UNIVERSIDAD EAFIT
VIGILADA | MINEDUCACIÓN

Escuela de
Ciencias Aplicadas
e Ingeniería

ST7003 Procesamiento Natural del Lenguaje

Lecture04b – BERT

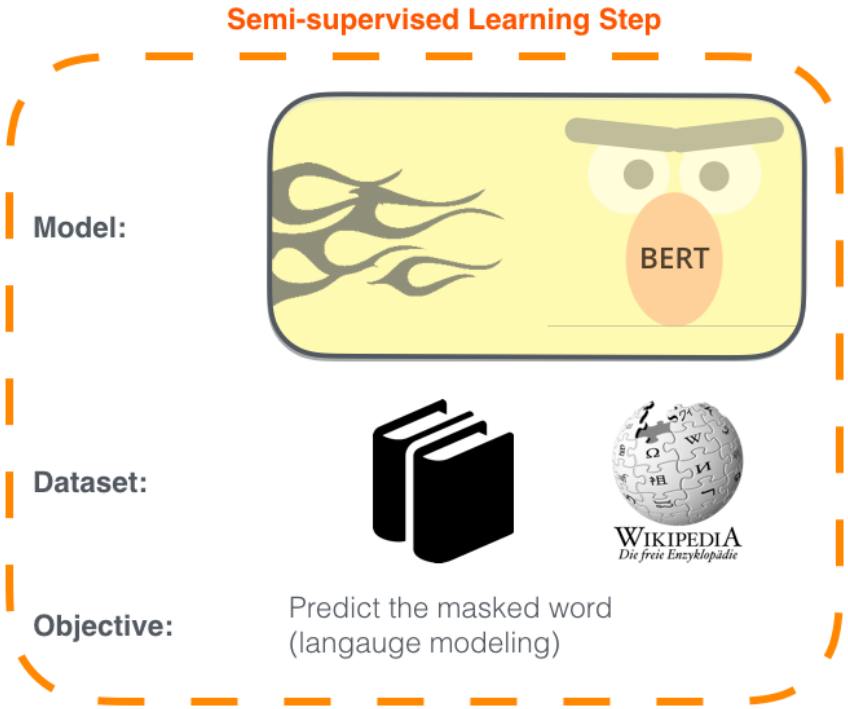
Contenido

1. Learning problems
2. Model architecture
3. Pre-training
4. Applications
5. Hands-on

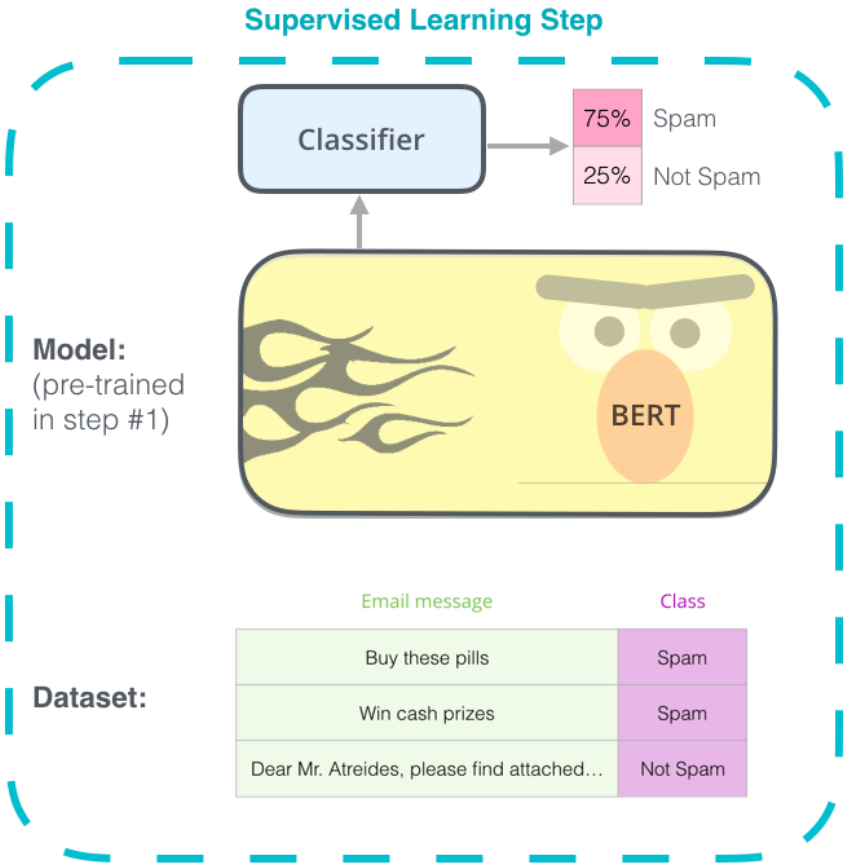
Self supervised learning

1 - Semi-supervised training on large amounts of text (books, wikipedia..etc).

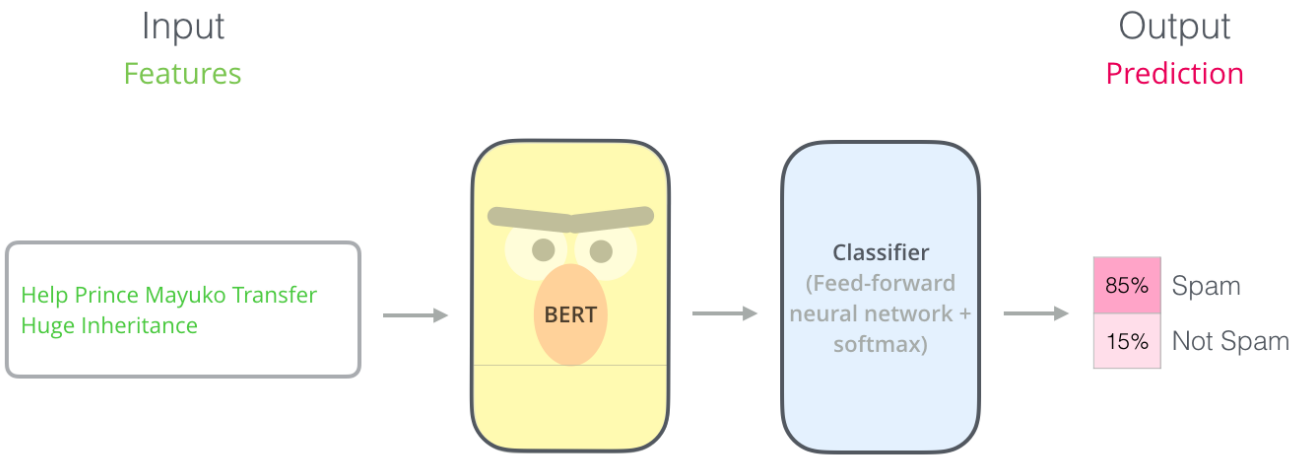
The model is trained on a certain task that enables it to grasp patterns in language. By the end of the training process, BERT has language-processing abilities capable of empowering many models we later need to build and train in a supervised way.



2 - Supervised training on a specific task with a labeled dataset.



Transfer learning



Email message	Class
Buy these pills	Spam
Win cash prizes	Spam
Dear Mr. Atreides, please find attached…	Not Spam

