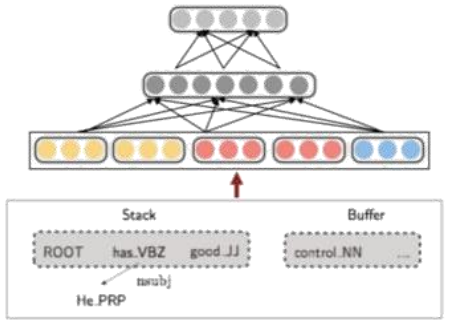
BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding 论文导读

&

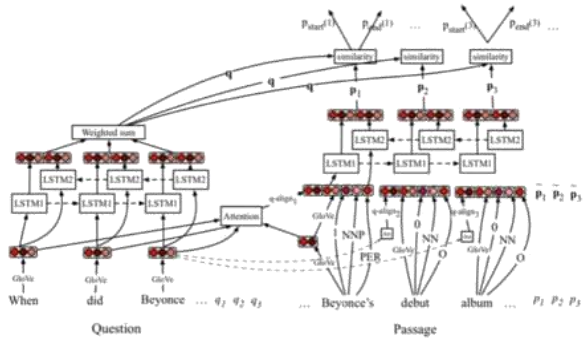
Bert 详解

Why Bert ?

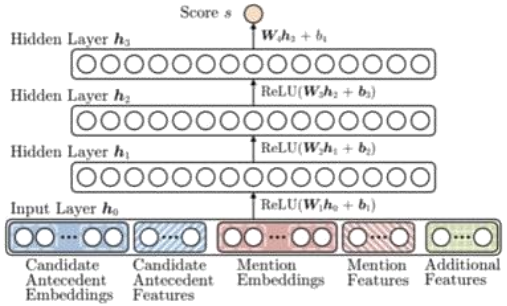
Various Model Architectures for Different NLP Tasks



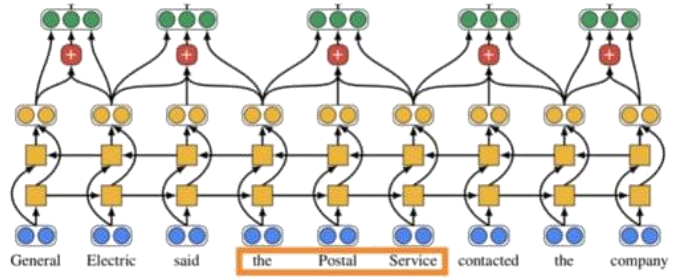
Dependency Parsing



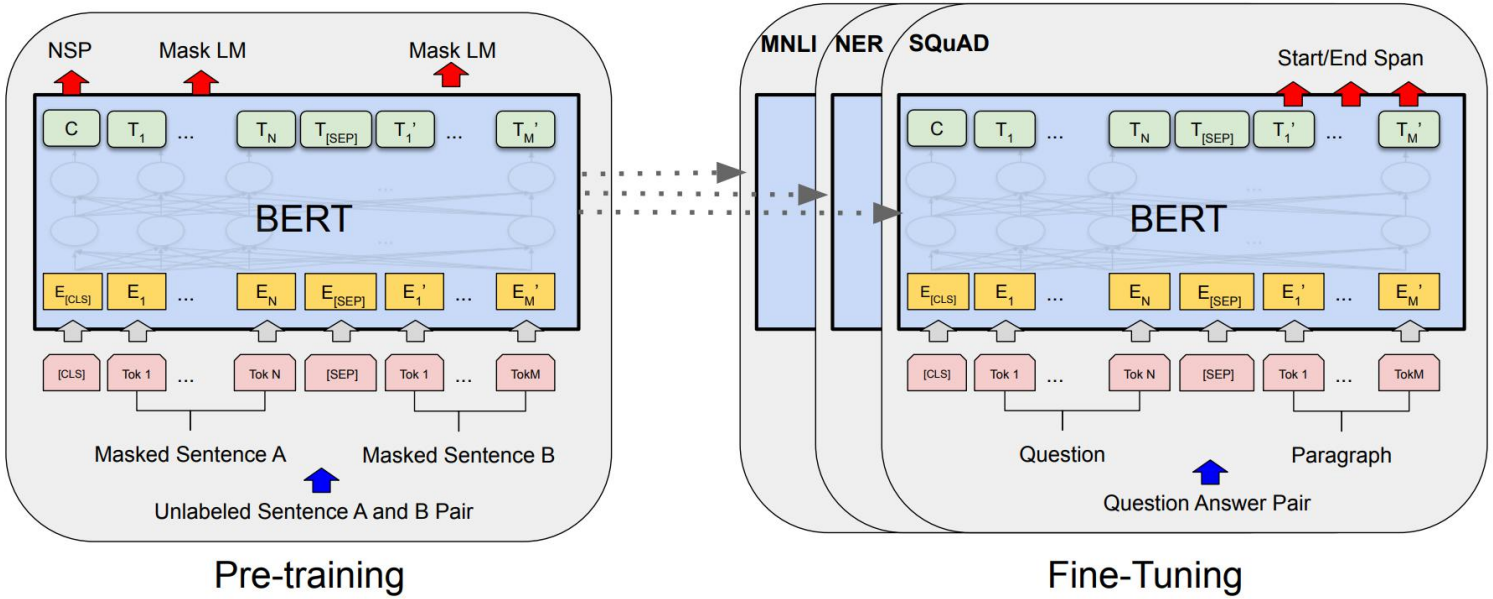
Question Answering



Coreference example 1



Coreference example 2



Pre-training

Fine-Tuning

论文信息

BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding

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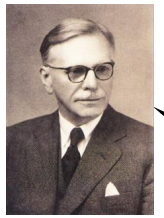
Kenton, J. D. M. W. C., & Toutanova, L. K. (2019). BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding. In Proceedings of NAACL-HLT (pp. 4171-4186).

Language Model

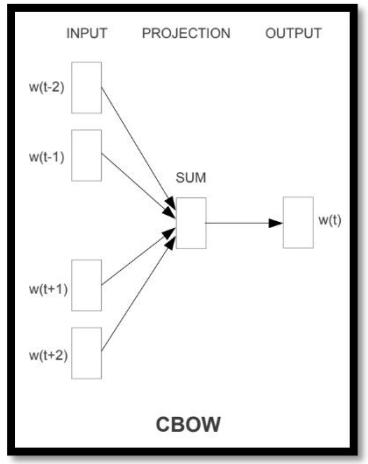
语言模型：

给定词典 V，计算出任意单词序列 w1，w2，...，wn 是一句话的概率: p(w1，w2，...，wn), p > = 0.



John Rupert Firth

You shall know a word by the company it keeps.



word embedding

语言模型 — 2003 Bengio

词嵌入阶段：

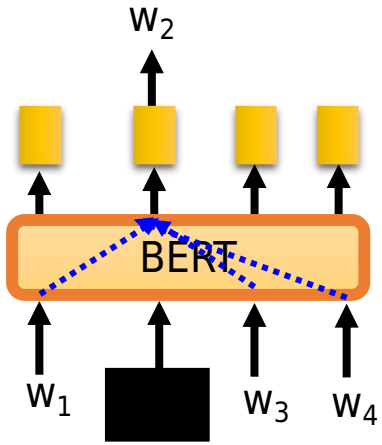
- word2vec — 2013 Mikolov
- glove — 2014 Jeffrey
- fasttext — 2016 facebook

