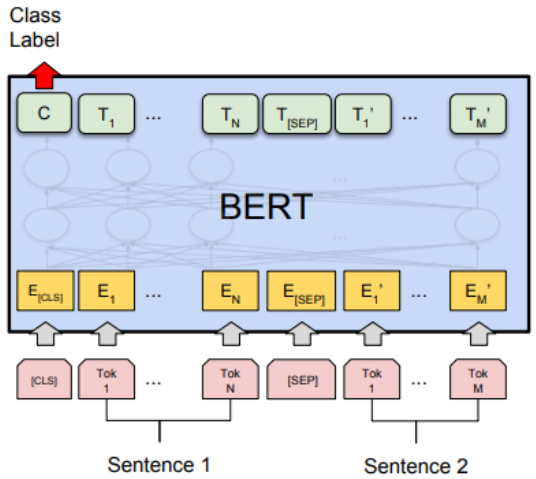
Using the Transformer

BERT – Fine-tuning

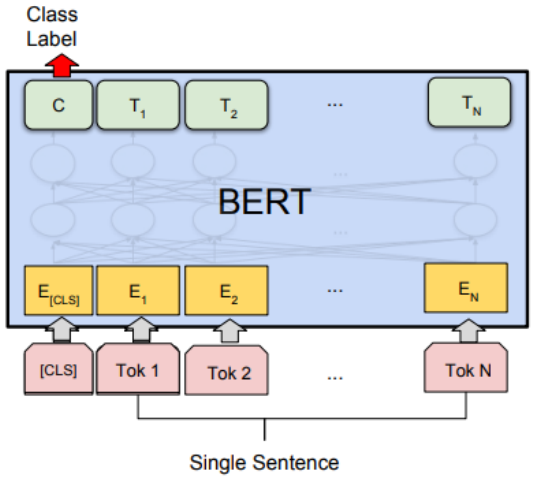
Learning goals

- Understand the fine-tuning procedure
- Learn the differences between token- and sequence classification

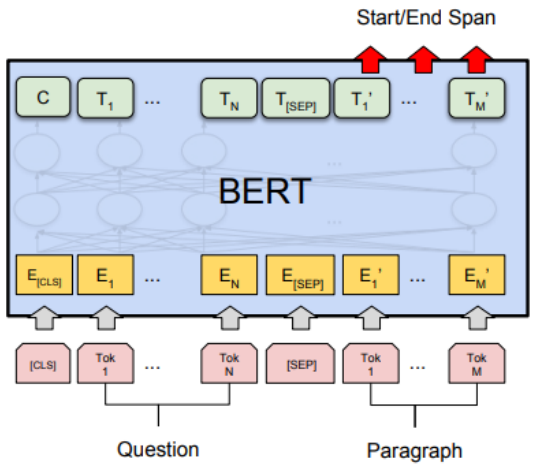
FINE-TUNING BERT



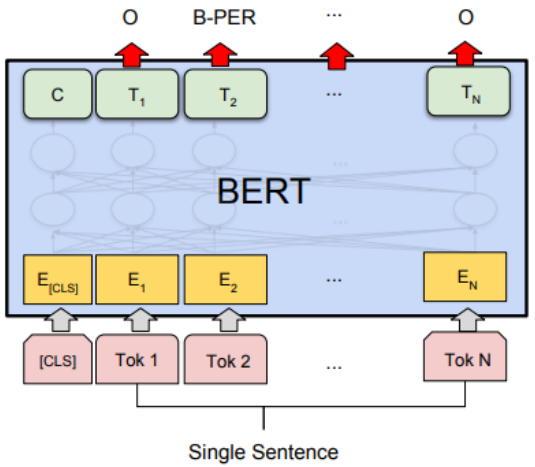
(a) Sentence Pair Classification Tasks: MNLI, QQP, QNLI, STS-B, MRPC, RTE, SWAG



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



(c) Question Answering Tasks: SQuAD v1.1



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

Source: Devlin et al. (2018)

FINE-TUNING BERT

System	MNLI-(m/mm) 392k	QQP 363k	QNLI 108k	SST-2 67k	CoLA 8.5k	STS-B 5.7k	MRPC 3.5k	RTE 2.5k	**Average** -
Pre-OpenAI SOTA	80.6/80.1	66.1	82.3	93.2	35.0	81.0	86.0	61.7	74.0
BiLSTM+ELMo+Attn	76.4/76.1	64.8	79.8	90.4	36.0	73.3	84.9	56.8	71.0
OpenAI GPT	82.1/81.4	70.3	87.4	91.3	45.4	80.0	82.3	56.0	75.1
$\text{BERT}_{\text{BASE}}$	84.6/83.4	71.2	90.5	93.5	52.1	85.8	88.9	66.4	79.6
$\text{BERT}_{\text{LARGE}}$	**86.7/85.9**	**72.1**	**92.7**	**94.9**	**60.5**	**86.5**	**89.3**	**70.1**	**82.1**

