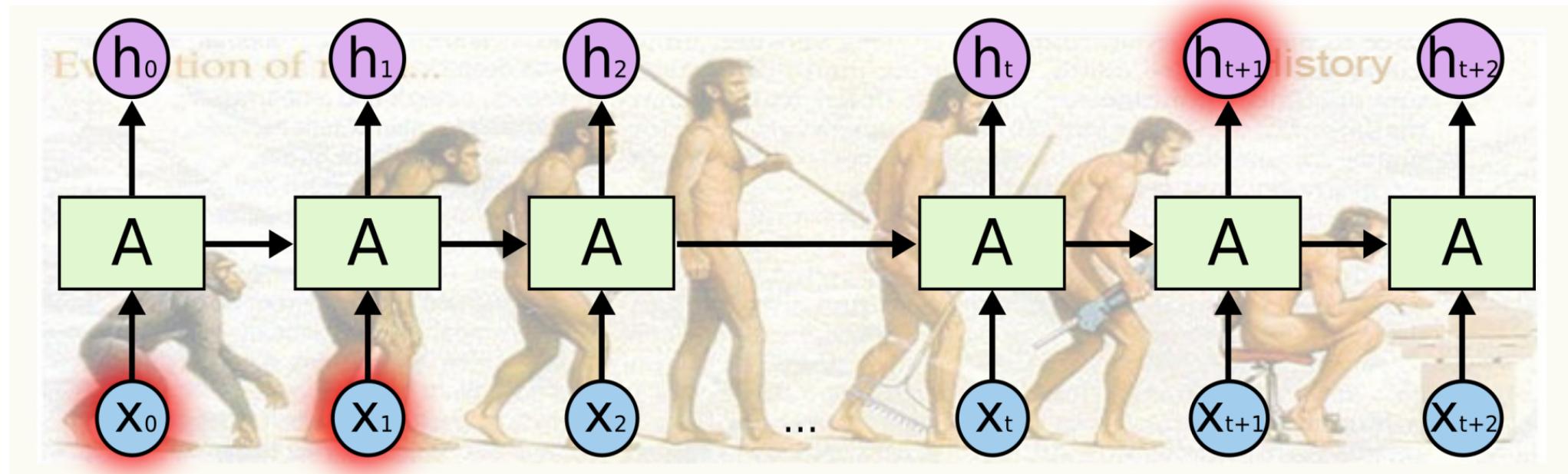
Recurrent Neural Network

- Short-term dependencies

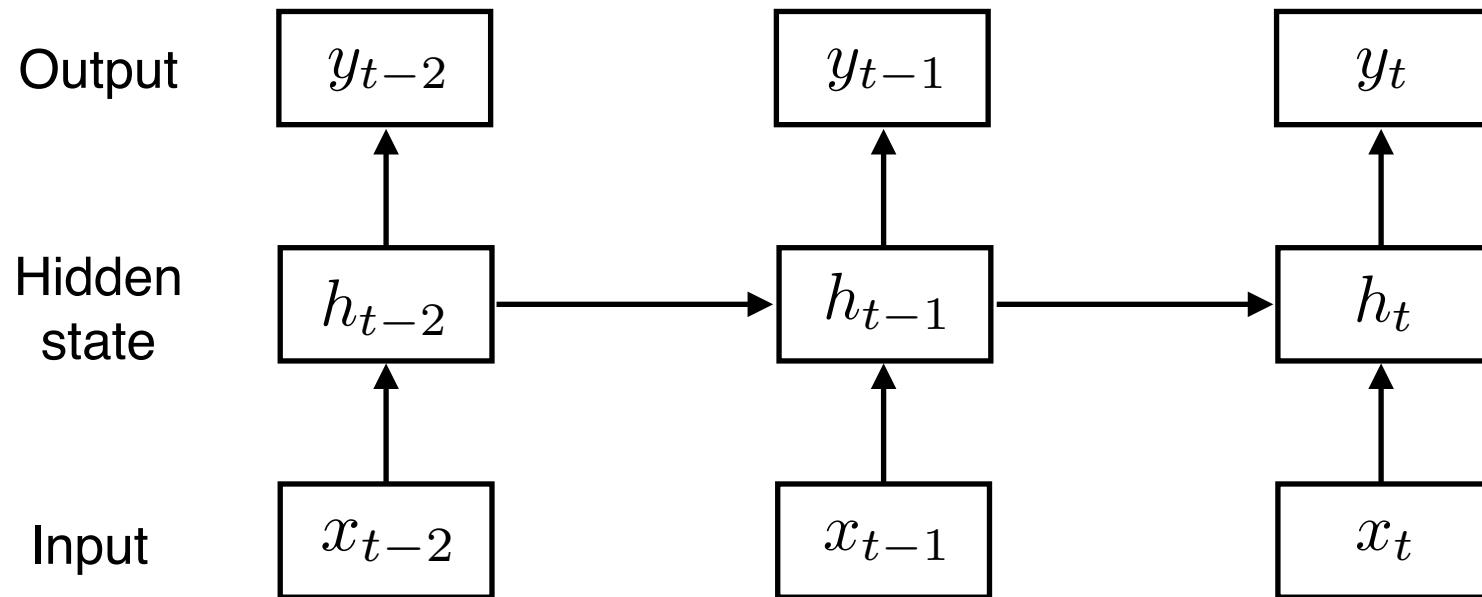


Recurrent Neural Network

- **Long-term dependencies**



Recurrent Neural Network



