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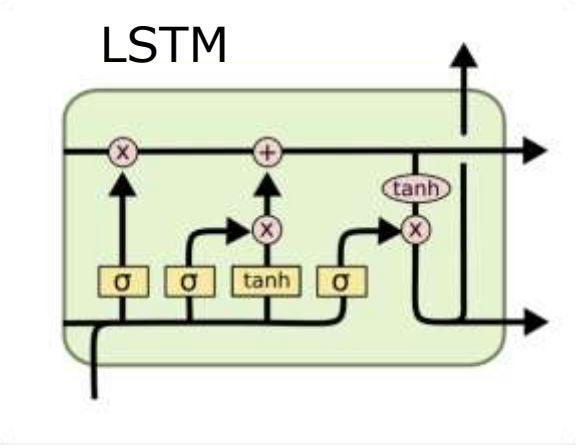
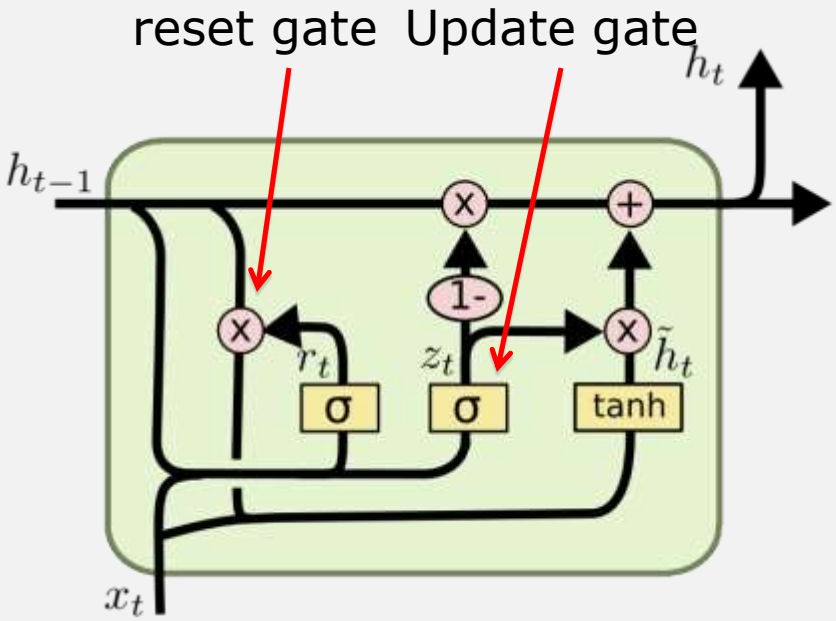
Gated Recurrent Units(GRU)

GRU – Gated Recurrent Unit

(more compression)





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

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

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

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

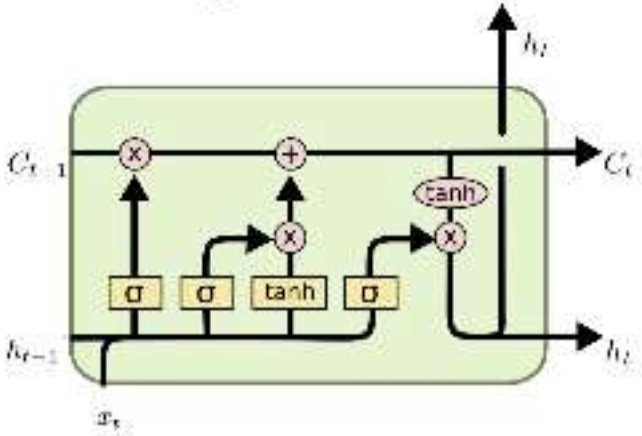
It combines the forget and input into a single update gate.

