

# Part-of-Speech Tagging with Word Embeddings

## CS 9875 Final Project

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# Outline

Part-of-Speech Tagging

Word Embedding Models

Evaluation and Theoretical Analysis

# Part-of-Speech Tagging

# Parts of Speech

- ▶ Each word in a sentence carries out a syntactic role: denote an object, denote an action, modify an object, etc.
- ▶ This role is mapped to the word using a part-of-speech (PoS) tag

# Spelled the Same, Used Differently: Syntactic and Semantic Differences

Words can be different parts of speech (do different things) depending on where they are in the sentence and what is around them

## 1. Noun-Verb: “spot”

- ▶ “Your nose has a spot on it.” (N)
- ▶ “Can you spot him?” (V)

## 2. Noun-Adjective: “red”

- ▶ “I like to eat an orange after working out.” (N)
- ▶ “The orange car has arrived.” (A)

# Tagging

Given a sentence, assign a PoS tag to each word in the sentence.

Can   you   spot   the   large   spot   on   your   nose   ?

# Tagging

Given a sentence, assign a PoS tag to each word in the sentence.

Can	you	spot	the	large	spot	on	your	nose	?
VB	D	VB	D	Adj	N	PP	D	N	.

# Tagging

Given a sentence, assign a PoS tag to each word in the sentence.

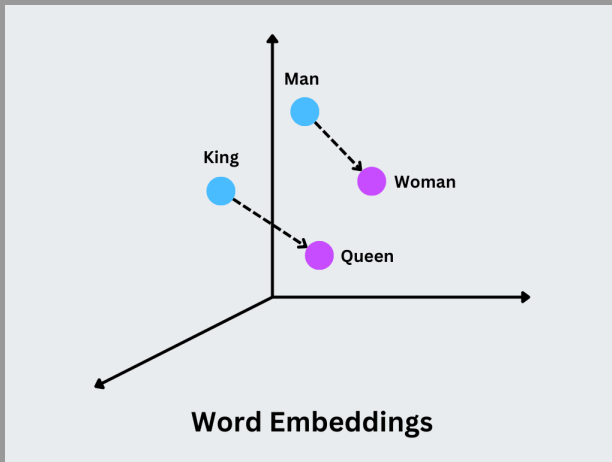
Can	you	<u>spot</u>	the	large	<u>spot</u>	on	your	nose	?
VB	D	VB	D	Adj	N	PP	D	N	.

What makes PoS tagging challenging: context is very important.



# Word Embedding Models

# What are word embeddings?

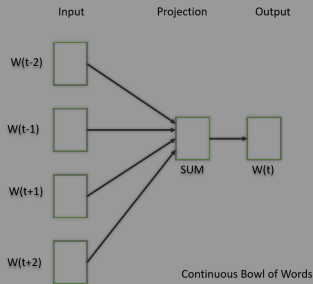


[https://assets.zilliz.com/Figure\\_Word\\_Embeddings\\_b021a5a759.png](https://assets.zilliz.com/Figure_Word_Embeddings_b021a5a759.png)

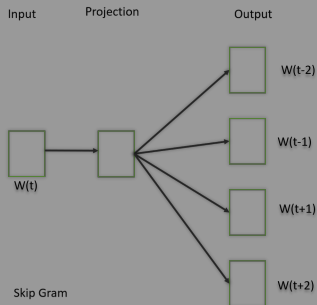
# Static Word Embeddings

What are static word embedding models?

# Word2Vec



CBOW



Skip Gram

## Word2Vec Training Procedures

<https://www.geeksforgeeks.org/nlp/word-embeddings-in-nlp/>

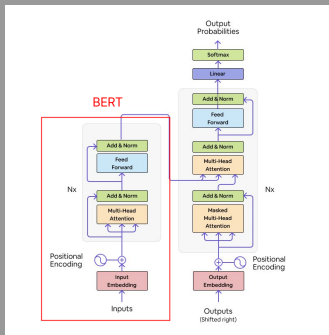
# Word2Vec

$$\begin{bmatrix} W_{00} & W_{01} & W_{02} & \dots \\ W_{10} & W_{11} & W_{12} & \dots \\ W_{20} & W_{21} & W_{22} & \dots \\ \dots & \dots & \dots & \dots \end{bmatrix}$$

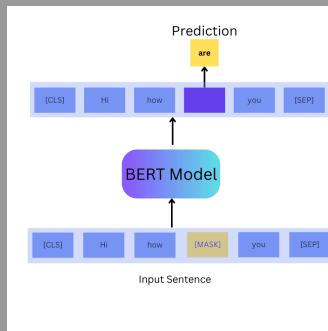
# Contextual Word Embeddings

What are contextual word embeddings?

# BERT



Transformer architecture

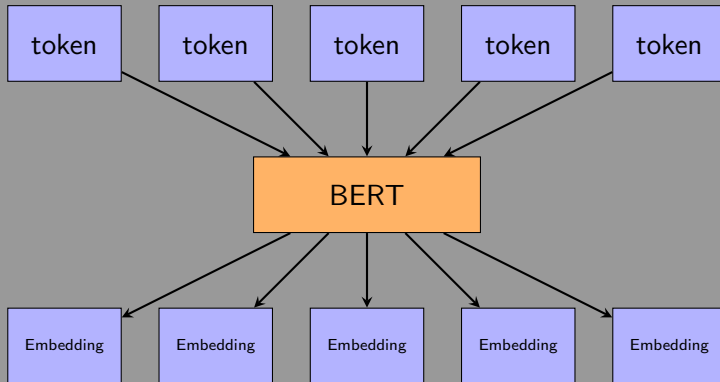


MLM

Transformer architecture: <https://deeplobe.ai/wp-content/uploads/2021/04/1.jpg>

MLM: <https://learnopencv.com/wp-content/uploads/2023/10/bert-masked-language-modeling-1.png> Devlin, Jacob; Chang, Ming-Wei; Lee, Kenton; Toutanova, Kristina, 2018. BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding

# BERT





How do we use these embeddings?

How do we use these embeddings?  
As input for a downstream model: SVM, Boosting, CNN, etc.

# Evaluation and Theoretical Analysis

# Dataset Used

## Brown Corpus:

- ▶ 1 million tagged words, validated by humans
- ▶ American English
- ▶ Provided by the Natural Language ToolKit (NLTK)

# Methodology

- ▶ 90%-10% training-test split
- ▶ Using an  $\sim 10,000$ -word subset, splitting only on sentence boundaries
- ▶ We will train 6 embedding-classifier combinations on the same training set, and test each using the same testing set.
  - ▶ Embeddings: Word2Vec (Static), BERT, ELMo
  - ▶ Classifiers: SVM, AdaBoost
- ▶ The performance of each combination will be evaluated using F1 score and AUC-ROC

# Theoretical Analysis

We will conduct a theoretical analysis on the word embedding models.

# Anticipated Results

We anticipate achieving near perfect scores in both evaluation metrics using embeddings from contextual models like BERT and a simple classification model like an SVM, outperforming static embedding models like Word2Vec.