$$h_1 = \phi(W^T h_0 + U^T x_1)$$

$$h_2 = \phi(W^T \phi(W^T h_0 + U^T x_1) + U^T x_2)$$

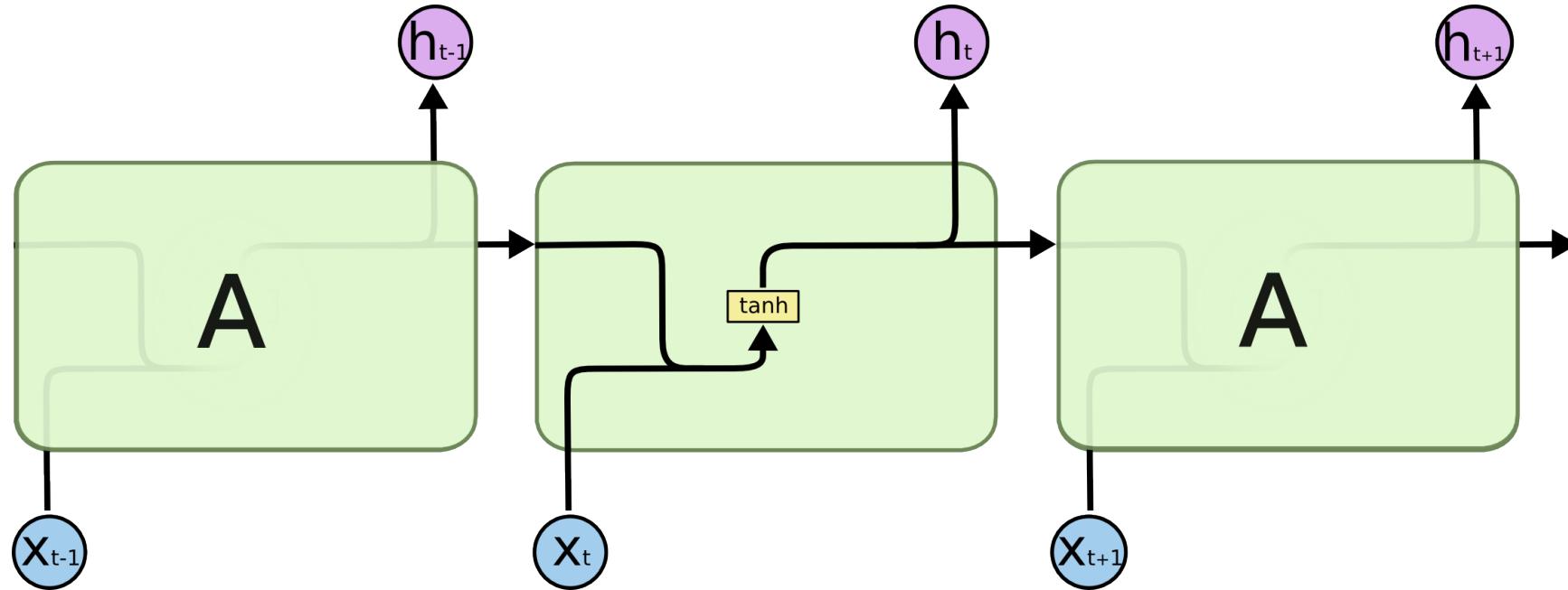
$$h_3 = \phi(W^T \phi(W^T \phi(W^T h_0 + U^T x_1) + U^T x_2) + U^T x_3)$$