\+ 复杂网络模型

预训练语言模型阶段：

- Elmo — 2018.2 Allen
- GPT — 2018.6 OpenAI
- BERT — 2018.10 google

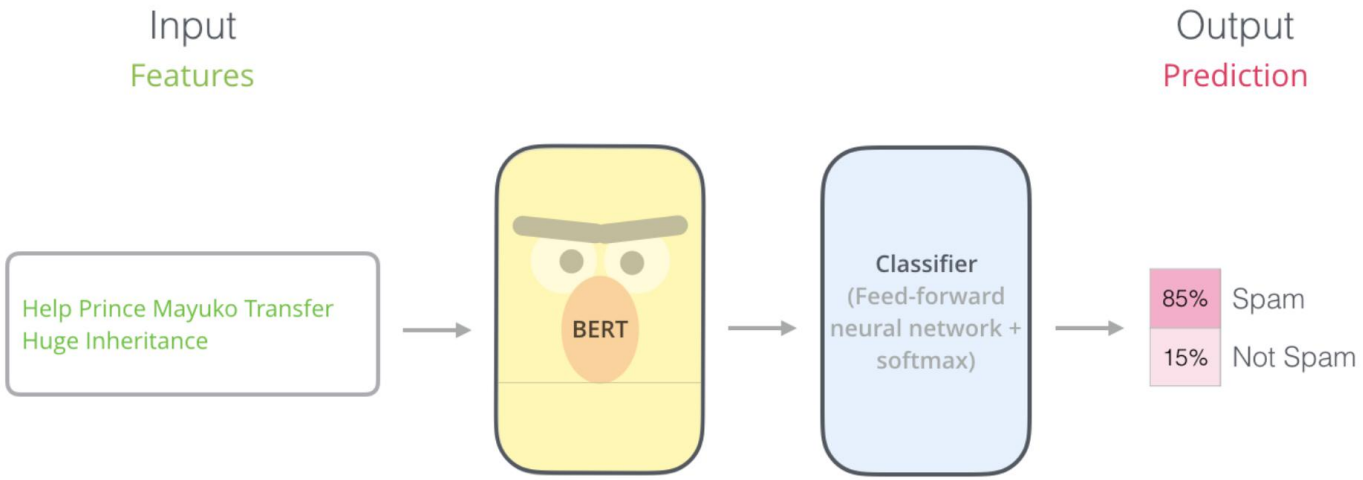
\+ 简单 MLP

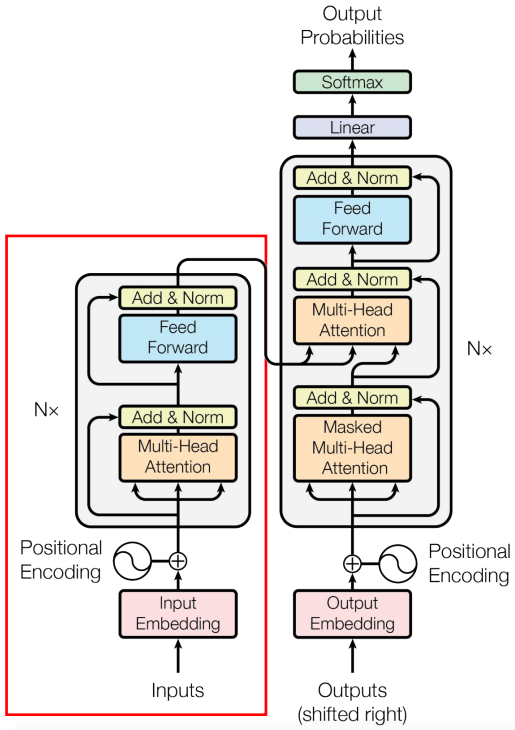


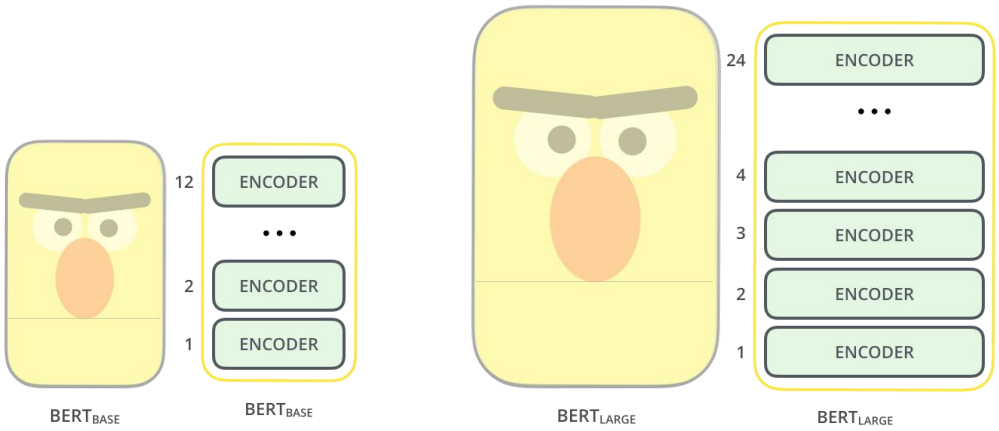
Contextualized word embedding

Bert 架构

Bidirectional Encoder Representation from Transformer





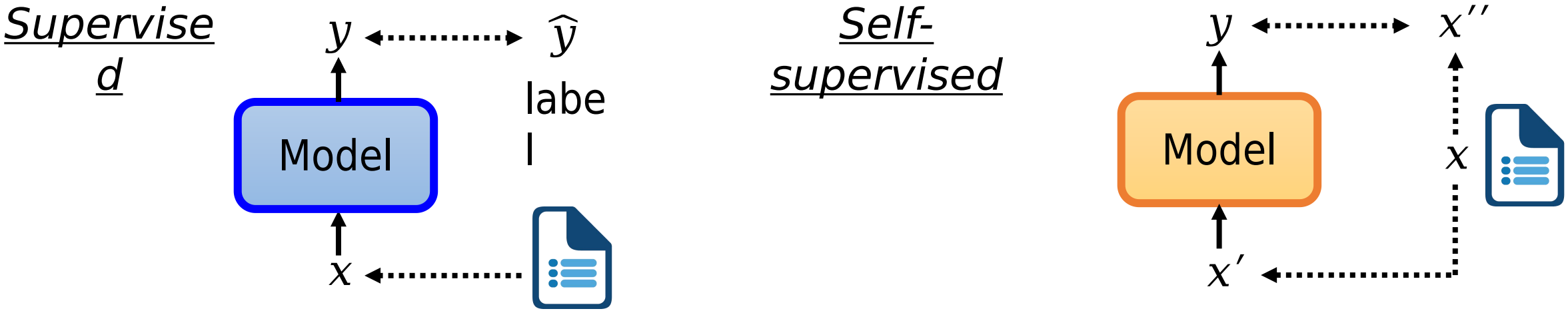


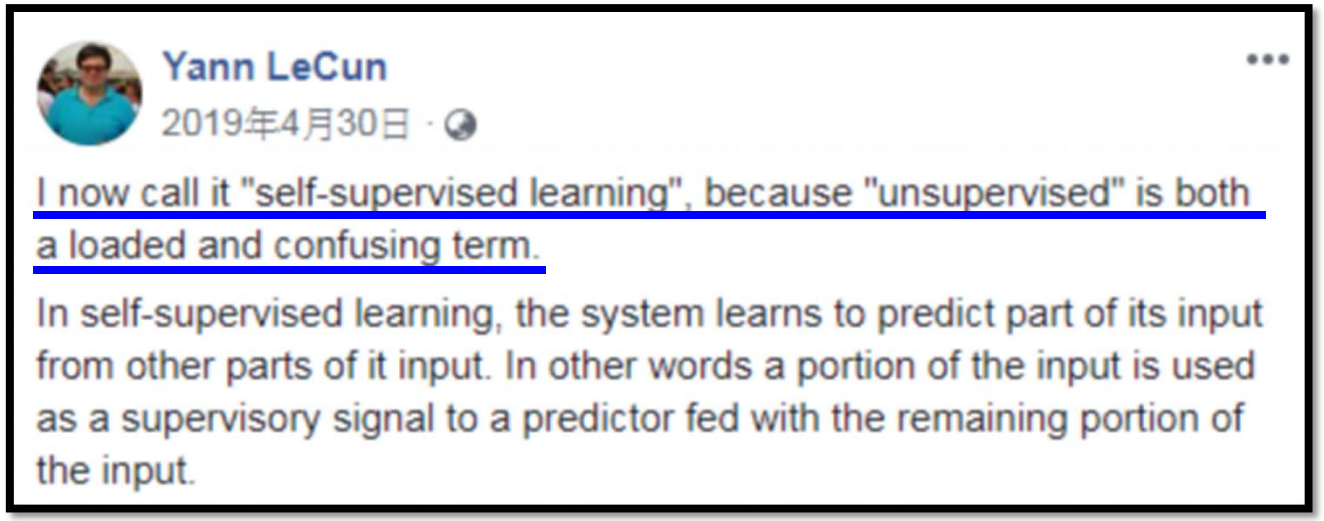
$Bert_{BASE}$：L=12，H=768，A=12，参数总量 110M
$Bert_{LARGE}$：L=24，H=1024，A=16，参数总量 340M

