Deep Learning for Natural Language Processing

Dr. Minlie Huang (黄民烈)

aihuang@tsinghua.edu.cn

Computer Science Department

Tsinghua University

Homepage: http://coai.cs.Tsinghua.edu.cn/hml

Convolutional Network for NLP

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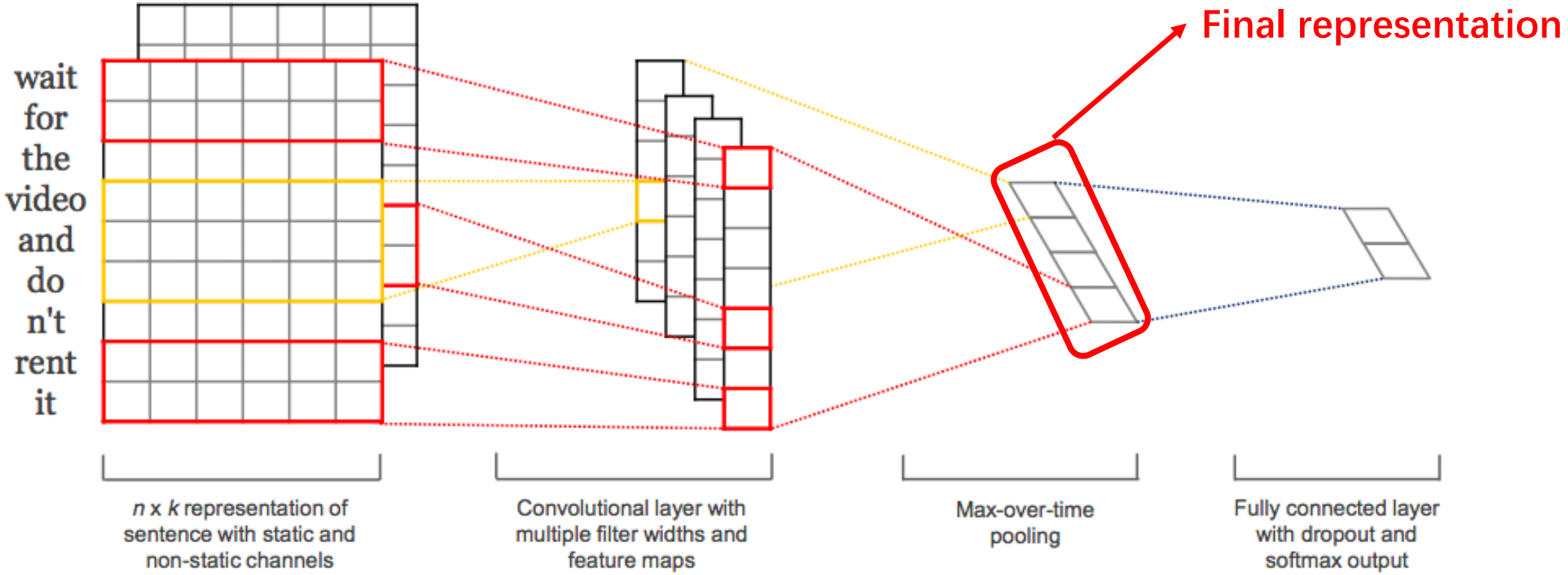


Yoon Kim. 2014. Convolutional Neural Networks for Sentence Classification. In *EMNLP*. Association for Computational Linguistics, 1746–1751.

Convolution Layer

- Word vectors: $\mathbf{x}_i \in \mathbb{R}^k$

- Sentence (concatenating words sequentially):

$$\mathbf{x}_{1:n} = \mathbf{x}_1 \oplus \mathbf{x}_2 \oplus \ldots \oplus \mathbf{x}_n$$

- **Words in range (a vector)**: $\mathbf{x}_{i:i+j}$

- Convolutional filter (**a vector**), h is a window of h words:

$$\mathbf{w} \in \mathbb{R}^{hk}$$

Convolution Layer

- The feature value of position i:

$$c_i = f(\mathbf{w}^T \mathbf{x}_{i:i+h-1} + b)$$

- All possible windows:

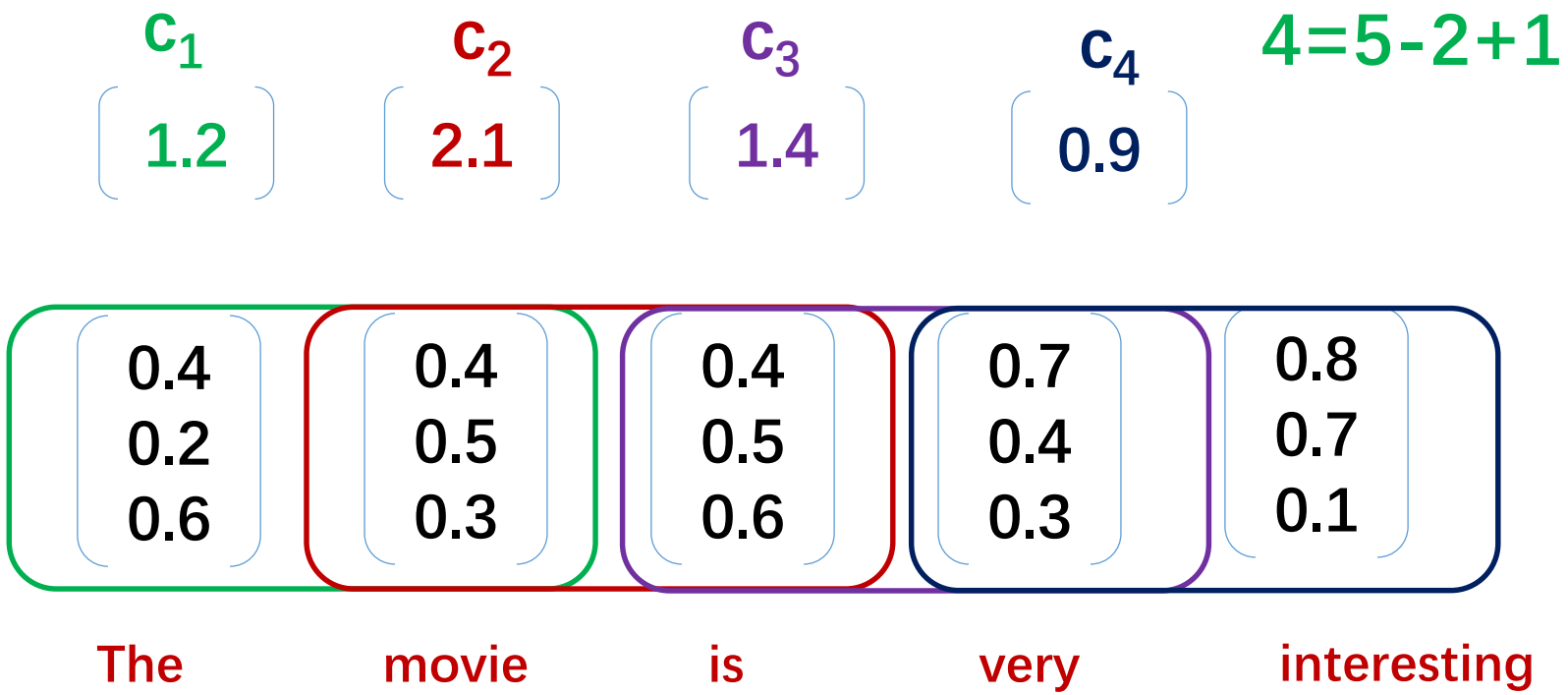
$$\{\mathbf{x}_{1:h}, \mathbf{x}_{2:h+1}, \ldots, \mathbf{x}_{n-h+1:n}\}$$

- The resulting feature map:

$$\mathbf{c} = [c_1, c_2, \ldots, c_{n-h+1}] \in \mathbb{R}^{n-h+1}$$

Convolution Layer

When the window width h=2



Pooling Layer

- Feature map with **W**:

$$\mathbf{c} = [c_1, c_2, \ldots, c_{n-h+1}] \in \mathbb{R}^{n-h+1}$$

- Pooling this vector to a single scalar (max, min, mean):

$$\hat{c} = \max\{\mathbf{c}\}$$

- But only **ONE** value here? Machine learning generally requires more input values

Final Softmax Layer

- Using **multiple filters W** (~100), and **multiple window h**
  - The final vector is of **N_w*N_h**
- The final feature vector

  $Z=[c_{h\_1,1}, c_{h\_1,2}, \cdots, c_{h\_1,N\_w}, c_{h\_2,1}, c_{h\_2,2}, \cdots, c_{h\_2,N\_w} \cdots]$