It also merges the cell state and hidden state. This is simpler

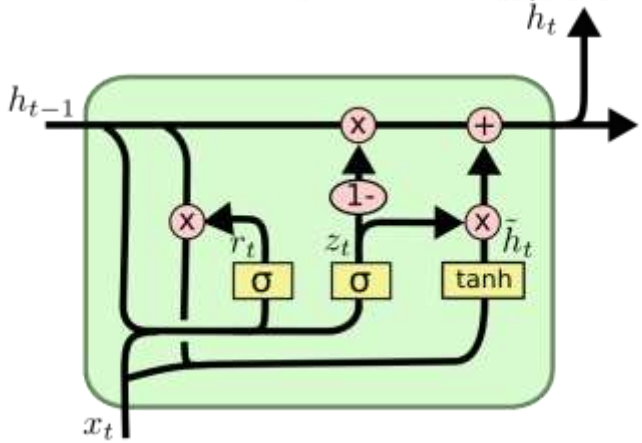
than LSTM. There are many other variants too. X,*: element-wise multi

LSTM and GRU

- LSTM [Hochreiter&Schmidhuber97]



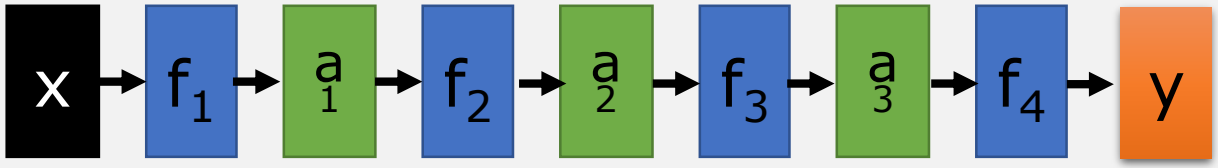
- GRU [Cho+14]



GRUs also takes x_t and h_{t-1} as inputs. They perform some calculations and then pass along h_t. What makes them different from LSTMs is that GRUs don't need the cell layer to pass values along. The calculations within each iteration insure that the h_t values being passed along either retain a high amount of old information or are jump-started with a high amount of new information.

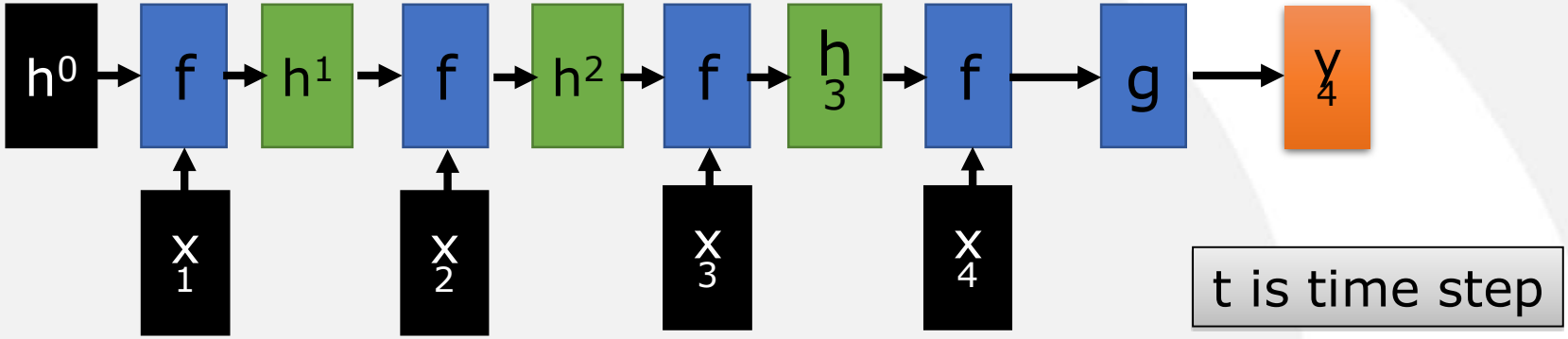
Feed-forward vs Recurrent Network

1. Feedforward network does not have input at each step
2. Feedforward network has different parameters for each layer



$a^t = f_t(a^{t-1}) = \sigma(W^t a^{t-1} + b^t)$

t is layer



t is time step

$a^t = f(a^{t-1}, x^t) = \sigma(W^h a^{t-1} + W^i x^t + b^i)$

We will turn the recurrent network 90 degrees.

