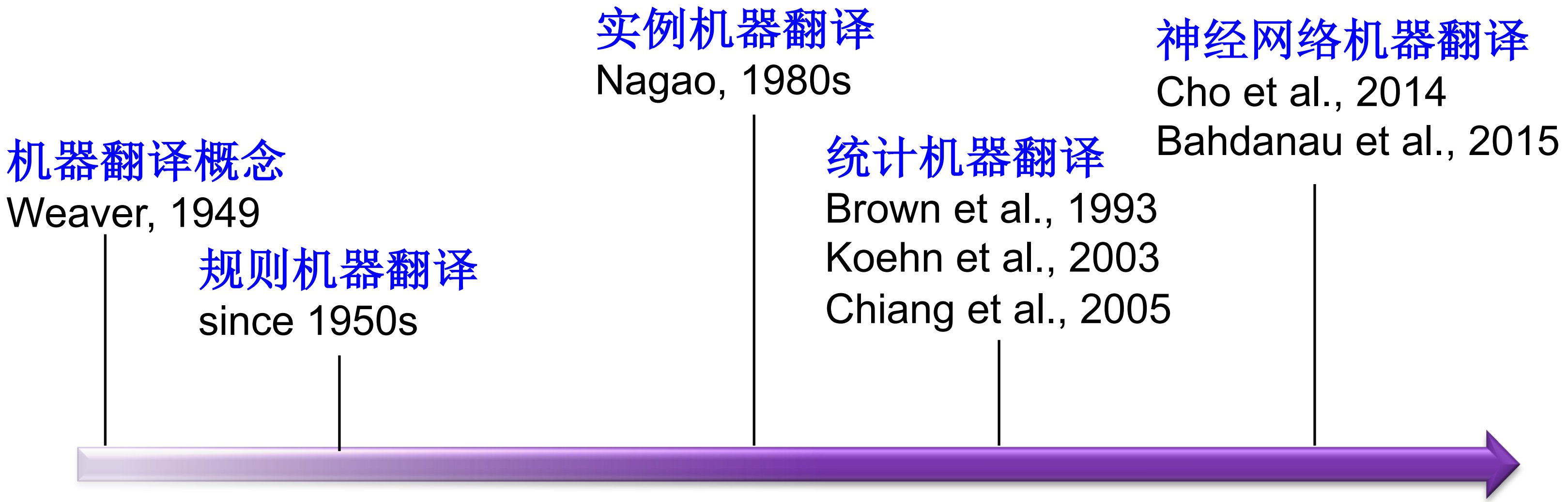
NLP 南京大学 自然语言处理研究组 Natural Language Processing Group

南京大學 NANJING UNIVERSITY

机器翻译的研究历程 --神经网络机器翻译

黄书剑

机器翻译的发展



机器翻译概念
Weaver, 1949

规则机器翻译
since 1950s

实例机器翻译
Nagao, 1980s

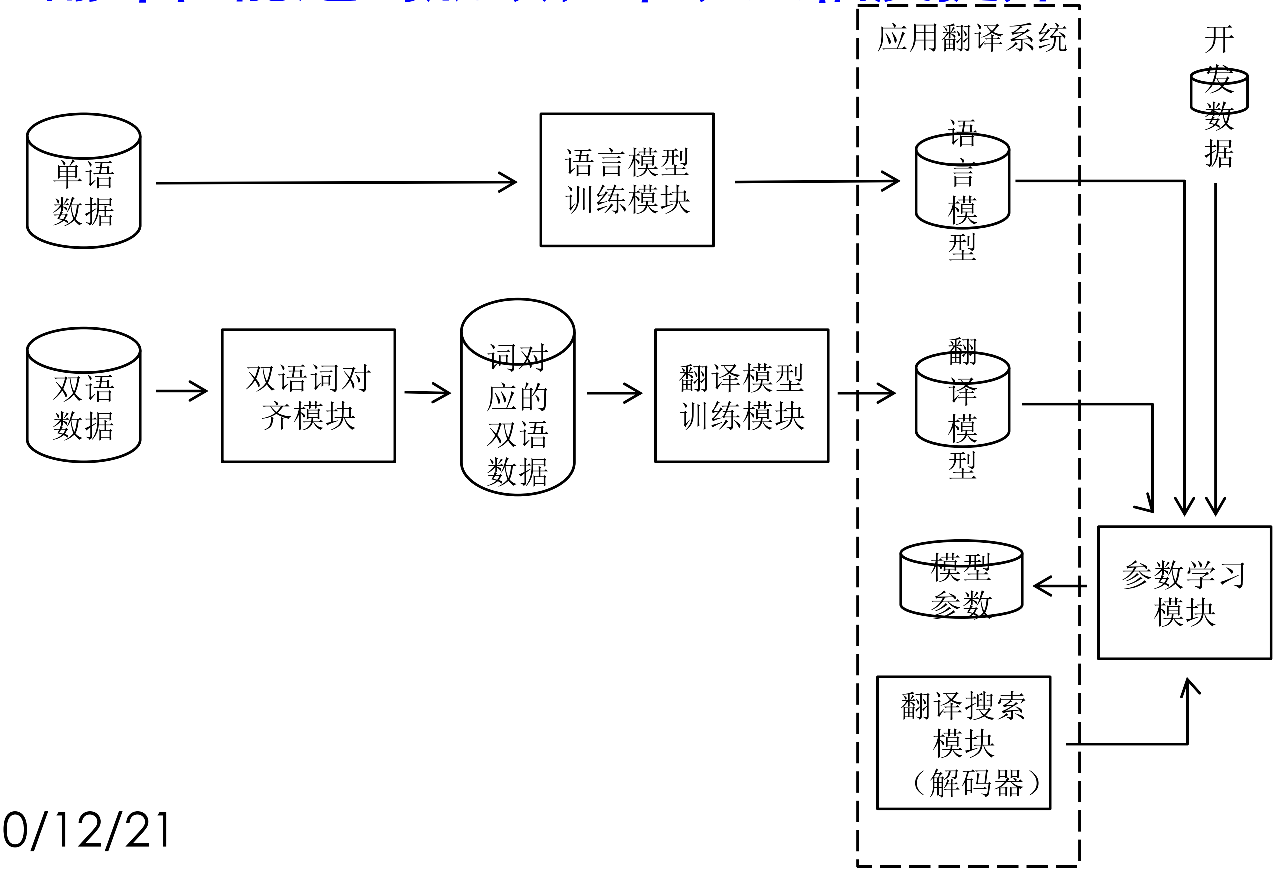
统计机器翻译
Brown et al., 1993
Koehn et al., 2003
Chiang et al., 2005