L：block数量
H：隐藏层维度
A：注意力头的数量

Bert 训练

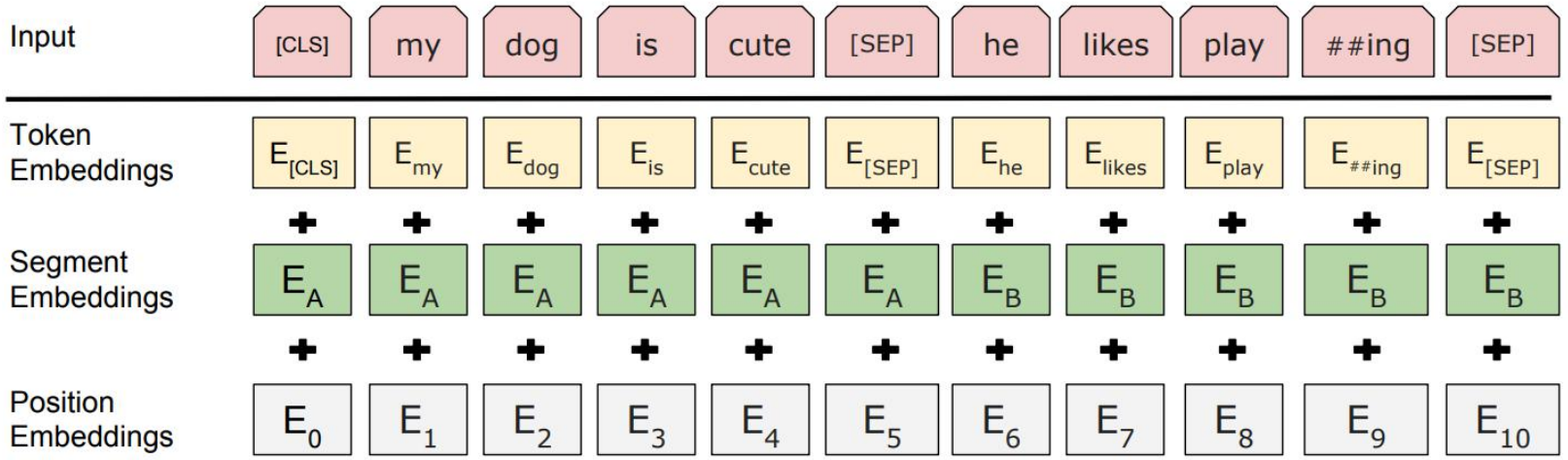
Supervised & Self-Supervised





Bert 训练

输入向量



将单词转换为固定维度的向量

区分句子对的上下句

标记句中每个词的位置

Segment Embeddings 示例：

[CLS] 我 的 狗 很 可 爱 [SEP] 企 鹅 不 擅 长 飞 行 [SEP]
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1

Bert 训练

任务一：MLM（Masked Language Modeling）

MASK 策略示例：

对于语句“my dog is hairy”，随机把句中15%的token替换为以下内容：

80%的几率被替换成[MASK]：

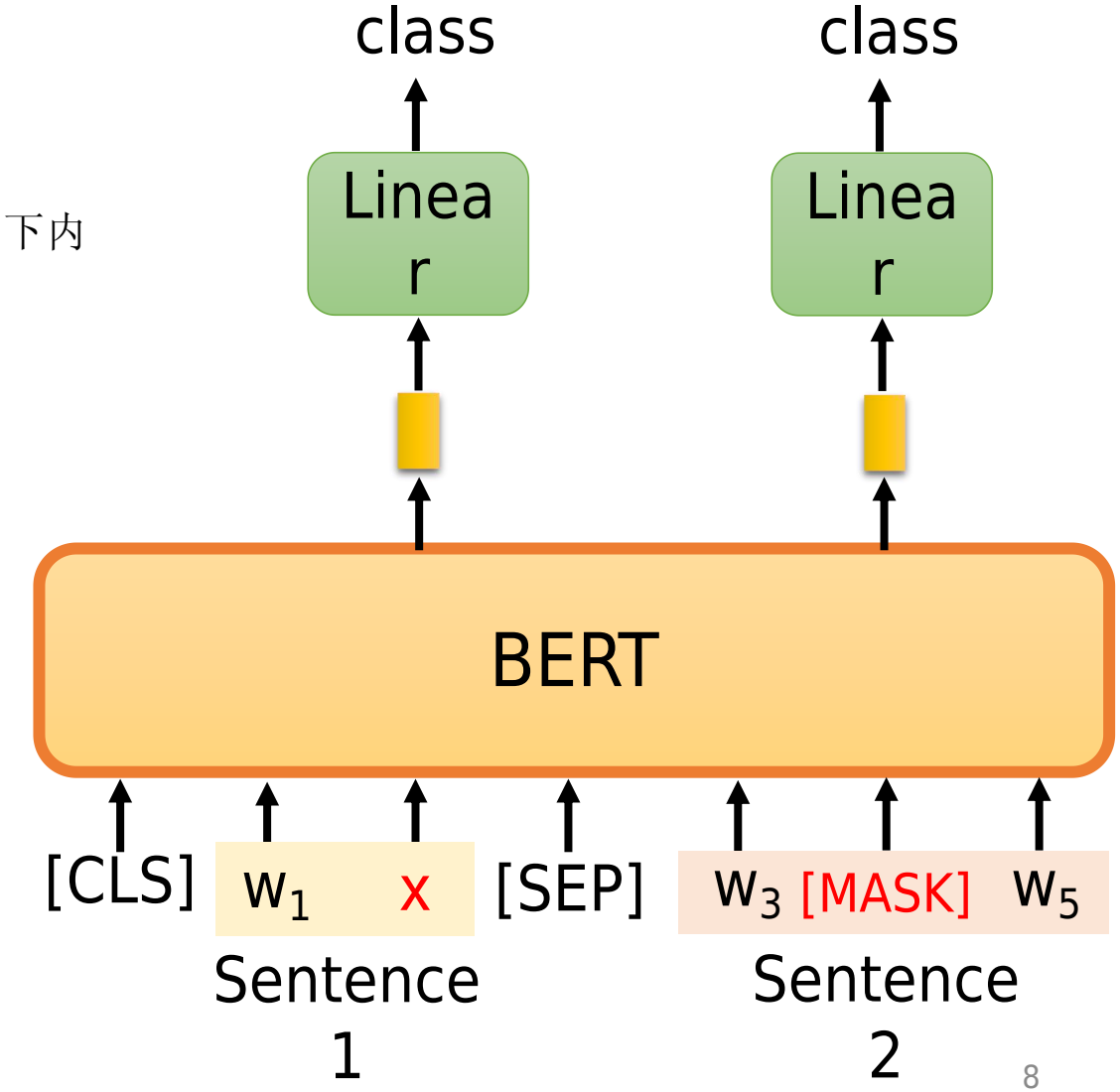
“my dog is hairy” → “my dog is [MASK]”

10%的几率被替换成其他token：

“my dog is hairy” → “my dog is apple”

10%的几率原封不动：

“my dog is hairy” → “my dog is hairy”