GRU → Highway Network

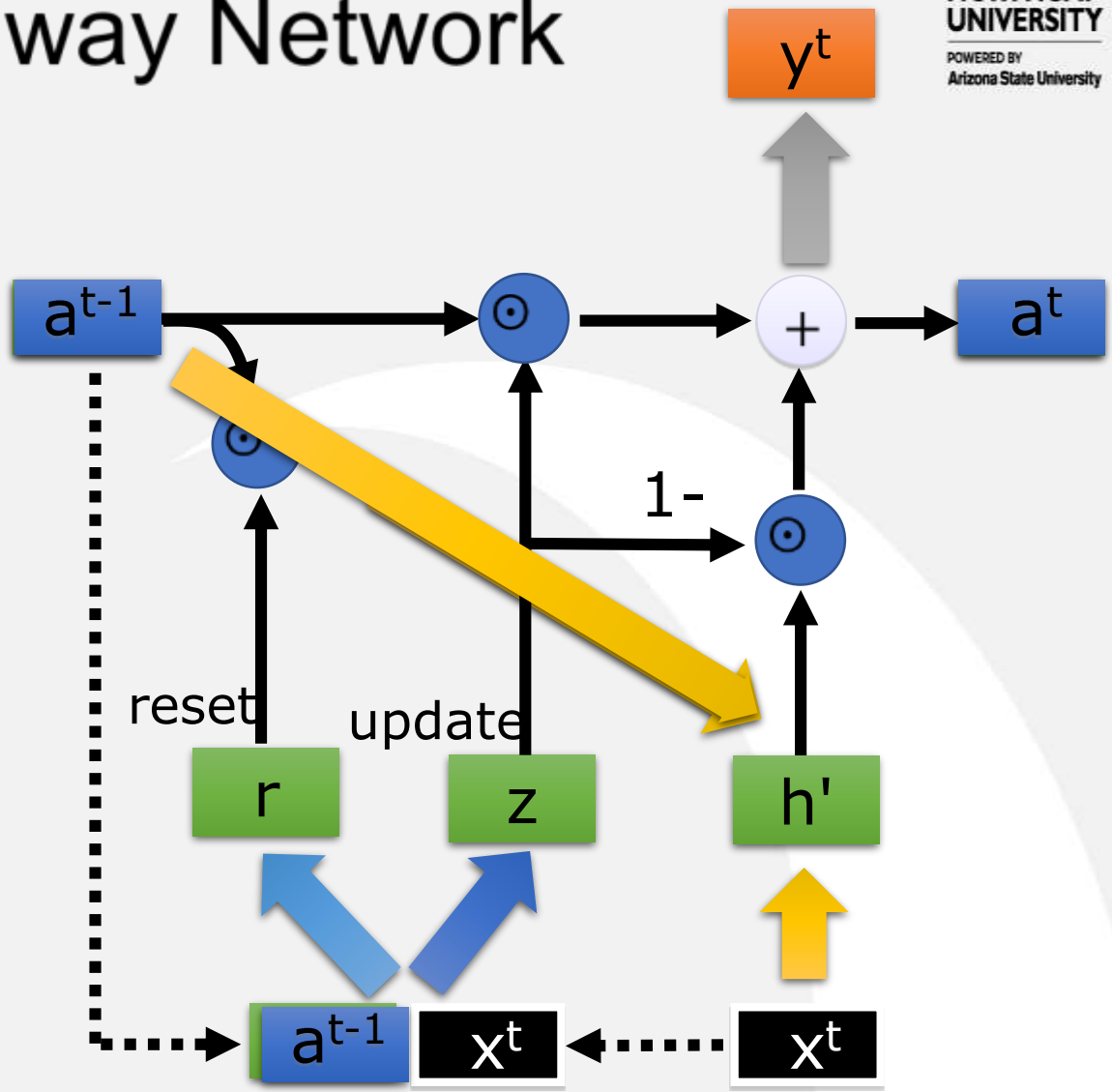
No input x^t at each step

No output y^t at each step

a^{t-1} is the output of the (t-1)-th layer

a^t is the output of the t-th layer

