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# Recurrent Neural Network

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# Text Recognition

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How do we recognize this image?



Maybe we should segment like this, and feed each character image into a classifier like CNN.



But context information is missing. Any better solutions?



# Multilayer Perceptrons

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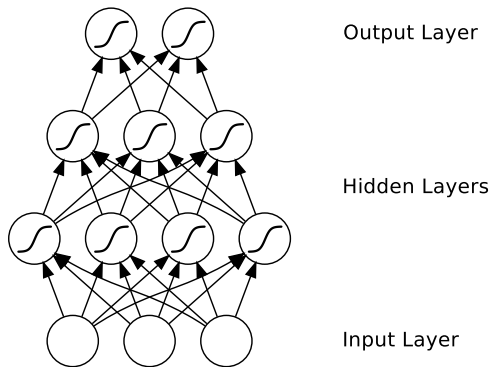
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**Figure:** A multilayer perceptron. The output of an MLP depends only on the current input, and not on any past or future inputs. More suitable for pattern classification than for sequence labelling.

# Simple RNN

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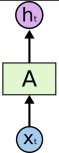
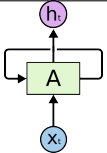
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MLP	RNN
$h = W^h x$	$h_t = W^{(hh)} \phi(h_{t-1}) + W^h x_t$
$y = W^y \phi(h)$	$y_t = W^y \phi(h_t)$
	

# Unfold

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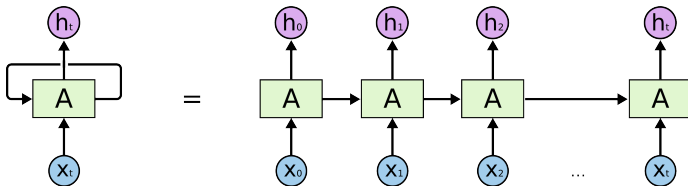
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# Exploding and vanishing gradients

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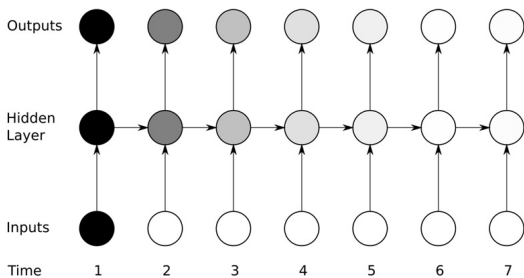


Figure: Gradients vanish or explode through time. From Alex Grave.



# Exploding and vanishing gradients

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$$\frac{\partial E}{\partial W^h} = \sum_{t=1}^S \frac{\partial E_t}{\partial W^h}$$

$$\frac{\partial E_t}{\partial W^h} = \sum_{k=1}^t \frac{\partial E_t}{\partial y_t} \frac{\partial y_t}{\partial h_t} \frac{\partial h_t}{\partial h_k} \frac{\partial^+ h_k}{\partial W_h}$$

$$\left\| \frac{\partial h_t}{\partial h_k} \right\| = \left\| \prod_{i=k+1}^t \frac{\partial h_i}{\partial h_{i-1}} \right\| \leq (\gamma_{W^h} \gamma_\phi)^{t-k}$$

- 1 Pascanu R, etc. On the difficulty of training recurrent neural networks[J]. arXiv preprint arXiv:1211.5063, 2012.
- 2 Bengio Y, etc. Learning long-term dependencies with gradient descent is difficult[J]. Neural Networks, IEEE Transactions on, 1994, 5(2): 157-166.

# TanH

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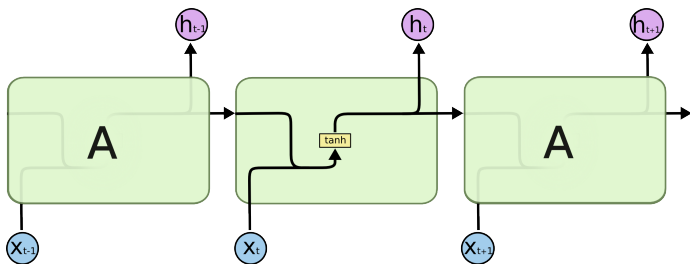
**TanH**

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# LSTM (Long Short Term Memory)

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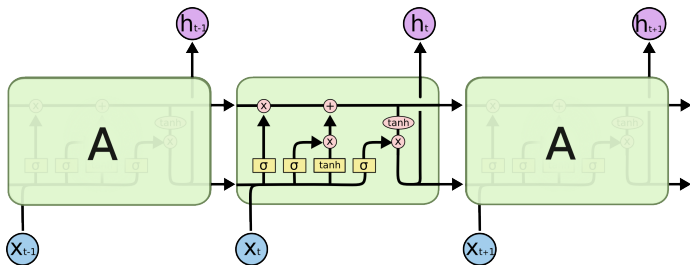
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LSTM (Hochreiter and Schmidhuber, 1997):

Advantage: avoid vanishing

Disadvantage: complex



# Key idea

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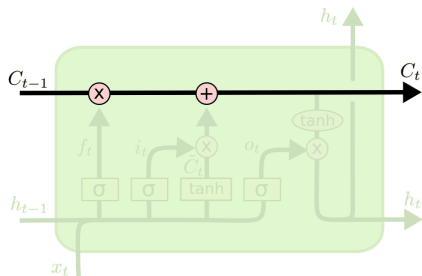
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Memory cell: easy for information to just flow along it unchanged.