神经网络机器翻译
Cho et al., 2014
Bahdanau et al., 2015

数据资源越来越丰富
计算能力越来越强

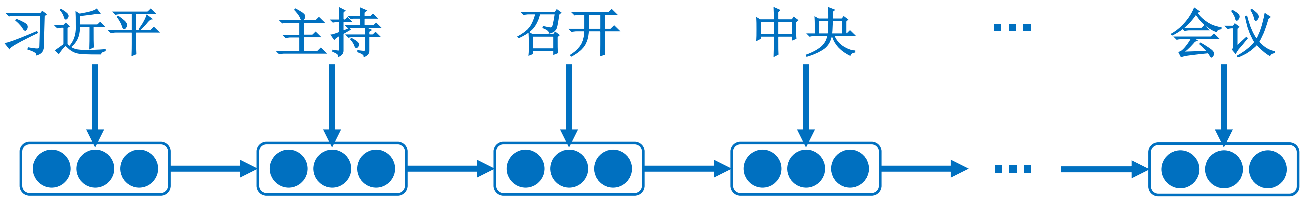
统计机器翻译回顾

- 可以一定程度上从数据中自动挖掘翻译知识
- 流程相对复杂，其中各个部分都不断被改进和优化
- 翻译性能遇到瓶颈，难以大幅度提升



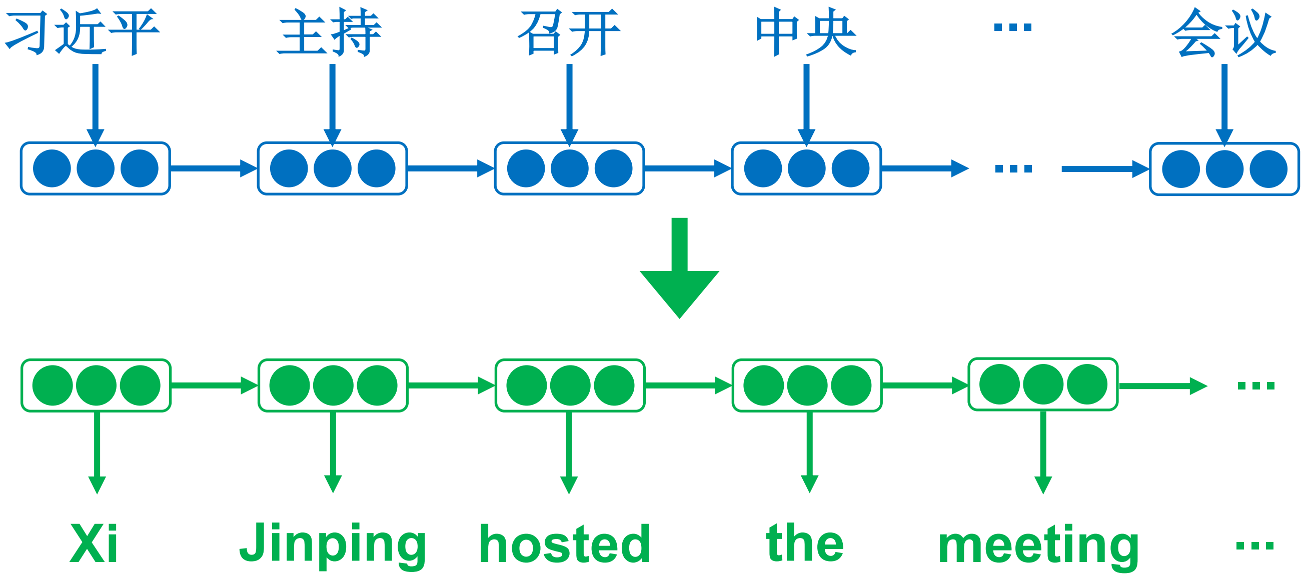
神经网络机器翻译

- 从单词序列到单词序列的翻译方式
  - 简单直接的把句子看做单词序列
  - 不再依赖大量从语料库中学习得到的有噪音规则
  - 例如：习近平主持召开中央全面深化改革领导小组会议



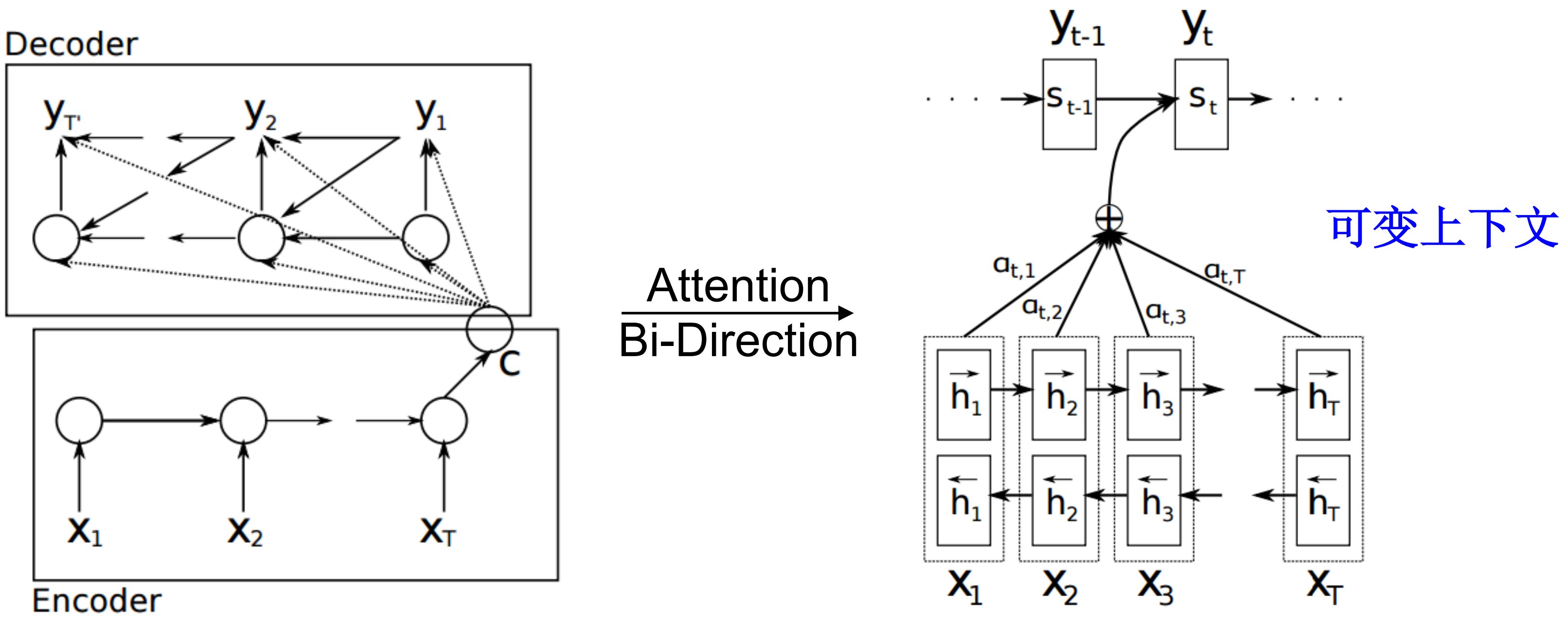
神经网络机器翻译

- 从单词序列到单词序列的翻译方式
  - 简单直接的把句子看做单词序列
  - 不需要建模规则的组合关系
  - 例如：习近平主持召开中央全面深化改革领导小组会议