No reset gate



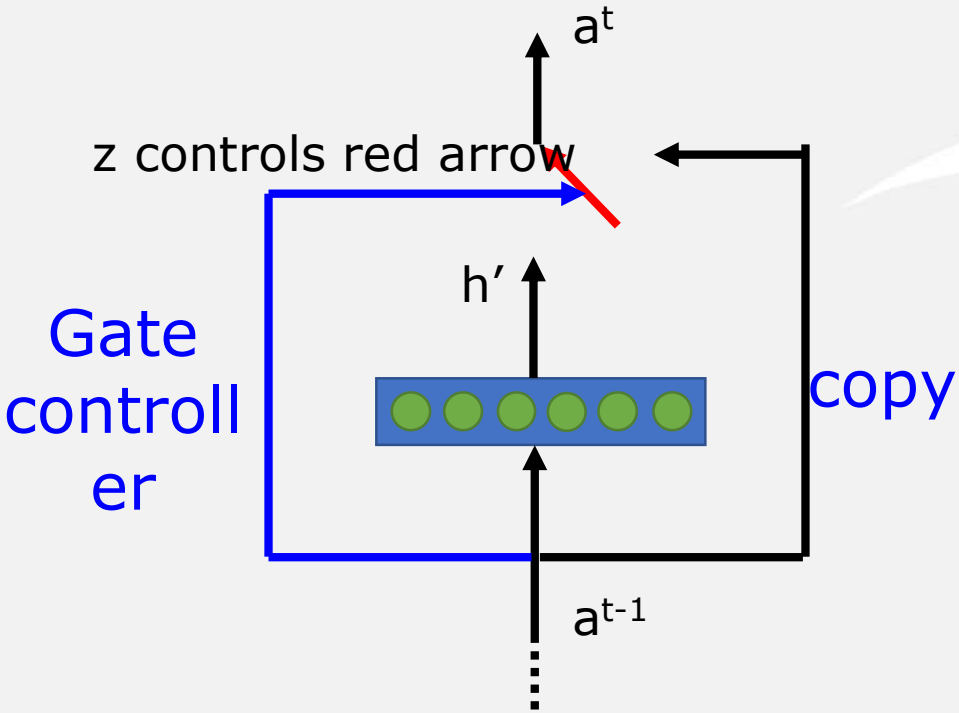
Highway Network

$$h' = \sigma(Wa^{t-1})$$

$$z = \sigma(W'a^{t-1})$$

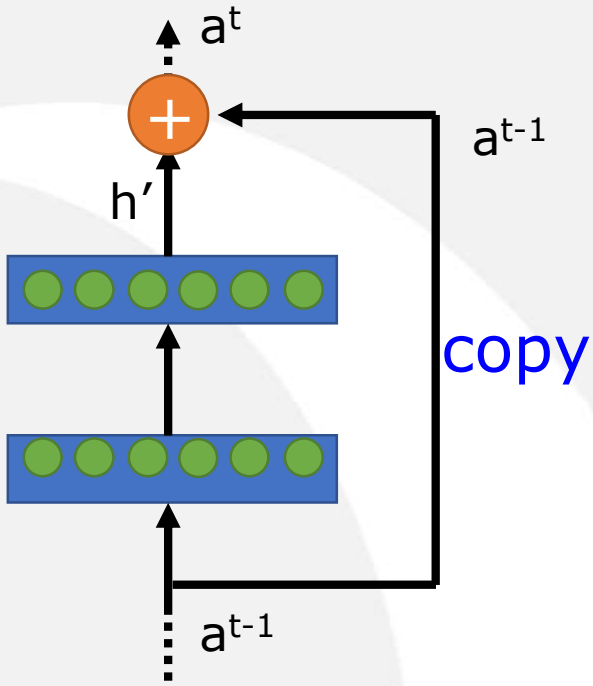
$$a^t = z \odot a^{t-1} + (1-z) \odot h'$$

