

VerifAI: Verified Generative AI (Vision)

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Outline

- What
- How
- Results
- Opportunities

image

table

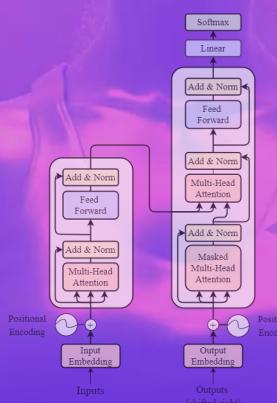
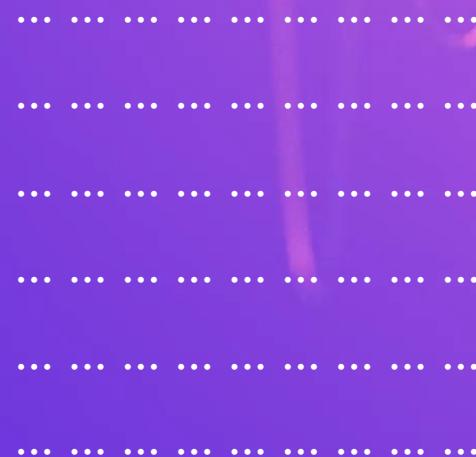
text graph

2018: GPT-1 and GPT-2

2020: GPT-3 (Wow)

2022: ChatGPT (Amazing)

2023: GPT-4 (Unbelievable)



Large Language Models

2017

Attention Is All You Need

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Abstract

The dominant sequence transduction models are based on complex recurrent or convolutional neural networks that include an encoder and a decoder. The best performing models also connect the encoder and decoder through an attention mechanism. We propose a new simple network architecture, the Transformer, based solely on attention mechanisms, dispensing with recurrence and convolutions entirely. Experiments on two machine translation tasks show these models to be superior in quality while being more parallelizable and requiring significantly less computation per word. They also serve as the baseline for translating English-to-German translation task, improving over the existing best results, including ensembles, by over 2 BLEU. On the WMT 2014 English-to-French translation task, our model establishes a new single-model state-of-the-art BLEU score of 41.8 after training for 3.5 days on eight GPUs, a small fraction of the training costs of the best models from the literature. We show that the Transformer generalizes well to other tasks by applying it successfully to English constituency parsing both with large and limited training data.

*Equal contribution. Listing order is random. Jakob proposed replacing RNNs with self-attention and started the effort to evaluate this idea. Ashish, with Ilia, designed and implemented the first Transformer models and has been crucially involved in every aspect of this work. Noam proposed scaled dot-product attention, multi-head attention, and the position-wise feed-forward networks. Lukasz became the lead developer of the codebase, nearly every detail. He designed, implemented, tuned and evaluated countless model variants in our original codebase and tensor2tensor. Llion also experimented with novel model variants, was responsible for our initial codebase, and efficient inference and visualizations. Lukasz and Aidan spent countless long days designing various parts of and implementing tensor2tensor, replacing our earlier codebase, greatly improving results and massively accelerating our research.

[†]Work performed while at Google Brain.

[‡]Work performed while at Google Research.

31st Conference on Neural Information Processing Systems (NIPS 2017), Long Beach, CA, USA.

100,000+ citations

(a) ChatGPT for
tuple generation/completion/augmentation

晨宇 You

Please help me fill in the missing values denoted by 'NULL' in this table and provide me with the completed one:

[title]: United States House of Representative Elections **2004 in Ohio**

district incumbent candidates
Ohio's 1st congressional district NULL NULL
Ohio's 2st congressional district NULL NULL
Ohio's 3st congressional district NULL NULL

 district	incumbent	candidates
Ohio's 1st congressional district		
Ohio's 2nd congressional district		
Ohio's 3rd congressional district		

Please fill these values

Do you trust the results?

