# Recurrent Neural Networks

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#### Recurrent neuron

 Unlike simple/convolutional neurals, recurrent ones can use their internal state (memory) to process sequences of inputs.

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## RNN

- Contains recurrent neurons
- Processes the input in temporal order
- The training is hard due to the self-loops

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#### Backpropagation Through Time

It begins by unfolding a recurrent neural network in time. The unfolded network contains k inputs and outputs, but every copy of the network shares the same parameters. Then the backpropagation algorithm is used to find the gradient of the cost with respect to all the network parameters.

# BPTT

$$\begin{array}{c} \mathbf{a}_{t} \xrightarrow{} f \xrightarrow{} \mathbf{x}_{t+1} \xrightarrow{} g \xrightarrow{} \mathbf{y}_{t+1} \\ \xrightarrow{\mathbf{v}} \mathbf{unfold through time} \xrightarrow{\mathbf{v}} \\ \mathbf{a}_{t} \xrightarrow{} f_{1} \xrightarrow{} \mathbf{x}_{t+1} \xrightarrow{} f_{2} \xrightarrow{} \mathbf{x}_{t+2} \xrightarrow{} f_{3} \xrightarrow{} \mathbf{x}_{t+3} \xrightarrow{} g \xrightarrow{} \mathbf{y}_{t+3} \end{array}$$

## LSTM

- Long short-term memory (LSTM) cell is a special type of recurrent neurons
- Unlike standard feedforward neural networks, LSTM networks has feedback connections that make it a "general purpose computer"
- A common LSTM unit is composed of a cell, an input gate, an output gate and a forget gate.
- The cell remembers values over arbitrary time intervals and the three gates regulate the flow of information into and out of the cell.

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## LSTM





## GRU

Gated Recurrent Unit is a variation on the LSTM because both are designed similarly.



## Practice

Python tutorial: practice\_09.ipynb