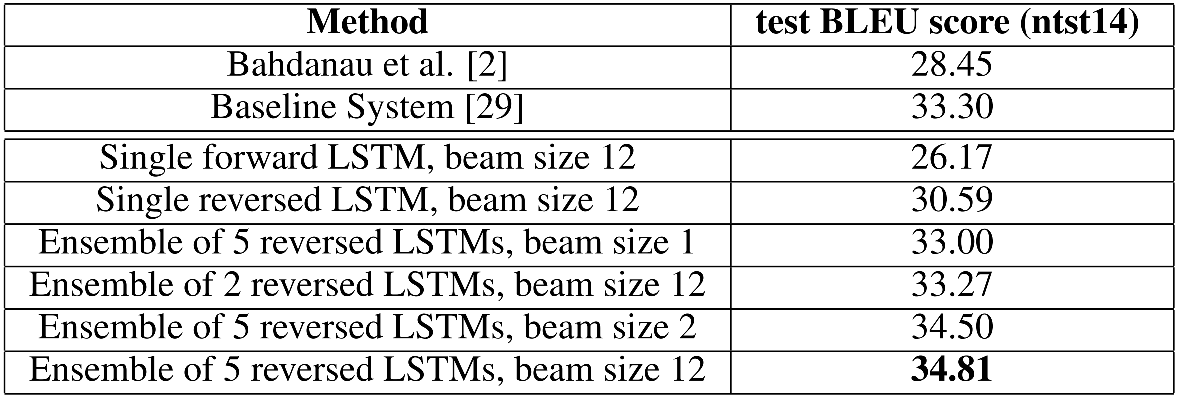
神经网络机器翻译

- **从单词序列到单词序列的翻译方式**
  - 简单直接的把句子看做单词序列
  - Bi-directional RNN + Attention



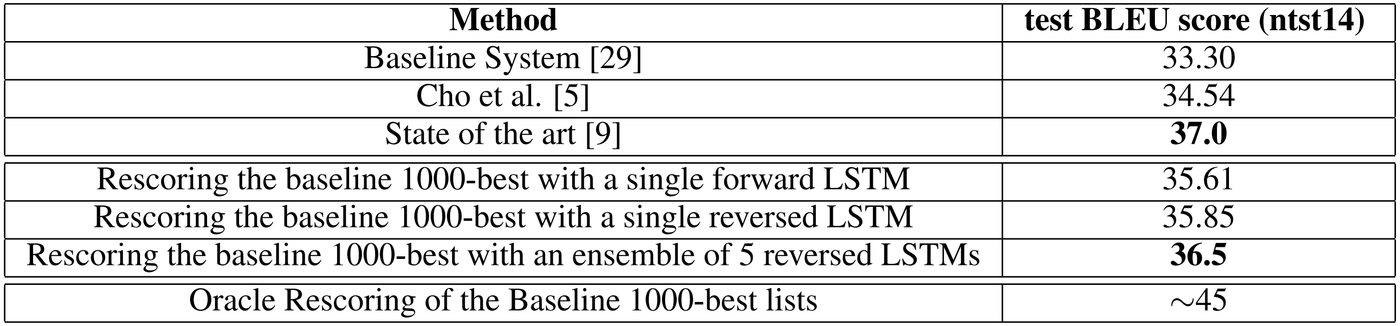
(Cho et al., 2014)

(Bahdanau et al., 2015)



Method	test BLEU score (ntst14)
Bahdanau et al. [2]	28.45
Baseline System [29]	33.30
Single forward LSTM, beam size 12	26.17
Single reversed LSTM, beam size 12	30.59
Ensemble of 5 reversed LSTMs, beam size 1	33.00
Ensemble of 2 reversed LSTMs, beam size 12	33.27
Ensemble of 5 reversed LSTMs, beam size 2	34.50
Ensemble of 5 reversed LSTMs, beam size 12	**34.81**

Table 1: The performance of the LSTM on WMT'14 English to French test set (ntst14). Note that an ensemble of 5 LSTMs with a beam of size 2 is cheaper than of a single LSTM with a beam of size 12.

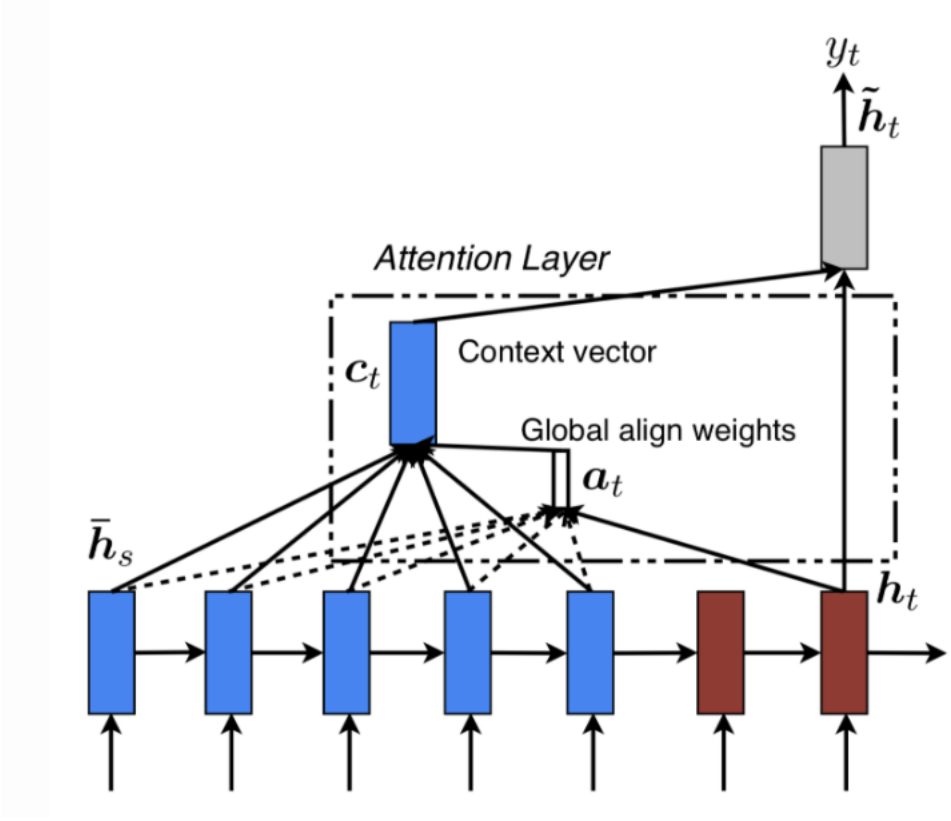


Method	test BLEU score (ntst14)
Baseline System [29]	33.30
Cho et al. [5]	34.54
State of the art [9]	**37.0**
Rescoring the baseline 1000-best with a single forward LSTM	35.61
Rescoring the baseline 1000-best with a single reversed LSTM	35.85
Rescoring the baseline 1000-best with an ensemble of 5 reversed LSTMs	**36.5**
Oracle Rescoring of the Baseline 1000-best lists	∼45

Table 2: Methods that use neural networks together with an SMT system on the WMT'14 English to French test set (ntst14).