- **Highway Network**

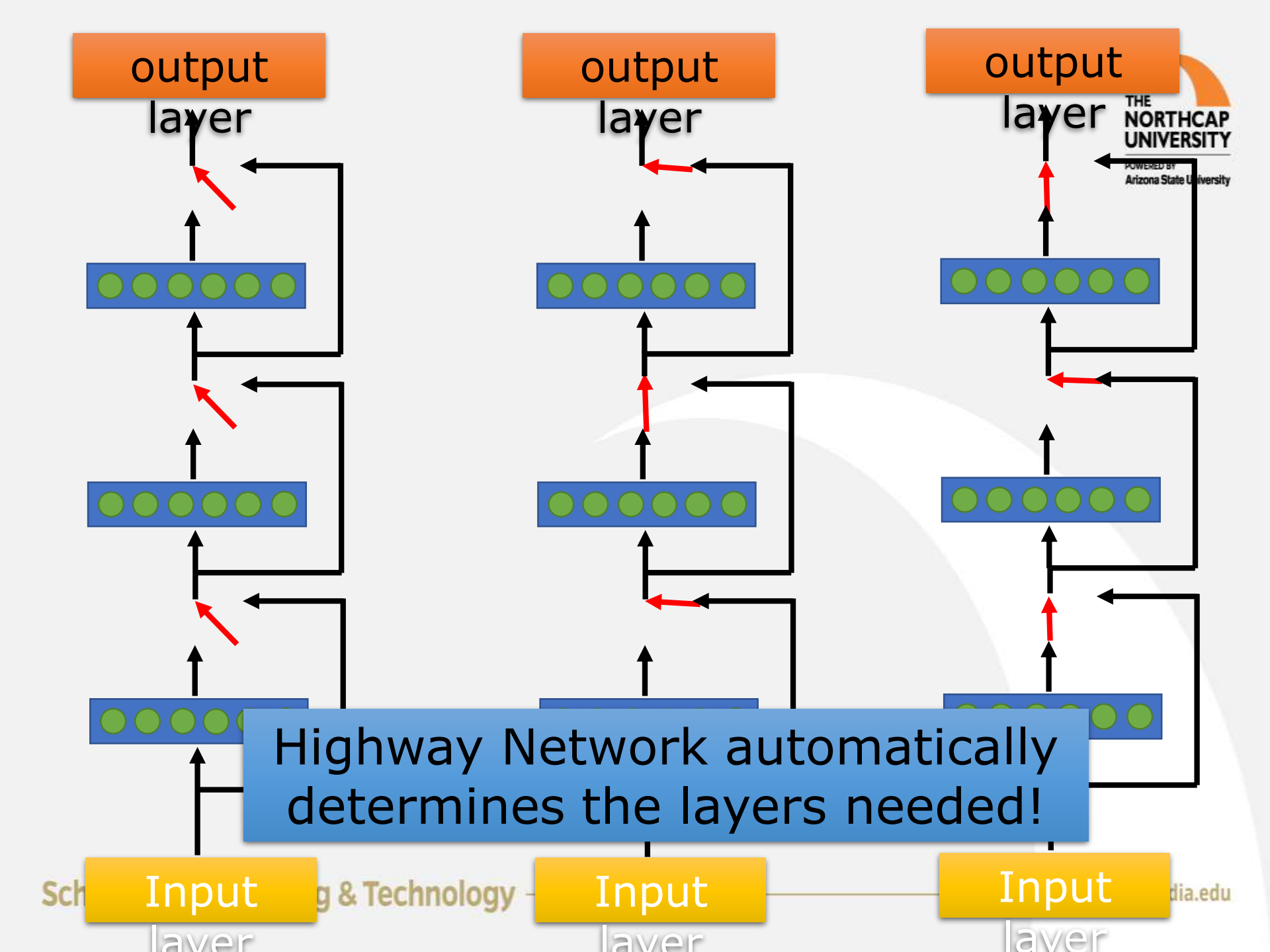


Training Very Deep Networks
https://arxiv.org/pdf/1507.06228v2.pdf

- **Residual Network**



Deep Residual Learning for Image Recognition
http://arxiv.org/abs/1512.03385


output layer
