CSC485/2501 A2

TA: Ruiyu Teddy Wang

Assignment 2

- Now available!
- Due 17.00 Monday, Nov 3.

Assignment 2

- Word Sense Disambiguation (q0, q1, q2) <- this tutorial!
- LLM causal tracing (q3)
- After A2, you will be familiar with…
  - NLTK
  - WordNet
  - The Lesk algorithm
  - Word embeddings methods such as word2vec and BERT
  - How LLMs work internally when prompting

Word Sense Disambiguation

Given a word in a sentence, find the correct sense of it

- A word can have a lot of different meanings!

Naturally: breaking down sentences into words and use word processing methods to do that

- NLTK and WordNet!

WordNet and NLTK

WordNet provides some useful functions for retrieving word senses and other information.

```
>>> from nltk.corpus import wordnet as wn
```

Synset basic: use synsets() to look up a word, its hypernyms and hyponyms

```
>>> wn.synsets('dog')
        [Synset('dog.n.01'), Synset('frump.n.01'), Synset('dog.n.03'), Synset('cad.n.01'),
        Synset('frank.n.02'), Synset('pawl.n.01'), Synset('andiron.n.01'), Synset('chase.v.01')]
```

Hypernyms have broader meanings than the current word; hyponyms are more specific

```
>>> wn.synsets('dog')[0].hypernyms()
        [Synset('canine.n.02'), Synset('domestic_animal.n.01')]
>>> wn.synsets('dog')[0].hyponyms()
        [Synset('basenji.n.01'), Synset('corgi.n.01'), Synset('cur.n.01'), Synset('dalmatian.n.02'),
        Synset('great_pyrenees.n.01'), Synset('griffon.n.02'), Synset('hunting_dog.n.01'),
        Synset('lapdog.n.01'), Synset('leonberg.n.01'), … (rest omitted)]
```

WordNet and NLTK

WordNet provides a simple **tokenizer** that splits word sequences into discrete tokens (which can be used by various nlp methods for computation)

```
>>> from nltk.tokenize import word_tokenize
>>> word_tokenize('this is an example sentence!')
        ['this', 'is', 'an', 'example', 'sentence', '!']
```

*Note that modern language models have different tokenization algorithms, instead of simply splitting sentences into words

- $3.88: ['$3.88'] or ['$', '3', '.', '88']?
- sometimes: ['sometimes'] or ['some', 'times']?
- We will cover this part later in this tutorial!

WordNet and NLTK

Stopwords are the common words that are often filtered out for text processing.

```
>>> from nltk.corpus import stopwords
>>> stopwords.words('english')
        ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', 'your', 'yours',
        'yourself', 'yourselves', 'he', 'him', 'his', 'himself', 'she', 'her', 'hers',
        ……
        'than', 'too', 'very', 's', 't', 'can', 'will', 'just', 'don', 'should', 'now']
```

*Why do we remove them?

**Do we want them to be removed in all the scenarios? ()

WSD: The Lesk Algorithm

Algorithm 1: The simplified Lesk algorithm.

```
input : a word to disambiguate and the sentence in which it appears
best_sense ⟵ most_frequent_sense word
best_score ⟵ 0
context ⟵ the bag of words in sentence
for each sense of word do
    signature ⟵ the bag of words in the definition and examples of sense
    score ⟵ Overlap(signature, context)
    if score > best_score then
        best_sense ⟵ sense
        best_score ⟵ score
    end
end
return best_sense
```

Scoring

- Overlap(): count the intersections!
- What is the intersection?
  - The bag of words as context and signatures
  - Why bag of words? (frequency matters)
- Can we improve the algorithm?

Scoring

- Overlap(): count the intersections!
- What is the intersection?
  - The bag of words as context and signatures
  - Why bag of words? (frequency matters)
- Can we improve the scoring?
  - Yes! Using word vectors!
  - Represent the surrounding using numerical representations
    1. Count vectors via BOW representations