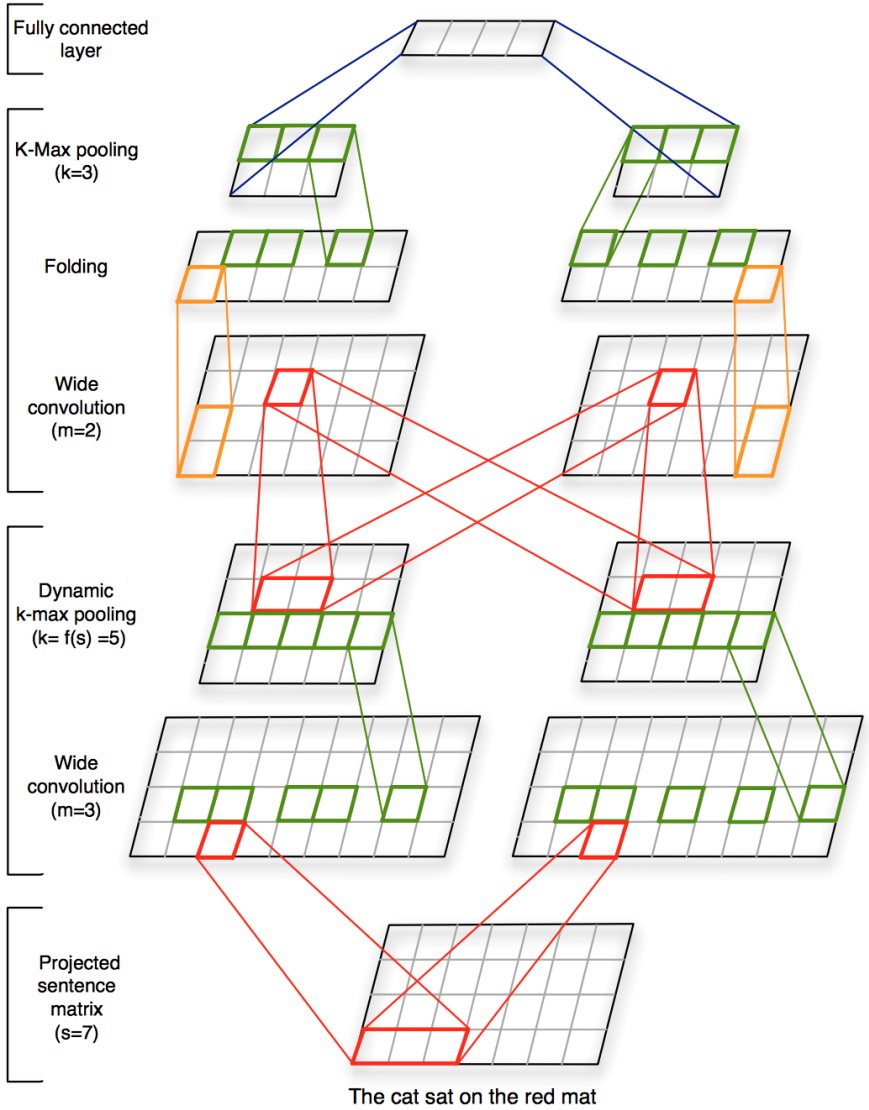
  h_i: how many types of windows

  N_w: how many filters

- The final softmax layer (or another MLP layer) takes z as input:

$$y = softmax\left(W^{(S)}z + b\right)$$

Advanced CNN Models for NLP

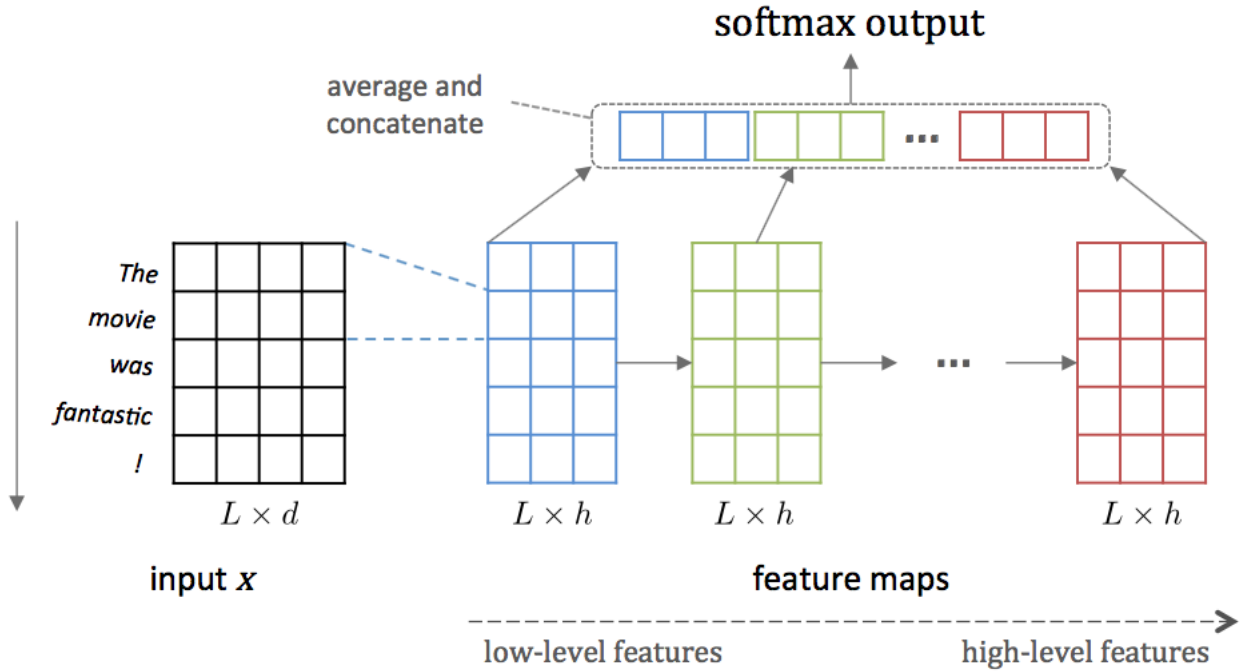


- One-dimensional convolution
- K-max pooling over time
- Multiple filters and multiple channels
- Very similar to image processing

N. Kalchbrenner, E. Grefenstette, and P. Blunsom. A Convolutional Neural Network for Modelling Sentences . In: Proceedings of ACL. 2014.

Advanced CNN Models for NLP

- Convolutional Neural Network



Model	Fine-grained		Binary	
	Dev	Test	Dev	Test
RNN		43.2		82.4
RNTN		45.7		85.4
DRNN		49.8		86.8
RLSTM		51.0		88.0
DCNN		48.5		86.9
CNN-MC		47.4		88.1
CNN	48.8	47.2	85.7	86.2
PVEC		48.7		87.8
DAN		48.2		86.8
SVM	40.1	38.3	78.6	81.3
NBoW	45.1	44.5	80.7	82.0
Ours	49.5	50.6	87.0	87.0
+ phrase labels	53.4	**51.2**	88.9	**88.6**

Lei T, Barzilay R, Jaakkola T. Molding cnns for text: non-linear, non-consecutive convolutions[J]. EMNLP, 2015.

Comments on CNN for NLP

- Suitable for **longer** text
- **Deep structures** (multiple con/pool operations) seem to be NOT that helpful
- **Not as strong as** other models such as recursive/recurrent models