output layer
output layer
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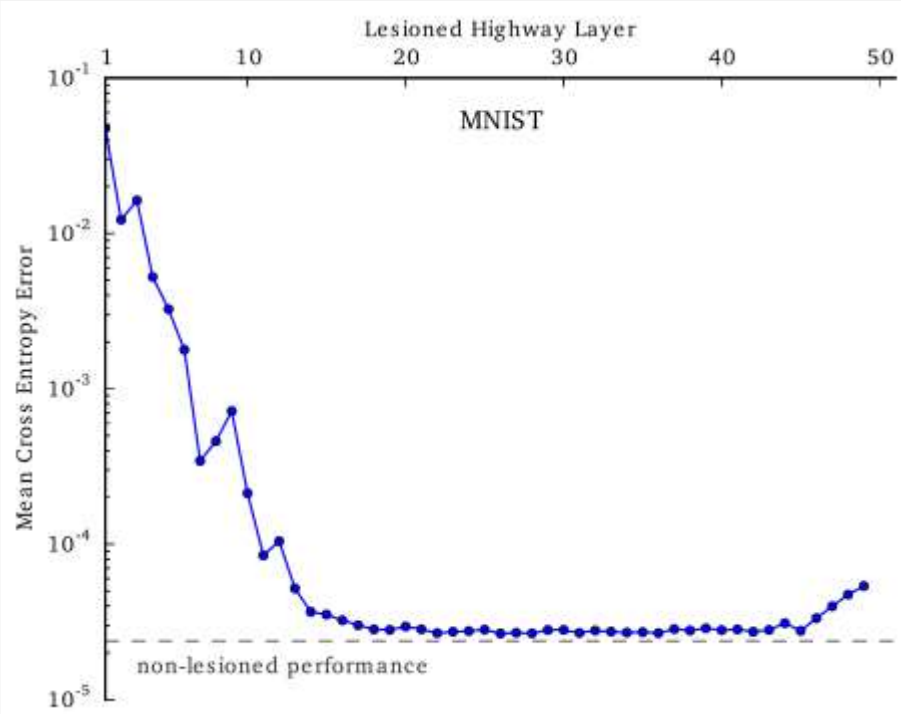
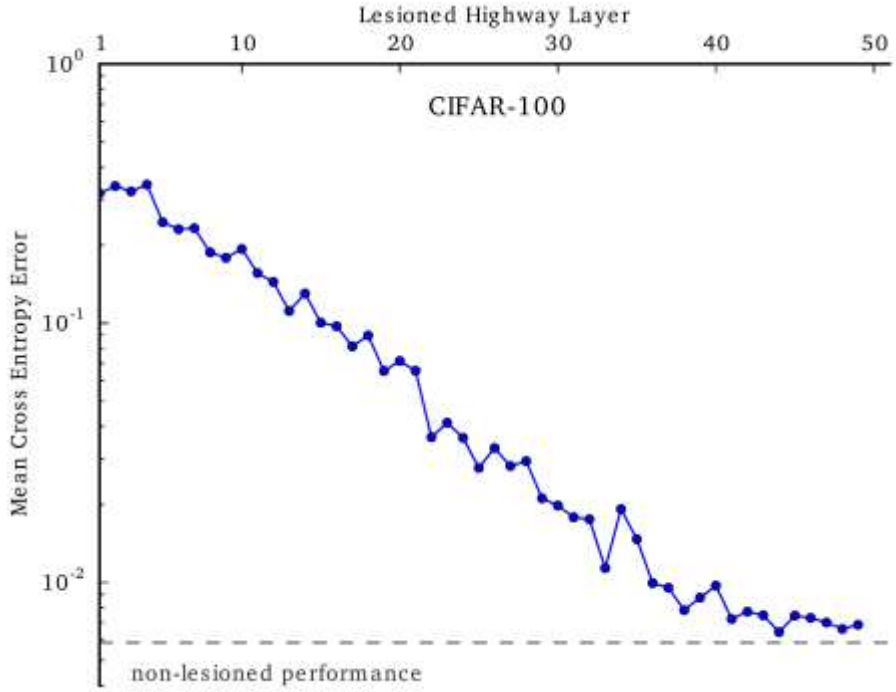
Highway Network automatically determines the layers needed!
Input layer
Input layer
Input layer