Bert 训练

任务二：NSP（Next Sentence Prediction）

正负句子对样本：

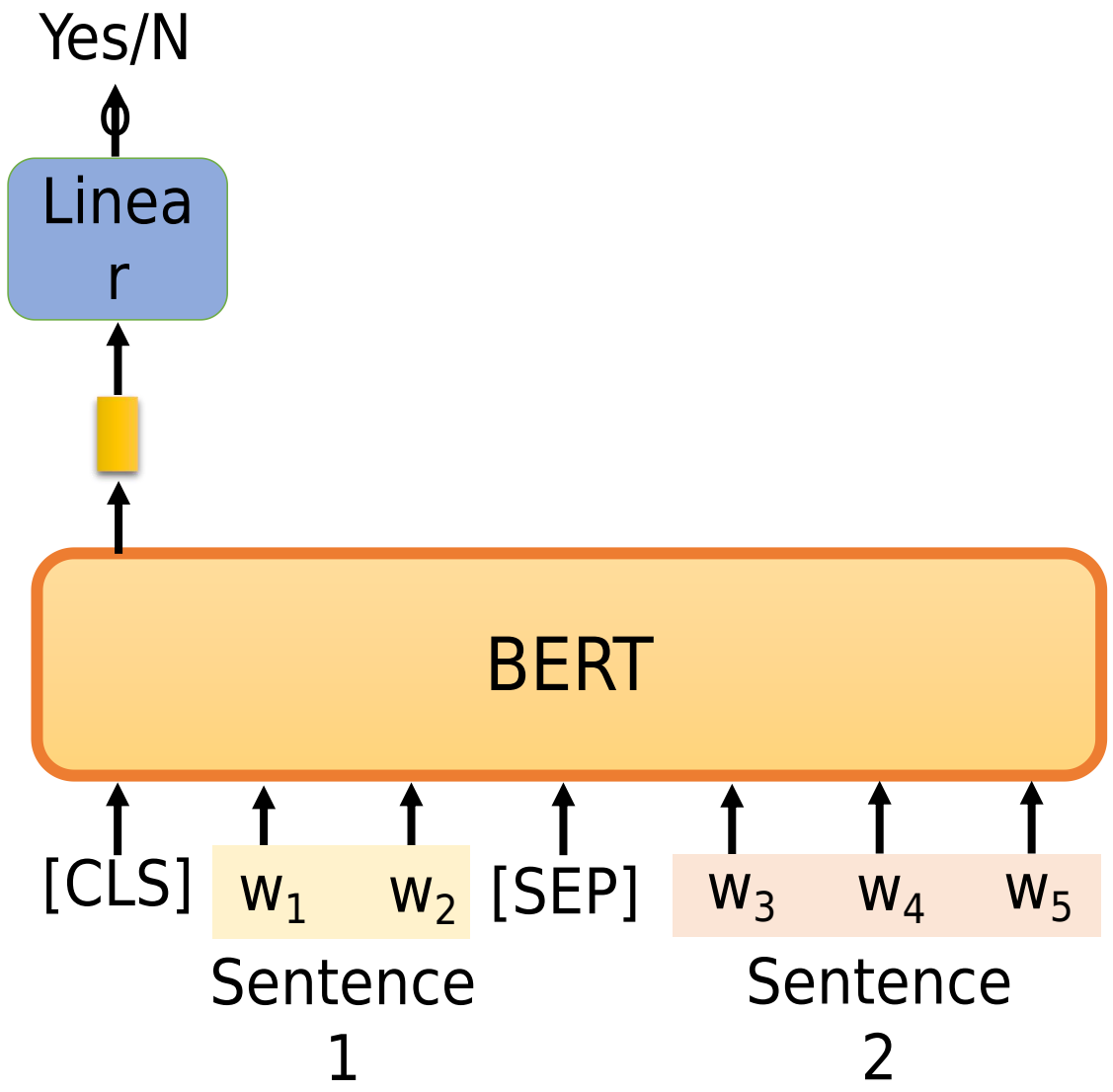
50% 的正样本：训练语料库中的两个连续段落

50% 的负样本：来自不同文档的两个随机段落

示例：

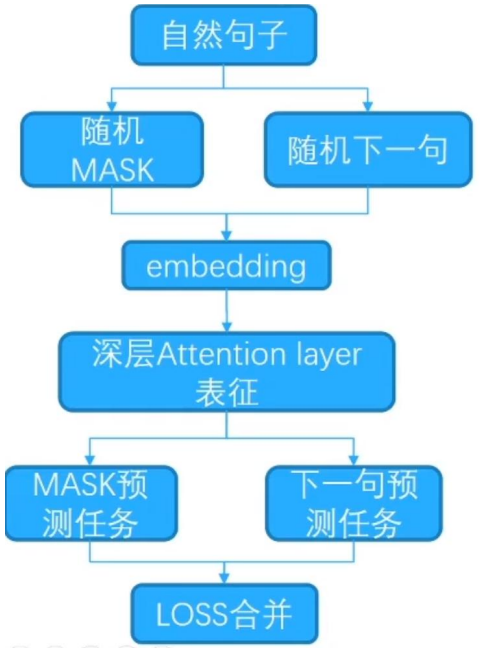
Input：[CLS] 博学而笃志 [SEP] 切问而近思 [SEP]
Target：Yes

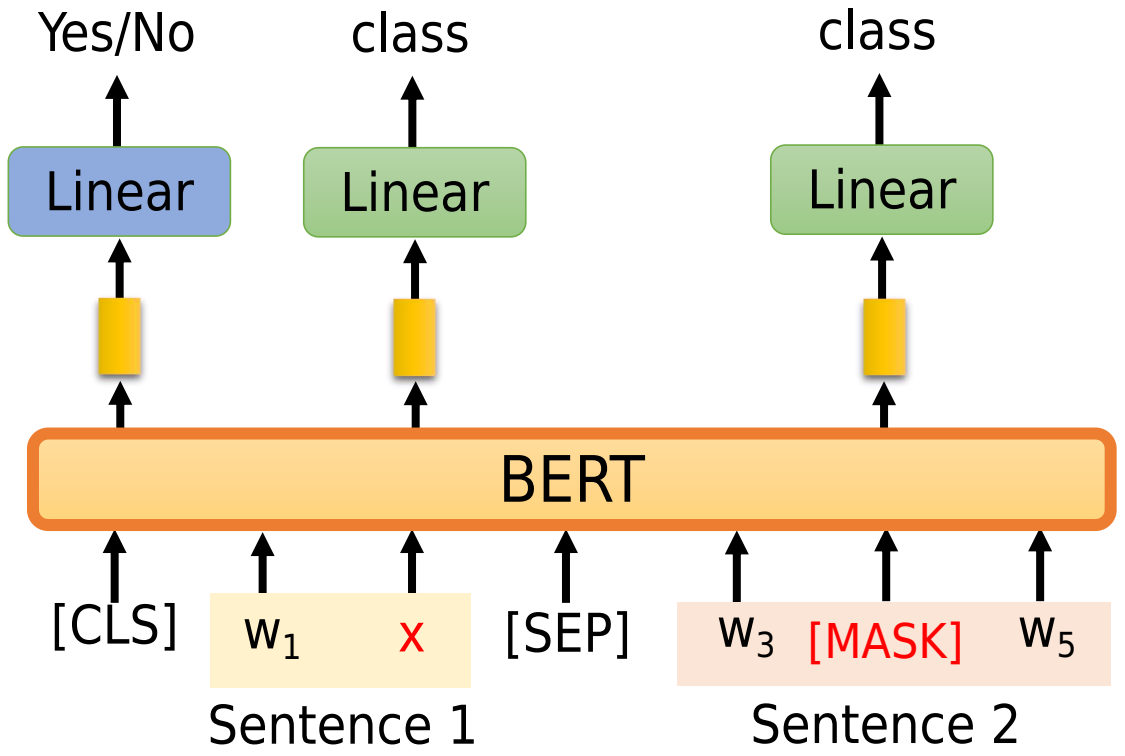
Input： [CLS] 博学而笃志 [SEP] 今天风好大 [SEP]
Target：No



Bert 训练

Multi-Task Learning



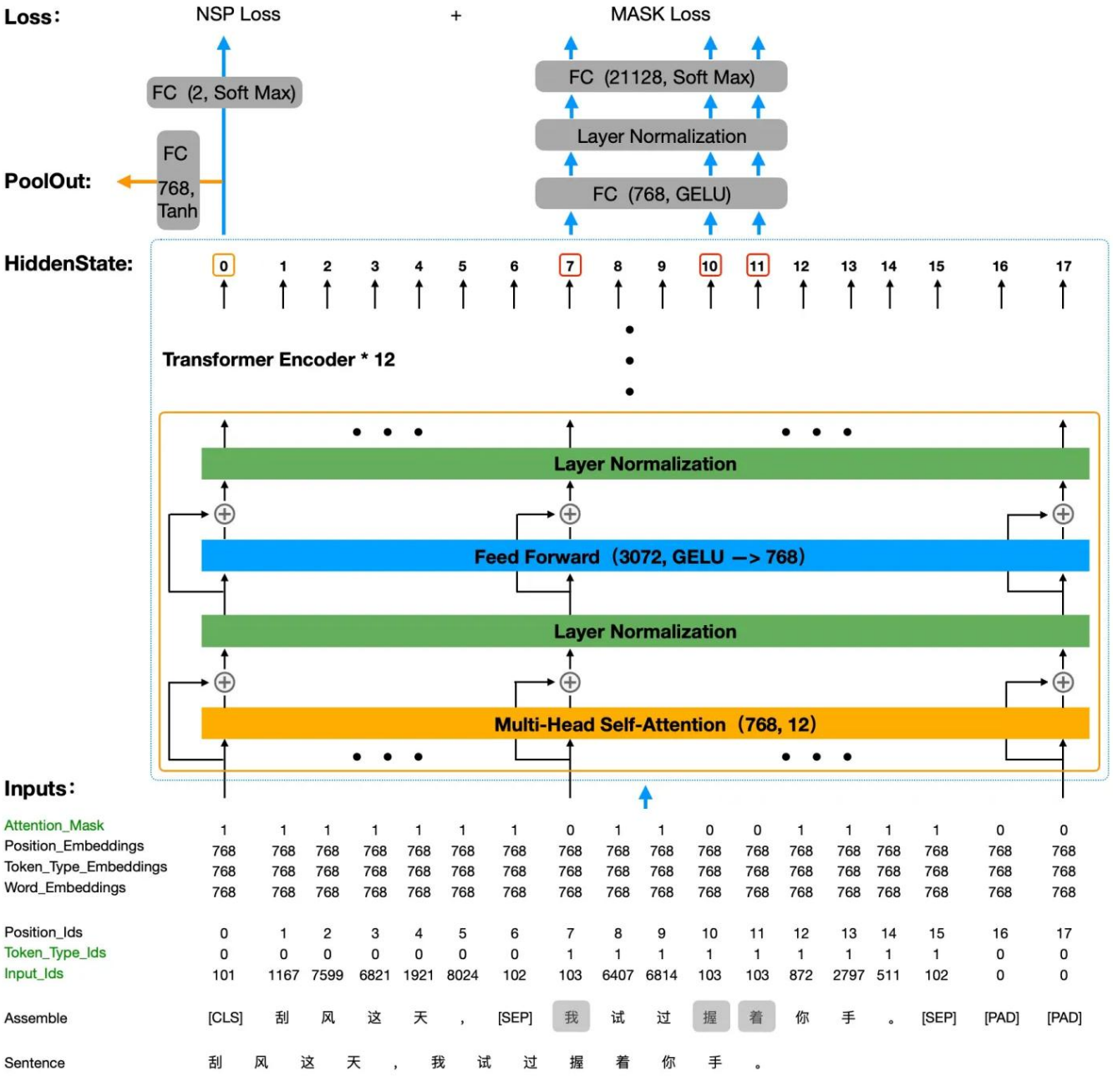


Input: [CLS] calculus is a branch of math [SEP] panda is native to [MASK] central china [SEP]
Targets: false, south