[Sutskever et al. 2014]

Attention Mechanism



$$\begin{aligned}\boldsymbol{a}_t(s) &= \operatorname{align}(\boldsymbol{h}_t, \bar{\boldsymbol{h}}_s)\\ &= \frac{\exp\left(\operatorname{score}(\boldsymbol{h}_t, \bar{\boldsymbol{h}}_s)\right)}{\sum_{s'} \exp\left(\operatorname{score}(\boldsymbol{h}_t, \bar{\boldsymbol{h}}_{s'})\right)}\end{aligned}$$

$$\operatorname{score}(\boldsymbol{h}_t, \bar{\boldsymbol{h}}_s) = \begin{cases} \boldsymbol{h}_t^\top \bar{\boldsymbol{h}}_s & \textit{dot}\\ \boldsymbol{h}_t^\top \boldsymbol{W_a} \bar{\boldsymbol{h}}_s & \textit{general}\\ \boldsymbol{W_a}[\boldsymbol{h}_t; \bar{\boldsymbol{h}}_s] & \textit{concat} \end{cases}$$

Thang Luong et al. 2015

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$$a_t(s_i) = \frac{\exp(score(h_t, h_{s_i}))}{\sum_j \exp(score(h_t, h_{s_j}))}$$

$$c_t(s) = \sum_j a_t(s_j) h_{s_j}$$

$$\mathrm{score}(\boldsymbol{h}_t, \bar{\boldsymbol{h}}_s) = \begin{cases} \boldsymbol{h}_t^\top \bar{\boldsymbol{h}}_s & \textit{dot} \\ \boldsymbol{h}_t^\top \boldsymbol{W_a} \bar{\boldsymbol{h}}_s & \textit{general} \\ \boldsymbol{W_a}[\boldsymbol{h}_t; \bar{\boldsymbol{h}}_s] & \textit{concat} \end{cases}$$

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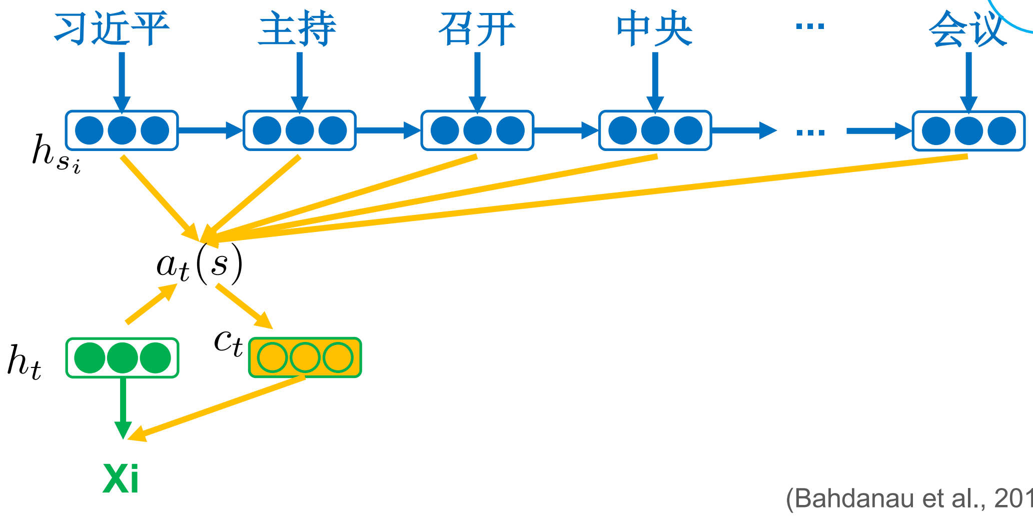

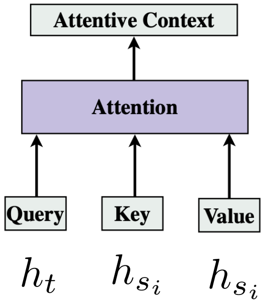

(Bahdanau et al., 2015)

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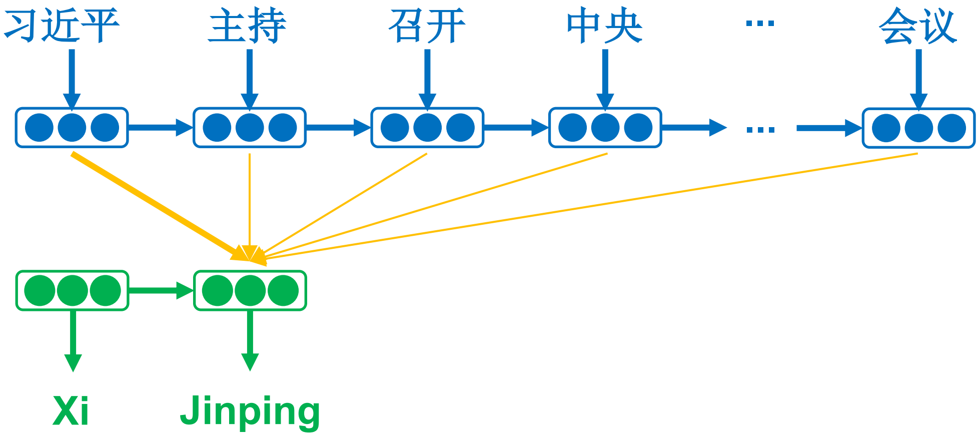

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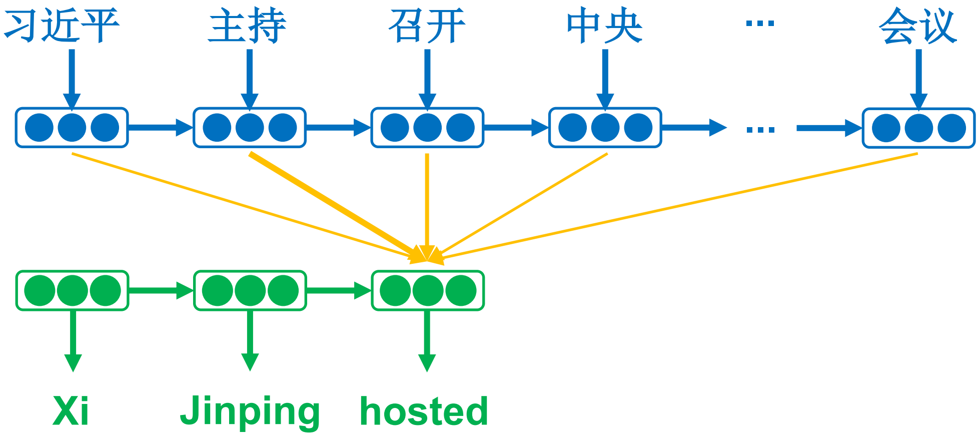