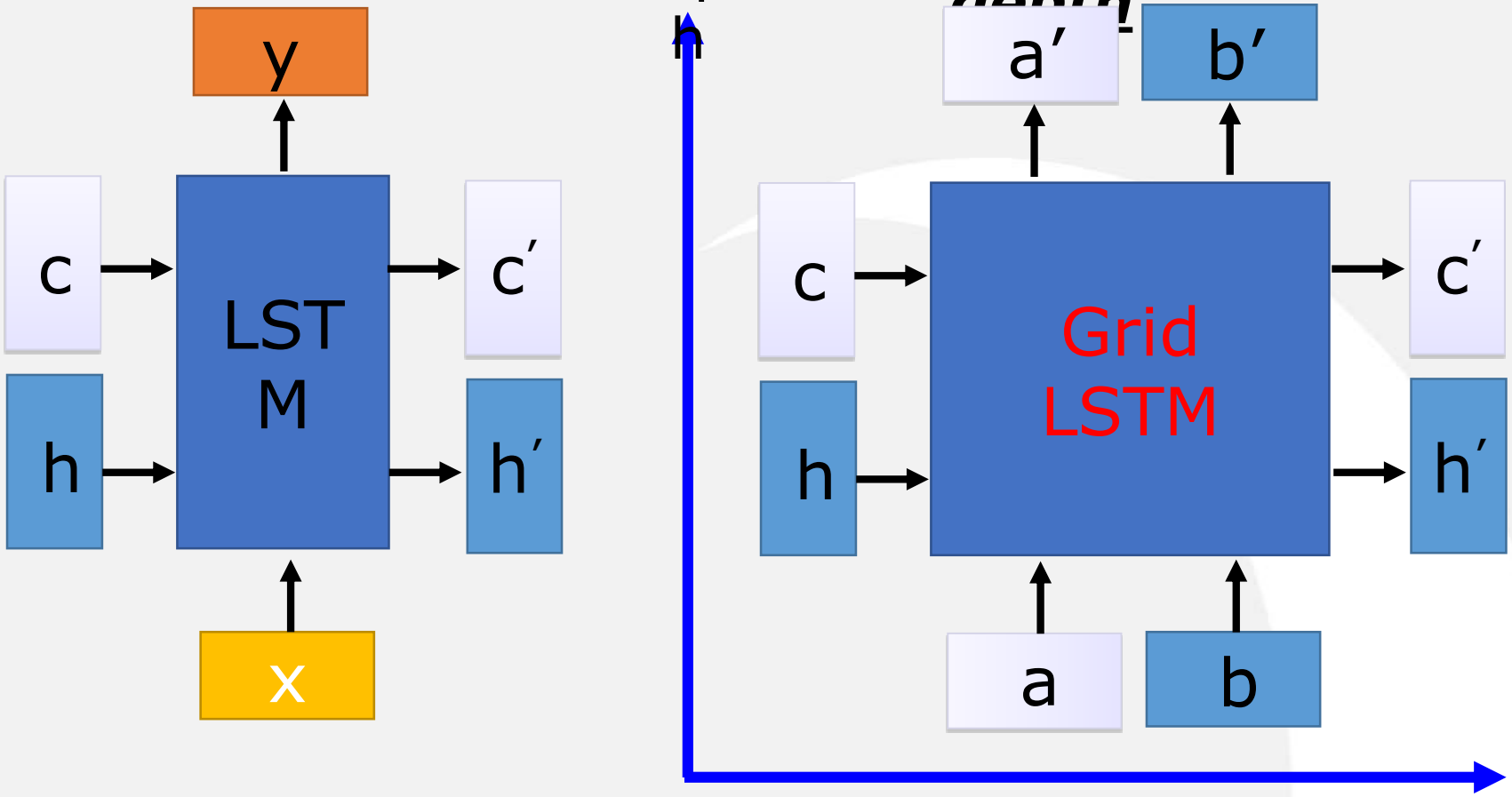
Highway Network Experiments



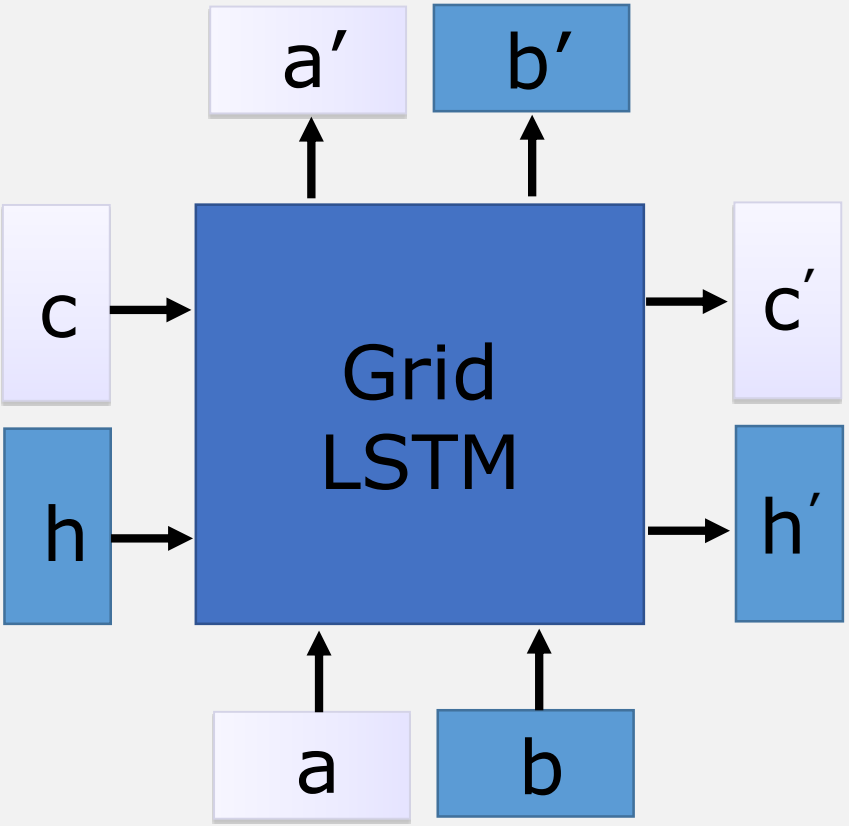