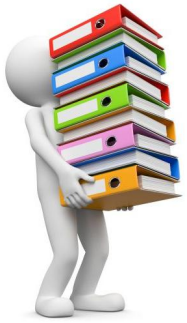
Input: [CLS] calculus is a [MASK] of math [SEP] it [MASK] developed by newton and leibniz [SEP]
Targets: true, branch, was

Bert 训练

Multi-Task Learning



Bert 使用



Self-supervised Learning

Pre-train

BERT

- Masked token prediction
- Next sentence prediction

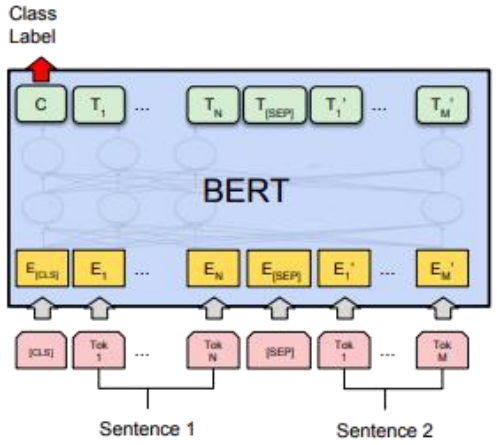
Fine-tune

Model for Task 1

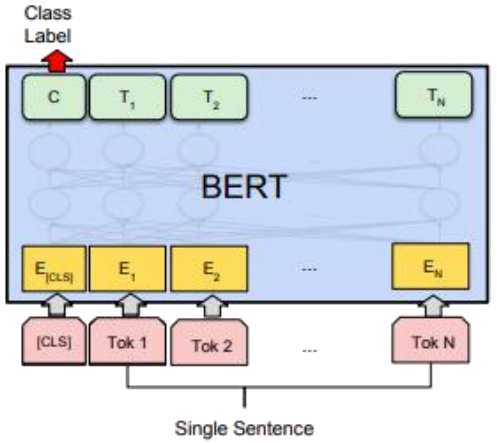
Model for Task 2

…

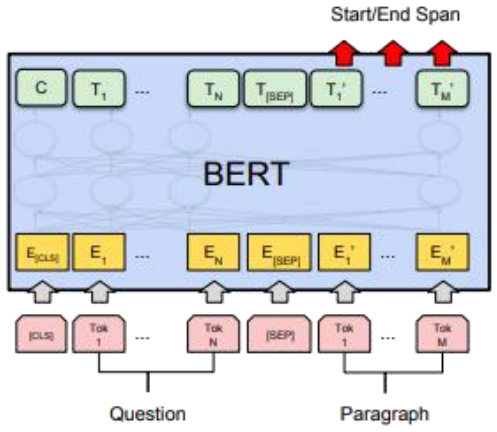
Model for Task N



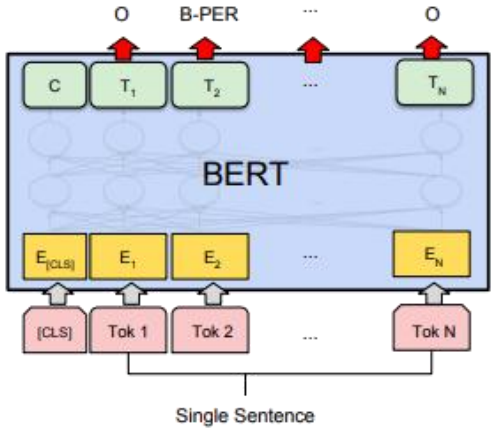
(a) Sentence Pair Classification Tasks: MNLI, QQP, QNLI, STS-B, MRPC, RTE, SWAG



(b) Single Sentence Classification Tasks: SST-2, CoLA



(c) Question Answering Tasks: SQuAD v1.1



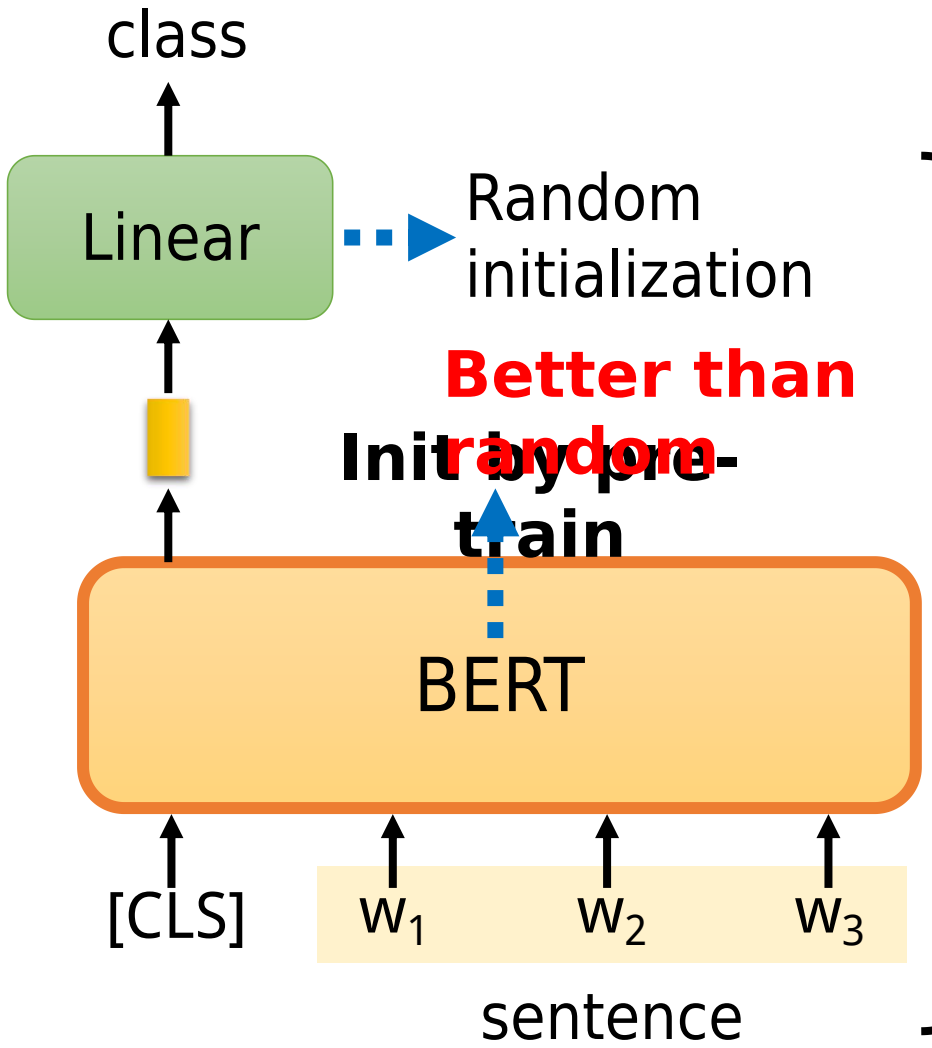
(d) Single Sentence Tagging Tasks: CoNLL-2003 NER

Downstream Tasks

- The tasks we care
- We have a little bit labeled data.

Bert 使用

应用场景 **1** 文本分类



This is the model to be learned.

