

EEP 596: LLMs: From Transformers to GPT || Lecture 5

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Deep Learning References

Deep Learning

Great reference for the theory and fundamentals of deep learning: Book by Goodfellow and Bengio et al [Bengio et al](#)

[Deep Learning History](#)

Embeddings

[SBERT](#) and its usefulness [SBert Details](#)

Sentence Transformer

Last lecture

- Recap of Embeddings and Cosine Similarity
- Glove Embeddings
- Sentence Embeddings with Glove and Sentence Transformer
- In-Class Coding Exercise (second half)

Today's Lecture



- Product2Vec and X2Vec - Industry use-cases
- Embedding Theory
- Sentence Transformers / SBERT
- ~~Vector Databases~~ (next week)

Product2Vec



ML Visualization:- t-SNE

Represent products in product space with a large matrix of embedding coordinate vectors "L"

					
$L =$	$\begin{pmatrix} 1.5 & 1.9 & 1.8 & 1.4 & \cdots & 0.4 \\ 0.6 & 0.1 & 1.0 & 1.6 & \cdots & 1.9 \\ 0.6 & 1.6 & 1.6 & 1.6 & \cdots & 1.8 \\ 0.6 & 1.0 & 0.1 & 1.6 & \cdots & 0.6 \\ 0.8 & 1.4 & 1.9 & 0.8 & \cdots & 0.7 \end{pmatrix}$				

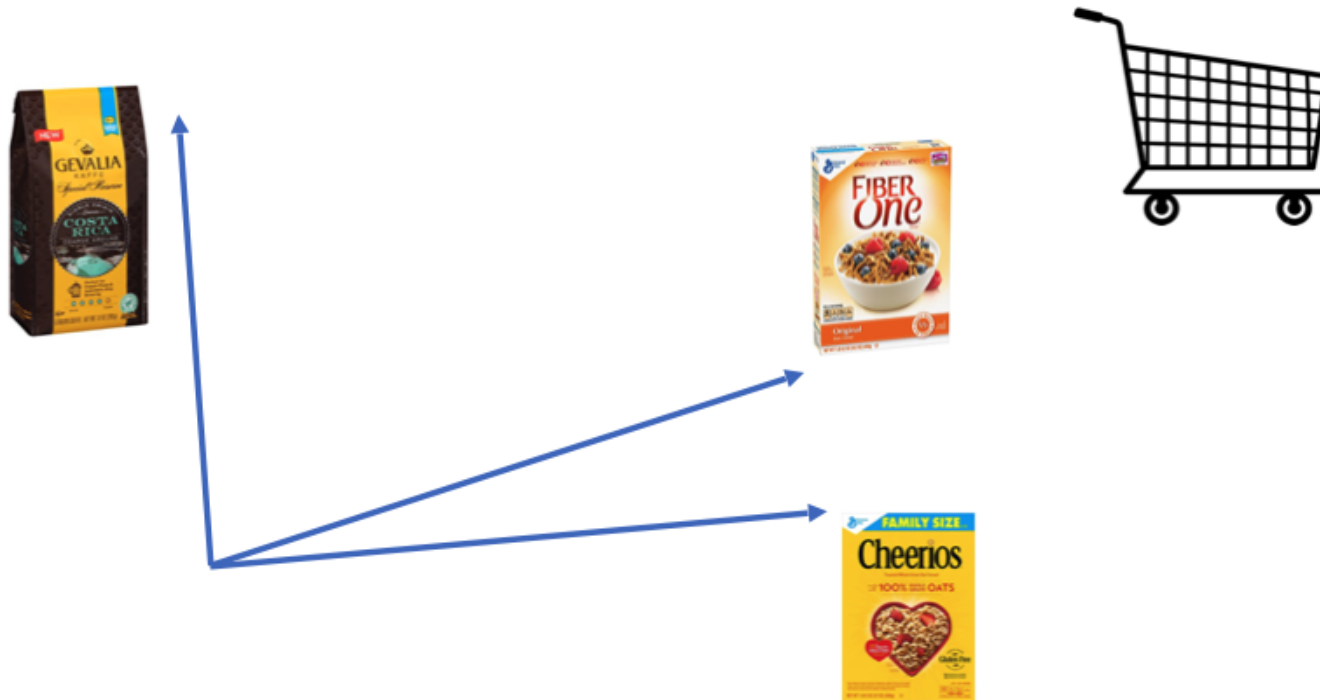
→ Snacks
→ Clean
→ ++

We obtain these embedding vectors from the Product2Vec service [London et al, 2017]

