Lecture 12
RNN

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http://hunkim.github.io/ml/
Sequence data

• We don’t understand one word only
• We understand based on the previous words + this word. (time series)
• NN/CNN cannot do this
Sequence data

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- We understand based on the previous words + this word. (time series)
- NN/CNN cannot do this

http://colah.github.io/posts/2015-08-Understanding-LSTMs/
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Recurrent Neural Network
Recurrence Neural Network

usually want to predict a vector at some time steps
Recurrent Neural Network

We can process a sequence of vectors $\mathbf{x}$ by applying a recurrence formula at every time step:

$$h_t = f_W(h_{t-1}, \mathbf{x}_t)$$

new state

old state

some function with parameters $W$

input vector at some time step
Recurrent Neural Network

We can process a sequence of vectors $\mathbf{x}$ by applying a recurrence formula at every time step:

$$h_t = f_W(h_{t-1}, x_t)$$

Notice: the same function and the same set of parameters are used at every time step.
(Vanilla) Recurrent Neural Network

The state consists of a single “hidden” vector $h$:

$$h_t = f_W(h_{t-1}, x_t)$$

$$h_t = \tanh(W_{hh}h_{t-1} + W_{xh}x_t)$$

$$y_t = W_{hy}h_t$$
Notice: the same function and the same set of parameters are used at every time step.

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Character-level language model example

Vocabulary: [h,e,l,o]

Example training sequence: “hello”
Character-level language model example

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\[ y_t = W_{hy} h_t \]

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RNN applications


- Language Modeling
- Speech Recognition
- Machine Translation
- Conversation Modeling/Question Answering
- Image/Video Captioning
- Image/Music/Dance Generation

http://jiwonkim.org/awesome-rnn/
Recurrent Networks offer a lot of flexibility:

Vanilla Neural Networks
Recurrent Networks offer a lot of flexibility:

e.g. Image Captioning
image -> sequence of words
Recurrent Networks offer a lot of flexibility:

- one to one
- one to many
- many to one
- many to many

e.g. **Sentiment Classification**
sequence of words -> sentiment
Recurrent Networks offer a lot of flexibility:

- **one to one**
- **one to many**
- **many to one**
- **many to many**

E.g. **Machine Translation**

seq of words -> seq of words
Recurrent Networks offer a lot of flexibility:

- **one to one**
- **one to many**
- **many to one**
- **many to many**

e.g. Video classification on frame level
Multi-Layer RNN
Training RNNs is challenging

• Several advanced models
  - Long Short Term Memory (LSTM)
  - GRU by Cho et al. 2014
Next

RNN in TensorFlow