Input: sequence

output: class

Example: Sentiment analysis

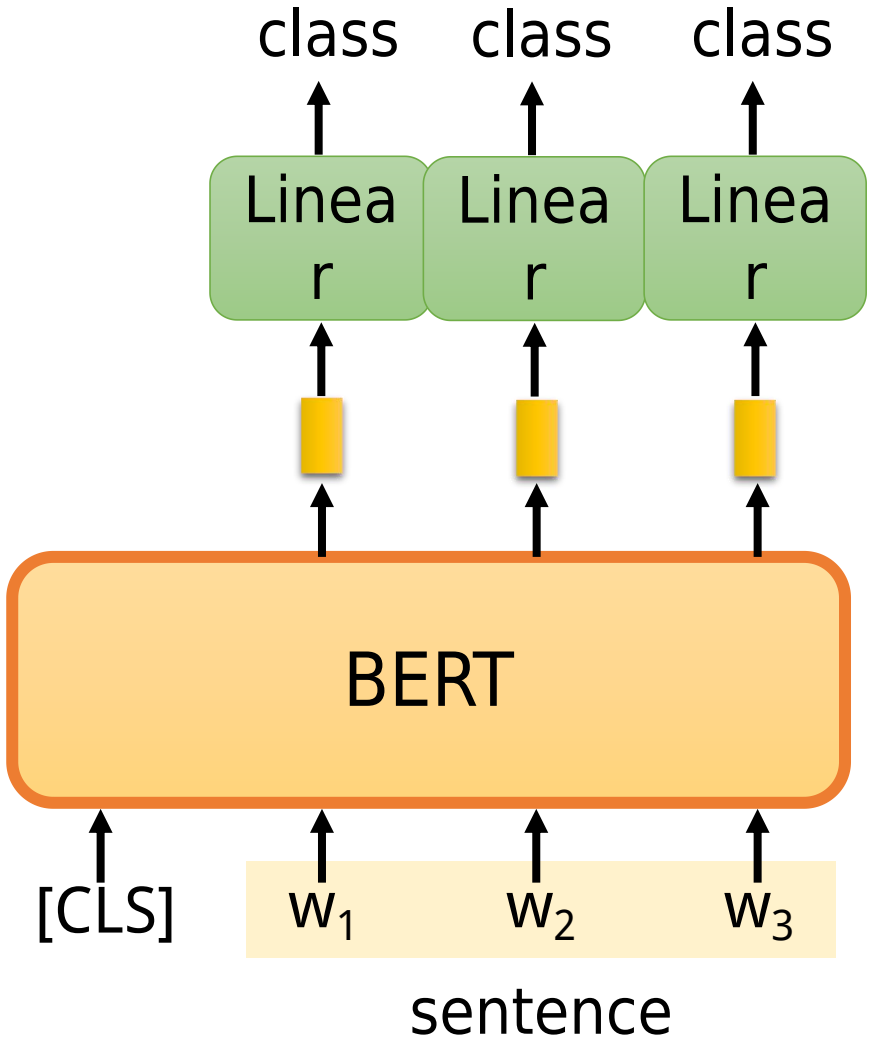
this is good

↓

positive

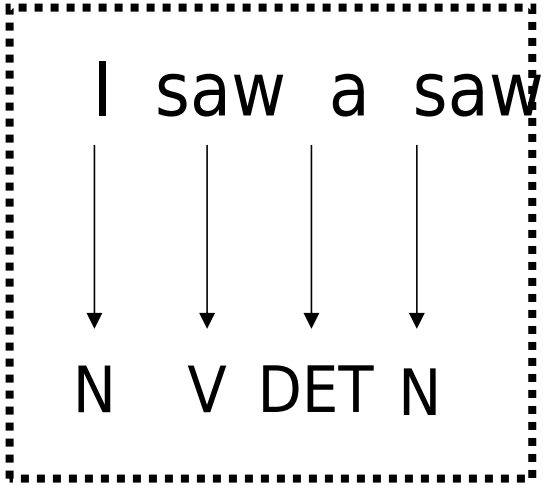
Bert 使用

应用场景 2 序列标注



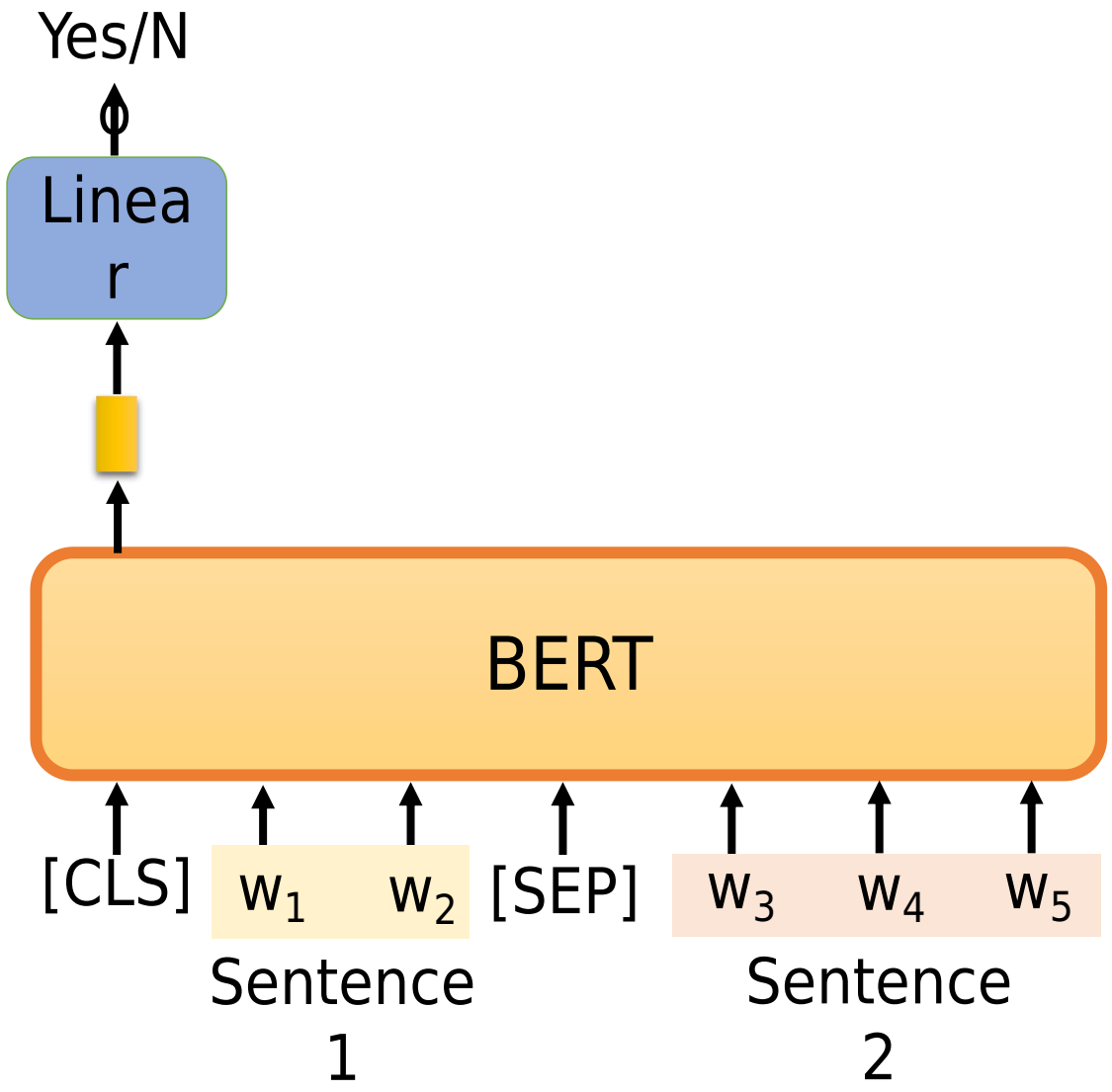
Input: sequence
output: same as input

Example: POS tagging



Bert 使用

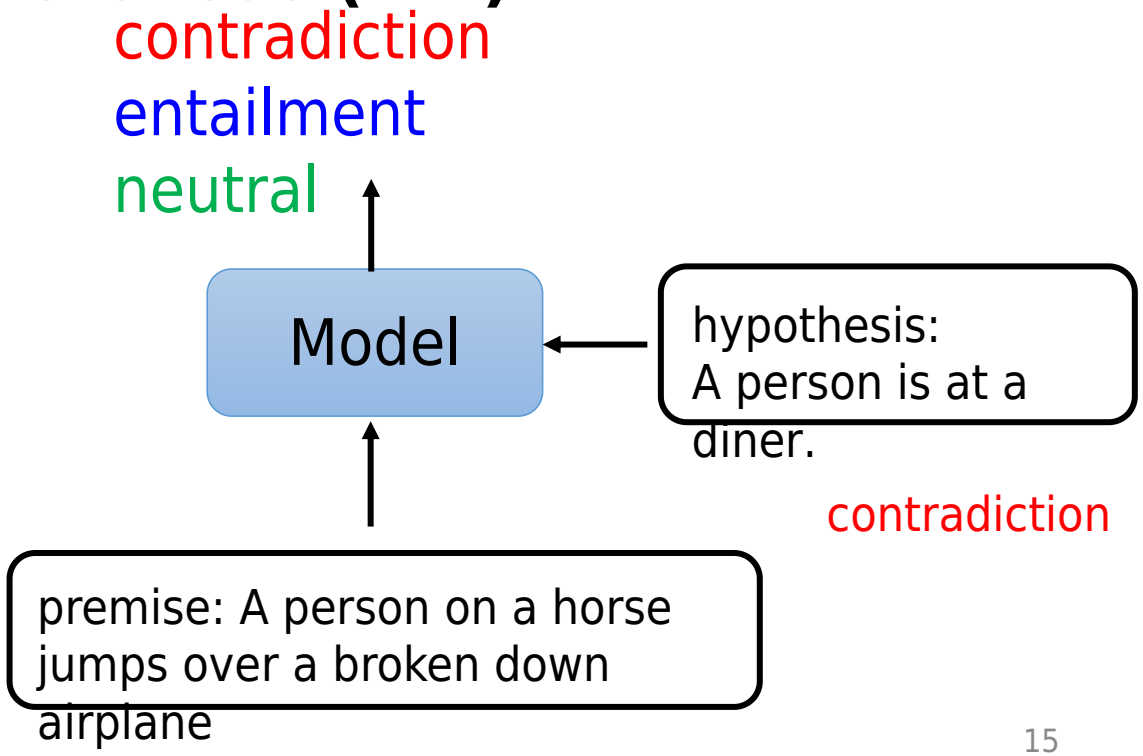
应用场景 3 自然语言推理



Input: two sequences

Output: a class

Example: Natural Language Inferencee (NLI)



Bert 使用

应用场景 4 抽取式问答

Query: $Q = \{q_1, q_2, \cdots, q_M\}$

Document $D = \{d_1, d_2, \cdots, d_N\}$

output: two integers (s, e)

Answer: $A = \{d_s, \cdots, d_e\}$

In meteorology, precipitation is any product of the condensation of [1 7]spheric water vapor that falls under gravity. The main forms of precipitation include drizzle, rain, sleet, snow, graupel and hail... Precipitation forms as smaller droplets coalesce via collision with other rain drops or ice crystals within a cloud. Short, intense periods of rain [7 7]atte[7 9]cations are called "showers".