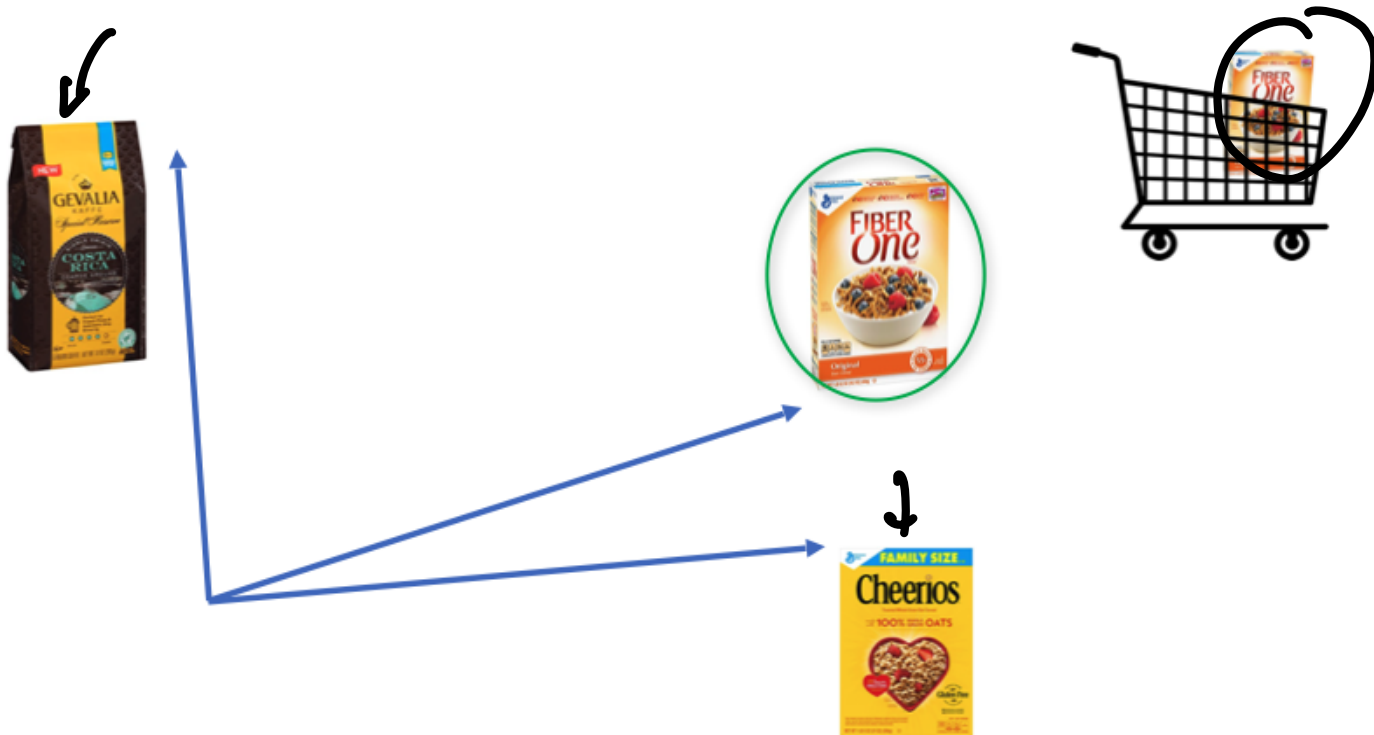
Industry Appln.:
1. Latency
2. Performance
3. Memory
4. Cost

2d Embeddings:- Good for visualization
k-d Embedding:- Good for ML Task / AI for Business
k → 100 - 1000