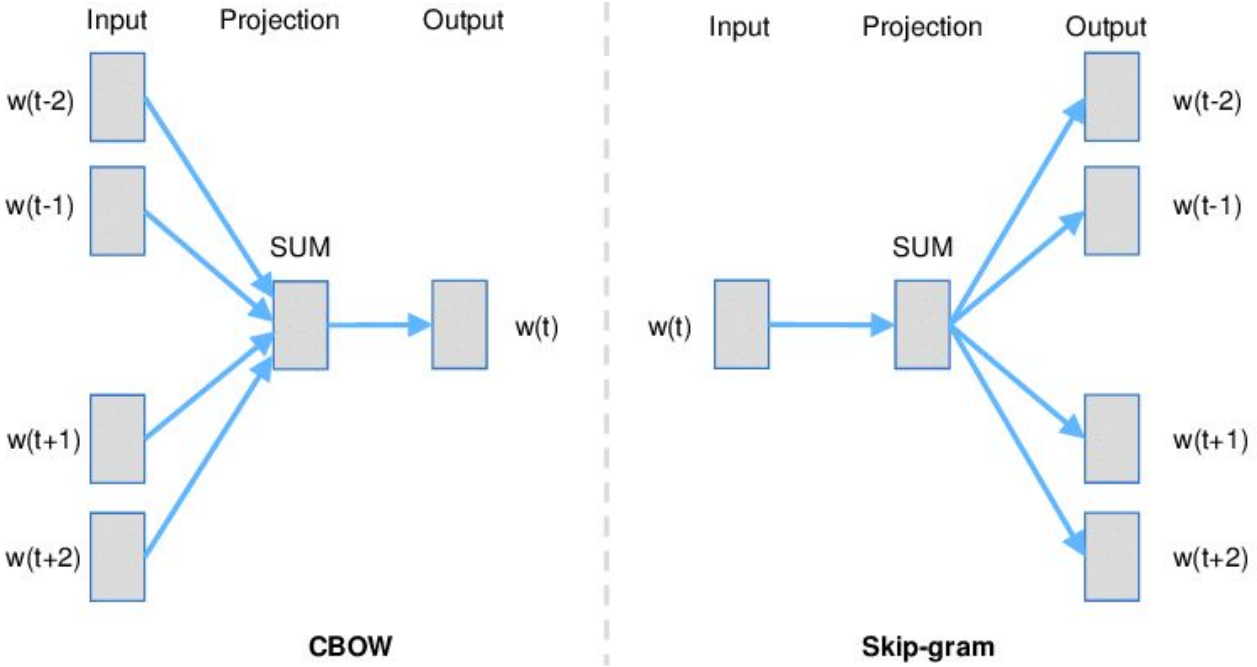
       {a, a, b, a} -> [3, 1, 0], {a, b, c} -> [1, 1, 1]
    2. Pretrained embeddings (e.g. **word2vec**)
  - Compute the score using vector similarity metrics
    - Euclidean distance, Cosine similarity, etc.

Word2vec

Efficient Estimation of Word Representations in Vector Space. NeurIPS 13'.

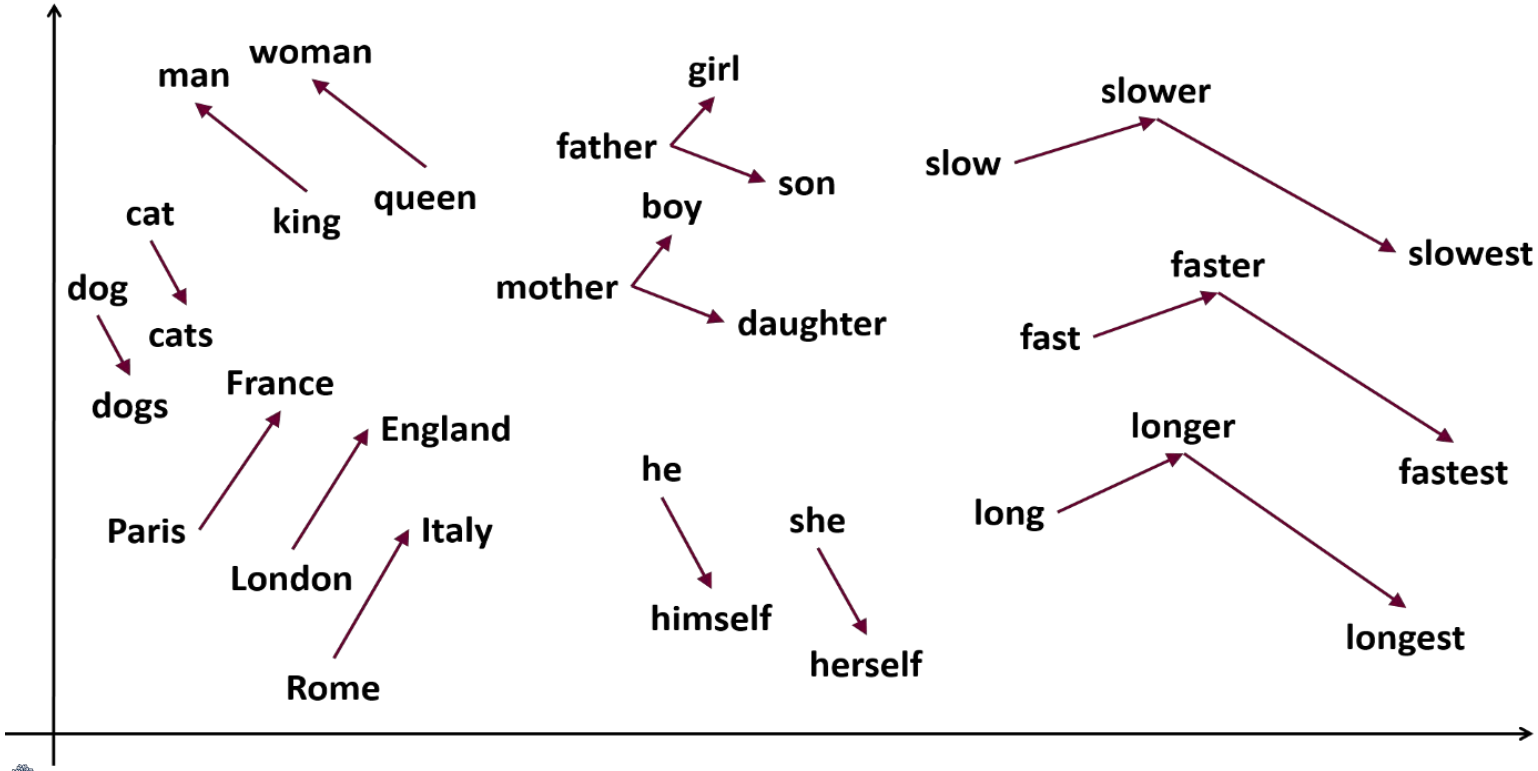
- Pretrained word vectors from large amount of text (‘pretrained’ means you don’t have to train this again in this course).
- Words are mapped to vectors of real numbers.
  - word2vec(word:str)->vector:np.array()
- Instead of counting bag of word entries, we average the word vectors of each of them to create a new representation for the context/signatures

