91258 Natural Language Processing

Lesson 20. Beyond

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Transformers[1]

[1] Partially based on https://neptune.ai/blog/bert-and-the-transformer-architecture-reshaping-the-ai-landscape

Attention (Vaswani et al., 2017)

- RNNs are [were] at the core of NLU tasks —language modeling, machine translation and question answering
- **Attention is all you need**[2] introduced the "self-attention" mechanism for MT: en–de and en–fr
- Comparison against recurrent and convolutional models:
  - Higher translation quality
  - Less computation cost
- By reading one word at a time, RNNs have a hard time modelling distant word interactions
- CNN's get all the info at once, but combining distant relationships comes late

https://ai.googleblog.com/2017/08/transformer-novel-neural-network.html

[2] I just passed by a paper with title "pre-training without attention"...

Transformer (Devlin et al., 2019)

- A small/constant number of steps (chosen empirically)
- The self-attention mechanism models relationships between all words in a sentence, **regardless of their respective position**
- Attention: scores that determine how much each of the other words should contribute to the next representation of each of them

Example:

I arrived at the bank after crossing the river
I arrive at the bank after crossing the road

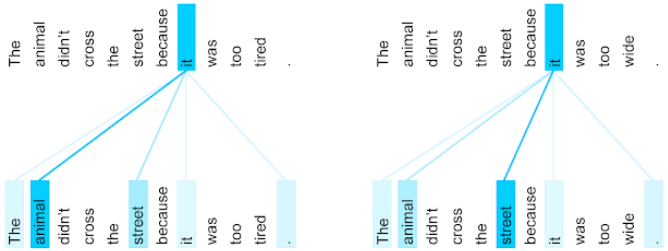
Let us look at an animated example for MT: transform20fps.gif

1. Initial embedding representations (empty circles)
2. new representation (filled circles) ← aggregating info (attention) from all other words (context)[3]

[3] In parallel for all words, multiple times

Transformer (Devlin et al., 2019)

The attention can be *observed*, here within two contexts:

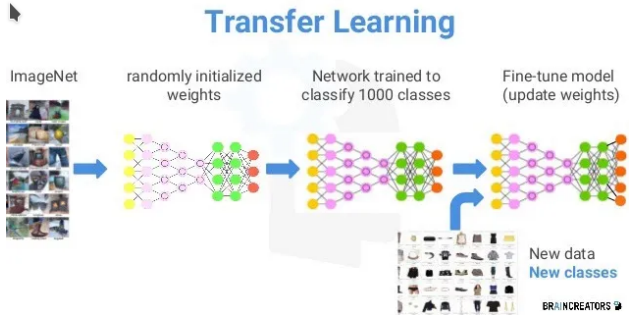


How to translate **it** in these cases?

https://ai.googleblog.com/2017/08/transformer-novel-neural-network.html

Pre-trained models

Transfer learning (image recognition, again)



1. Train a model on a (large) [open,out-of]-domain corpus
2. Fine-tune it with new data to your task of interest

* Change of paradigm wrt, for instance, word2vec

Picture from https://madhuramiah.medium.com/deep-learning-using-resnets-for-transfer-learning-d7f4799fa863

Pre-trained models

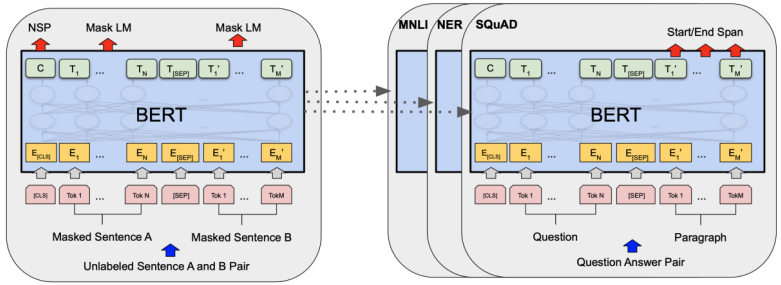
Typical current setting

1. An organisation with large computing capabilities trains a large language model[4]
2. Download and fine-tune the model with a few thousand instances[5]