Hallucination

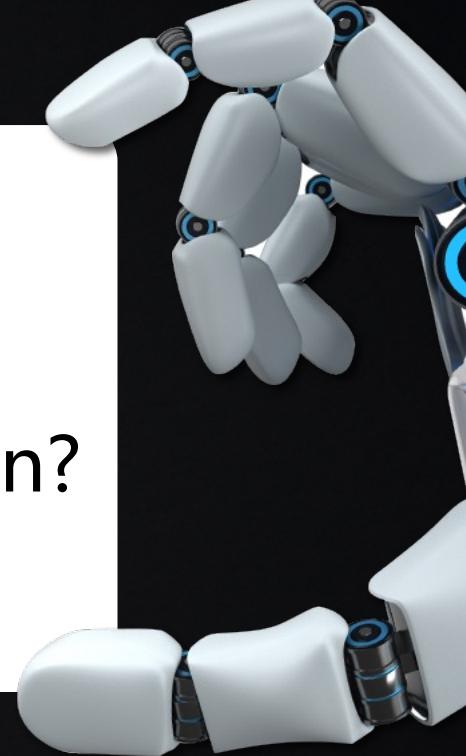
- Inaccurate decision-making
- Spread misinformation
- Privacy violation
- Legal liabilities
- Damage to trust
-

Downstream tasks?
Errors can be propagated ...

- **LLMs: Generative AI**
 - Learn a distribution from finite data
 - Generalize to infinite data points
- **Goals of Generative AI**
 - Generalizable and natural
 - Not factual
- **LLMs vs. data compression models?**
 - Is not
 - Can not

Question
Can we
remove
hallucination?

NO



Outline

- **What: Verify the outputs of LLMs (True/False)**
- How
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Generative AI



(a) ChatGPT for tuple generation/completion/augmentation

展示 You

Please help me fill in the missing values denoted by 'NULL' in this table and provide me with the completed one:

[title]: United States House of Representative Elections **2004 in Ohio**

| district | incumbent | candidates |

| Ohio's 1st congressional district | NULL | NULL |

| Ohio's 2nd congressional district | NULL | NULL |

| Ohio's 3rd congressional district | NULL | NULL |



district	incumbent	candidates
Ohio's 1st congressional district	Steve Chabot (R)	Steve Chabot (R), John Cranley (D), James Berns (Libertarian)
Ohio's 2nd congressional district	Rob Portman (R)	Rob Portman (R), Charles W. Sanders (D), Edward S. Focke (Green)
Ohio's 3rd congressional district	Tony P. Hall (D)	Tony P. Hall (D), Richard E. Stobbs (R), John Fockler (Libertarian)



(b) ChatGPT for text generation

MC

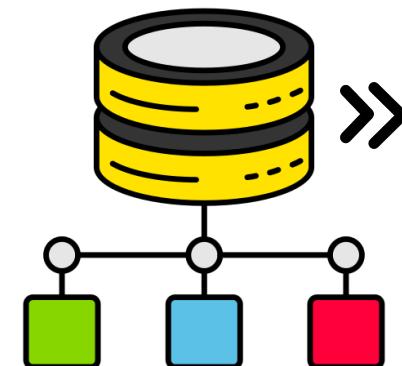
Does Meagan Good play a role in Stomp the Yard?



No, Meagan Good does not appear in the 2007 film "Stomp the Yard." "Stomp the Yard" is a dance drama film directed by Sylvain White, and Meagan Good is not listed as part of the main cast or credited with a role in the film. The main cast of "Stomp the Yard" includes actors such as Columbus Short, Chris Brown, Ne-Yo, and Brian White, among others. Meagan Good is an American actress known for her roles in films such as "Think Like a Man," "Eve's Bayou," and "Waist Deep," but she did not appear in "Stomp the Yard."



Generative AI



Data Lake



(a) ChatGPT for tuple generation/completion/augmentation

展示 You

Please help me fill in the missing values denoted by 'NULL' in this table and provide me with the completed one:

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| district | incumbent | candidates |

| Ohio's 1st congressional district | NULL | NULL |

| Ohio's 2nd congressional district | NULL | NULL |

| Ohio's 3rd congressional district | NULL | NULL |

district	incumbent	candidates
Ohio's 1st congressional district	Steve Chabot (R)	Steve Chabot (R), John Cranley (D), James Berns (Libertarian)
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Steve Chabot

Article Talk

From Wikipedia, the free encyclopedia

Steven Joseph Chabot (/ʃæbət/ SHAB-ət; born January 22, 1953) is an American politician and lawyer who represented [Ohio's 1st congressional district](#) in the [United States House of Representatives](#) from 1995 to 2009 and again from 2011 to 2023. A member of the Republican Party, he lost his 2022 reelection bid to Democrat Greg Landsman. Until his election loss, he was the dean of [Ohio's GOP delegation to the House of Representatives](#), after the retirement of former Speaker John Boehner.^[1]

General election results [edit]

Ohio's 3rd Congressional District election, 2004 ^[1]			
Party	Candidate	Votes	%
Republican	Mike Turner (Incumbent)	197,290	62.29
Democratic	Jane Mitakides	119,448	37.71
	Total votes	316,738	100
Republican hold			



(b) ChatGPT for text generation

MC

Does Meagan Good play a role in Stomp the Yard?