$$h_4 = \phi(W^T \phi(W^T \phi(W^T \phi(W^T h_0 + U^T x_1) + U^T x_2) + U^T x_3) + U^T x_4)$$

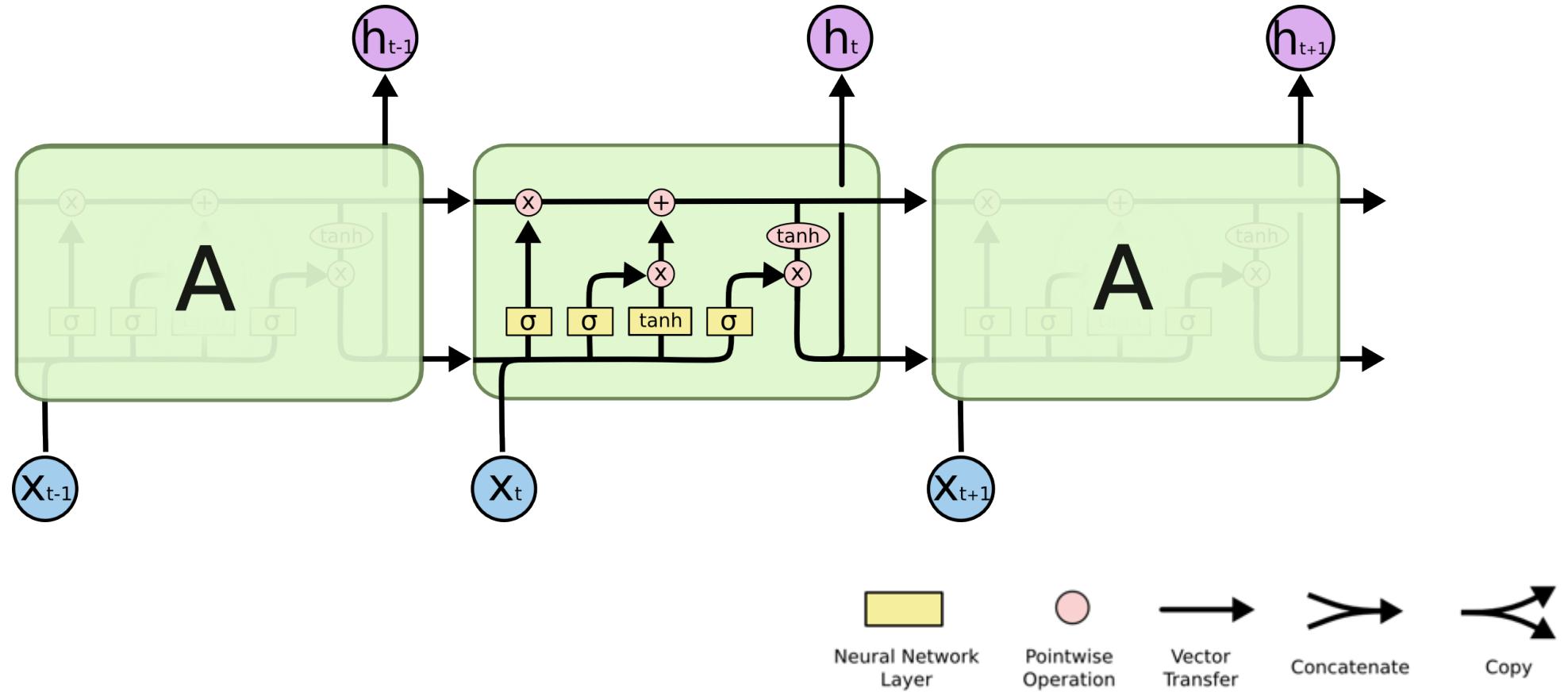
Vanishing / exploding gradient

