# **Dive into Deep Learning for NLP**

4. Contextual Representations

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13:15-14:15	Natural Language Processing and Deep Learning Basics
14:15-14:25	Break
14:25-15:15	Context-free Representations with Word Embeddings
15:15-15:55	Machine Translation and Sequence Generation
15:55-16:35	Contextual Representations with BERT
16:35-16:45	Break
16:45-17:15	Model Deployment with TVM

#### **Context Matters: Retail Bank or River Bank?**

1. I jog along the **bank** of Duwamish River every day.

2. I went to the **bank** to open a savings account.



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With word embedding, the vector representing "bank" is the same in both sentences



# Can we have representations that depend on the **context**?



# Representations

- Context-free representation
  - CBOW/Skip-gram
  - FastText
- Contextual representation
  - ELMo: Embedding from Language Model
  - BERT: Bidirectional Embedding Representation from Transformers



# **BERT**

**Bidirectional Embedding from Transformers** 



# General Language Understanding Evaluation (GLUE Benchmark)

#### Including datasets for:

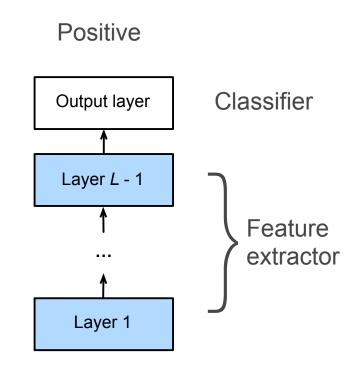
- acceptability
- sentiment
- paraphrase
- sentence similarity
- natural language inference

Model	Avg Score	
CBOW	58.6	
BERT	80.5	



#### **BERT**

- Pre-training: learn contextual representation on large scale corpus
- 2. Fine-tuning: add a simple output layer on BERT and fine-tune with the task at hand



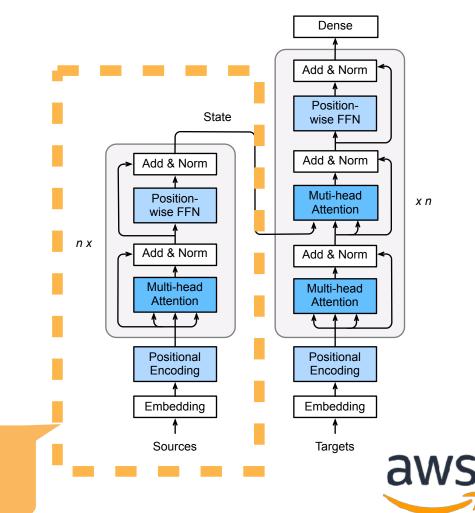
I love this movie



#### **BERT Architecture**

- A (big) Transformer encoder
- BERT Base
  - # blocks = 12
  - # parameters = 110M
- BERT Large
  - # blocks = 24
  - # parameter = 340M

BERT



# **BERT Pre-training**

- Pre-training tasks:
  - masked language modeling
  - next sentence prediction
- Dataset: Wikipedia and BooksCorpus (>3B words)



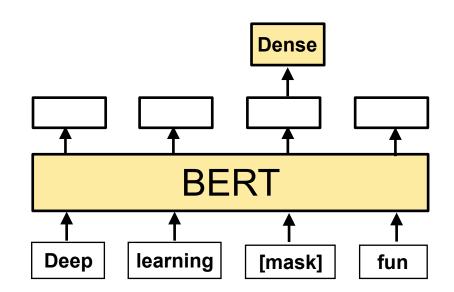
# Pre-training Task 1: Masked Language Model

Original sentence:

Deep learning is fun.

Masked sentence:

Deep learning [mask] fun.



$$loss = -\log p(is | deep, learning, [mask], fun)$$



#### **Pre-training Task 2: Next Sentence Prediction**

Each example is a pair of sentences

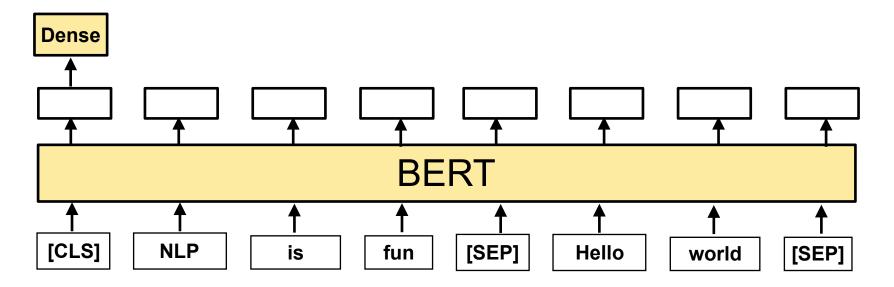
**is\_next\_sentence**: NLP is fun. GluonNLP is awesome.

not\_next\_sentence: NLP is fun. Hello world.