No, Meagan Good does not appear in the 2007 film "Stomp the Yard." "Stomp the Yard" is a dance drama film directed by Sylvain White, and Meagan Good is not listed as part of the main cast or credited with a role in the film. The main cast of "Stomp the Yard" includes actors such as Columbus Short, Chris Brown, Ne-Yo, and Brian White, among others. Meagan Good is an American actress known for her roles in films such as "Think Like a Man," "Eve's Bayou," and "Waist Deep," but she did not appear in "Stomp the Yard."

Stomp the Yard

Article Talk

From Wikipedia, the free encyclopedia

The film stars [Columbus Short](#), [Meagan Good](#), [Darrin Henson](#), [Brian White](#), [Laz Alonso](#), and [Valarie Pettiford](#), with [Harry Lennix](#), and, in their film debuts, R&B singers [Ne-Yo & Chris Brown](#). *Stomp the Yard* was filmed in [Atlanta, Georgia](#), on the campuses of [Morris Brown College](#), [Georgia Institute of Technology](#), [Morehouse College](#), and [Clark Atlanta University](#), and in the [MAK Historic District of Decatur, Georgia](#). Elsewhere Short, Alonso and Brown had also starred together in the film [This Christmas](#).

Meagan Good's Filmography

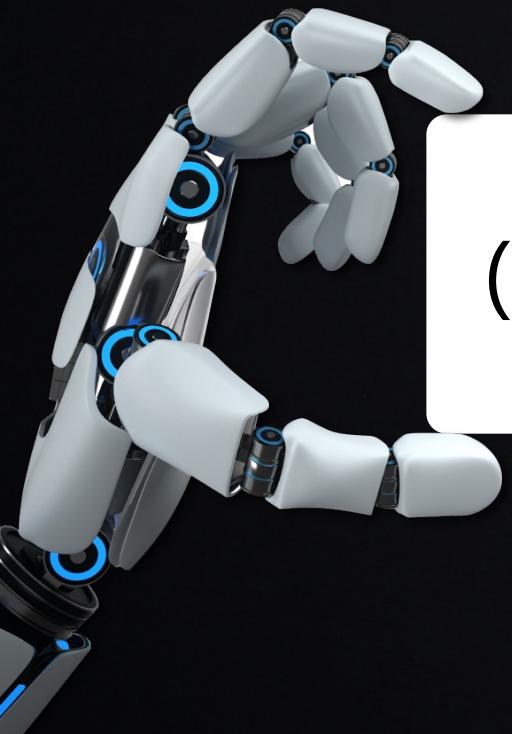
Film [edit]

Year	Title	Role	Notes
2005	<i>Brick</i>	Kara	
	<i>Venom</i>	Cece	
	<i>Roll Bounce</i>	Naomi Phillips	
2006	<i>Miles from Home</i>	Natasha Freeman	
	<i>Waist Deep</i>	Coco	
2007	<i>Stomp the Yard</i>	April Palmer	

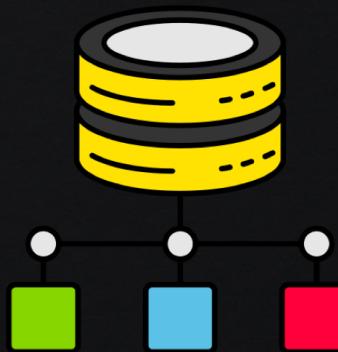


Outline

- **What:** Verify the outputs of LLMs (True/False)
- **How**
- **Results**
- **Opportunities**



Retrieve **relevant** dataset(s)
to verify **factual (not
subjective)** answers



- textual files
- table
- (sub)graphs
- images
- HTML files
- a combination

Outline

- **What:** Verify the outputs of LLMs (True/False)
- **How:** **Retrieval**
- **Results**
- **Opportunities**

Retrieval

- Retrieval-augmented generation (RAG)
- VerifAI: Retrieval-based matching
- Question-Answer Similarity
- Answer-Answer Similarity (matching)



A Deep Look into Neural Ranking Models for Information Retrieval

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^a*University of Chinese Academy of Sciences, Beijing, China*
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Abstract