What causes precipitation to fall?
gravity

$s = 17, e = 17$

What is another main form of precipitation besides drizzle, rain, snow, sleet and hail?
graupel

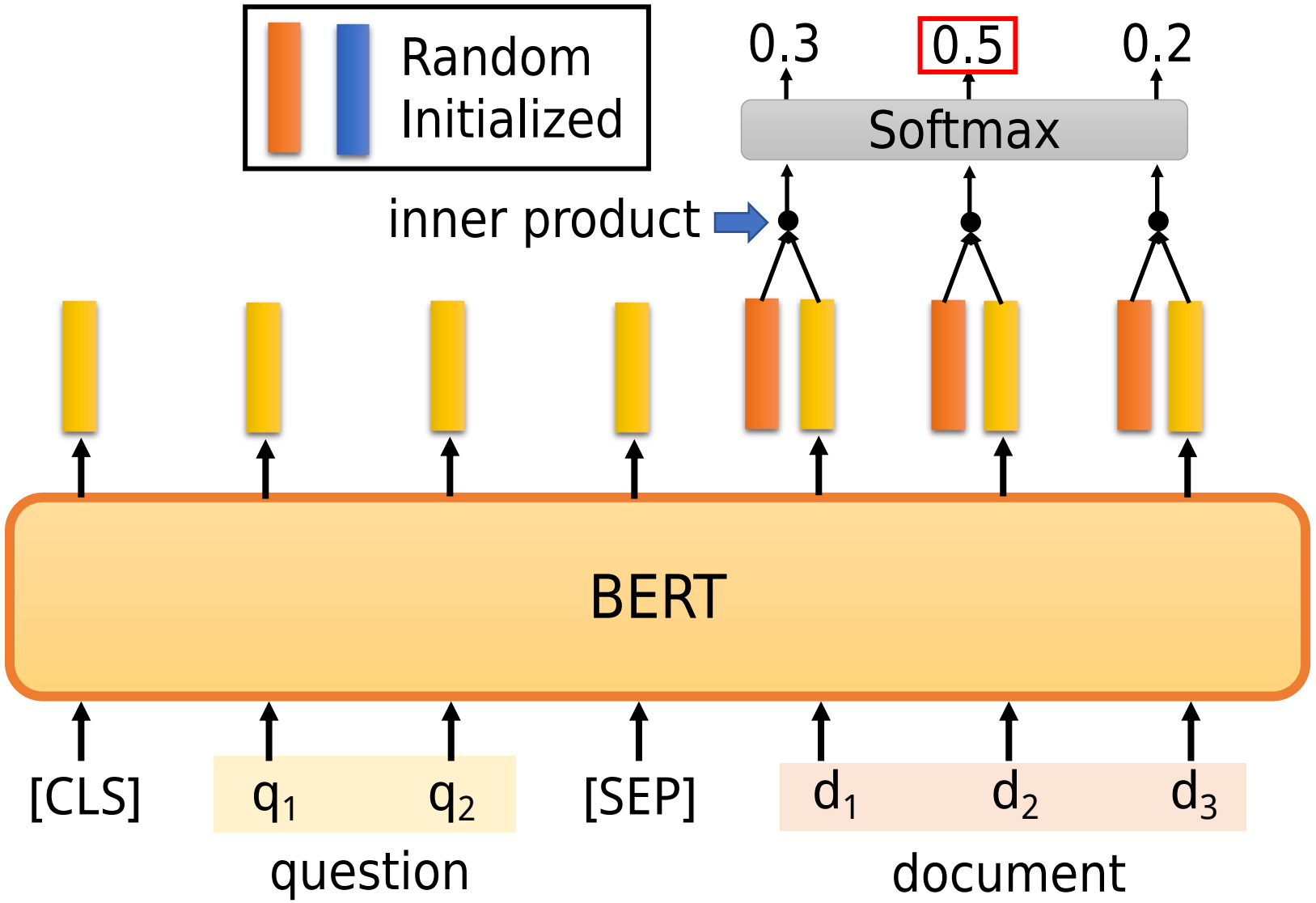
Where do water droplets collide with ice crystals to form precipitation?
within a cloud

