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

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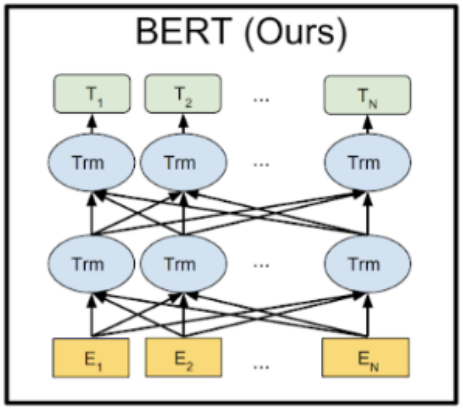
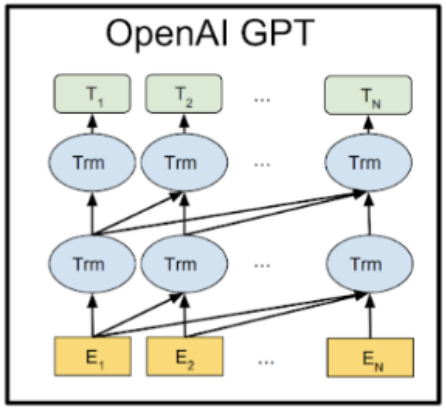
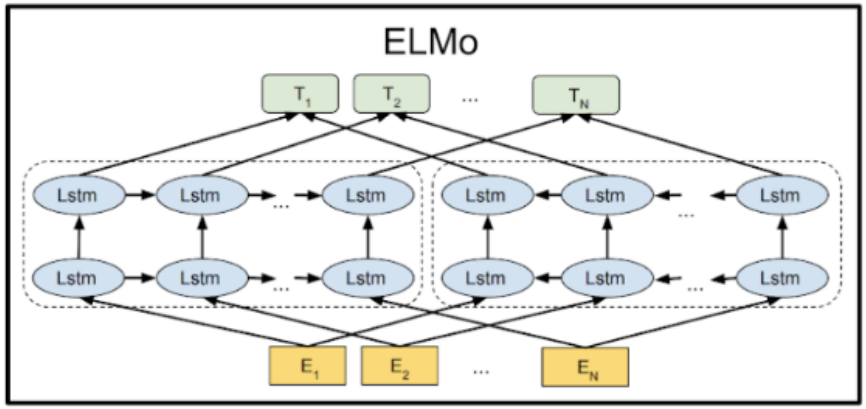
1 Introduction