Ranking models lie at the heart of research on information retrieval (IR). During the past decades, different techniques have been proposed for constructing ranking models, from traditional heuristic methods, probabilistic methods, to modern machine learning methods. Recently, with the advance of deep learning technology, we have witnessed a growing body of work in applying shallow or deep neural networks to the ranking problem in IR, referred to as neural ranking models in this paper. The power of neural ranking models lies in the ability to learn from the raw text inputs for the ranking problem to avoid many limitations of hand-crafted features. Neural networks have sufficient capacity to model complicated tasks, which is needed to handle the complexity of relevance estimation in ranking. Since there have been a large variety of neural ranking models proposed, we believe it is the right time to summarize the current status, learn from existing methodologies, and gain some insights for future development. In contrast to existing reviews, in this survey, we will take a deep look into the neural ranking models from different dimensions to analyze their underlying assumptions, major design principles, and learning strategies. We compare these models through benchmark tasks to obtain a comprehensive empirical understanding of the existing techniques. We will also discuss what is missing in the current literature and what are the promising and desired future directions.

... like "Mama's Song," Carrie Underwood won the fourth season of the American singing competition television series "American Idol" in 2005 ...

You are wrong!!!

Question:

Which contest did the singer of the song Mama's Song win?

Ground Truth: American Idol

Passage 1: The Eurovision Song Contest 2001 was ...
Passage 2: The Eurovision Song Contest 1996 was ...
Passage 3: The Junior Eurovision Song Contest 2010 was ...



The singer of the song "Mama's Song" **did not win** any specific contest related to the song. The song was released as a single by country music artist Carrie Underwood and was well-received by fans and critics alike.



1. LLM

The singer of the song \"Mama's Song\" won the Junior Eurovision Song Contest in 2010. This is evident from the passage: \"The contest was won by Vladimir Arzumanyan from Armenia