Model architecture

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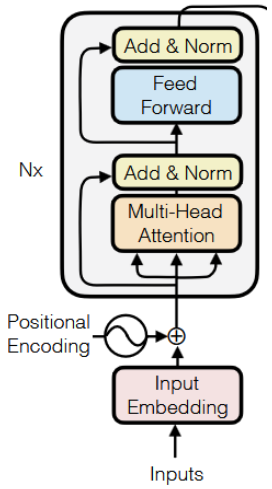
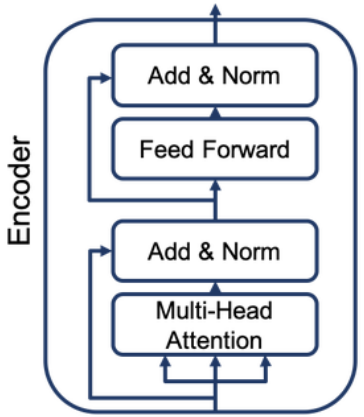
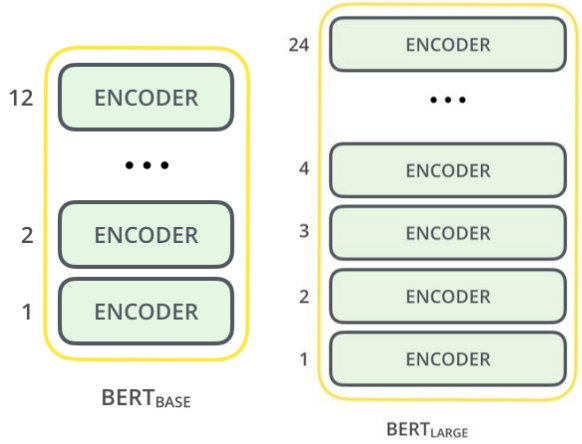
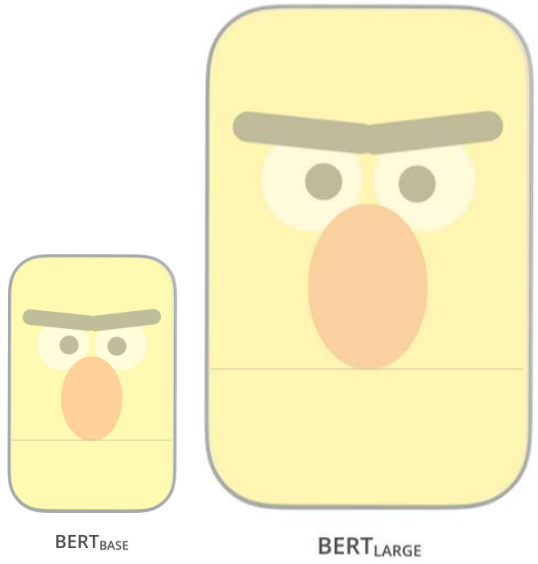