Natural Language Processing's Imagenet

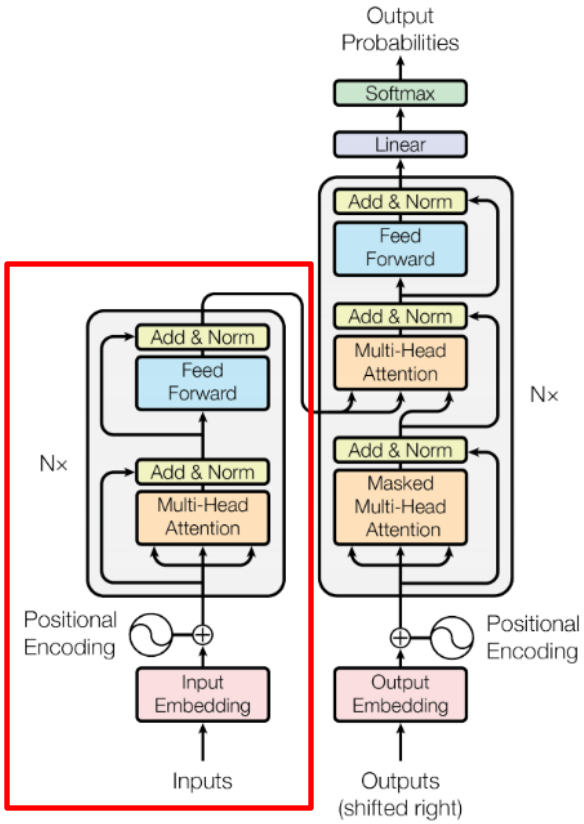






2 Recap

Transformer Model



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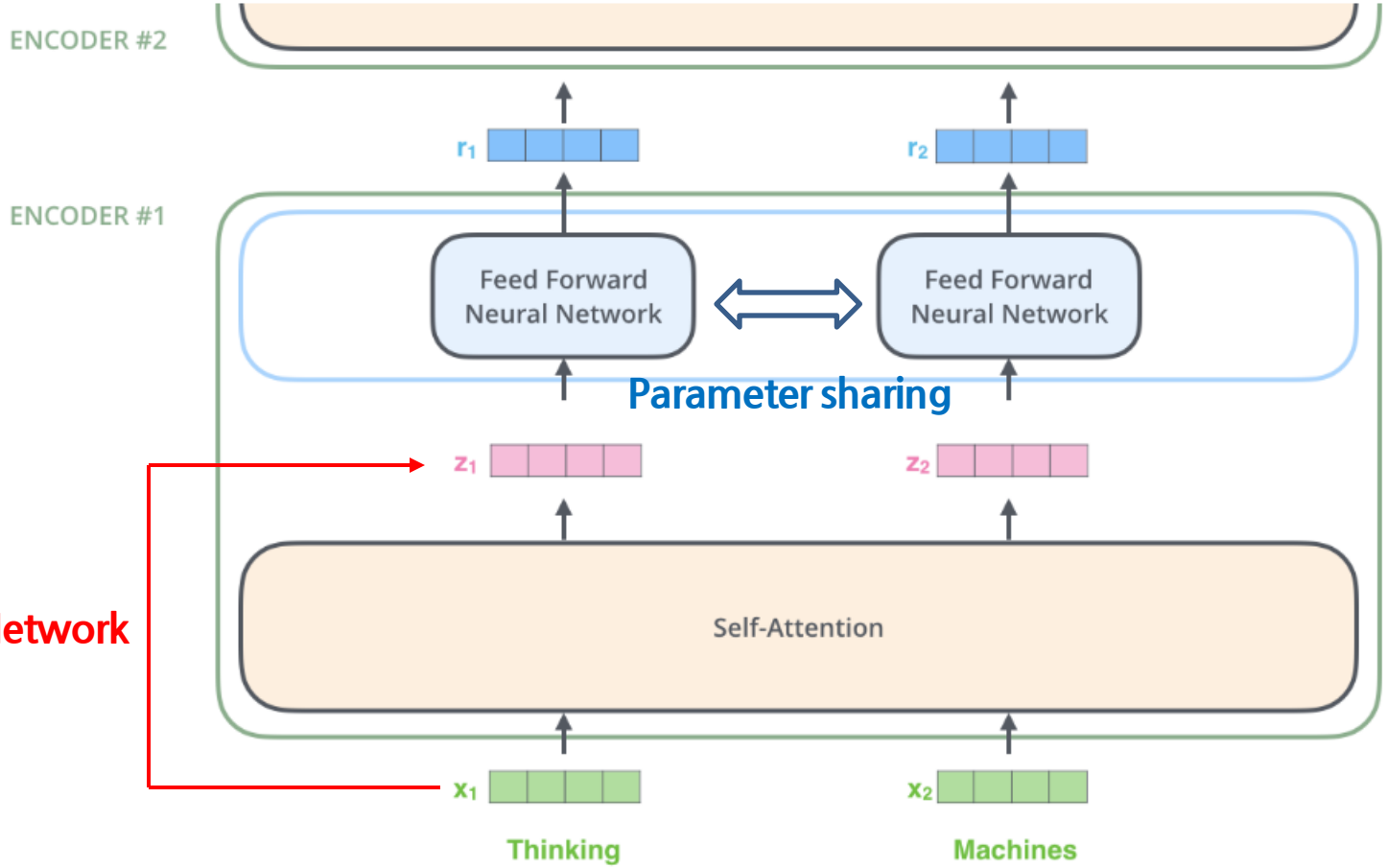