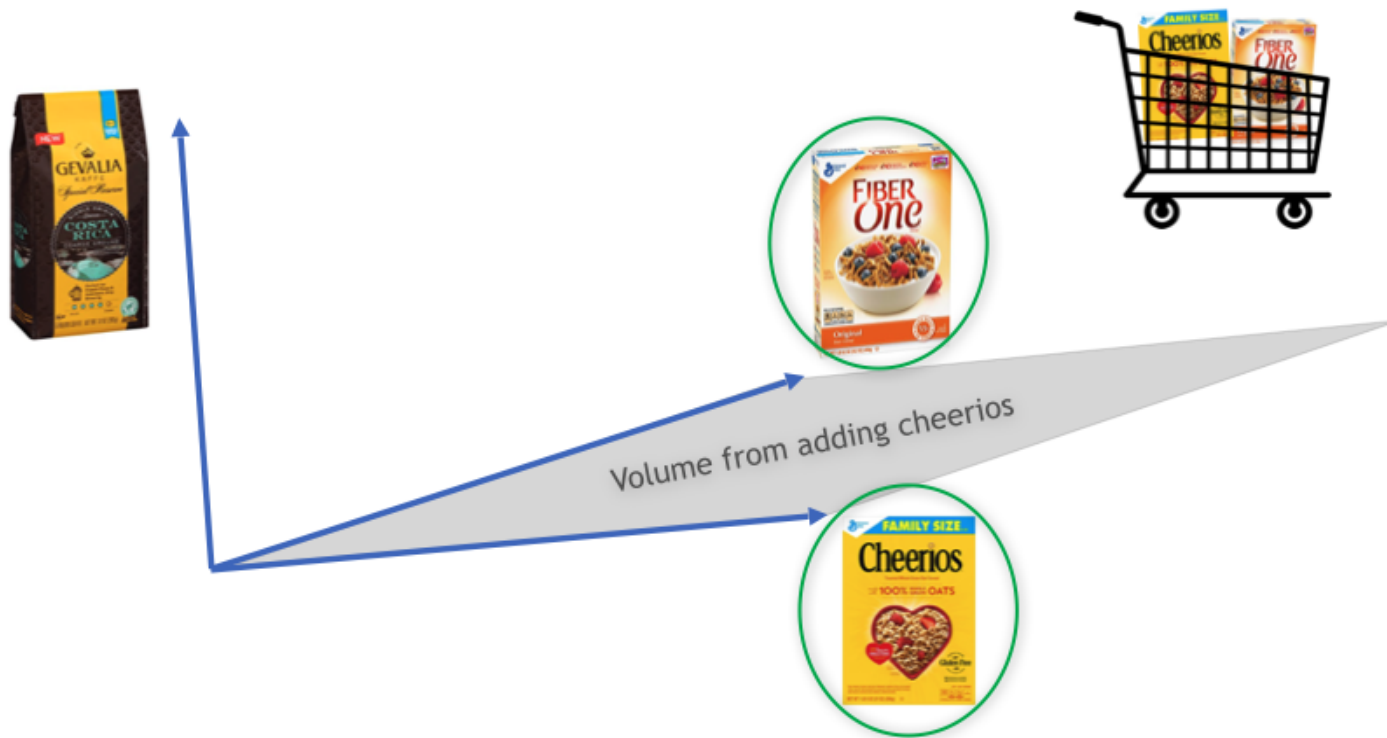
Product2Vec application



Product2Vec application



Product2Vec application



Product2Vec application



↑
Diversity/Coverage
Appln. of Embeddings

Industry Use-Case:-
Session Recommendations
(Real-Time)
using Diversity + Relevance

ICE #1

View Similarity or Purchase Similarity

Consider a company that sells products online. As we know, embedding representations for words or products in this case are learned from data. The question is which data to use? These are referred to as signals sometimes. So the question is, does **view similarity** of products represent a better signal for learning embeddings or **purchase similarity**? Remember: Good embeddings embed similar products close to each other dis-similar products away from each other.

ICE #1: View or Purchase Similarity?

SPORTS RESEARCH

BIOTIN

Extra Strength⁺

5000MCG PER SERVING
SUPPORTS HEALTHY SKIN & HAIR*
VEGAN | NON-GMO | WITH COCONUT OIL

120 Veggie Softgels | Dietary Supplement

Roll over image to zoom in

- PREMIUM, POTENT FORMULAS: Take your pick between our High Potency Biotin 2,500 mcg, Extra Strength Biotin 5,000 mcg, and Max Strength Biotin 10,000 mcg—all gluten-free, soy-free, and made with cold-pressed 100% organic coconut oil
- THE SPORTS RESEARCH DIFFERENCE: Founded in Southern California in 1980, Sports Research is a family-owned business born from a passion for fitness and wellness. Our goal is to embrace the sport of life through research-backed products created for every body—inside and out

Report an issue with this product or seller

Consider a similar item

Amazon Elements Vegan Biotin 5000 mcg - Hair, Skin, Nails, 130 Capsules (4 month supply) (Packaging may vary)

130 Count (Pack of 1)

★★★★★ (32081)

\$9.46 (\$0.07/Count) ✓prime

Climate Pledge Friendly

Sports Research Vitamin K2 as MK-7 100mcg with Coconut MCT Oil - 120 Veggie Softgels (4 Month Supply)...

★★★★★ 11

\$33.95 ✓prime

Frequently bought together

This item: Sports Research Vegan Biotin 5000mcg with Organic Coconut Oil - Extra Strength... \$17.95 (\$0.15/Count) ✓prime

Sports Research Triple Strength Omega 3 Fish Oil - Burpless Fish Oil Supplement w/EPA & DHA... \$24.26 (\$0.27/Count) ✓prime

Sports Research Vitamin D3 K2 with 5000iu of Vegan D3 & 100mcg of Vitamin K2 as MK7... \$23.95 (\$0.40/Count) ✓prime

Total price: \$66.16

Add all 3 to Cart

Products related to this item

Biotin | Collagen | Keratin | Hyaluronic Acid - Hair Growth Support Pills, 25000 mc... \$27.89 (\$0.46/Count) ✓prime

PURE RESEARCH Liquid Biotin & Collagen Hair Growth Drops 60,000mcg - Biotin... \$21.89 (\$10.95/Fl Oz) ✓prime