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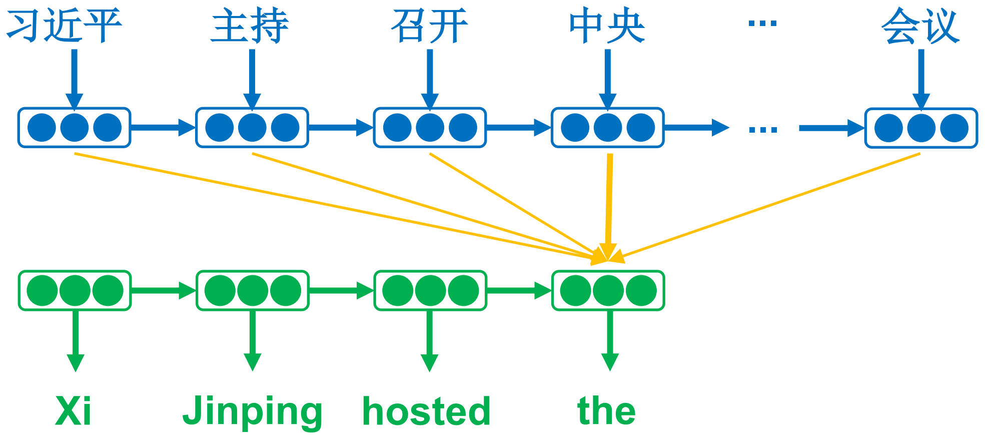

(Bahdanau et al., 2015)

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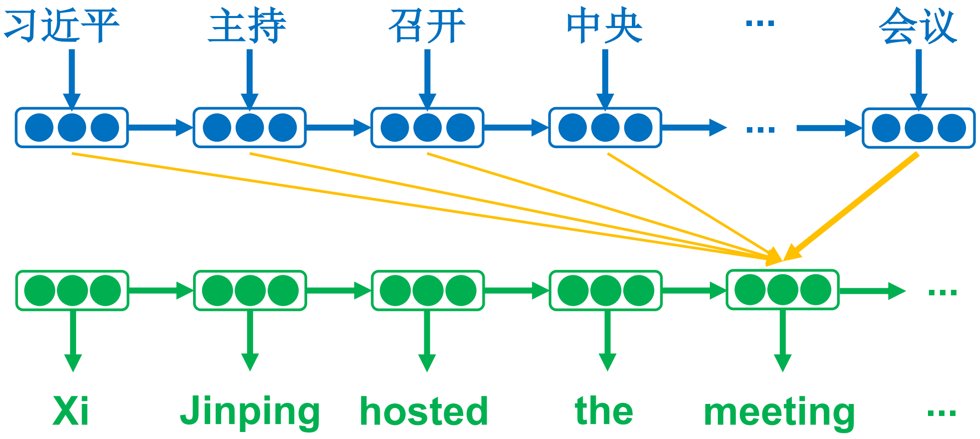
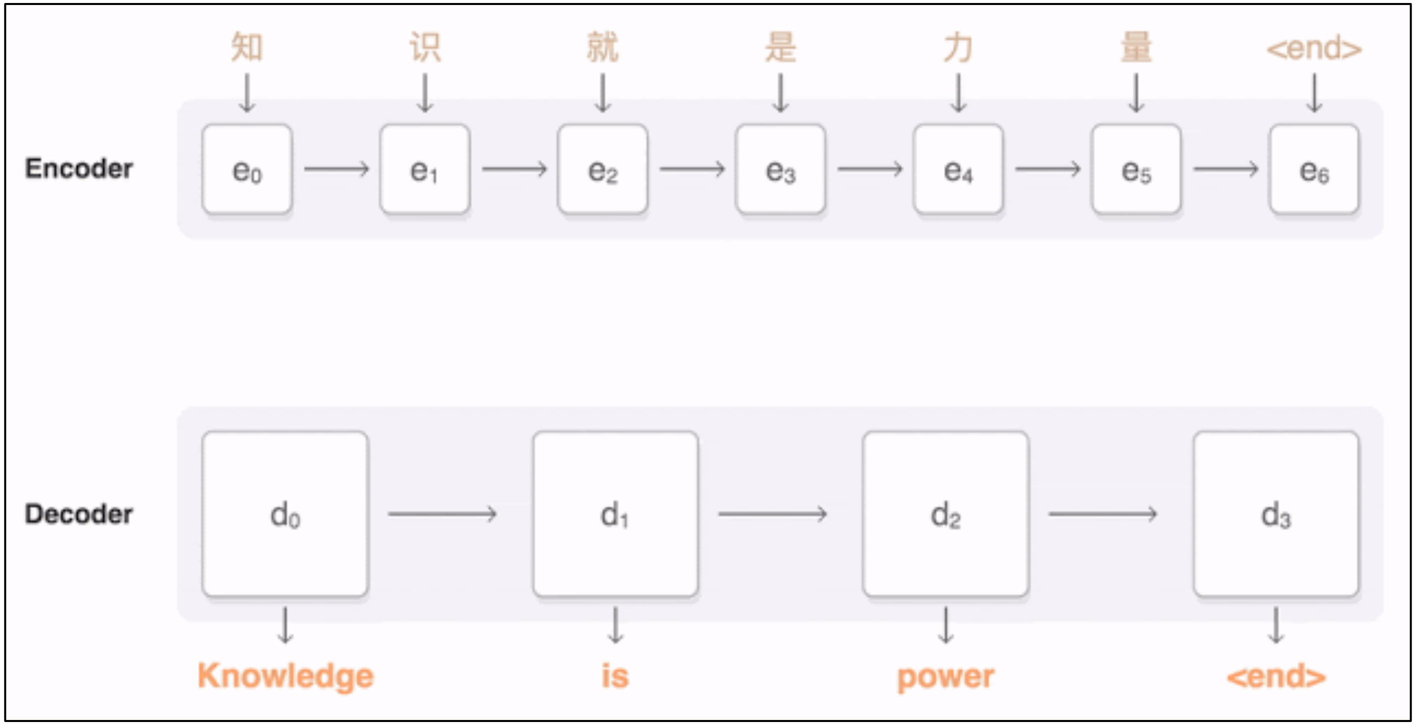
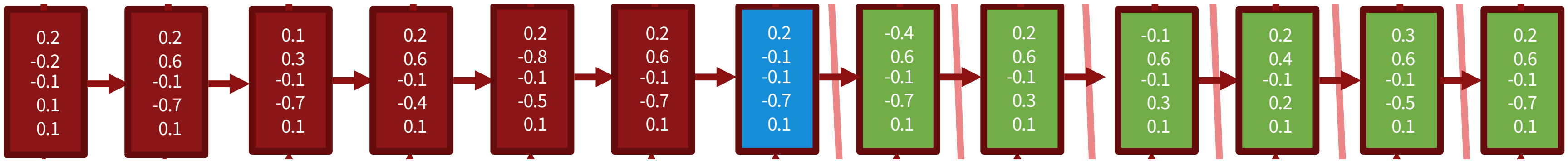