[4] GPT-3 is trained on 45TB of data; it has 175B parameters

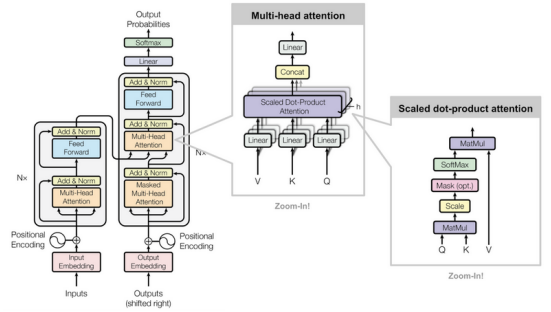
[5] Or even less: zero-shot and few-shot learning; e.g., Muti and Barrón-Cedeño (2022)

Fine-Tuning



Picture from Devlin et al. (2019)

Transformer architecture[6]



- Scaled dot-product attention multiple times, in parallel
- Similar to looping over an RNN, without vanishing gradient descent

Multiple times?

BERT : 24 attention layers
GPT-2 : 12 attention layers
GPT-3 : 96 attention layers

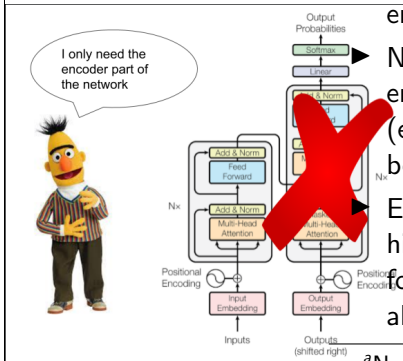
[6] Don't panic!

Bert

BERT

Bi-directional **e**ncoder **r**epresentations from **t**ransformers

- Encodes the semantic and syntactic information in the embedding[a]
- No decoding: it's output is an embedding, not text or a class (e.g., to compute similarities; bertscore)
- Extra training layer: predicts hidden or masked words to force the encoder to learn more about the context



[a] Not for text generation (it can generate words), allows for multiple languages

BERT

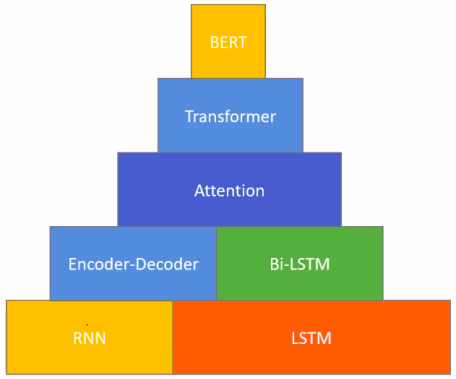
Masking (cloze test)

- When training to predict the next word, BERT might cheat and just copy it from the right-to-left component
- Instead of predicting the next word, we hide or "mask" a word, and then force the model to predict that word
  - 15% of the input tokens are masked (picked randomly):

%	masked with	Sentence
	(original)	BERT can see all the words in this sentence
80	MASK token	BERT can see all the **[MASK]** in this sentence
10	random word	BERT can see all the **ragù** in this sentence
10	same word	BERT can see all the **words** in this sentence

BERT

Learning Pyramid



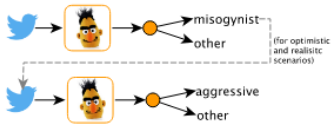
Picture from https://iq.opengenus.org/introduction-to-bert/

BERT in other Languages

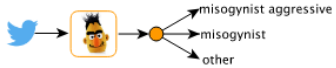
For instance:

- Spanish (Cañete et al., 2020)
- Italian (AIBERTo) (Polignano et al., 2019)

Use case: misogyny identification in Italian



(a) Cascaded architecture with two binary models (exps. `sing A` and `sing B`).



(b) Multi-class architecture model (exp. `multi`).

Figure 1: The two alternative system architectures for misogyny and aggressiveness identification.

(Muti and Barrón-Cedeño, 2020)