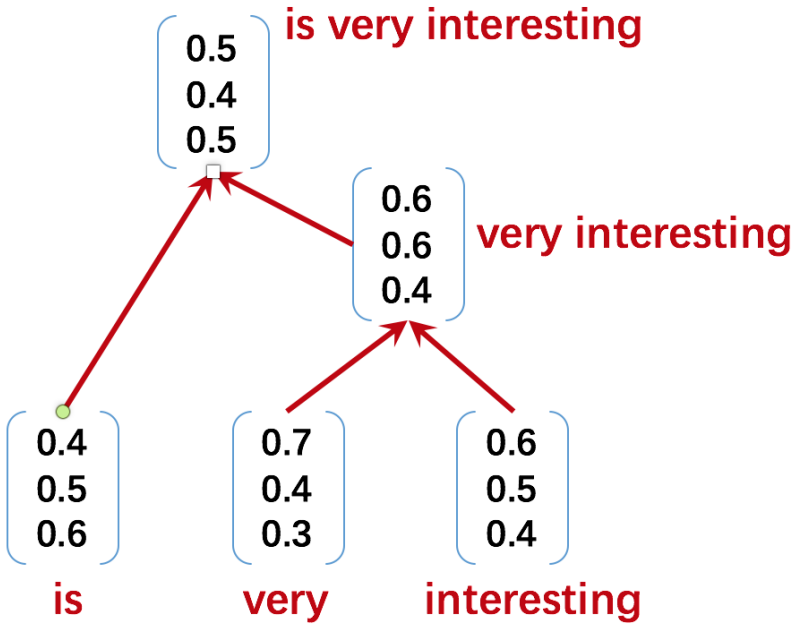
Summary

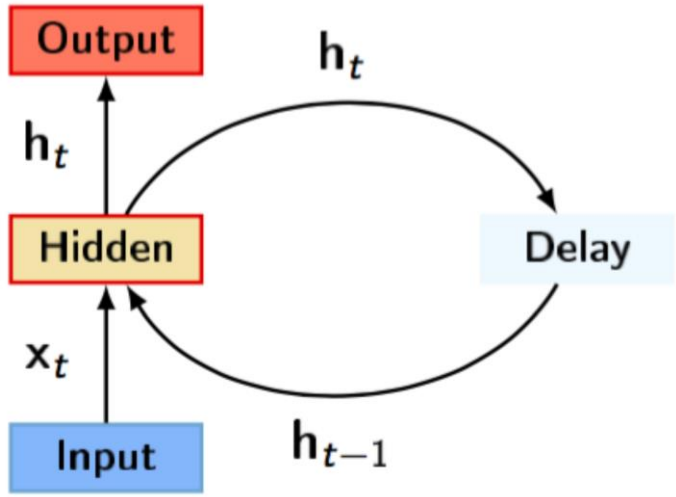
- Word representation
  - Word vectors
- Phrase/sentence representation
  - Recursive models
  - Recurrent models
  - CNN
- Document representation
  - CNN
  - Hierarchical models (RNN)
  - Hybrid models