# Gates

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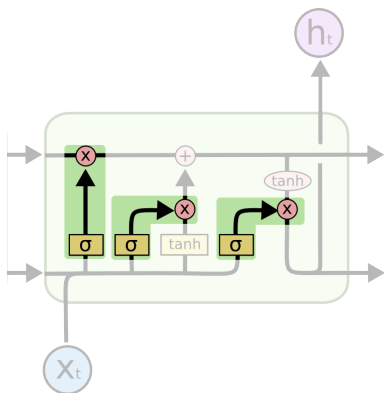
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Gates: a sigmoid neural net layer and a pointwise multiplication operation.

Control a value to flow through or not.



# GRNN (Gated Recurrent Neural Network)

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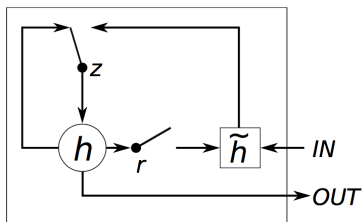
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## GRNN (Cho et al. 2014)



# Bidirectional RNN

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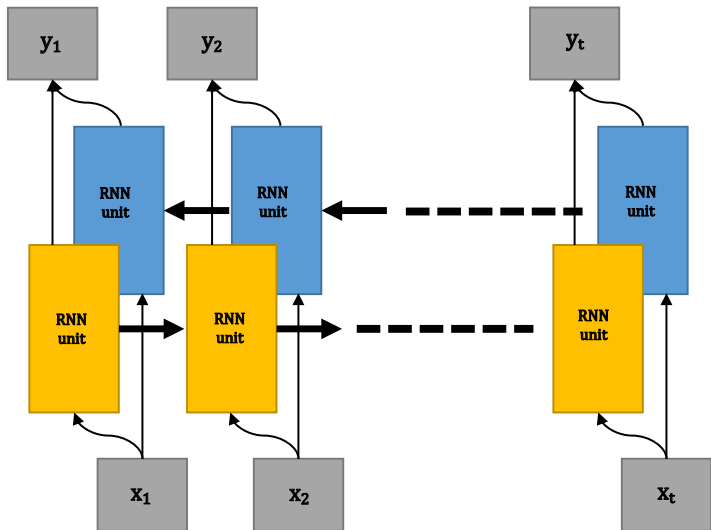
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# Stack RNN

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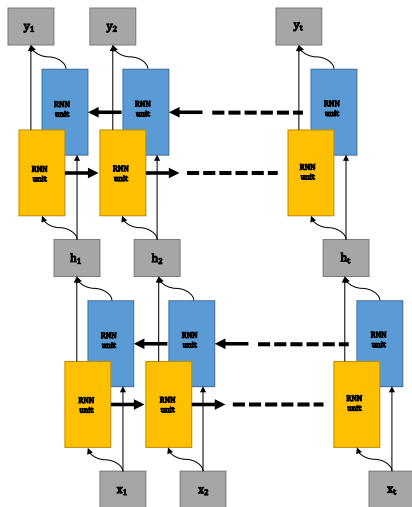
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- Video caption
- Image caption
- Video classification

# Language models

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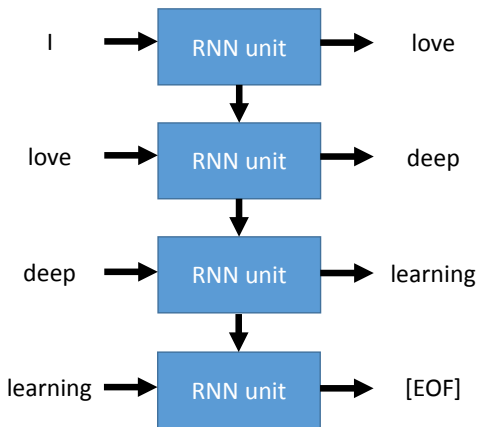
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# Translation

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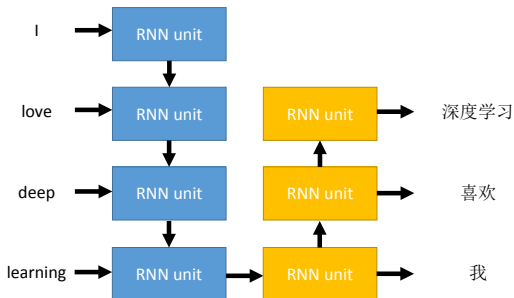
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# Image caption

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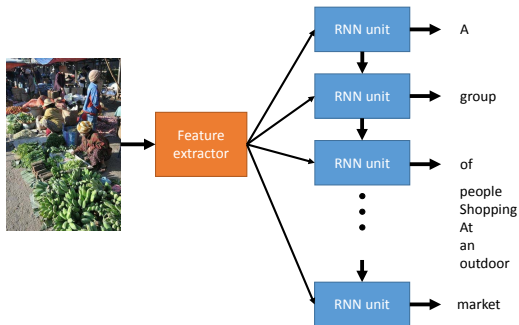


Figure: A image caption generator.

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# Thanks!