(Bahdanau et al., 2015)

Encoder-Decoder with Attention

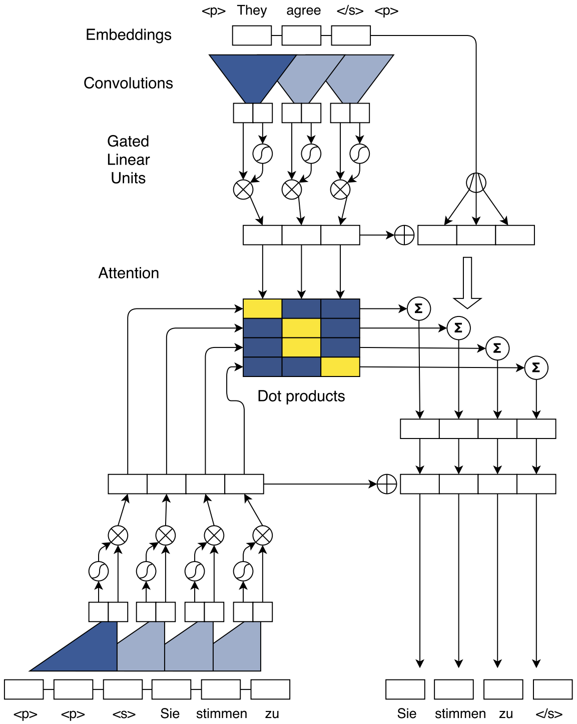


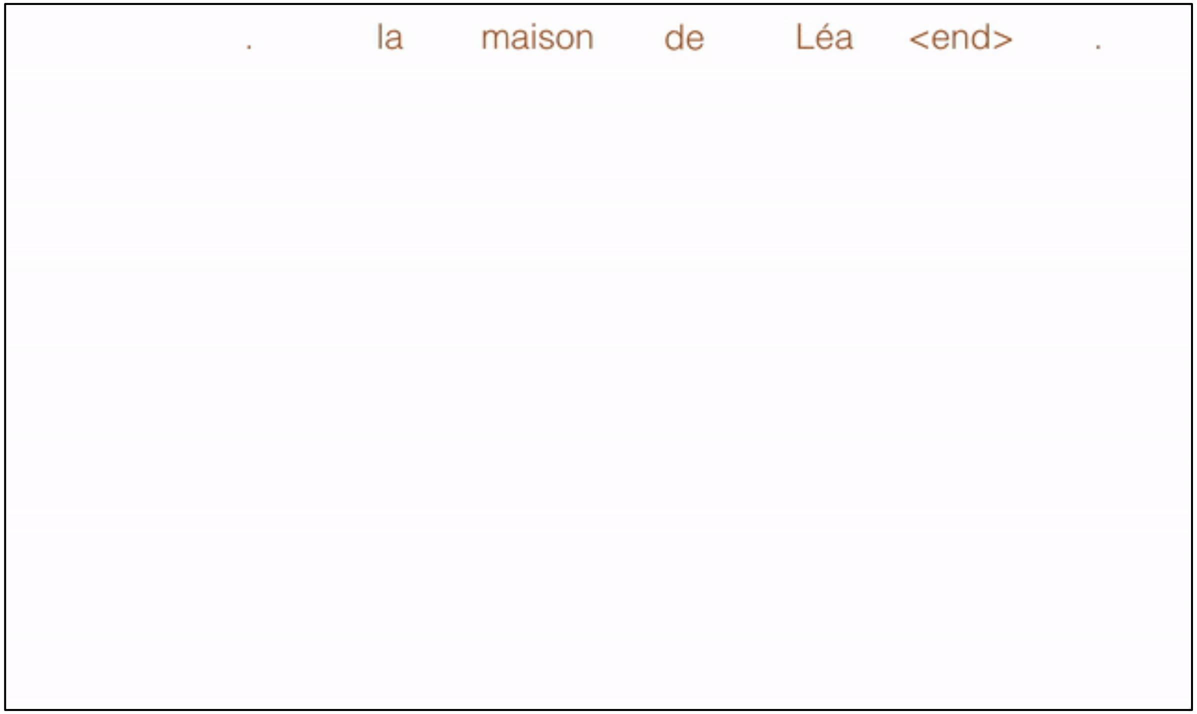
https://medium.com/analytics-vidhya/transformer-vs-rnn-and-cnn-18eeefa3602b



(Thang Luong et al., 2016)

CNN-based Encoder Decoder

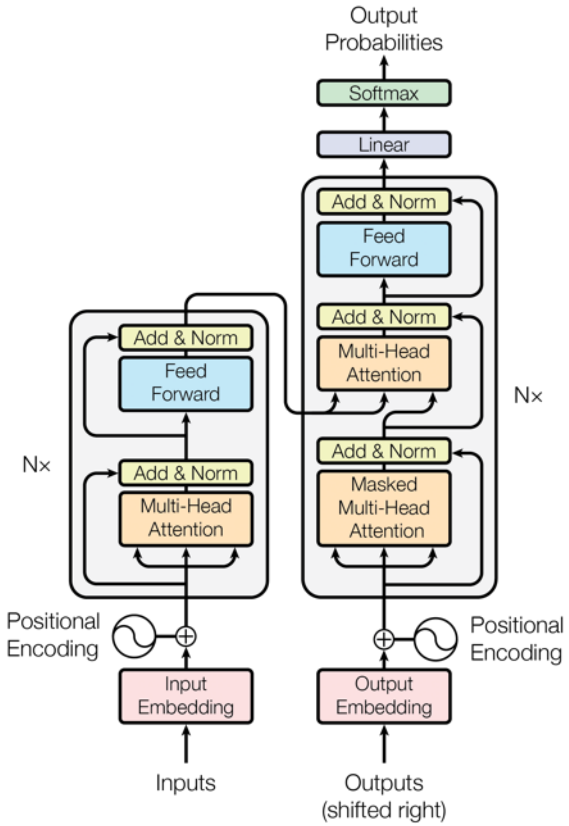




Gehring et al., (2017)

https://medium.com/analytics-vidhya/transformer-vs-rnn-and-cnn-18eeefa3602b

Self-Attention Networks (Transformer)