Long Short Term Memory

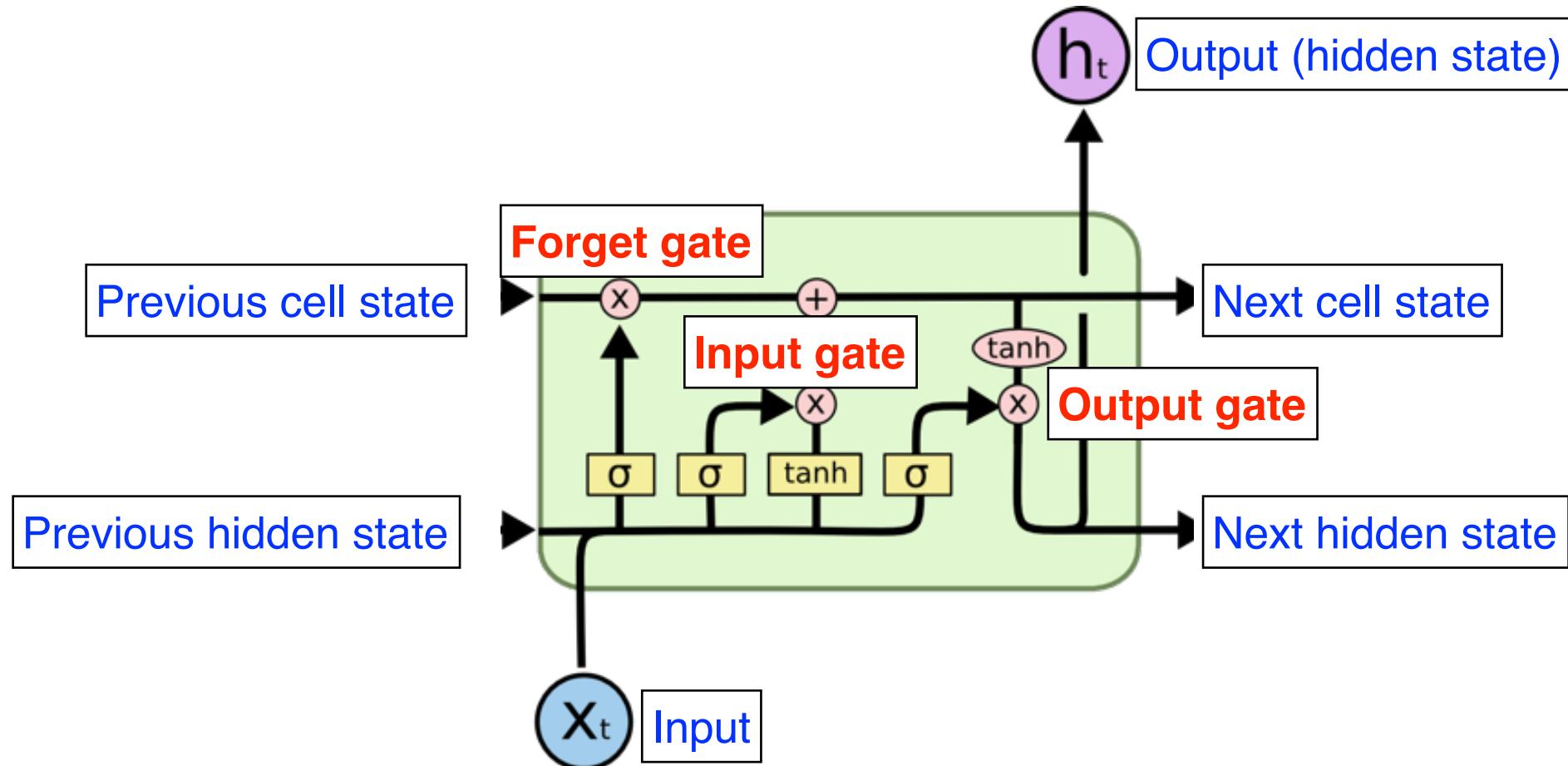
Recurrent Neural Network



Long Short Term Memory

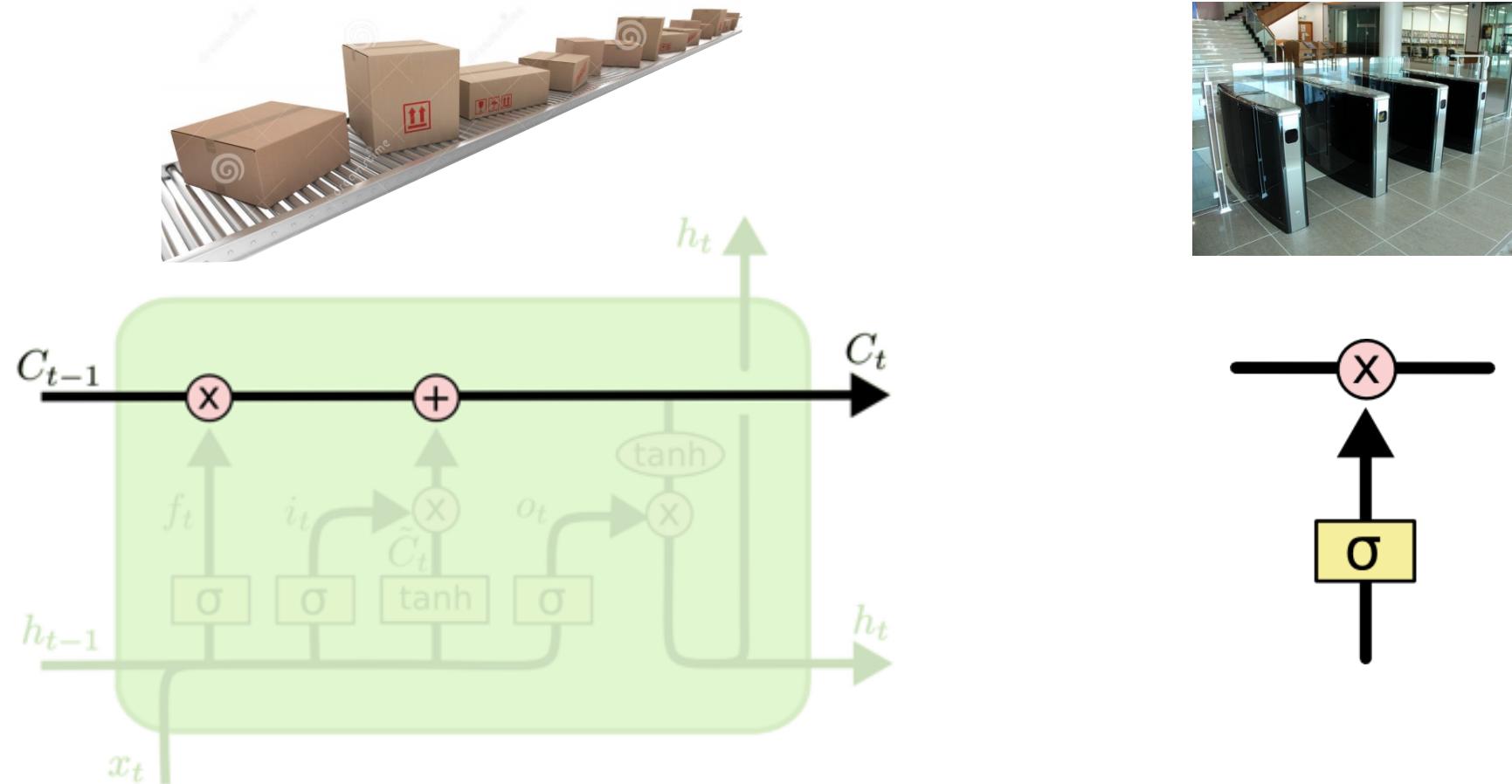


Long Short Term Memory