2. RAG

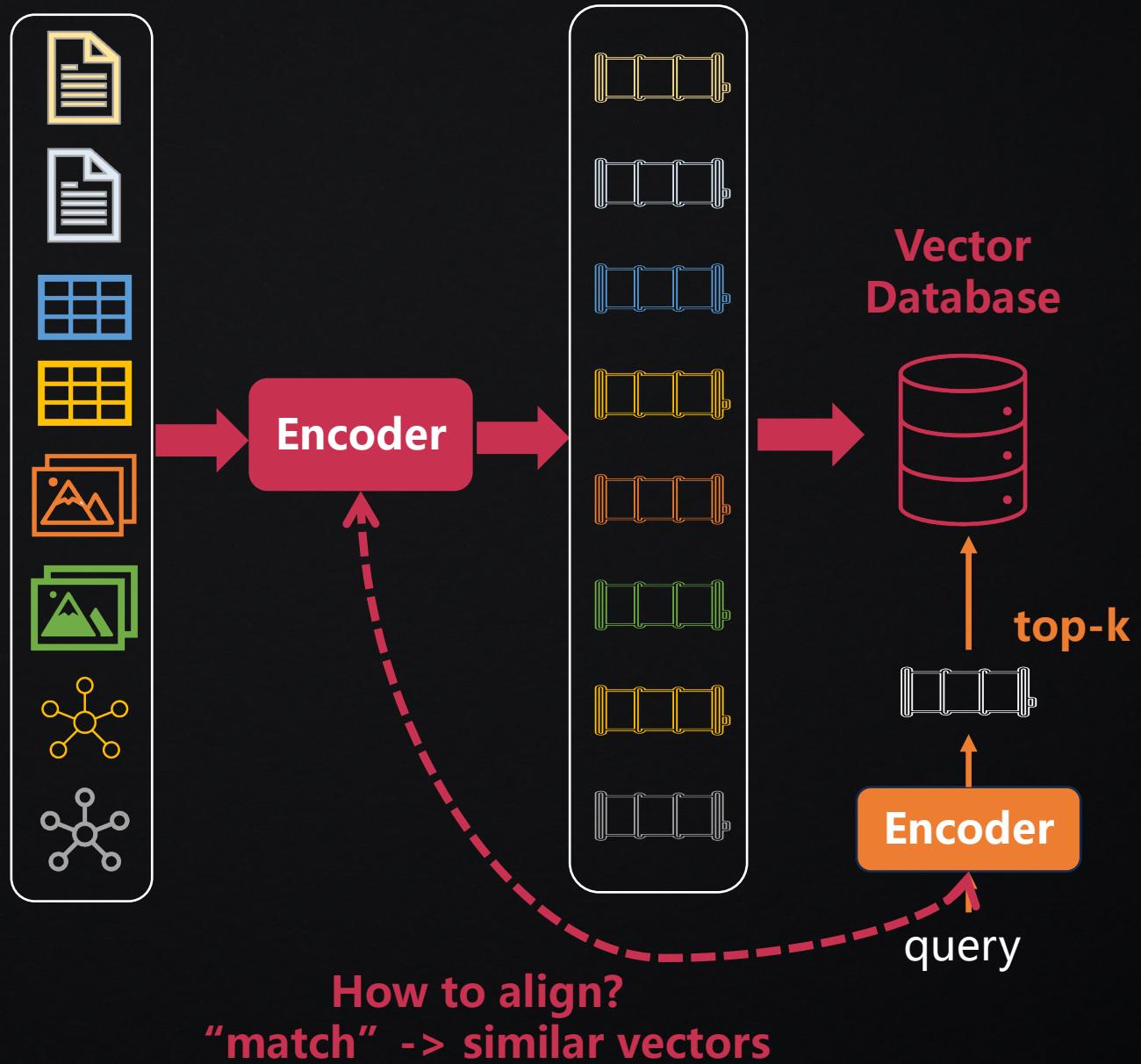
3. VerifAI

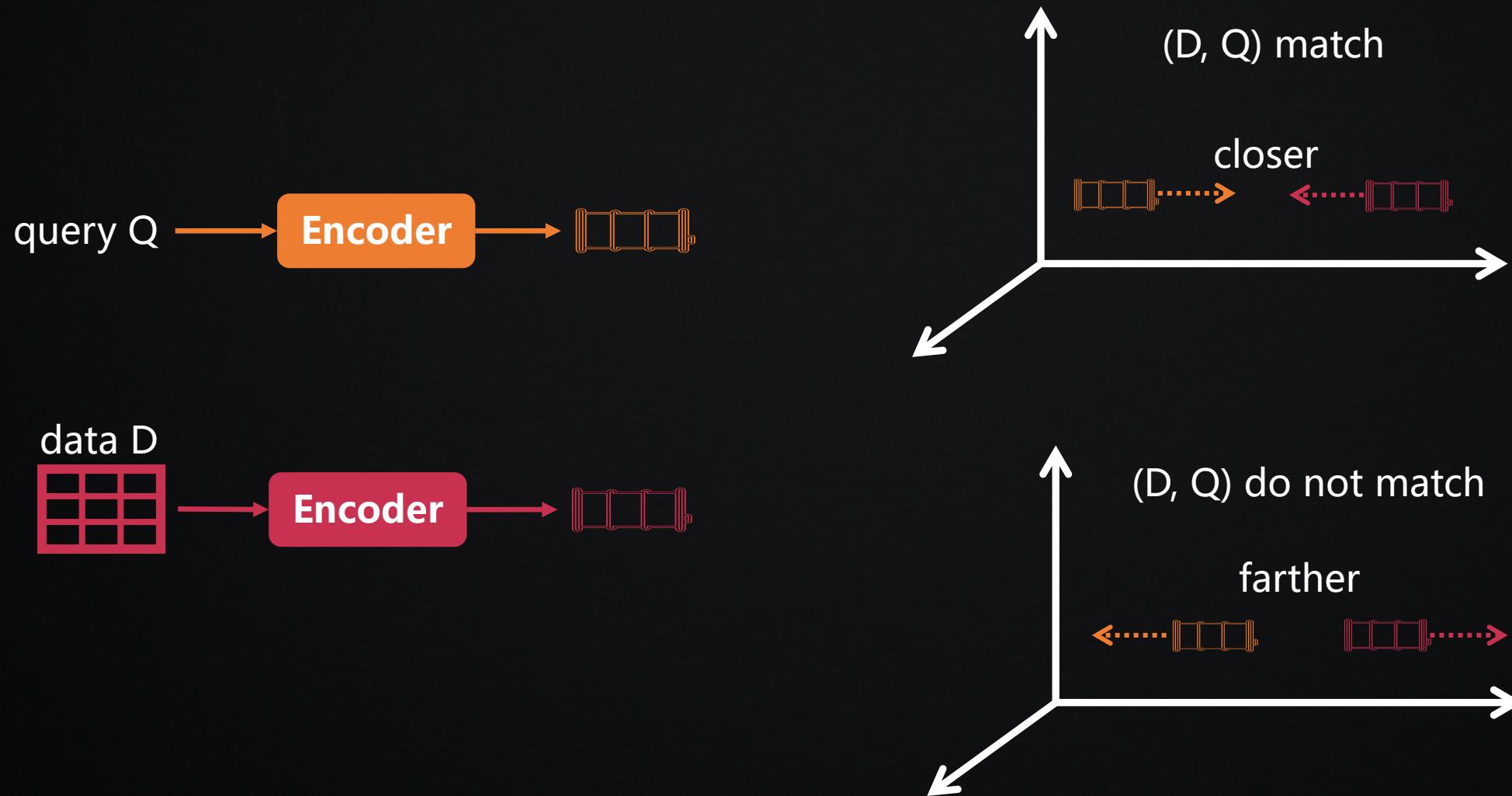
American Idol



Retrieval