Sports Research Vitamin D3 K2 with 5000iu of Vegan D3 & 100mcg of Vitamin K2 as MK7... \$23.95 (\$0.40/Count) ✓prime

Genius Biotin & Collagen Hair Growth Support Drops - Hair Supplement - Healthy Skin... \$19.99 (\$10.00/Fl Oz) ✓prime

Biotin Vitamins for Hair, Skin & Nails - Biotin 5000mcg, Keratin & Collagen - Hair... \$22.97 (\$0.38/Count) ✓prime

Sugarbear Hair Vitamins Extra Strength Biotin 6000mcg, Vitamin C, E, Coconut Oil, Z... \$29.99 (\$0.50/Count) ✓prime

Biotin Capsules with Collagen and Keratin - 25000MCG Per Serving - Biotin Vitamins... \$19.89 (\$0.33/Count) ✓prime

Purchase Similarity

View only Similarity

Breakout 1: Discuss your favorite X2Vec!

X2Vec (10 mins)

In your breakout group - Discuss an application from your company or pet project that you think would benefit from **Vector Similarity Search**. Be specific about it - What's the product? data, features, etc. What's your X here? Can you see how X2Vec representation and similarity search would benefit your application. How would you learn X2vec for your application? And how would you use it?

Let's list out some X's in X2Vec!

Property 2 vec
video 2 vec | video former 2 vec
ACC 2 vec
Ab 2 vec
vulnerability 2 vec
Book pages 2 vec → Assignment 3
(FAG)

Generating Sentence Embeddings from Glove

Averaging embeddings of words: If we have a word embedding, how do we generate the sentence embedding?

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Simple Solution: Just average the word embeddings

↳ MAP — Glove Embeddings don't do so well on sentence search (MAP)

MeanC@2000 queries → Mean

Average Precision

↳ Ranking metric

How do we improve Sentence Embeddings?

Sentence Embeddings

As you are probably observing in your Mini-Project 1 assignment - Averaging word embeddings doesn't "perform" as well. So we need sentence embeddings that do better than just averaging word embeddings

- Perhaps, capture the sequence of information flow in a sentence.

How do we improve Sentence Embeddings?

Sentence Embeddings

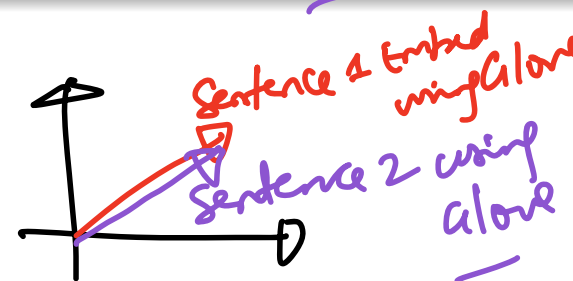
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Example 1

Sentence 1: "Me loves my friend"

Sentence 2: "My friend loves me"

Should they have the exact same sentence embeddings?



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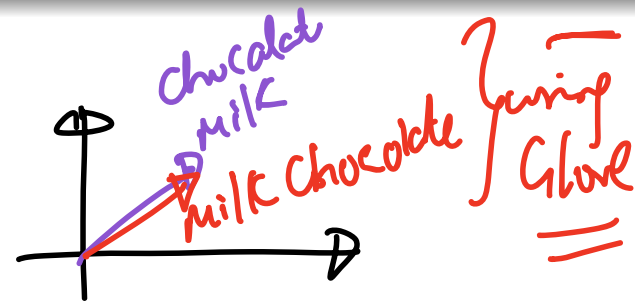
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Example 2

Sentence 1: "I like chocolate milk"

Sentence 2: "I like milk chocolate"

Should they have the same sentence embeddings?