Figure from http://jalammar.github.io/illustrated-transformer/

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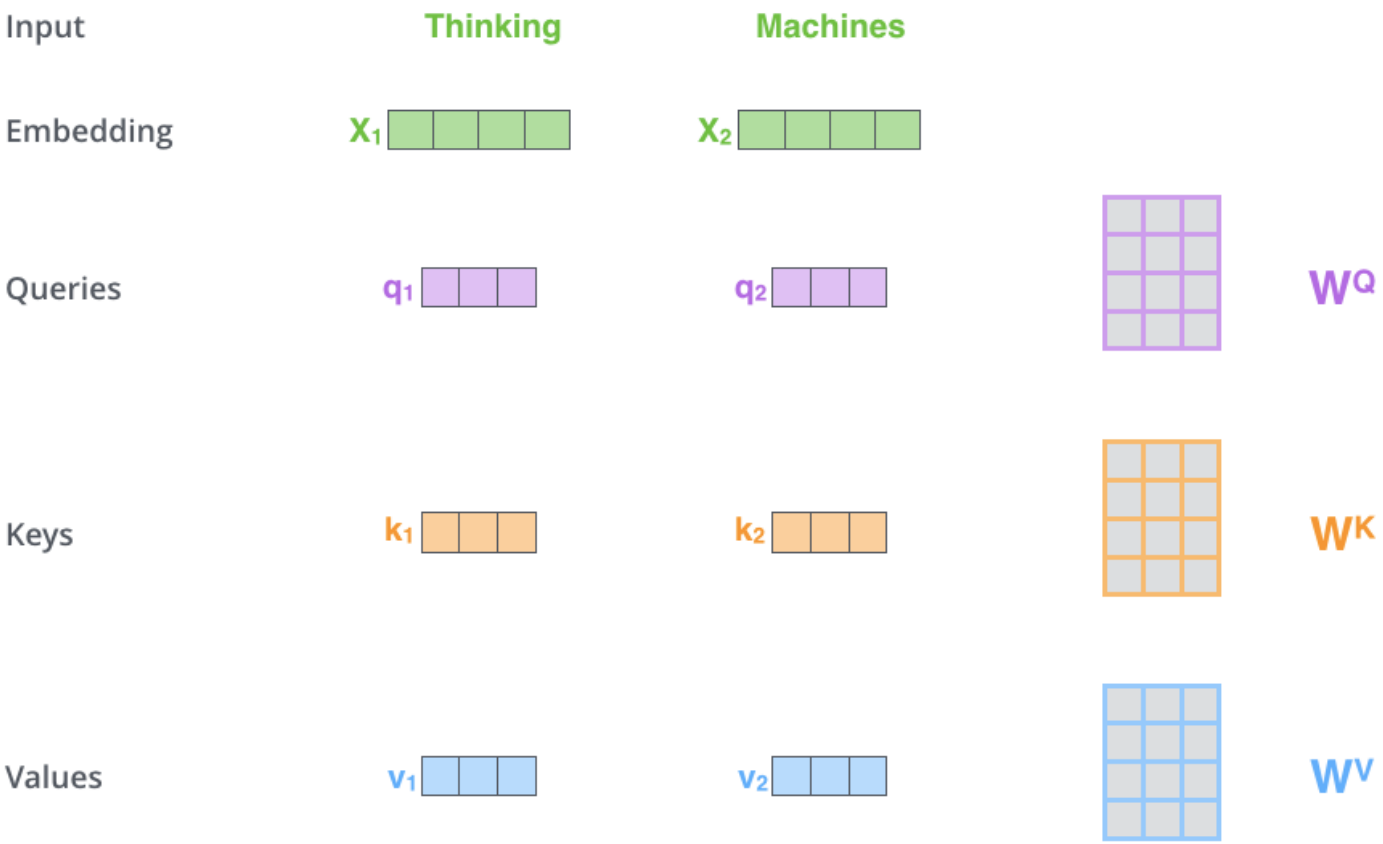

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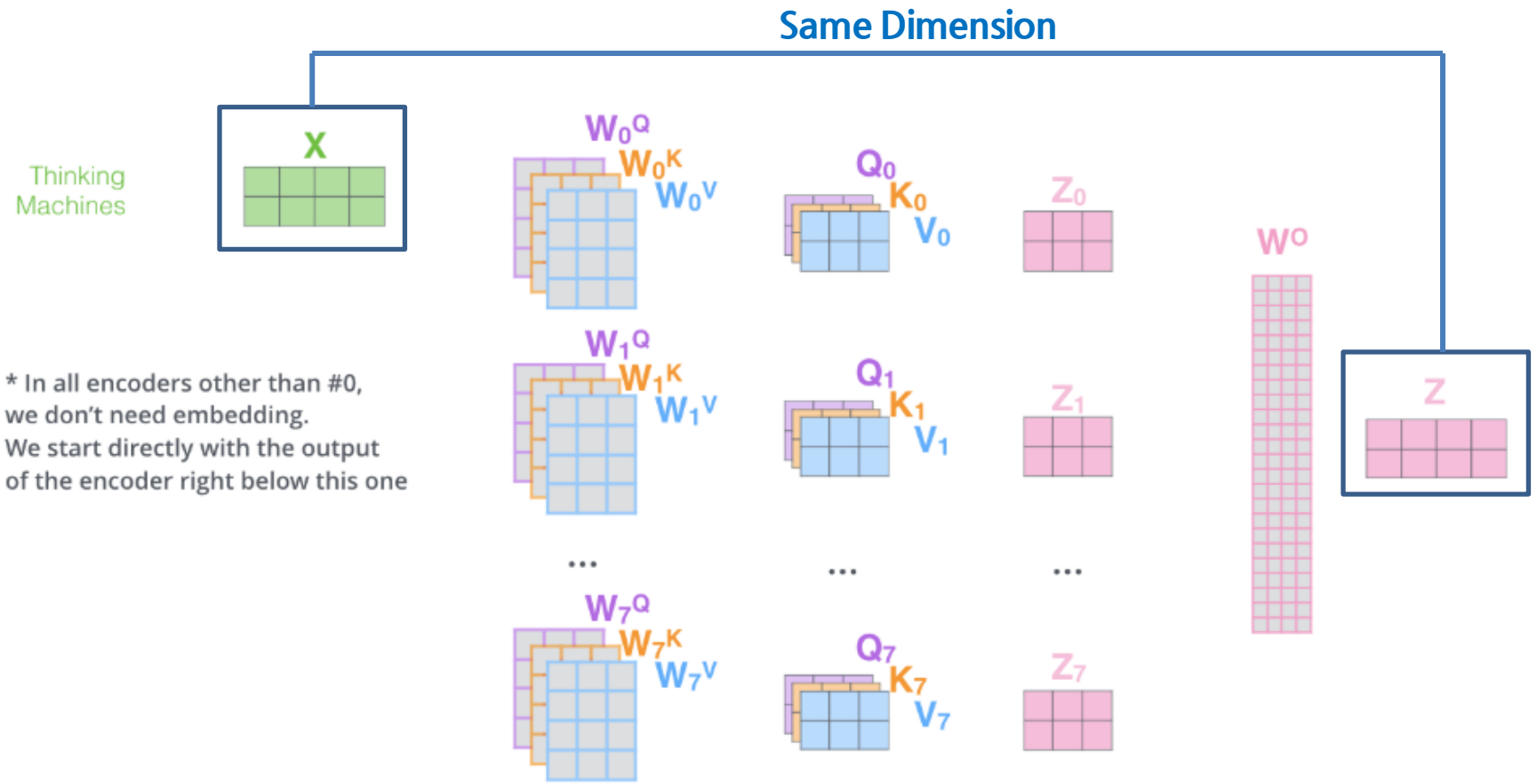