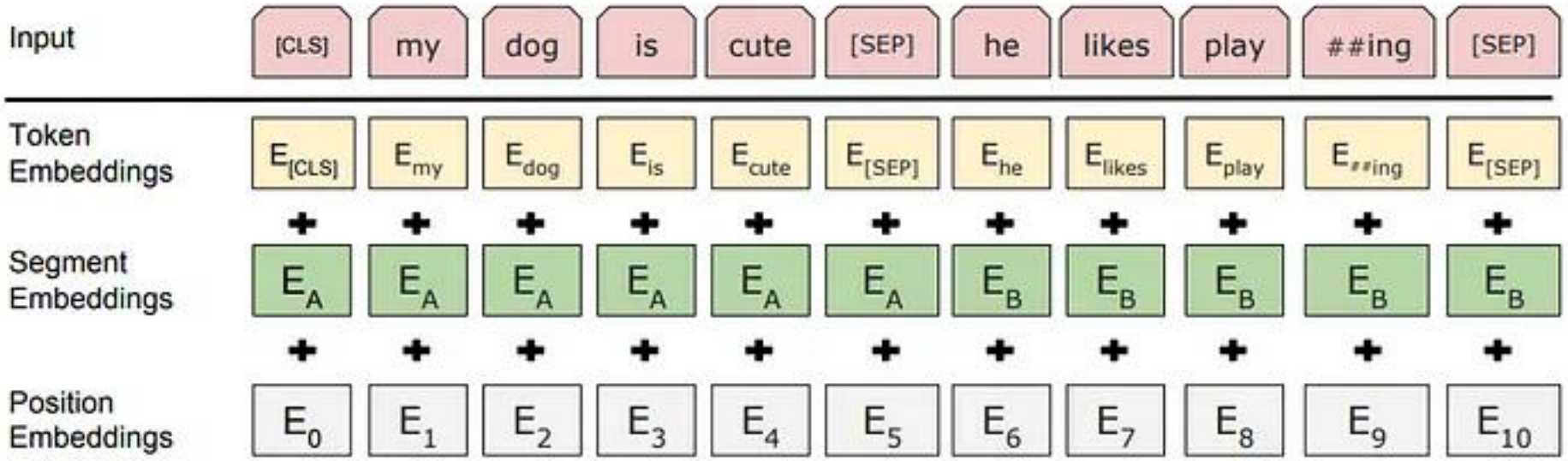


`bert-base-uncased`	12-layer, 768-hidden, 12-heads, 110M parameters. Trained on lower-cased English text.
`bert-large-uncased`	24-layer, 1024-hidden, 16-heads, 340M parameters. Trained on lower-cased English text.
`bert-base-cased`	12-layer, 768-hidden, 12-heads, 110M parameters. Trained on cased English text.
`bert-large-cased`	24-layer, 1024-hidden, 16-heads, 340M parameters. Trained on cased English text.
`bert-base-multilingual-uncased`	(Original, not recommended) 12-layer, 768-hidden, 12-heads, 110M parameters. Trained on lower-cased text in the top 102 languages with the largest Wikipedias (see details).
`bert-base-multilingual-cased`	(New, recommended) 12-layer, 768-hidden, 12-heads, 110M parameters. Trained on cased text in the top 104 languages with the largest Wikipedias (see details).





Model inputs



Pre-training: Masked Language Model

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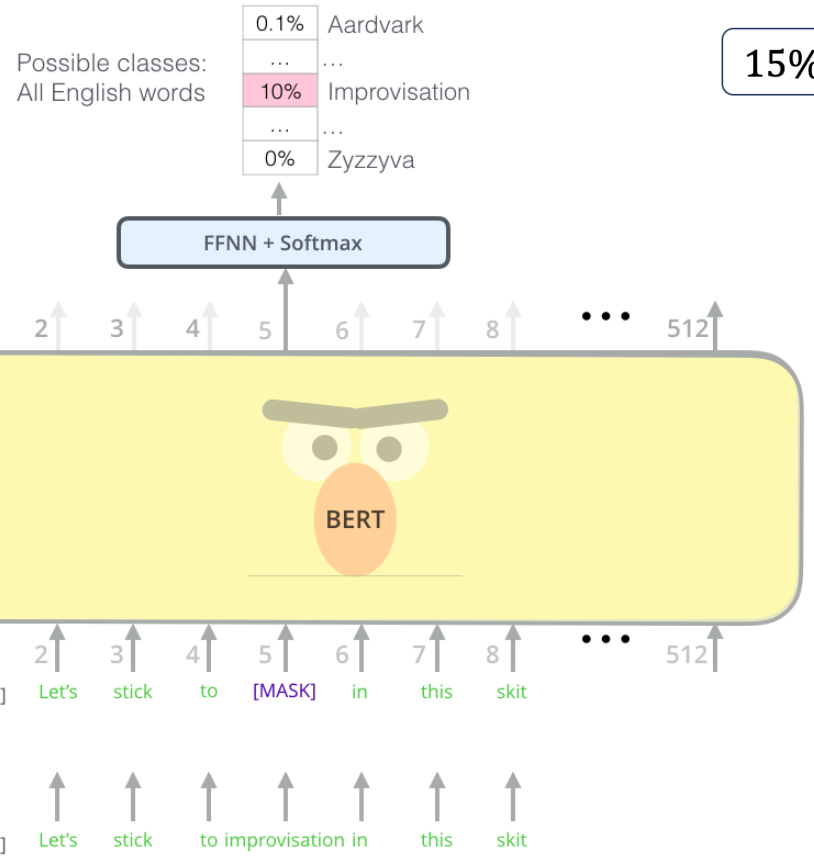
Use the output of the masked word's position to predict the masked word