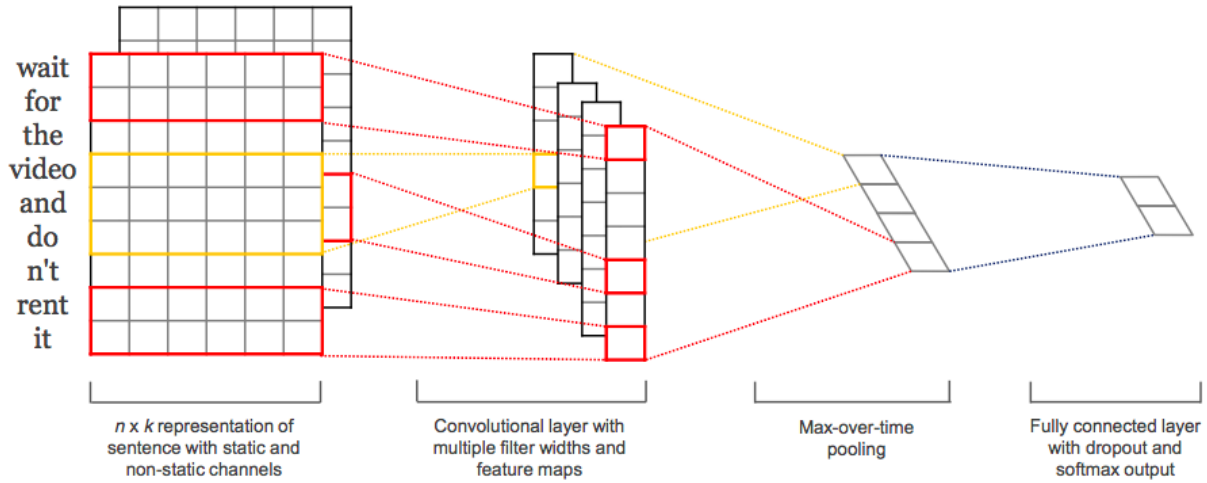
Summary

0.123
0.243
0.789
-0.150
0.893
0.163
-0.876

Deep



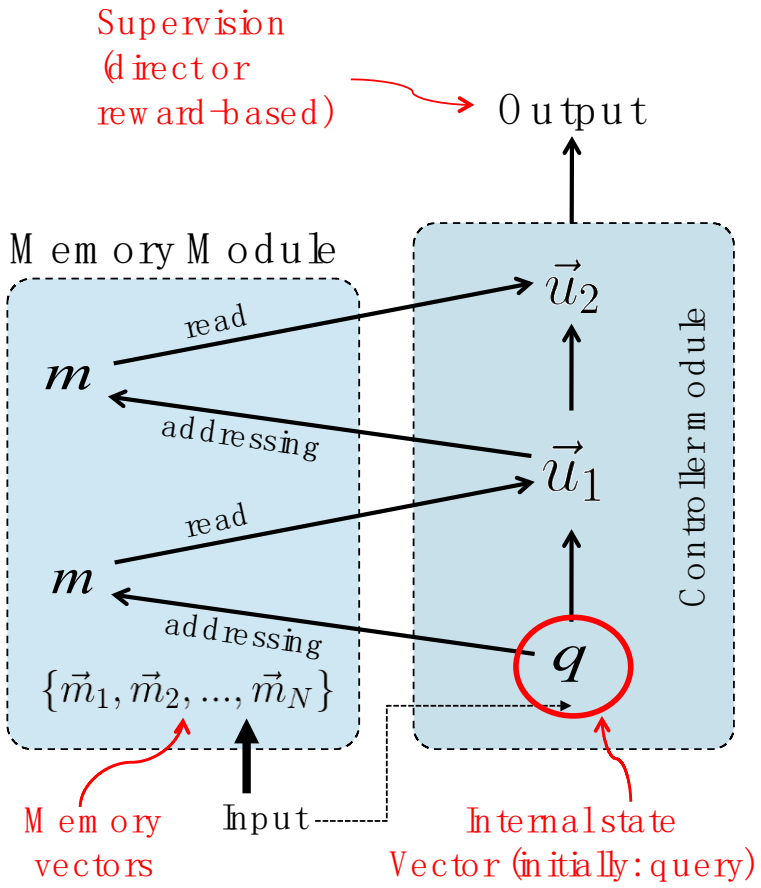


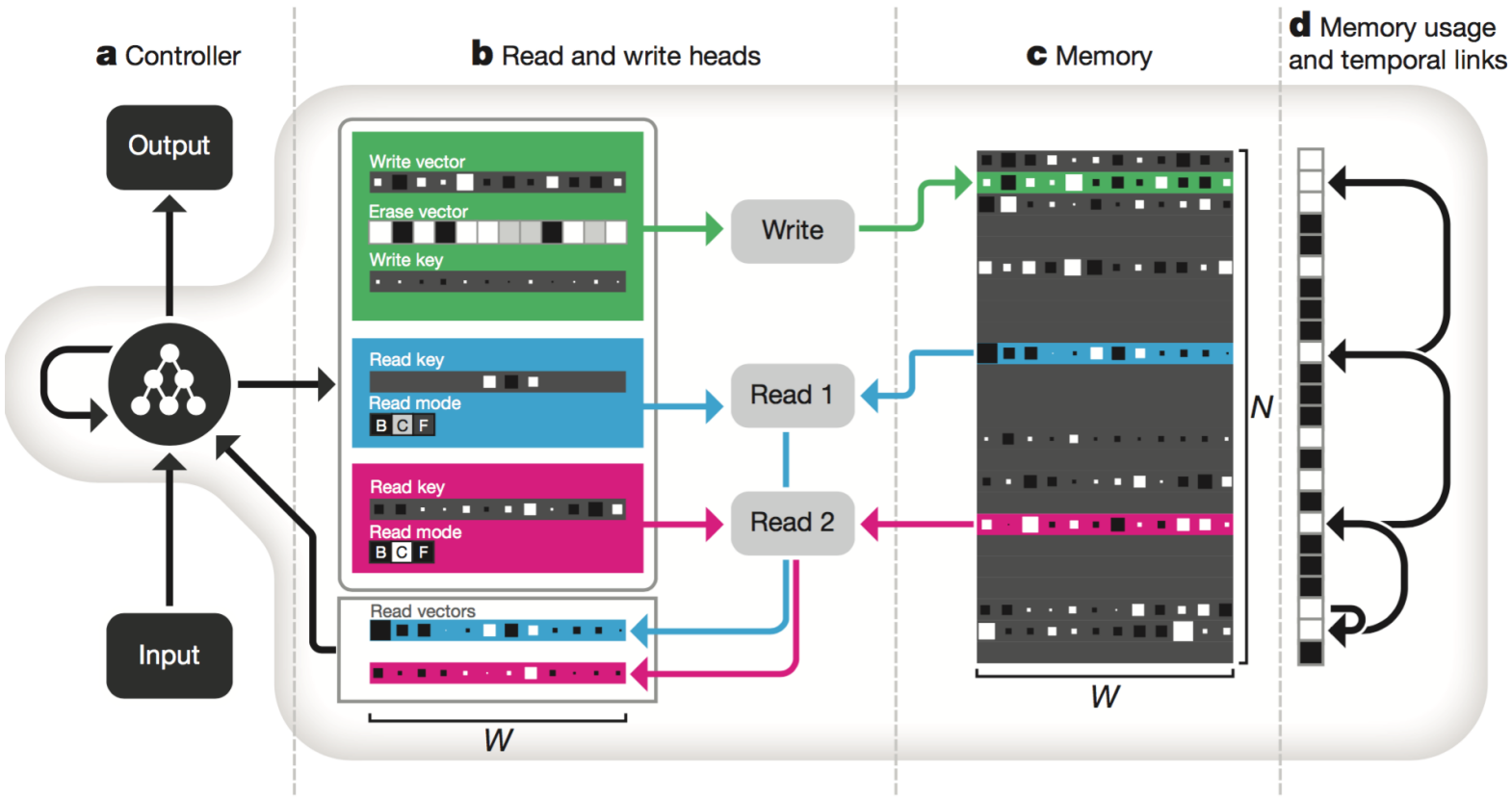


Advance Topics of Deep Learning for NLP

- Memory network