Word2vec



Mainstream word2vec embeddings are trained with Skip-Gram with Negative Sampling (SGNS)

Word2vec


man
woman
king
queen
cat
dog
cats
dogs
France
England
Paris
London
Italy
Rome
girl
father
son
boy
mother
daughter
he
she
himself
herself
slow
slower
slowest
faster
fast
fastest
long
longer
longest

Word2vec

Efficient Estimation of Word Representations in Vector Space. NeurIPS 13'.

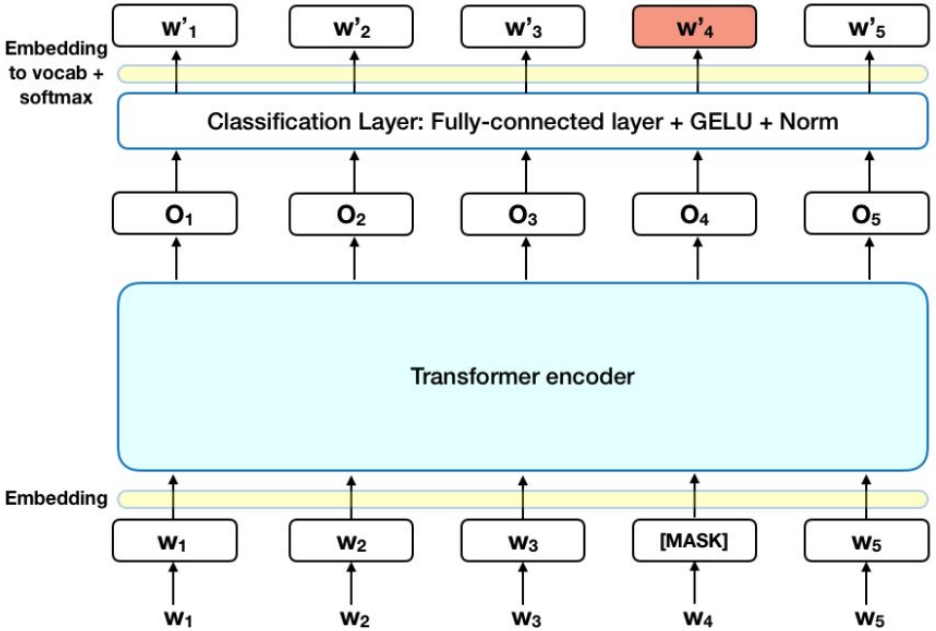
- Pretrained word vectors from large amount of text (‘pretrained’ means you don’t have to train this again in this course).
- Words are mapped to vectors of real numbers.
  - word2vec(word:str)->vector:np.array()
- Instead of counting bag of word entries, we average the word vectors of each of them to create a new representation for the context/signatures
- Each word only has one **fixed** vector representation, although it could have multiple senses.