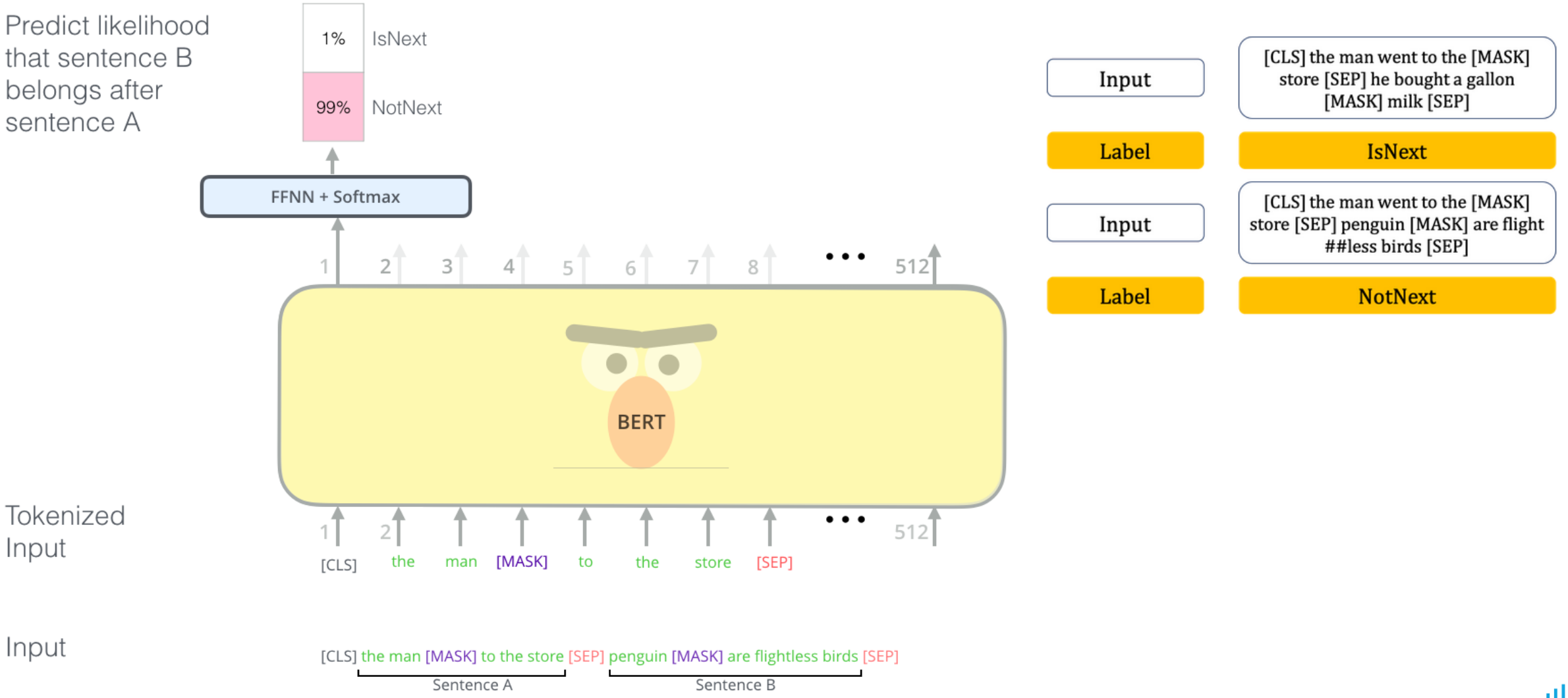
Randomly mask 15% of tokens

Input

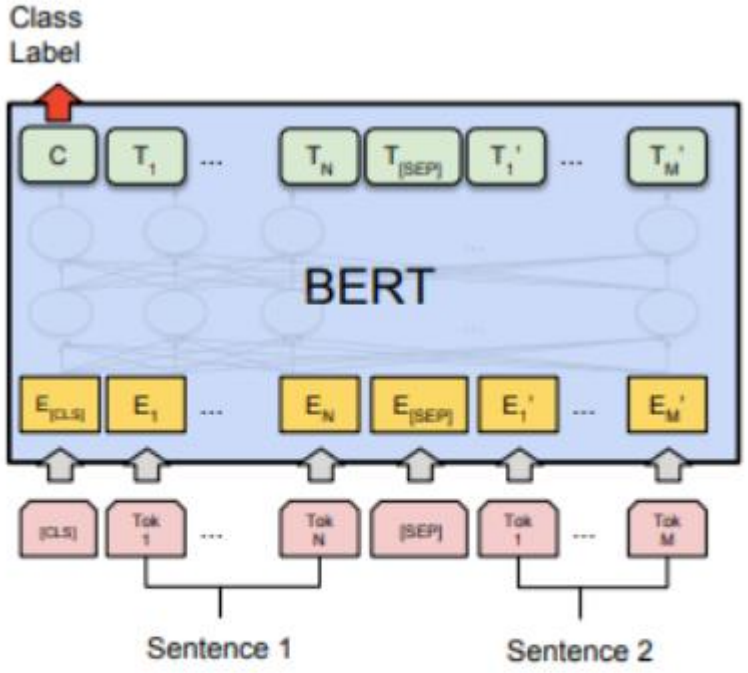
15%

80%	my dog is [MASK]
10%	my dog is apple
10%	my dog is hairy

Pre-training: Two sentences task



BERT Specific tasks



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

📌 **Objective**: Determine the relationship between two sentences.

✅ **Input**:

- Two sentences are concatenated with a [SEP] token in between.
- [CLS] is added at the beginning.
- Each token gets embeddings (**word, segment, positional**).

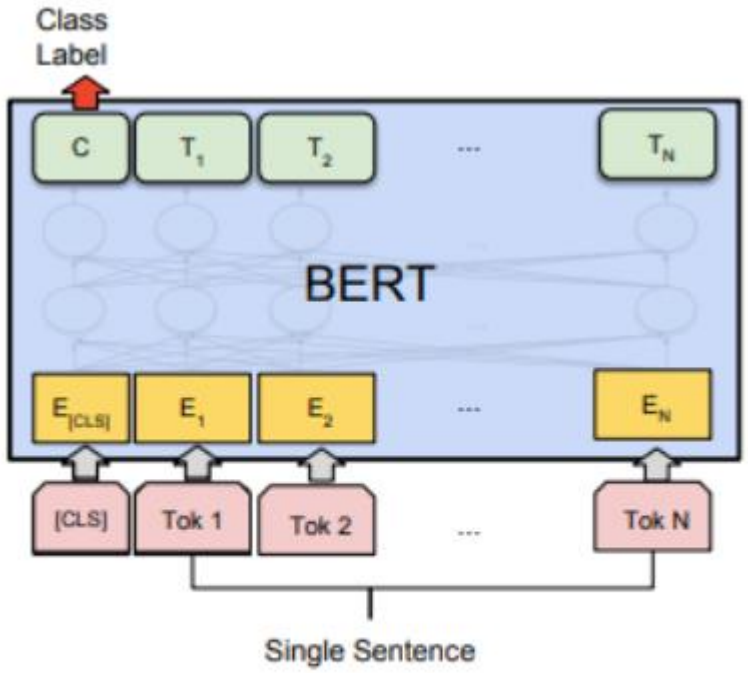
✅ **BERT Processing**:

- Applies **self-attention** over both sentences.
- [CLS] token is used to represent the **entire input**.

✅ **Output**:

- A **classifier** (fully connected layer + softmax) is applied to the [CLS] token to predict the **relationship** between sentences (e.g., entailment, contradiction).

BERT Specific tasks



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

📌 **Objective**: Classify the **entire sentence** into a category (e.g., sentiment analysis).

✅ **Input**:

- A single sentence with a [CLS] token at the start.