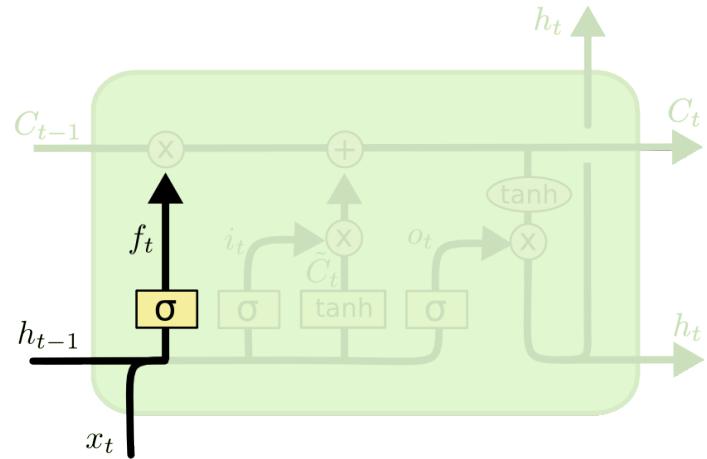
Long Short Term Memory

- Core idea



Long Short Term Memory

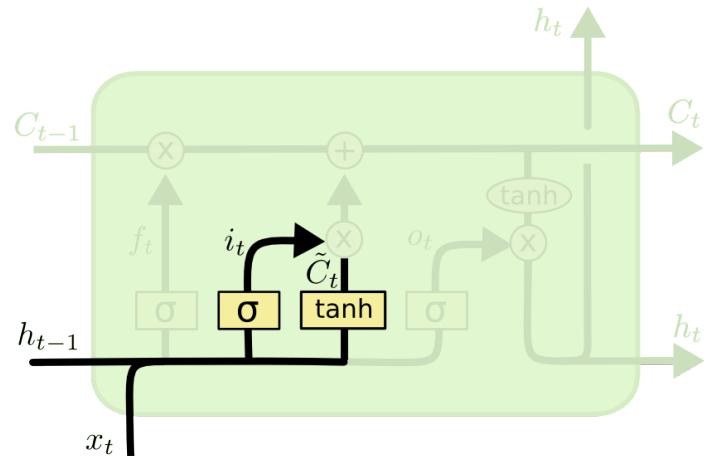
Forget Gate



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

Decide which information to **throw away**

Input Gate



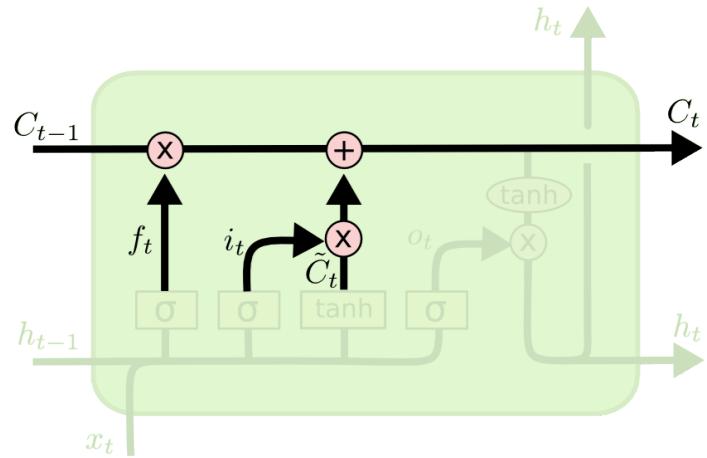
$$i_t = \sigma (W_i \cdot [h_{t-1}, x_t] + b_i)$$