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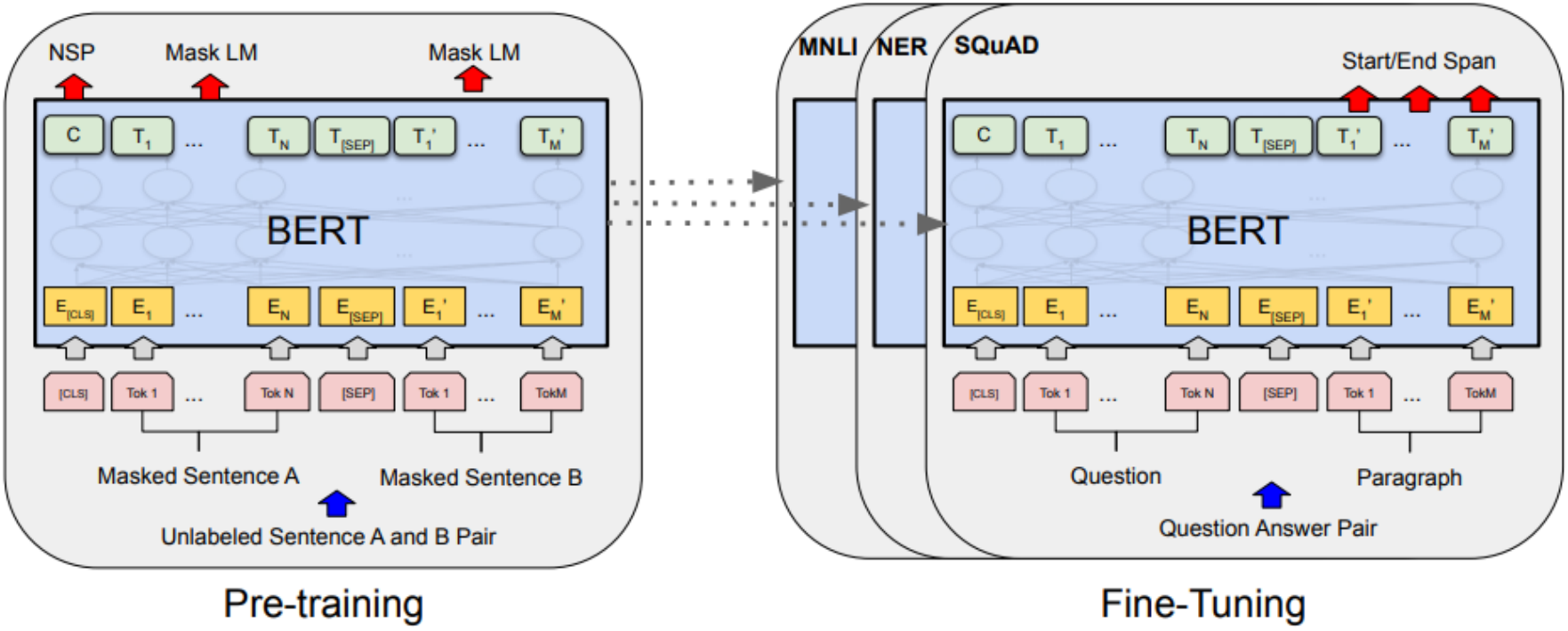
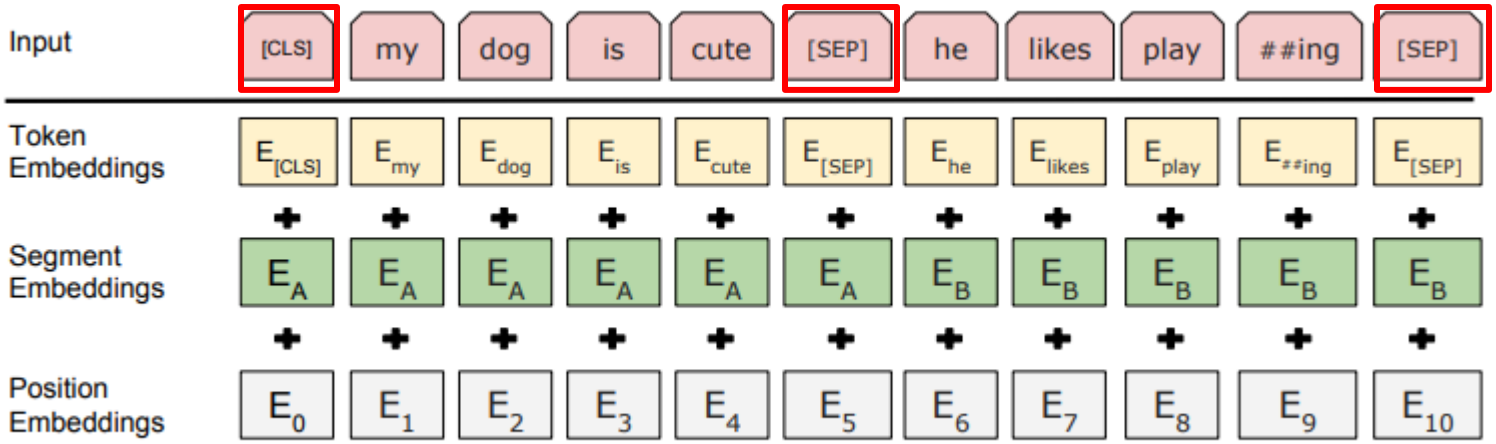
3 Method

