Recurrent Neural Network

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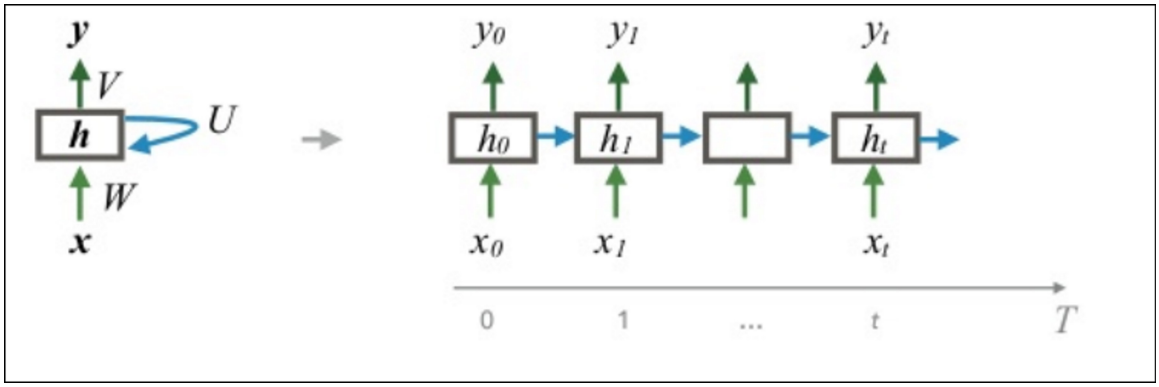
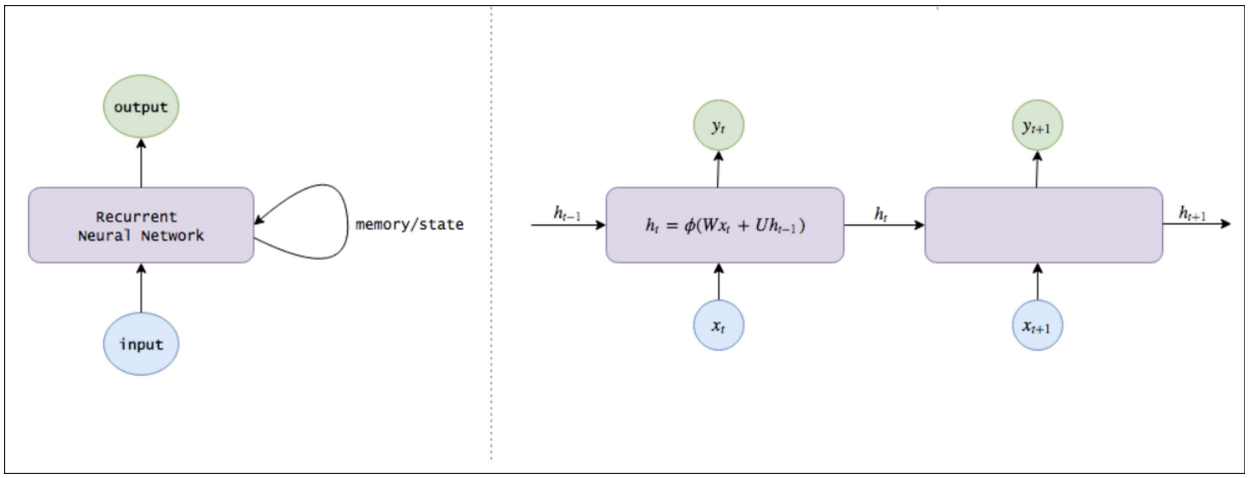
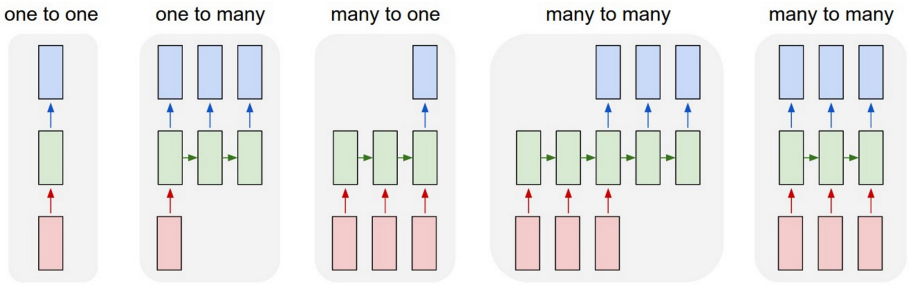
Recurrent Neural Network