Sentence level binary classification

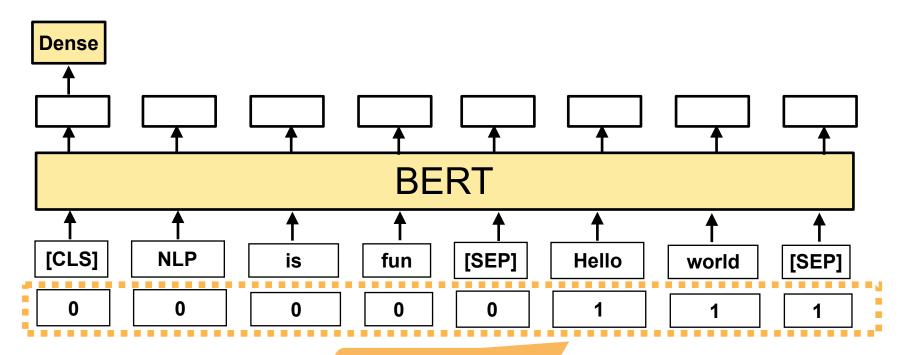


#### **Pre-training Task 2: Next Sentence Prediction**





#### **Pre-training Task 2: Next Sentence Prediction**

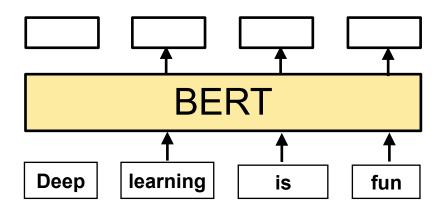


Segment Embedding



#### **BERT Fine-tuning**

- BERT returns a (contextual) feature vector for each token
- Different fine-tuning tasks use a different set of vectors





# Fine-tuning: Sentence Classification

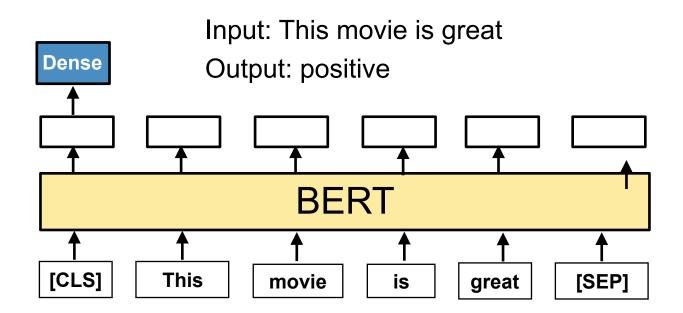
Input: This movie is great

Output: positive



# Fine-tuning: Sentence Classification

Feed the [CLS] token vector into a dense output layer.





#### **Fine-tuning: Sentence Pair Classification**

Input 0: The processor was announced in San Jose at the Forum.

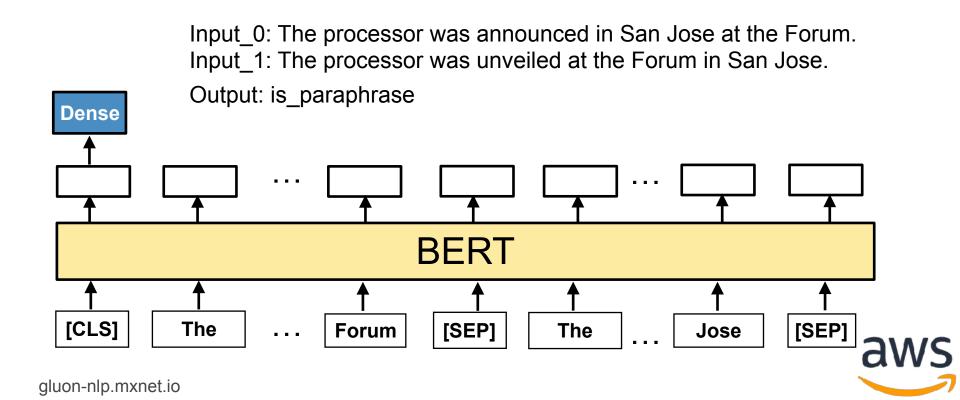
Input\_1: The processor was unveiled at the Forum in San Jose.