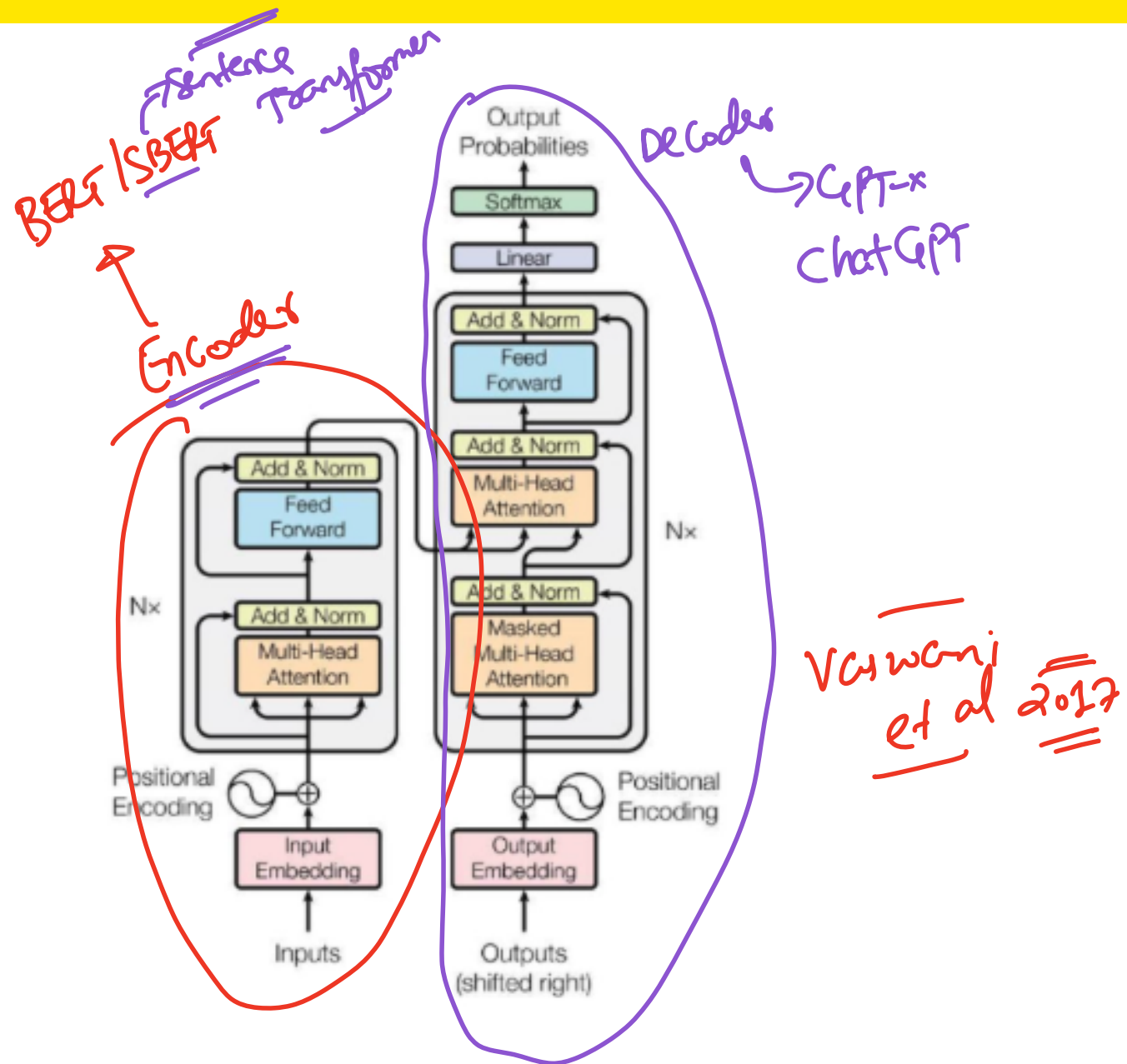


Next Topic: Transformers, BERT and connections to Embeddings

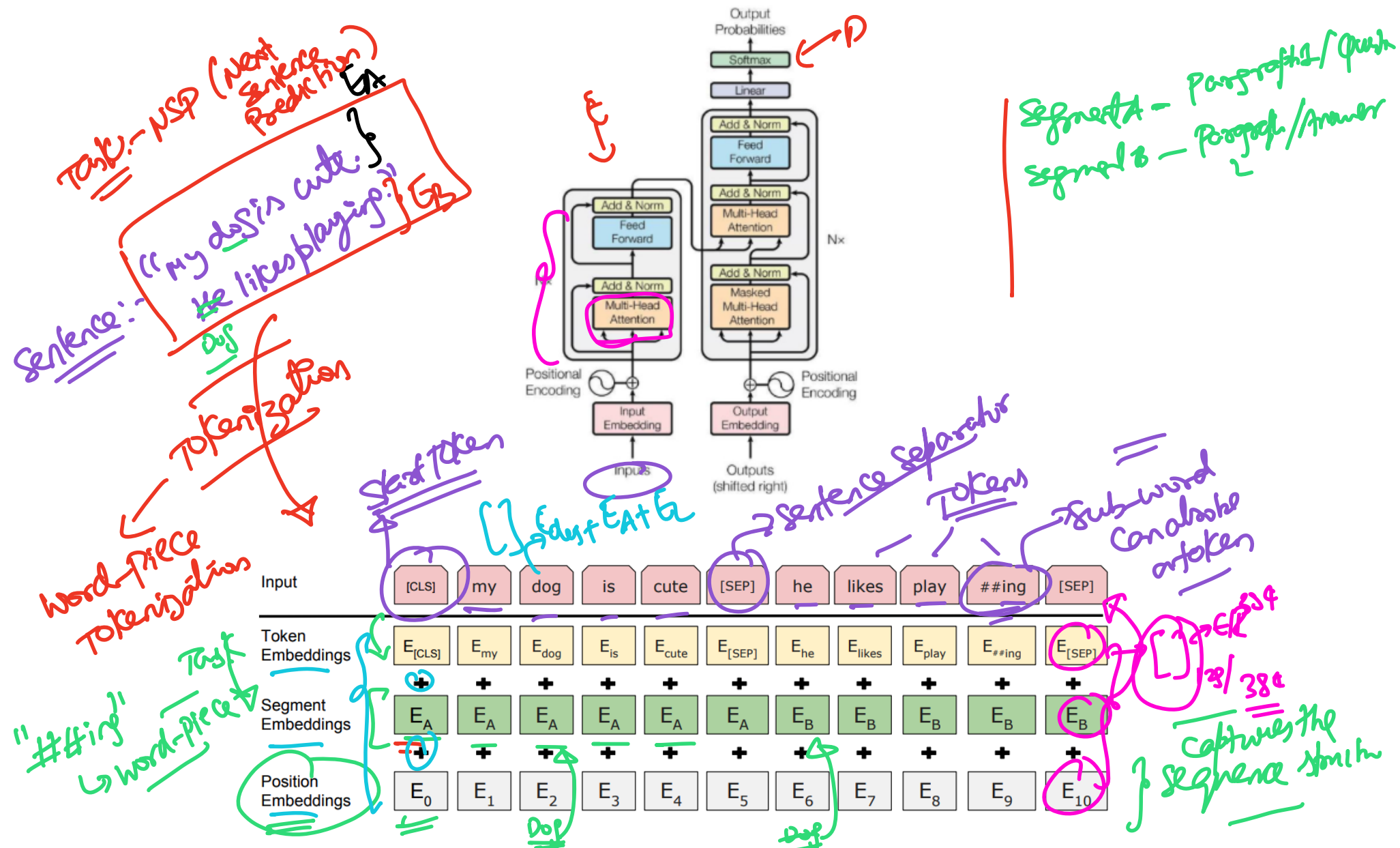
Capturing Sequence of information

As we discussed in the history of Deep Learning - RNNs and LSTMs are DL archs that are able to capture sequence information in a sentence to some extent (the **chocolate milk** vs **milk chocolate** example). On the other hand, they weren't robust to larger context or multiple sentences and could only operate with smaller sentence lengths. This is where the advent of Transformers was a breakthrough for ML/DL and AI in general - They could do much better in capturing context, sequential information, supported multiple sentences and paragraphs, etc.

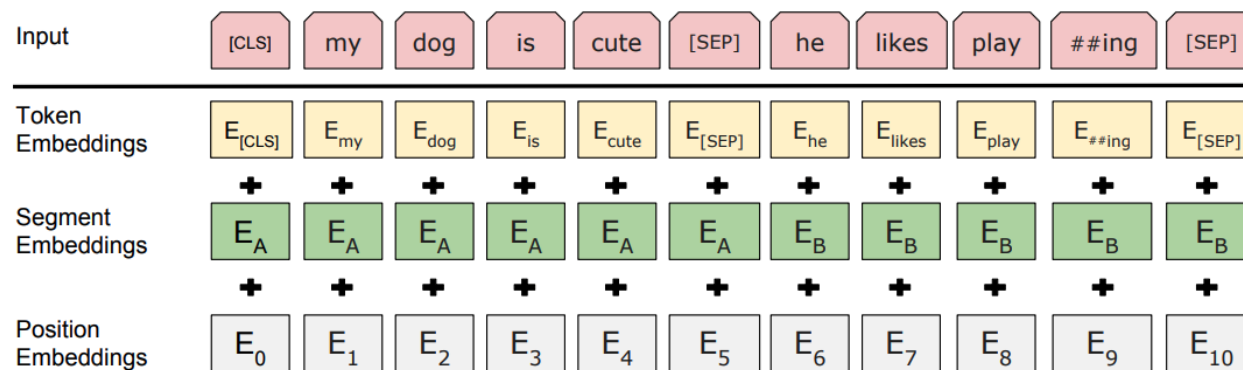
Transformers - Encoder and Decoder Architecture



Encoder and Encoder Embeddings



Understanding Encoder/BERT at high-level



BERT - Bi-directional Encoders from Transformers

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
BERT _{BASE}	84.6/83.4	71.2	90.5	93.5	52.1	85.8	88.9	66.4	79.6
BERT _{LARGE}	86.7/85.9	72.1	92.7	94.9	60.5	86.5	89.3	70.1	82.1

Parsing the Embeddings and Encoder/Decoder

Terminology

- ① **Encoder:** The **architecture component** of the transformer that transforms inputs through a series of Neural layers into a vector (embedding). This vector can then be useful for downstream tasks: Emotion detection, Classification, etc

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Example: You ask a question of ChatGPT and it starts generating words, one at a time - Just like it were typing. That's decoder in action.