$$h_t = \phi(WX_t + Uh_{t-1})$$
$$Y_t = Vh_t$$



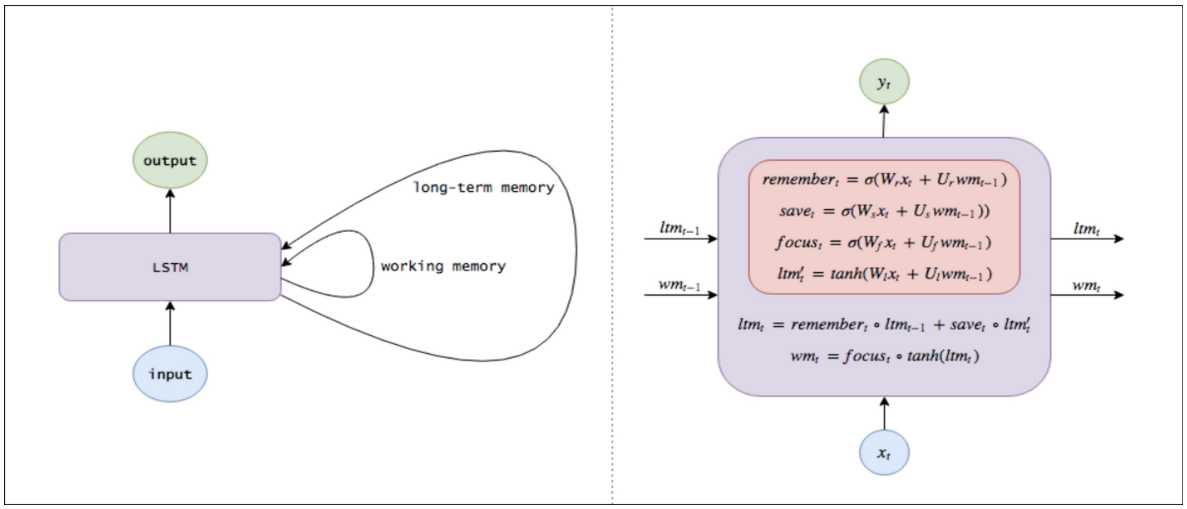


The Unreasonable Effectiveness of Recurrent Neural Networks From <http://karpathy.github.io/2015/05/21/rnn-effectiveness/>

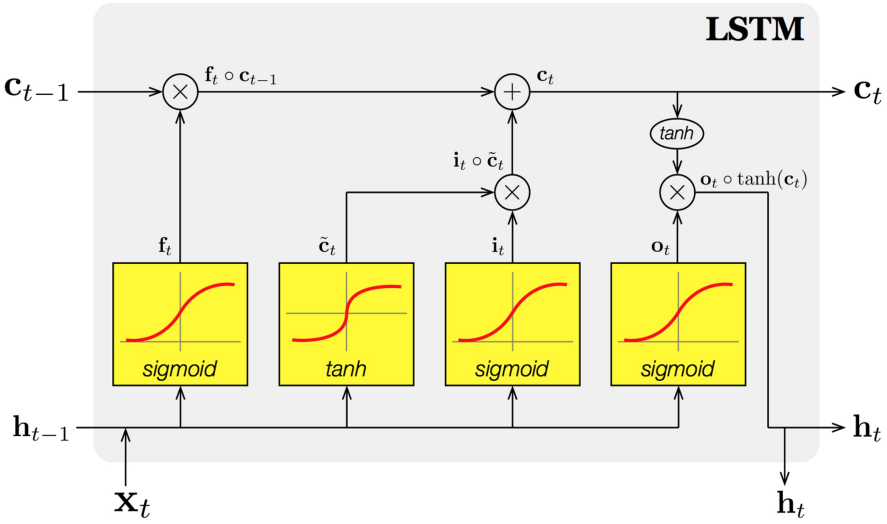
Usage

One to One -> Image Classification
One to Many -> Image Captioning
Many to One - > Sentiment Analysis
Many to Many (1) -> Machine Translation
Many to Many (2) -> Video Classification

LSTM (Long Short Term Memory)



LSTM Cell



Gating variables

$$\mathbf{f}_t = \sigma\left(\mathbf{W}_f[\mathbf{h}_{t-1}, \mathbf{x}_t] + \mathbf{b}_t\right)$$
$$\mathbf{i}_t = \sigma\left(\mathbf{W}_i[\mathbf{h}_{t-1}, \mathbf{x}_t] + \mathbf{b}_i\right)$$
$$\mathbf{o}_t = \sigma\left(\mathbf{W}_o[\mathbf{h}_{t-1}, \mathbf{x}_t] + \mathbf{b}_o\right)$$

Candidate (memory) cell state

$$\tilde{\mathbf{c}}_t = \tanh\left(\mathbf{W}_c[\mathbf{h}_{t-1}, \mathbf{x}_t] + \mathbf{b}_c\right)$$

Cell & Hidden state

$$\mathbf{c}_t = \mathbf{f}_t \circ \mathbf{c}_{t-1} + \mathbf{i}_t \circ \tilde{\mathbf{c}}_t$$
$$\mathbf{h}_t = \mathbf{o}_t \circ \tanh(\mathbf{c}_t)$$

Equations

$$\boldsymbol{remember_t = \sigma(W_r x_t + U_r wm_{t-1})}$$

$$\boldsymbol{ltm'_t = \phi(W_l x_t + U_l wm_{t-1})}$$

$$\boldsymbol{save_t = \sigma(W_s x_t + U_s wm_{t-1})}$$

$$\boldsymbol{ltm_t = remember_t \circ ltm_{t-1} + save_t \circ ltm'_t}$$

$$\boldsymbol{focus_t = \sigma(W_f x_t + U_f wm_{t-1})}$$

$$\boldsymbol{wm_t = focus_t \circ \phi(ltm_t)}$$

- The long-term memory, $\boldsymbol{ltm_t}$, is usually called the **cell state**, denoted $\boldsymbol{C_t}$.
- The working memory, $\boldsymbol{wm_t}$, is usually called the **hidden state**, denoted $\boldsymbol{h_t}$. This is analogous to the hidden state in vanilla RNNs.
- The remember vector, $\boldsymbol{remember_t}$, is usually called the **forget gate** (despite the fact that a 1 in the forget gate still means to keep the memory and a 0 still means to forget it), denoted $\boldsymbol{f_t}$
- The save vector, $\boldsymbol{save_t}$, is usually called the **input gate** (as it determines how much of the input to let into the cell state), denoted $\boldsymbol{i_t}$.
- The focus vector, $\boldsymbol{focus_t}$, is usually called the **output gate**, denoted $\boldsymbol{O_t}$