$$\tilde{C}_t = \tanh(W_C \cdot [h_{t-1}, x_t] + b_C)$$

Decide which information to **store** in the cell state

Long Short Term Memory

Update cell

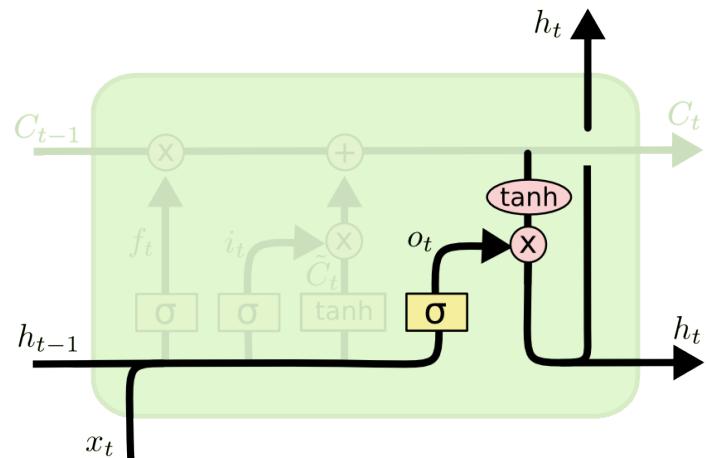


$$i_t = \sigma(W_i \cdot [h_{t-1}, x_t] + b_i)$$

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

Update the cell state.

Output Gate



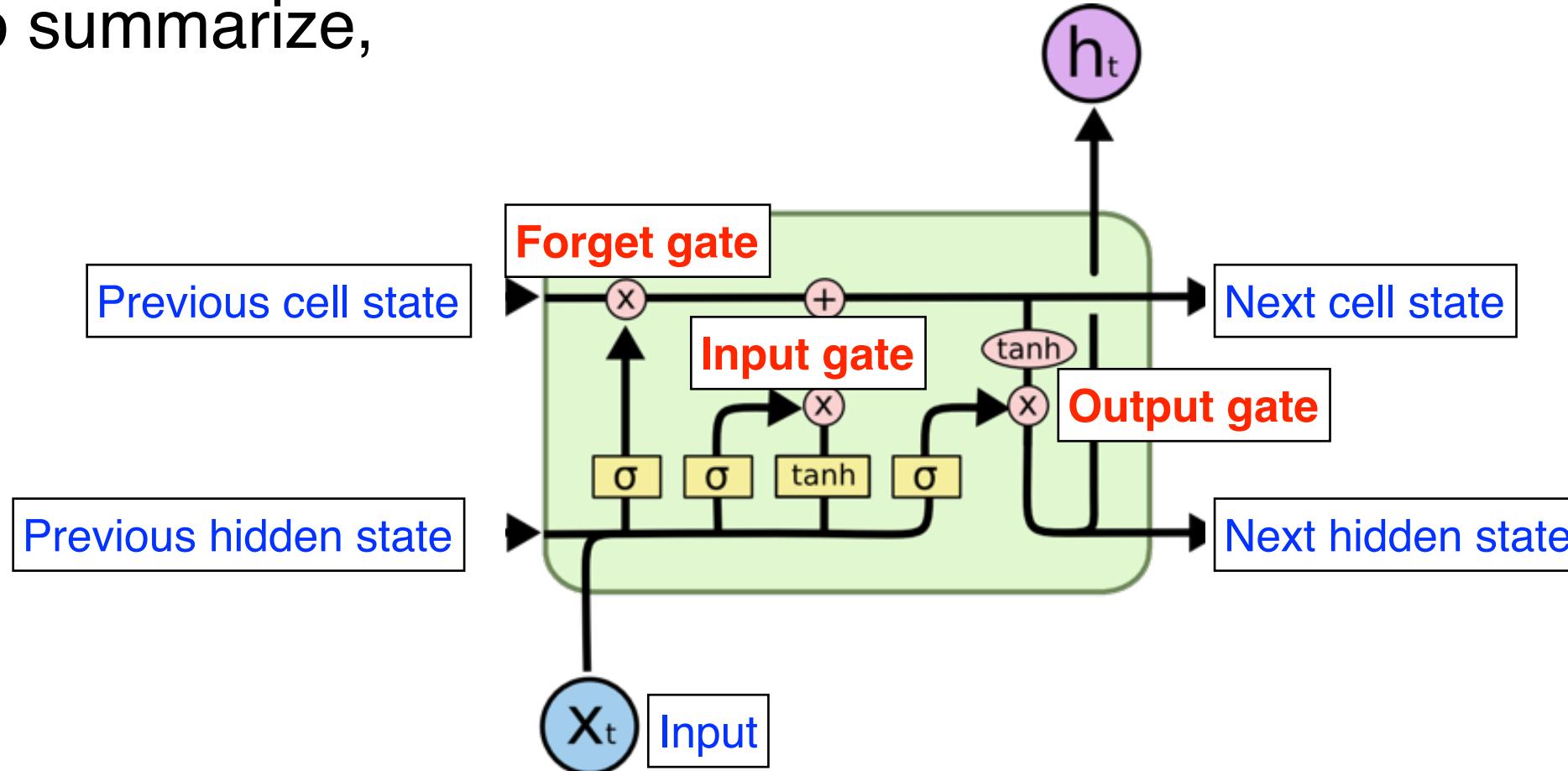
$$o_t = \sigma(W_o \cdot [h_{t-1}, x_t] + b_o)$$