Vaswani et al., (2017)

https://medium.com/analytics-vidhya/transformer-vs-rnn-and-cnn-18eeefa3602b

Self-Attention v.s. RNN/CNN

$$\text{Attention}(Q, K, V) = \text{softmax}(\frac{QK^T}{\sqrt{d_k}})V$$

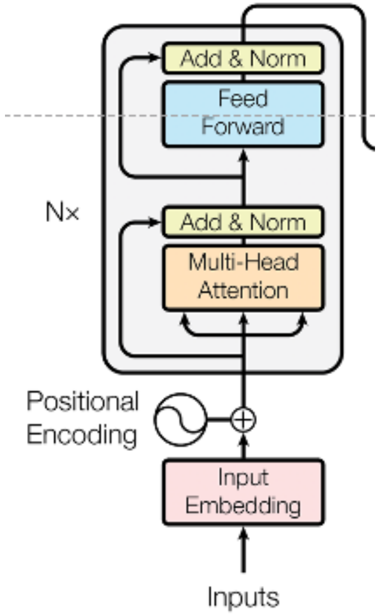
- Q=K=V for self-attention

- Total computational complexity
- The amount of computation that can be parallelized
- The path length between long-range dependencies in the network

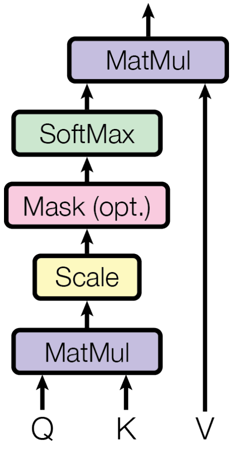
Vaswani et al., (2017)

其他实现技巧

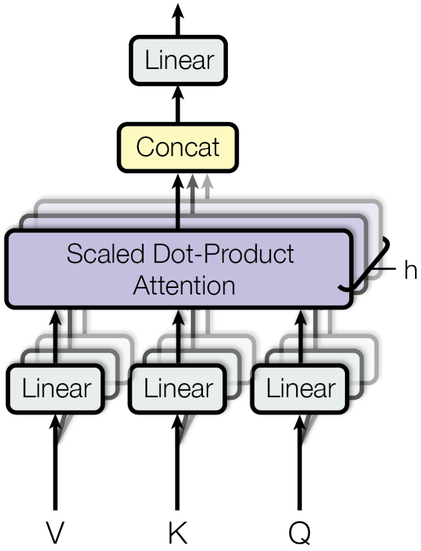
- Position, Layer Norm, Feed-Forward, Residual
- Scaled Dot-Product, Multi-Head
- Stacking