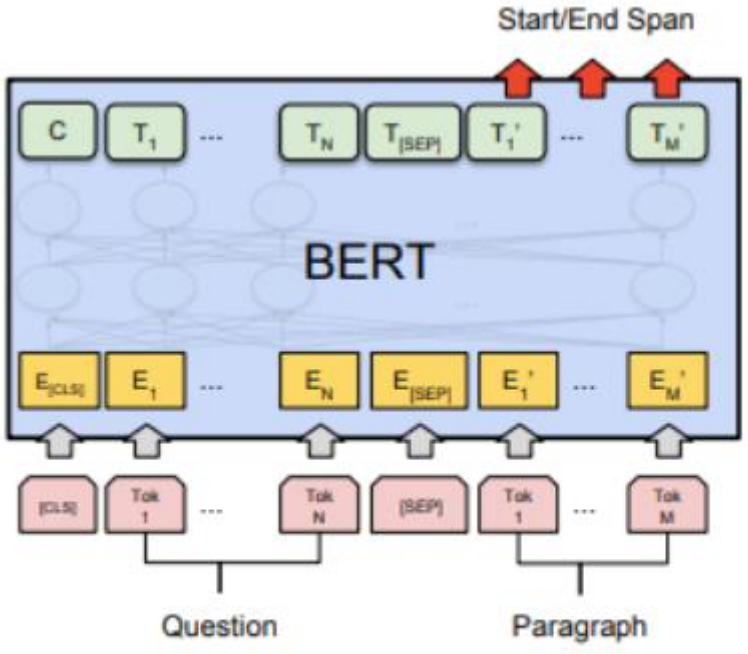
✅ **BERT Processing**:

- Self-attention processes the sentence.

✅ **Output**:

- The classifier is applied to the [CLS] token, which encodes sentence-level information.

BERT Specific tasks



(c) Question Answering Tasks: SQuAD v1.1

📌 **Objective**:Find the **start and end** of the answer span in a paragraph given a question.

✅ **Input**:

- The **question** and **paragraph** are separated by [SEP].

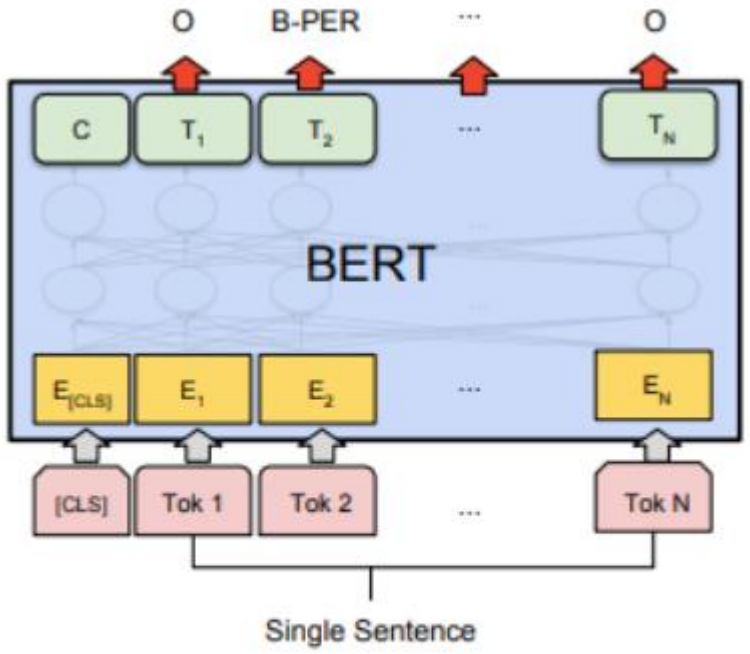
✅ **BERT Processing**:

- Self-attention captures relationships between the **question and the paragraph.**

✅ **Output**:

- Two classifiers predict:
    1. **Start position** of the answer.
    2. **End position** of the answer.

BERT Specific tasks



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

📌 **Objective**:Assign a **label** to each token in the sentence (e.g., Person, Organization, Location).

✅ **Input**:

- A single sentence with a [CLS] token

✅ **BERT Processing**:

- Self-attention captures context for each Word

✅ **Output**:

- Instead of using the [CLS] token, **each token** has its **own classification**.
- Labels are assigned to **each token** (e.g., "B-PER" for "beginning of a person's name").

Suggested readings

https://huggingface.co/blog/bert-101

https://huggingface.co/blog/pretraining-bert