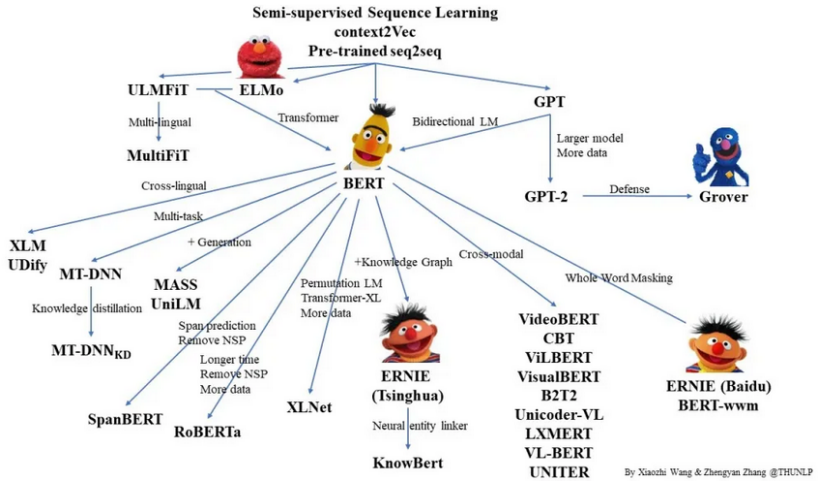
Multilingual models

What makes multilingual BERT multilingual? (Liu et al., 2020)

Use case: multilingual misogyny identification

(Muti and Barrón-Cedeño, 2022)

BERTology



Picture from `https://github.com/thunlp/`

(Other) Reference Libraries

- Spacy
  Industrial-Strength Natural Language Processing
  `https://spacy.io/`
- Stanza
  A Python NLP Package for Many Human Languages
  `https://stanfordnlp.github.io/stanza/`
- **Hugging Face**
  The AI community building the future
  `https://huggingface.co/`

Conferences (non-exhaustive)

NLP-ish	**IR-ish**	**MT-ish**
Top		
ACL	SIGIR	WMT
EMNLP	CIKM	EAMT
NAACL	WSDOM	
EACL	ECIR	
Nice		
SemEval	CLEF	
CICLing[7]	TREC	
LREC		
National		
CLIC-it	IIR	
Evalita		

[7] Apparently gone

Recap

Recap: The path

1. Baby steps into computing
2. What is NLP? From rule-based to statistical
3. Pre-processing text: tokens, stemming, stopwording...
4. From words to vectors: the vector space model
5. A few supervised models
6. Training and evaluating in machine learning
7. From words to meaning: topic modeling
8. Using one neuron: perceptrons
9. Fully-connected neural networks
10. From words to semantics: word embeddings
11. Taking snapshots of text: CNNs
12. Texts as sequences: (Bi)RNNs
13. Using a better memory: LSTM
14. LSTM to produce text
15. Intro to transformers

Recap: The future path

- We covered Parts 1 and 2 of Lane et al. (2019) (up to Section 9)
- That's 9 out of 13 chapters of Natural Language Processing in Action

Now go and celebrate the end of the course

...and worry about your project from Jan 2nd!

- I'm available during January for 1-to-1 discussion on your project **upon request!**

References I

Cañete, J., G. Chaperon, R. Fuentes, J.-H. Ho, H. Kang, and J. Pérez
2020. Spanish pre-trained bert model and evaluation data. In *PML4DC at ICLR 2020*.

Devlin, J., M.-W. Chang, K. Lee, and K. Toutanova
2019. Bert: Pre-training of deep bidirectional transformers for language understanding.

Lane, H., C. Howard, and H. Hapkem
2019. *Natural Language Processing in Action*. Shelter Island, NY: Manning Publication Co.

Liu, C.-L., T.-Y. Hsu, Y.-S. Chuang, and H. yi Lee
2020. What makes multilingual bert multilingual? *arXiv*.

References II

Muti, A. and A. Barrón-Cedeño
2020. UniBO@AMI: A Multi-Class Approach to Misogyny and Aggressiveness Identification on Twitter Posts Using AlBERTo. In *Proceedings of the 7th evaluation campaign of Natural Language Processing and Speech tools for Italian (EVALITA 2020)*.

Muti, A. and A. Barrón-Cedeño
2022. A checkpoint on multilingual misogyny identification. In *Proceedings of the 60th Annual Meeting of the Association for Computational Linguistics: Student Research Workshop*, Pp. 454–460, Dublin, Ireland. Association for Computational Linguistics.

References III

Polignano, M., P. Basile, M. de Gemmis, G. Semeraro, and V. Basile
2019. AlBERTo: Italian BERT Language Understanding Model for NLP Challenging Tasks Based on Tweets. In *Proceedings of the Sixth Italian Conference on Computational Linguistics (CLiC-it 2019)*, volume 2481, Bari, Italy. CEUR.

Vaswani, A., N. Shazeer, N. Parmar, J. Uszkoreit, L. Jones, A. N. Gomez, L. Kaiser, and I. Polosukhin
2017. Attention is all you need.