$s = 77, e = 79$

Bert 使用

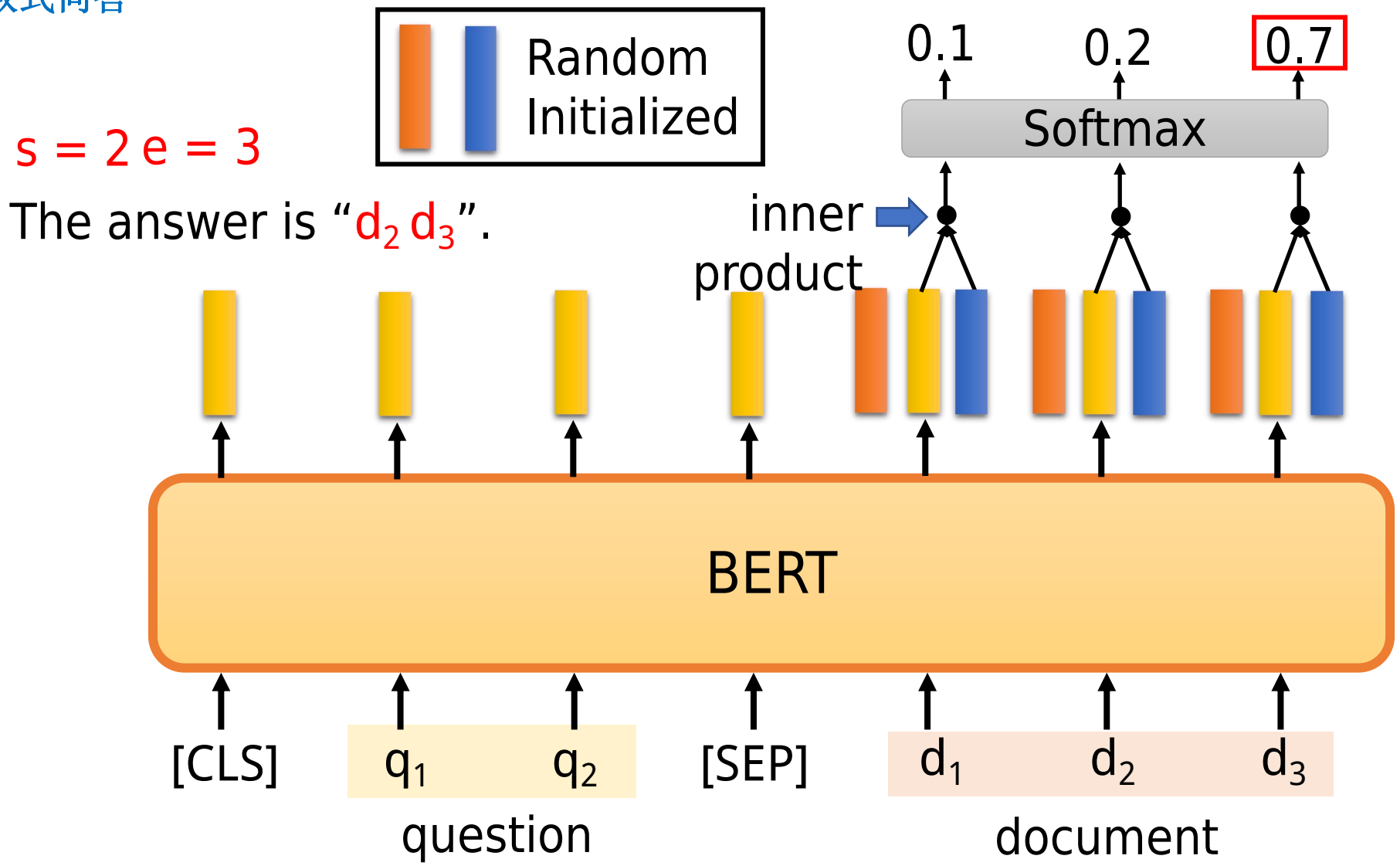
应用场景 **4** 抽取式问答

s = 2



Bert 使用

应用场景 **4** 抽取式问答



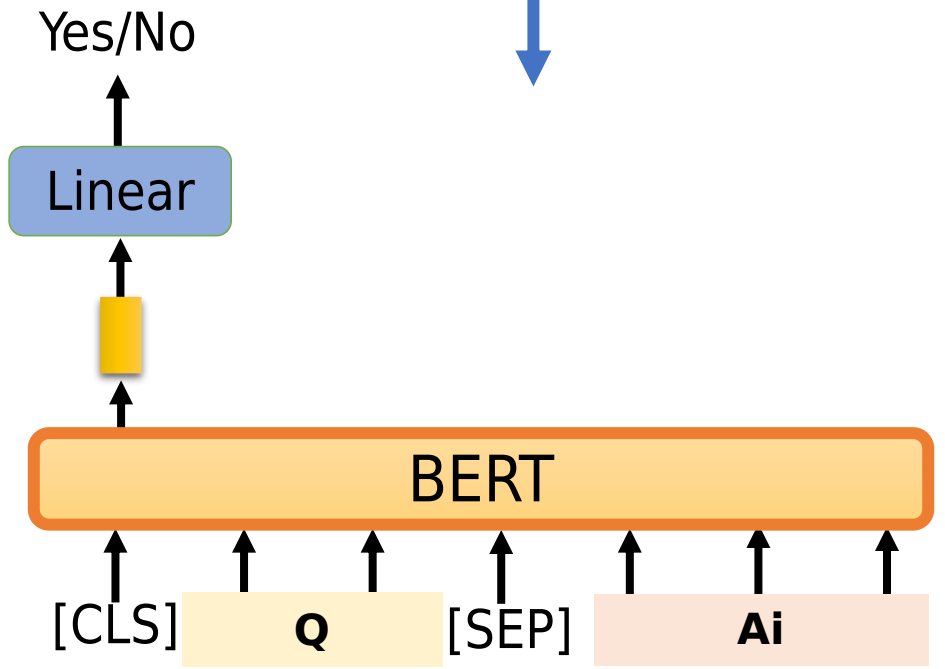
Bert 使用

应用场景 4 抽取式问答

北京奥运会是哪年举办？

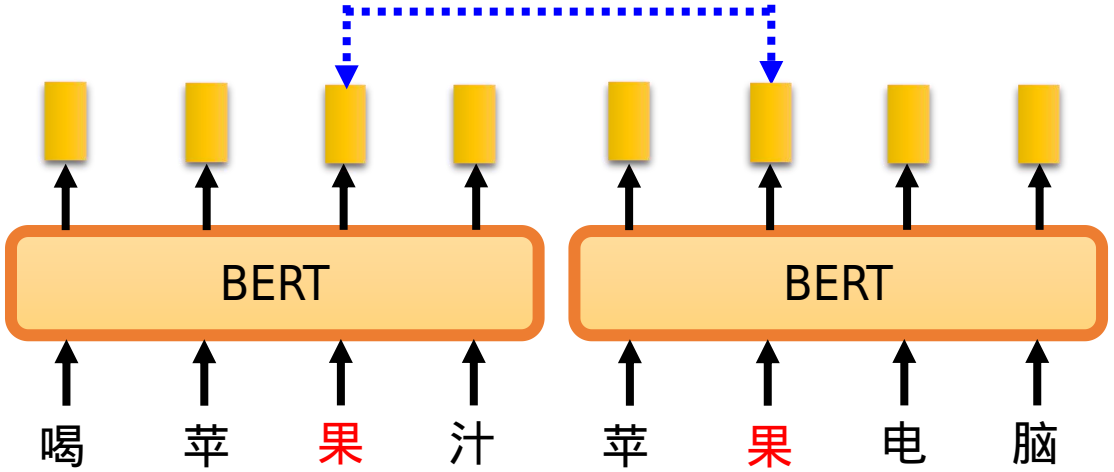
第29届夏季奥林匹克运动会（Games of the xxix olympiad），又称2008年北京奥运会，2008年8月8日晚上8时整在中华人民共和国首都北京举办。【1】
2008年北京奥运会主办城市是北京，上海、天津、沈阳、秦皇岛、青岛为协办城市。【2】
香港承办马术项目。【3】
2008年北京奥运会共有参赛国家及地区204个，参赛运动员11438人，设302项（28种）运动，共有60000多名运动员、教练员和官员参。加【4】
2008年北京奥运会共创造43项新世界纪录及132项新奥运纪录，共有87个国家和地区在赛事中取得奖牌，中国以51枚金牌居金牌榜首名，是奥运历史上首个登上金牌榜首的亚洲国家。【5】

1. 【Q】【A1】【label】
2. 【Q】【A2】【label】
3. 【Q】【A3】【label】
4. 【Q】【A4】【label】
5. 【Q】【A5】【label】

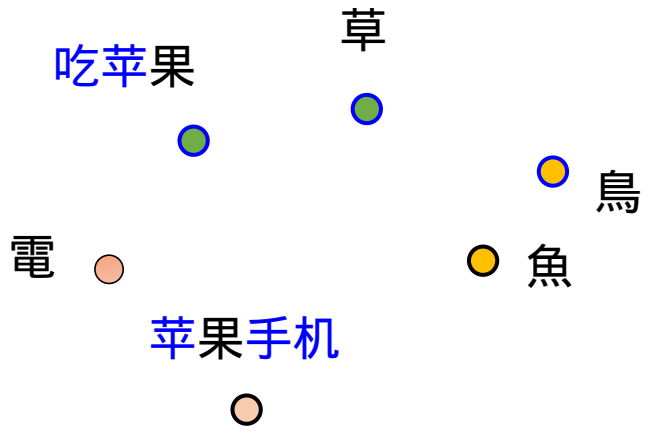


BERT 表征可视化

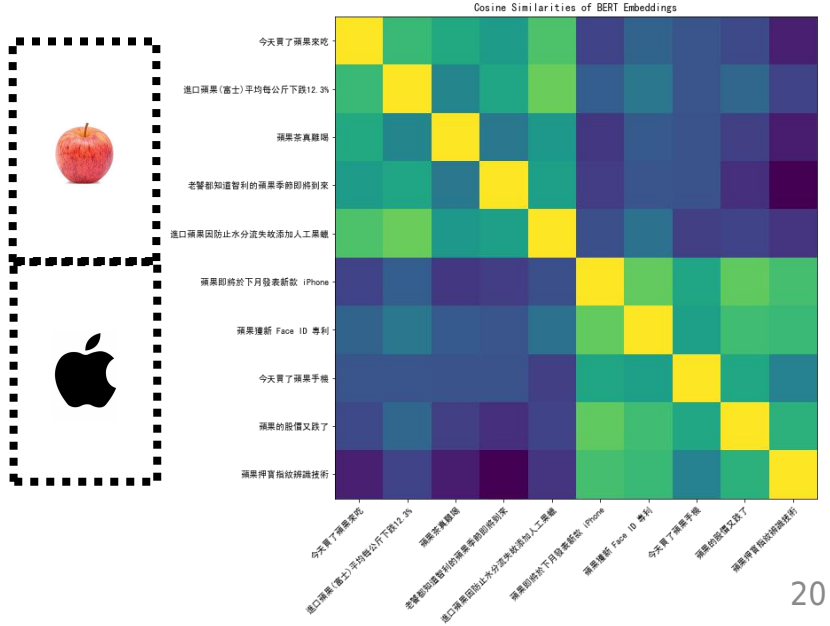
compute cosine similarity



The tokens with similar meaning have similar embedding.



Context is considered.



总结

1. **预训练的有效性：** BERT 改变了游戏规则，是因为相比设计复杂巧妙的网络结构，在海量无监督数据上预训练得到的BERT语言表示+少量训练数据微调的简单网络模型的实验结果取得了很大的优势。

2. **网络深度：**基于 传统语言模型 (NNLM，CBOW等) 获取词向量的表示已经在 NLP领域获得很大成功，而 BERT 预训练网络基于 Transformer 的 Encoder，可以做得很深。

3. **双向语言模型：**在 BERT 之前，ELMo 和 GPT 的主要局限在于标准语言模型是单向的，GPT 使用 Transformer 的 Decoder 结构，只考虑了上文的信息。ELMo 从左往右的语言模型和从右往左的语言模型其实是分开训练的，共享 embedding，将两个方向的 LSTM 拼接并不能真正表示上下文，其本质仍是单向的，且多层 LSTM难训练。

4. **目标函数：**对比以往语言模型任务只做预测下一个位置的单词，想要训练包含更多信息的语言模型，就需要让语言模型完成更复杂的任务，BERT 主要完成完形填空和句对预测的任务，即两个 loss：一个是 Masked Language Model，另一个是 Next Sentence Prediction。

参考资料

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Q & A