Fixed vs. Contextual Embedding

	Source	Nearest Neighbors
Fixed	play	playing, game, games, played, players, plays, player, Play, football, multiplayer
Contextual	Chico Ruiz made a spectacular play on Alusik 's grounder {...}	Kieffer , the only junior in the group , was commended for his ability to hit in the clutch , as well as his all-round excellent play .
	Olivia De Havilland signed to do a Broadway play for Garson {...}	{...} they were actors who had been handed fat roles in a successful play , and had talent enough to fill the roles competently , with nice understatement .

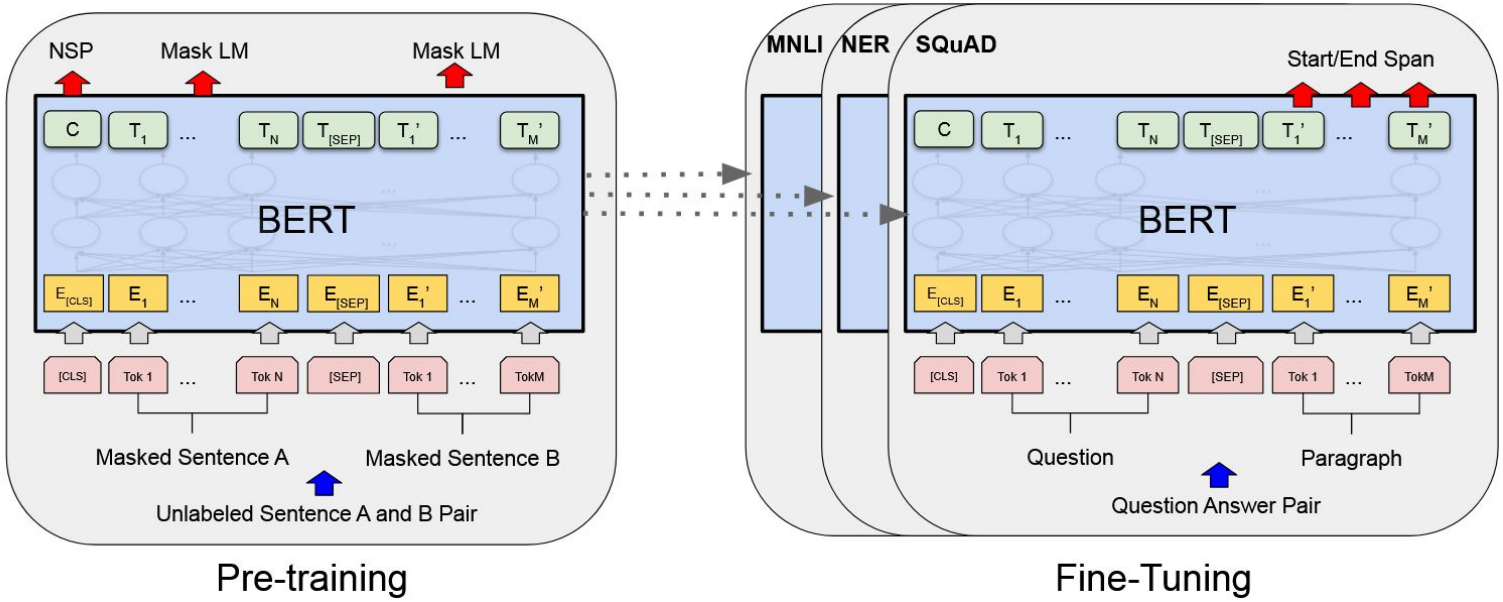
BERT

BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding. NAACL 19'



BERT

Pre-trained on two tasks: Masked Language Modeling (MLM) and Next Sentence Prediction (NSP)



BERT Tips

1. Tokenize your sentences before send them to BERT

   BERT does not take string inputs!

2. Be careful with your BERT tokens and how they corresponds to the initial sentence

   BERT tokenizer does not simply split sentences into words

   ```
   >>> out = tknz([['Multiple', ',', 'pre-tokenized', 'sentences', '!']], …)
   >>> out.tokens(0)
   ['[CLS]', 'Multiple', ',', 'pre', '-', 'token', '##ized', 'sentences', '!', '[SEP]']
   ```

3. In coding: do **not** loop tensors!

```
for (int i = 0; i < M; ++i)
        for (int j = 0; j < N; ++j)
                for (int k = 0; k < K; ++k)
                        C[i][j] += A[i][k] * B[k][j];
```

Too slow!!!

Use torch's built-in functions instead (e.g. torch.mm). Remember to keep track on dimensions

GLHF!

If you have questions:

- Ask now!
- Post them on piazza

*The handout will be posted on the course website