Scaled Dot-Product Attention



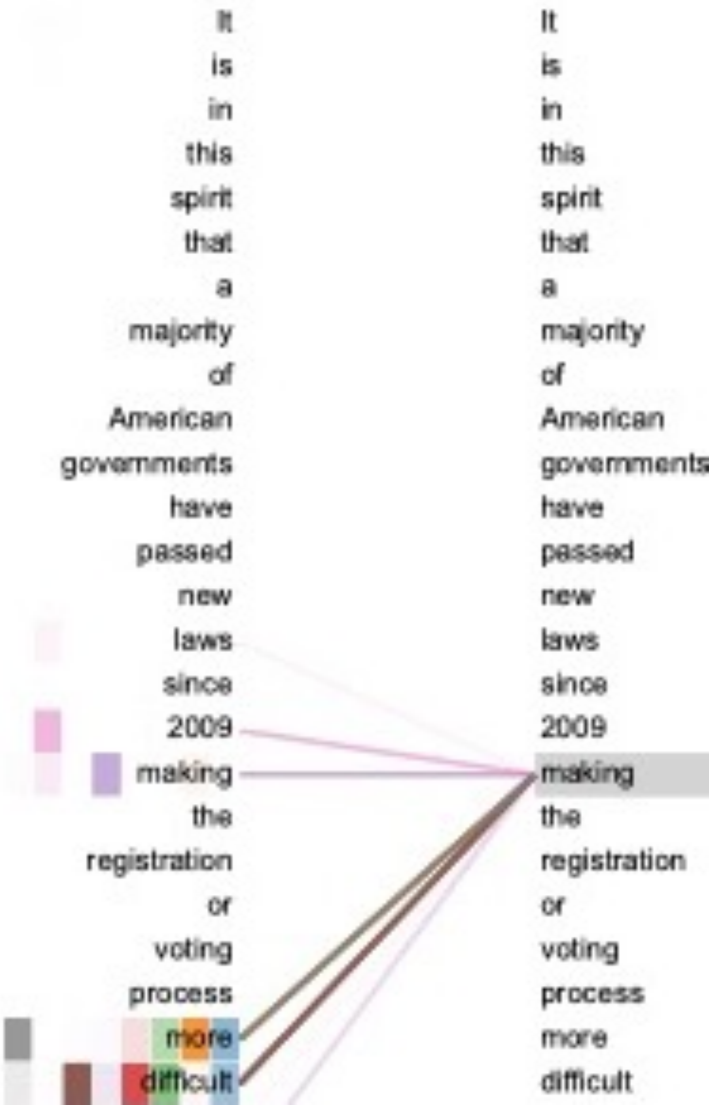
Multi-Head Attention



http://jalammar.github.io/illustrated-transformer/

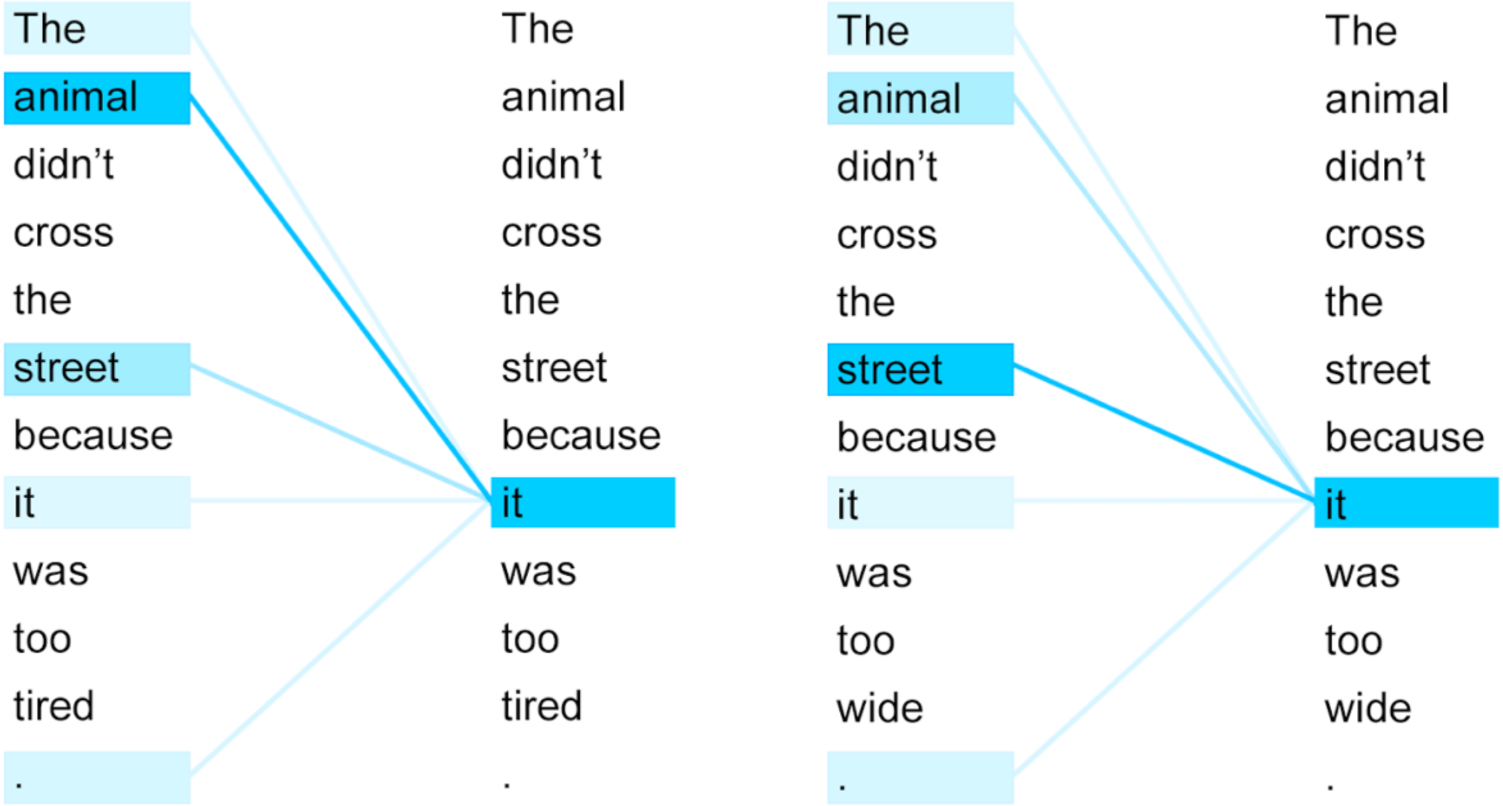
Self-Attention

- 捕捉相关的上下文



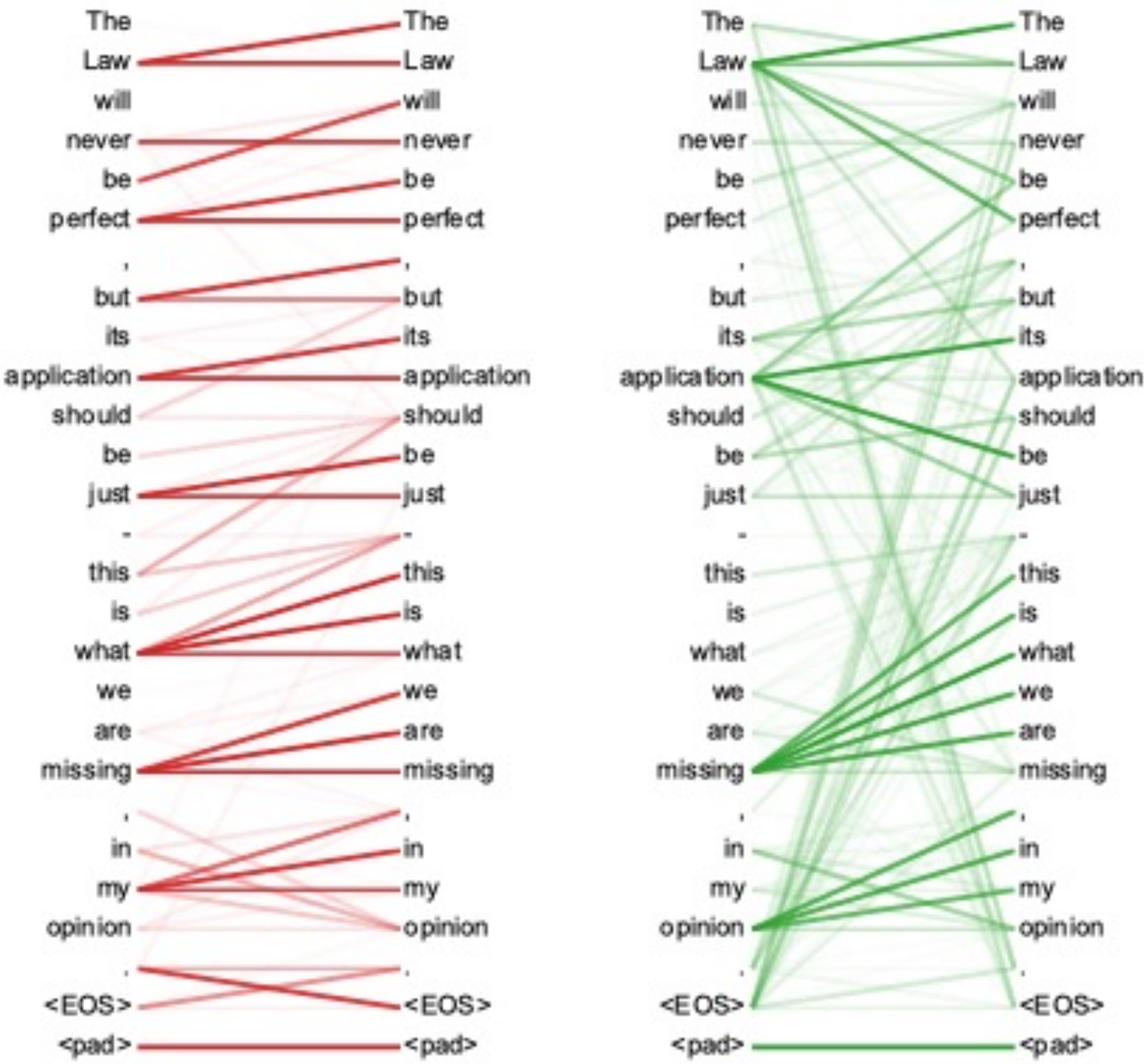
The animal didn't cross the street because it was too tired.
L'animal n'a pas traversé la rue parce qu'il était trop fatigué.

The animal didn't cross the street because it was too wide.
L'animal n'a pas traversé la rue parce qu'elle était trop large.



https://ai.googleblog.com/2017/08/transformer-novel-neural-network.html

Multi-Head Attention



小结

- 机器翻译能力随着机器计算能力的迅速发展而增长
  - 神经网络的引入从统计稀疏性和建模两个方面提升了机器翻译系统
  - 神经网络机器翻译是一种能够更加充分发挥机器长处的自动翻译方法
- 进一步的提升?

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