- Deep reinforcement learning
- Sequence2Sequence learning

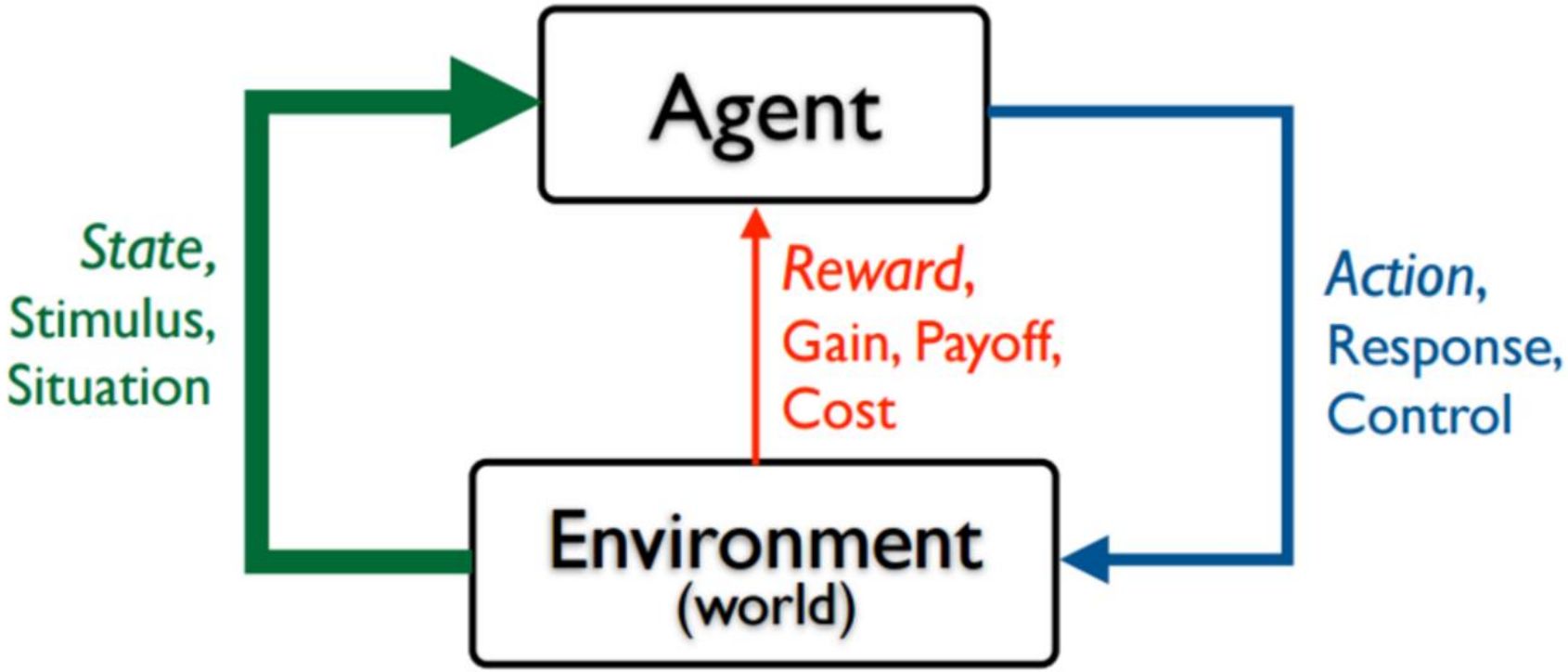
Memory Network Models





Neural Differentiable Computer

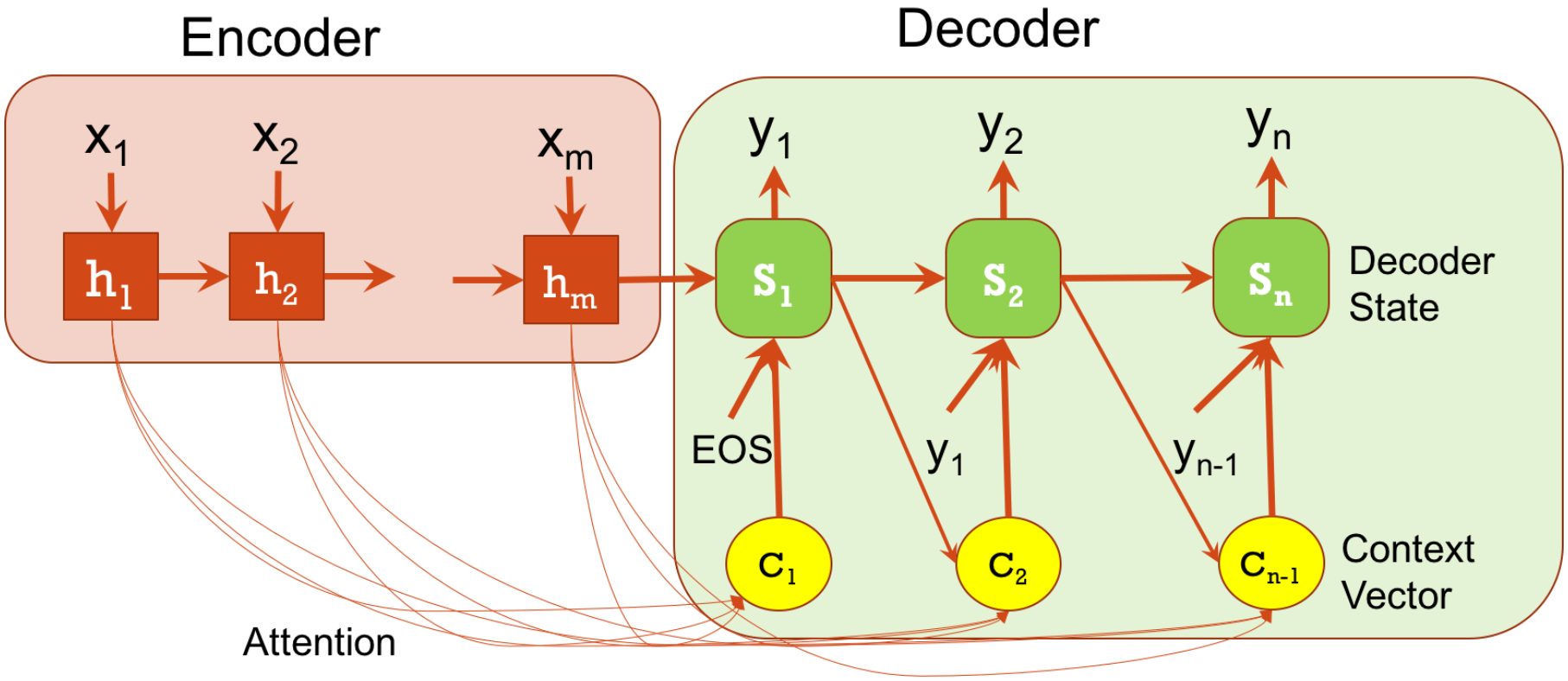
Deep Reinforcement Learning



Deep learning to represent states, actions, or policy functions

Sequence to Sequence Learning

- From Sequence X_1 X_2 $\cdots X_m$ to Y_1 $Y_2 \cdots Y_n$
- Machine translation, dialogue generation



Thanks for Attention

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