General Architecture



3 Method

Input Representation



Token Embedding : WordPiece Embedding

Segment Embedding : Corresponding Sentence Embedding

Position Embedding : Learned Positional Embedding(up to 512 tokens)

Pre-training Task #1 : Masked Language Modeling

Masking some input tokens, and predict only those masked ones(Cloze)

- Masking 15% of WordPiece tokens in each sequence
- Rather than always replacing the token with [MASK], sometimes replace the given word with another word, and also sometimes keep the word unchanged
- This'll close the gap between pre-training phase and fine-tuning phase
- May converge slowly

3 Method

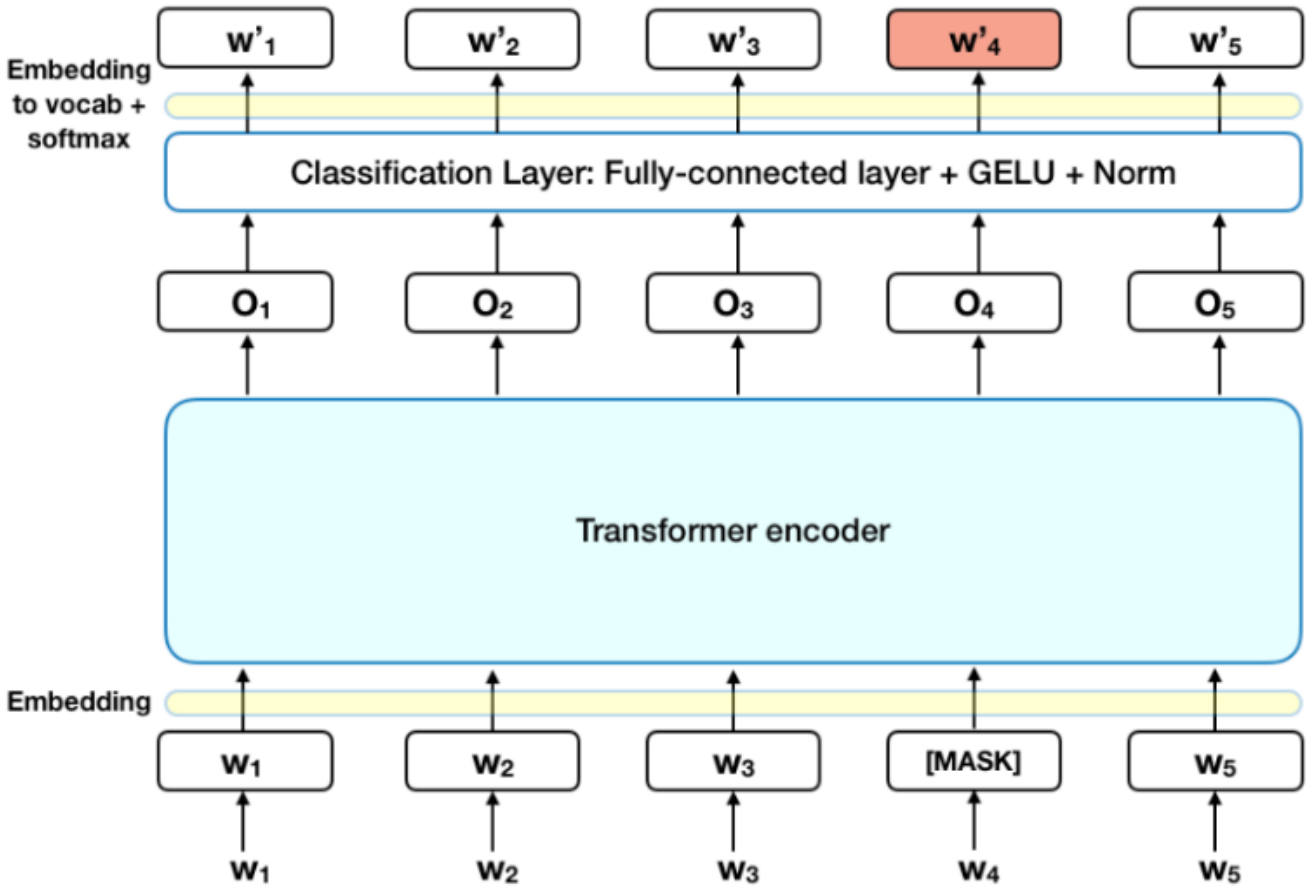


Figure from https://www.lyrn.ai/2018/11/07/explained-bert-state-of-the-art-language-model-for-nlp/

3 Method

Pre-training Task #2 :Next Sentence Prediction

Understanding the relationship between two senteces

- Binarized next sentence prediction task
- In monolingual text, 50% of the time, next sentence is the actual sentence which follows the previous one, whereas for the 50% of the time, the random sentence from corpus is given.

Input = [CLS] the man went to [MASK] store [SEP]
he bought a gallon [MASK] milk [SEP]
Label = IsNext

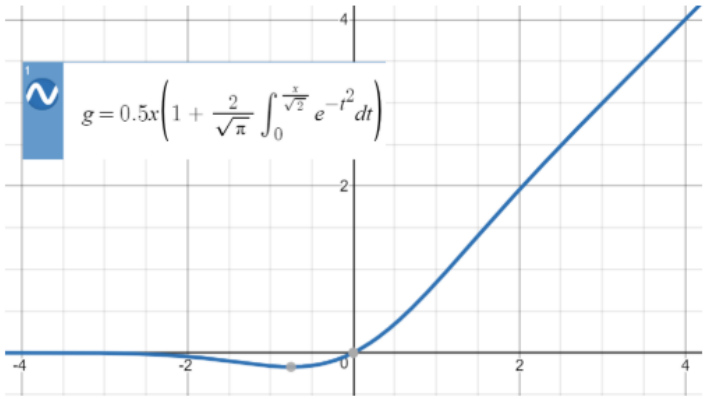
Input = [CLS] the man [MASK] to the store [SEP]
penguin [MASK] are flight ##less birds [SEP]
Label = NotNext