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

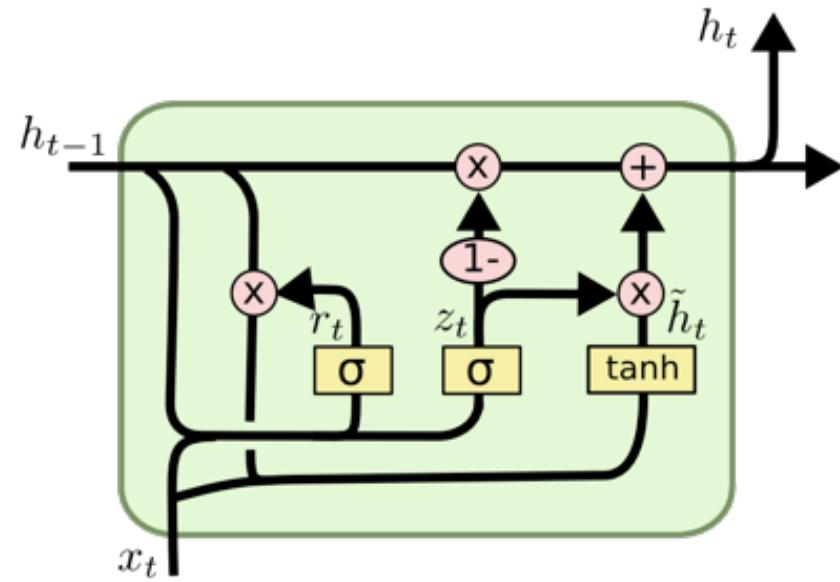
Make output using the updated cell state.

Long Short Term Memory

- To summarize,



Gated Recurrent Unit



$$z_t = \sigma (W_z \cdot [h_{t-1}, x_t])$$

$$r_t = \sigma (W_r \cdot [h_{t-1}, x_t])$$

$$\tilde{h}_t = \tanh (W \cdot [r_t * h_{t-1}, x_t])$$

$$h_t = (1 - z_t) * h_{t-1} + z_t * \tilde{h}_t$$

- Simpler architecture with two gates (**reset gate** and **update gate**).
- No **cell state**, just **hidden state**.

Thank you for listening