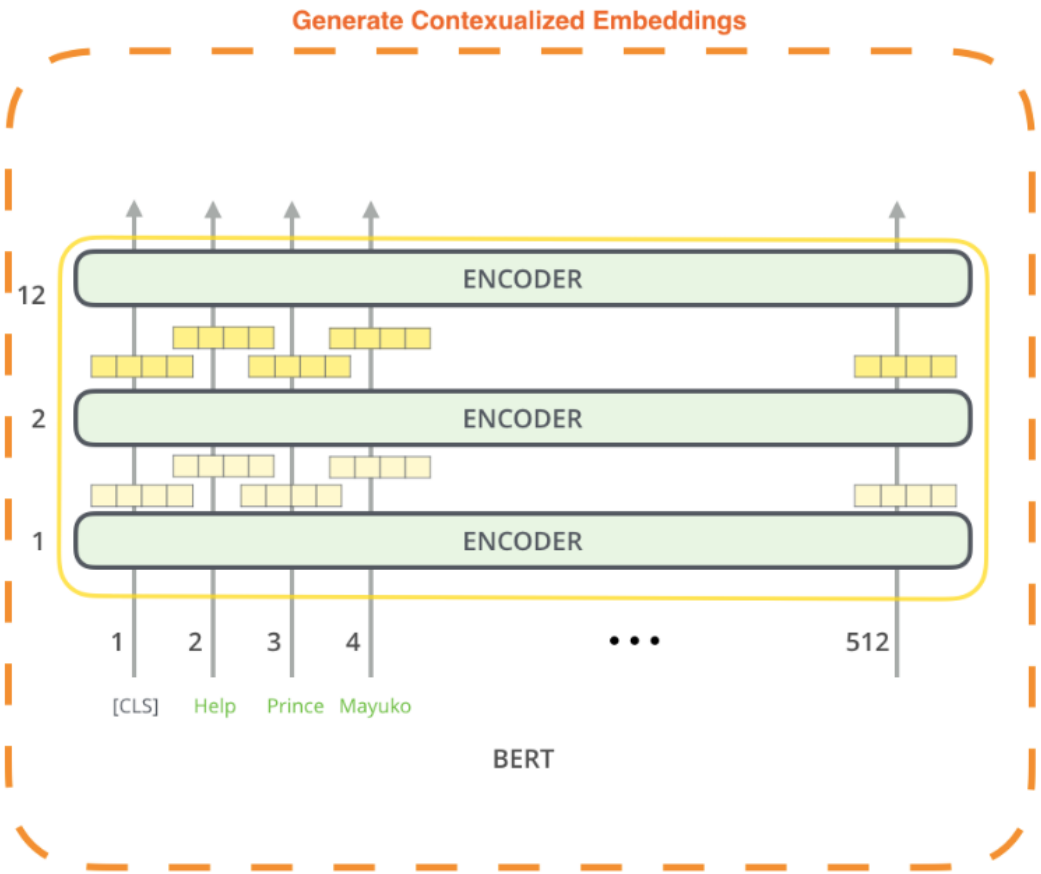
Source: Devlin et al. (2018)

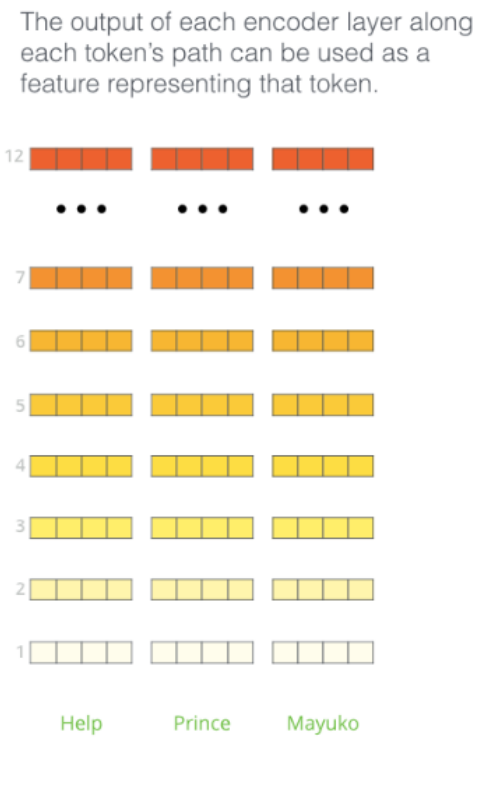
- Performance of BERT on the ▸ GLUE Benchmark
- Beats all of the previous state-of-the-art models
- In the meantime: Other models better than BERT

FINE-TUNING DETAILS

- Relatively cheap compared to pre-training:
  - $<$ 1 hour on a single Cloud TPU
  - "a few hours" on a GPU
- Recommendations for hyperparameters:
  - **Batch Size:** 16, 32
  - **Adam learning rate:** 5e-5, 3e-5, 2e-5
  - **#epochs:** 2, 3, 4
  - **Dropout probability:** 0,1
- Data sets w/ > 100k labeled examples rather insensitive to hyperparameters

FEATURE EXTRACTION FROM BERT





Source: *Jay Alammar*

FEATURE EXTRACTION FROM BERT

System	Dev F1	Test F1
ELMo (Peters et al., 2018a)	95.7	92.2
CVT (Clark et al., 2018)	-	92.6
CSE (Akbik et al., 2018)	-	**93.1**
Fine-tuning approach		
$\text{BERT}_{\text{LARGE}}$	96.6	92.8
$\text{BERT}_{\text{BASE}}$	96.4	92.4
Feature-based approach ($\text{BERT}_{\text{BASE}}$)		
Embeddings	91.0	-
Second-to-Last Hidden	95.6	-
Last Hidden	94.9	-
Weighted Sum Last Four Hidden	95.9	-
Concat Last Four Hidden	96.1	-
Weighted Sum All 12 Layers	95.5	-

Table 7: CoNLL-2003 Named Entity Recognition results. Hyperparameters were selected using the Dev set. The reported Dev and Test scores are averaged over 5 random restarts using those hyperparameters.

Source: Devlin et al. (2018)