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- ④ **Token Embedding:** This refers to the individual token embeddings or word embeddings (or sub-word embeddings)

↳ word-piece

Parsing the Embeddings and Encoder/Decoder Terminology

- ① **Segment Embedding:** This refers to a generic embedding that says this was segment 1 or segment 2 of the input

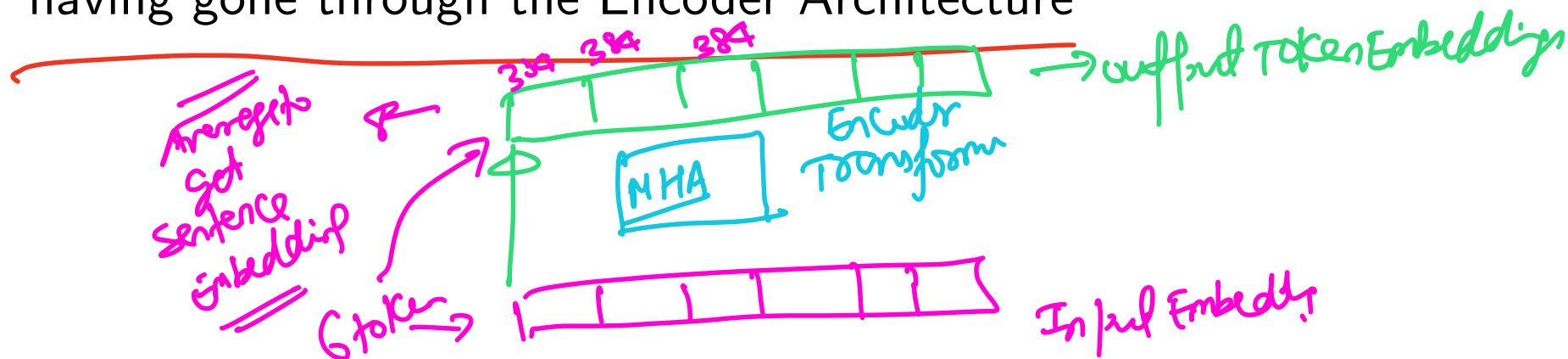

Task

Parsing the Embeddings and Encoder/Decoder Terminology

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- ② **Position Embedding:** This adds in the position information into the embedding. Did “chocolate” come in at the beginning of the sentence or middle or the end?

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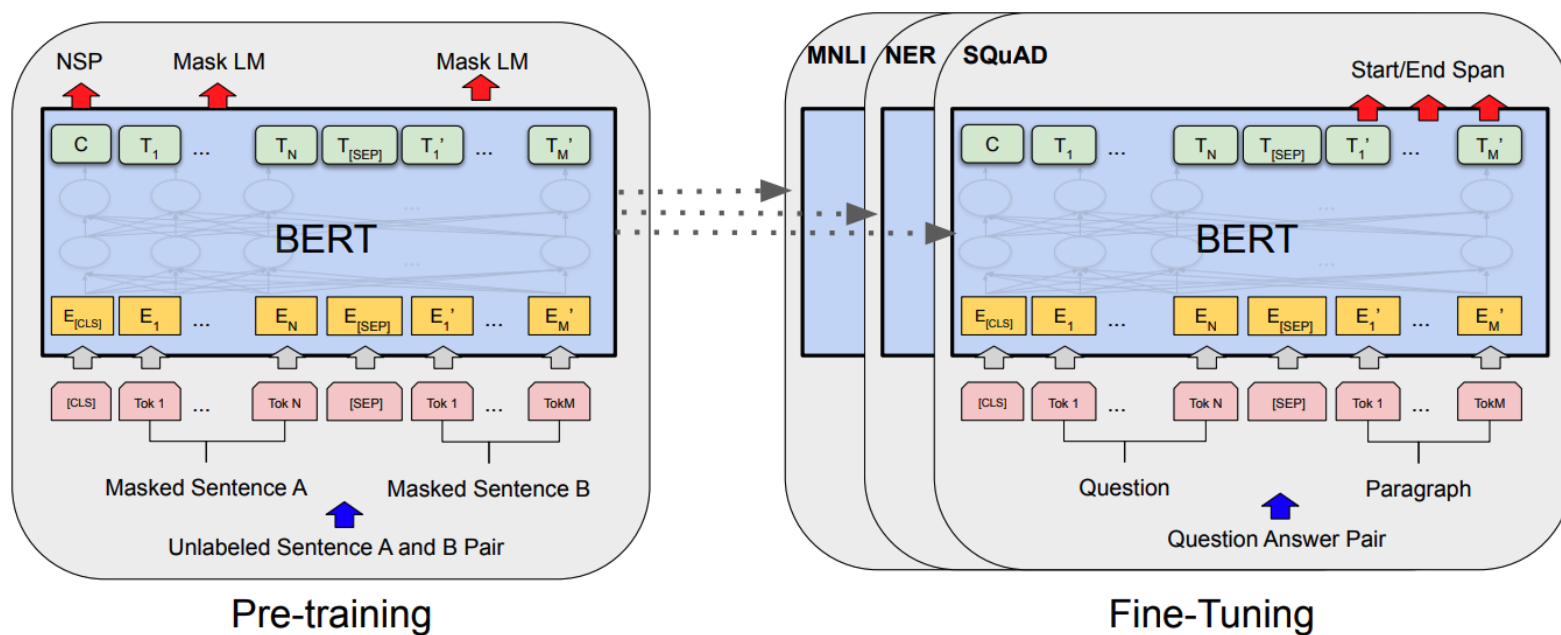
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- ④ **Sentence BERT (sBERT) Embedding:** This is the embedding that you are using in Mini-Project 1, an **encoding** into a vector that's optimized for sentence similarity! (More on this in a bit)