Output: is\_paraphrase



#### Fine-tuning: Sentence Pair Classification

Feed the [CLS] token vector into a dense output layer.



# Fine-tuning: Named Entity Recognition

Input: Jim bought 3000 shares of Amazon in 2006.

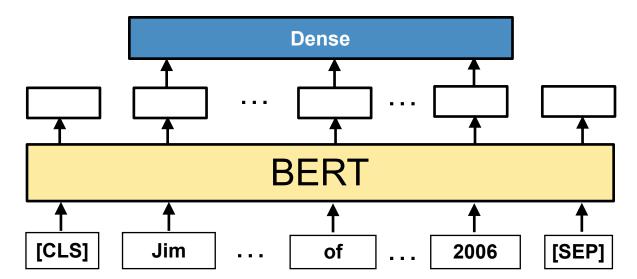
Output: [person] [organization] [time]



# Fine-tuning: Named Entity Recognition

Feed each non-special token vector into a dense output layer

Input: Jim bought 3000 shares of Amazon in 2006. Output: [person] [organization] [time]





# Fine-tuning: Question Answering

Given a question and a description text, find the answer, which is a text segment in the description

Input\_0: AMLC 2019 is held in Seattle

Input\_1: Where is AMLC held

Output: Seattle

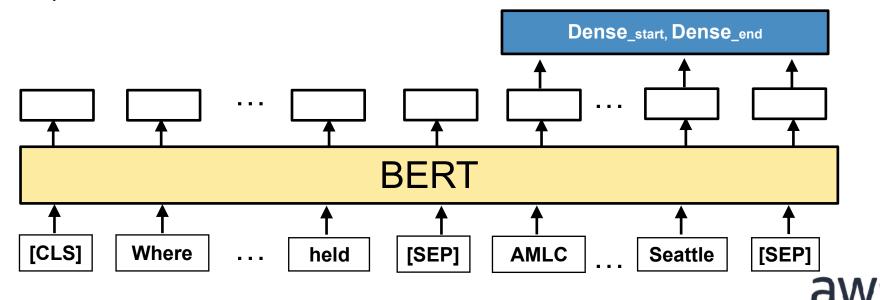


#### Fine-tuning: Question Answering

Input\_0: AMLC 2019 is held in Seattle

Input\_1: Where is AMLC held

Output: Seattle



#### BERT in GluonNLP

from gluonnlp import model model.get\_model( "bert\_12\_768\_12", dataset name="wiki cn cased"

# w.amazon.com?BERT

book\_corpus\_wiki\_en\_cased openwebtext\_book\_corpus\_wiki\_en\_uncased wiki\_multilingual\_uncased wiki\_multilingual\_cased **/** wiki\_cn\_cased scibert scivocab uncased scibert scivocab cased scibert basevocab uncased scibert basevocab cased ✓ biobert\_v1.0\_pmc\_cased biobert\_v1.0\_pubmed\_cased

book\_corpus\_wiki\_en\_uncased

biobert\_v1.0\_pubmed\_pmc\_case

biobert\_v1.1\_pubmed\_cased

clinicalbert\_uncased

ernie\_baidu\_cn\_uncased

# Available in **GluonNLP**

bert\_12\_768\_12

bert\_24\_1024\_16

 $\checkmark$ 

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Devlin, Jacob, et al. "Bert: Pre-training of deep bidirectiona arXiv preprint arXiv:1810.04805 (2018). gluon-nlp.mxnet.io

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#### **BERT in GluonNLP**

Source	Go	ogle	GluonNLP
Num layers	12	24	12
Dataset size (GB)	18	18	56
SST-2	93.5	94.9	95.3
RTE	66.4	70.1	73.6
QQP	71.2	72.1	72.3
SQuAD	88.5	90.9	91.0
STS-B	85.8	86.5	87.5
MNLI	83.4	85.9	84.9



#### **BERT inference with GluonNLP**

#### float32 inference

- BERT Base sentence classifier on Yahoo answers dataset
- with 4 cores on c5.12xlarge (out of 48 vCPUs)

Package	max_length	latency (ms)	accuracy
mxnet-mkl=1.4.1	256	178.04	74.6
latest mxnet	256	75.39	74.6



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#### int8 inference (coming soon)

- 1.7x latency reduction, 2.2x model size reduction
- <1% accuracy drop</p>



# **Demo: BERT for Question Answering**

04\_contextual\_representation/question\_answering.ipynb