3 Method

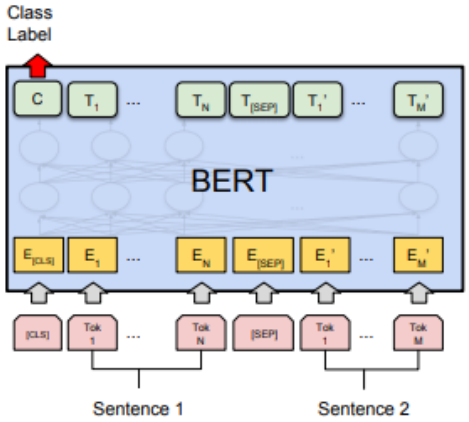
Pre-training Procedure

Understanding the relationship between two senteces

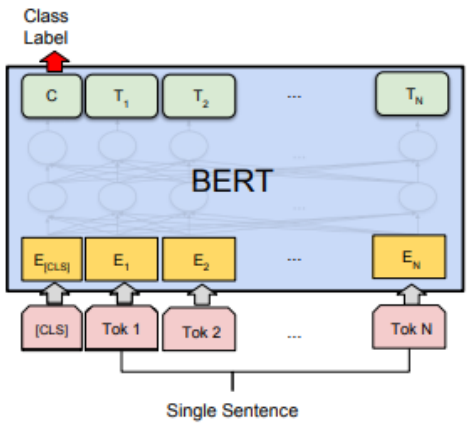
- Document Level Corpus was used for training(Book Corpus, Wikipedia)
- Sentences are generally longer than the usual sentences that we know
- Each sequence(combined of two sentences)'s length is smaller than 512
- GELU activation was used



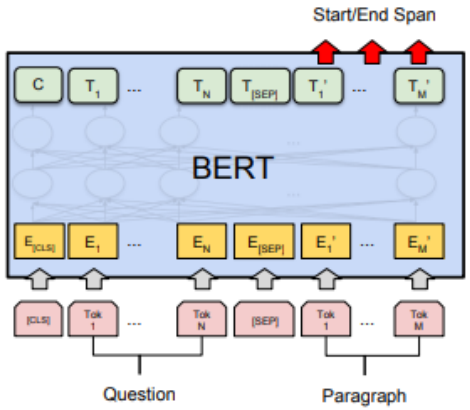
4 Experiment



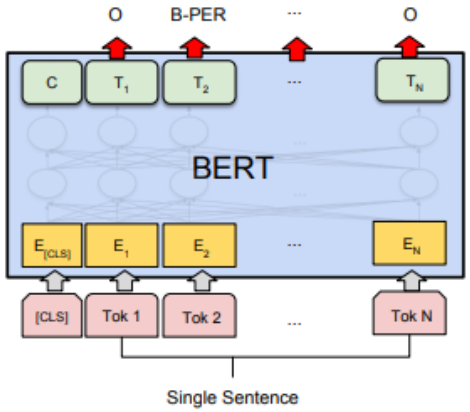
(a) Sentence Pair Classification Tasks: MNLI, QQP, QNLI, STS-B, MRPC, RTE, SWAG