BERT - Bi-directional Encoders from Transformers



BERT pre-training

Two Tasks

- ① **Masked LM Model:** Mask a word in the middle of a sentence and have BERT predict the masked word
- ② **Next-sentence prediction:** Predict the next sentence - Use both positive and negative labels. How are these generated?

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ICE: Supervised or Un-supervised?

- 1 Are the above two tasks supervised or un-supervised?

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Data set!

English Wikipedia and book corpus documents!

Loss Function for Masked Language Model (MLM)

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Cross-Entropy

$$L(p, \hat{p}) = - \sum_i [p_i \log(\hat{p}_i) + (1 - p_i) \log(1 - \hat{p}_i)]$$

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ICE: What is the loss function for Binary Classification?

BERT - Bi-directional Encoders from Transformers

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OpenAI GPT	82.1/81.4	70.3	87.4	91.3	45.4	80.0	82.3	56.0	75.1
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Sentence BERT a.k.a sBERT

Uses Siamese Twins architecture

Sentence BERT a.k.a sBERT

Uses Siamese Twins architecture

Advantages of sBERT

More optimized for Sentence Similarity Search.

SBERT - Siamese BERT architecture

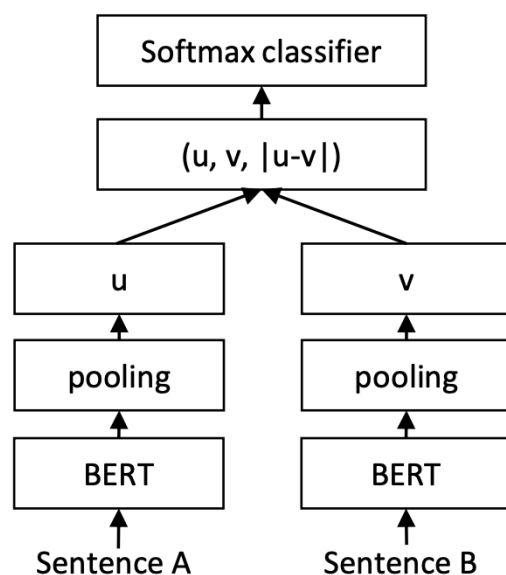


Figure 1: SBERT architecture with classification objective function, e.g., for fine-tuning on SNLI dataset. The two BERT networks have tied weights (siamese network structure).

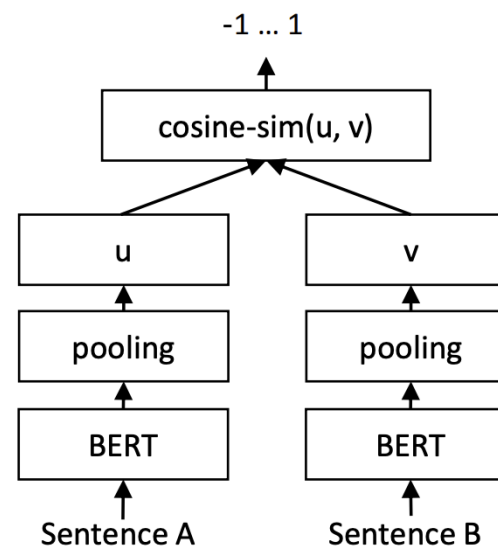


Figure 2: SBERT architecture at inference, for example, to compute similarity scores. This architecture is also used with the regression objective function.

Loss Function for SBERT

Breakouts Time #2

Retrieving Tables with Chat bots — 7 mins

You are building a chat-bot product at your company where queries come in from customers that own data in your company's cloud service. Your chat-bot responds and retrieves the right table or combination of tables (through merge/filter operations) that contains this information or returns back with follow up questions to get more precise information or get back with a "Sorry, I don't have that information" response. How would you go about building a chat-bot like this? What data would you use? What data stores/data bases would be appropriate? What Deep Learning models would you use, would it be supervised or un-supervised learning? What would be your evaluation metric? How would you test if your chat bot is accurate in its responses?