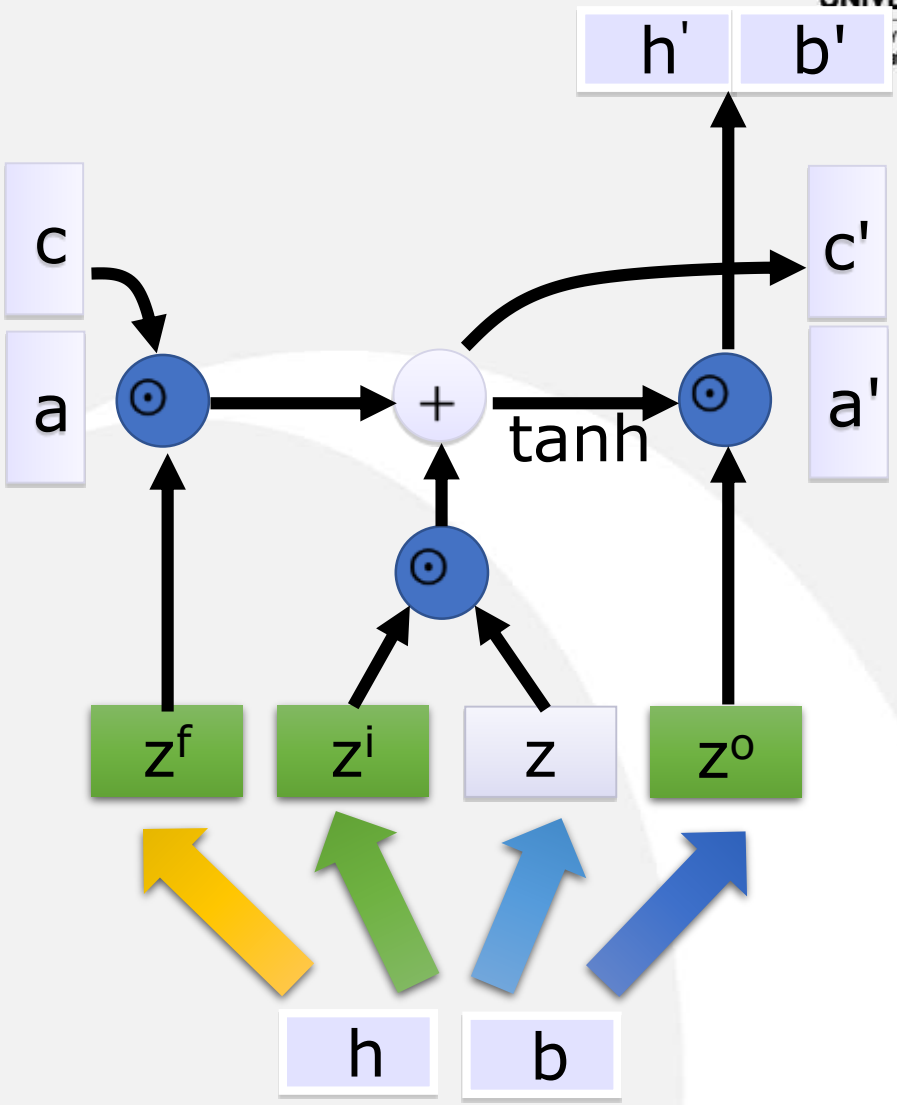
Grid LSTM

Memory for both ***time*** and ***depth***



Grid LSTM





You can generalize this to 3D, and more.