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



(c) Question Answering Tasks: SQuAD v1.1



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

What Does BERT Look At? An Analysis of BERT's Attention

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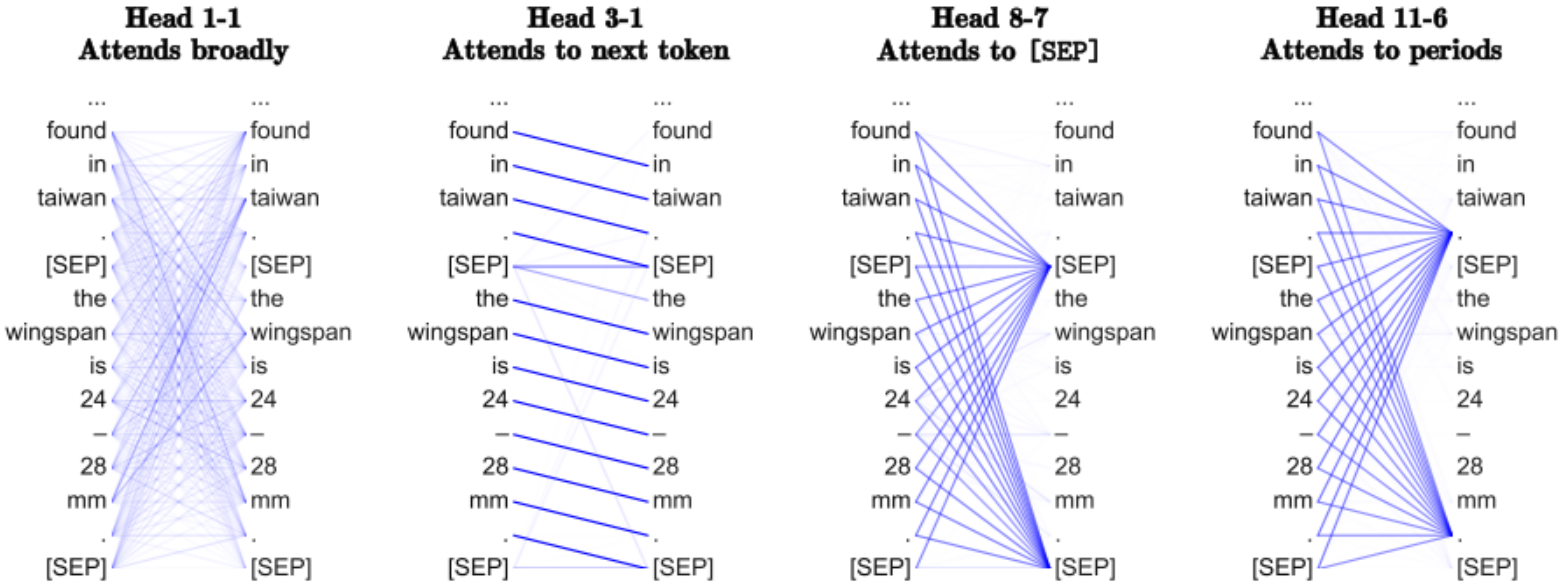
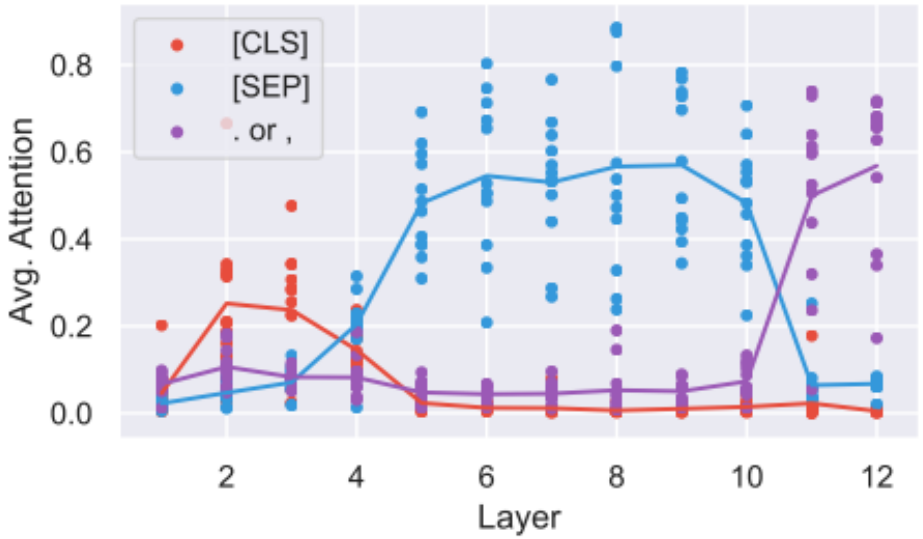
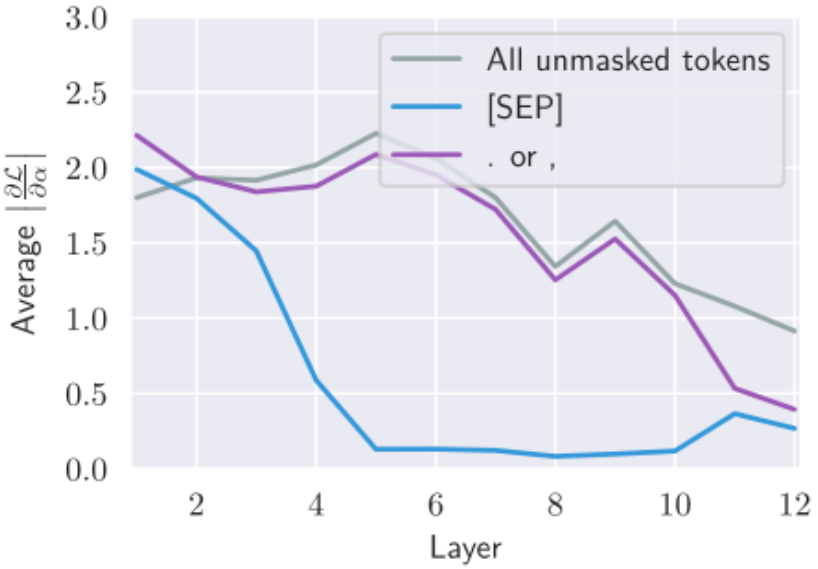
Insight



- In earlier layers, attention heads tend to put their attention to previous, or next token of given token's position.
- In the higher layers, entropies of attention distribution gets smaller.
- Substantial amount of BERT's attention focuses on a few tokens ([SEP], [CLS], ",", ".")

Insight





- Rather than being an artifact of stochastic training, high attention would have been caused by systematic reason. (Because, special tokens don't get masked away)
- Another possible explanation is that [SEP] is used to aggregate segment level information, however doubtful. (Right Figure) => Sort of "no-op"