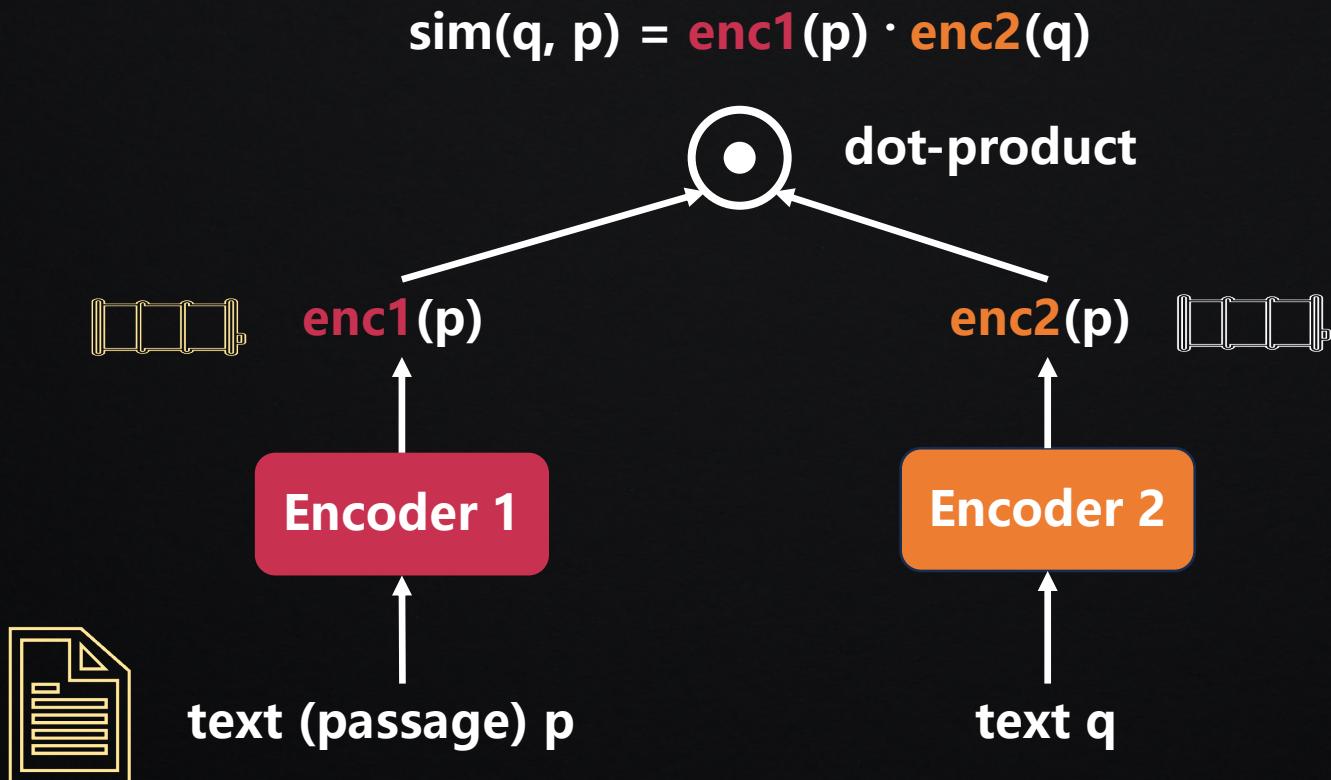
- Given a query, find
 - textual files
 - table (tuples)
 - (sub)graphs
 - images
 - HTML files
 - or a combination thereof





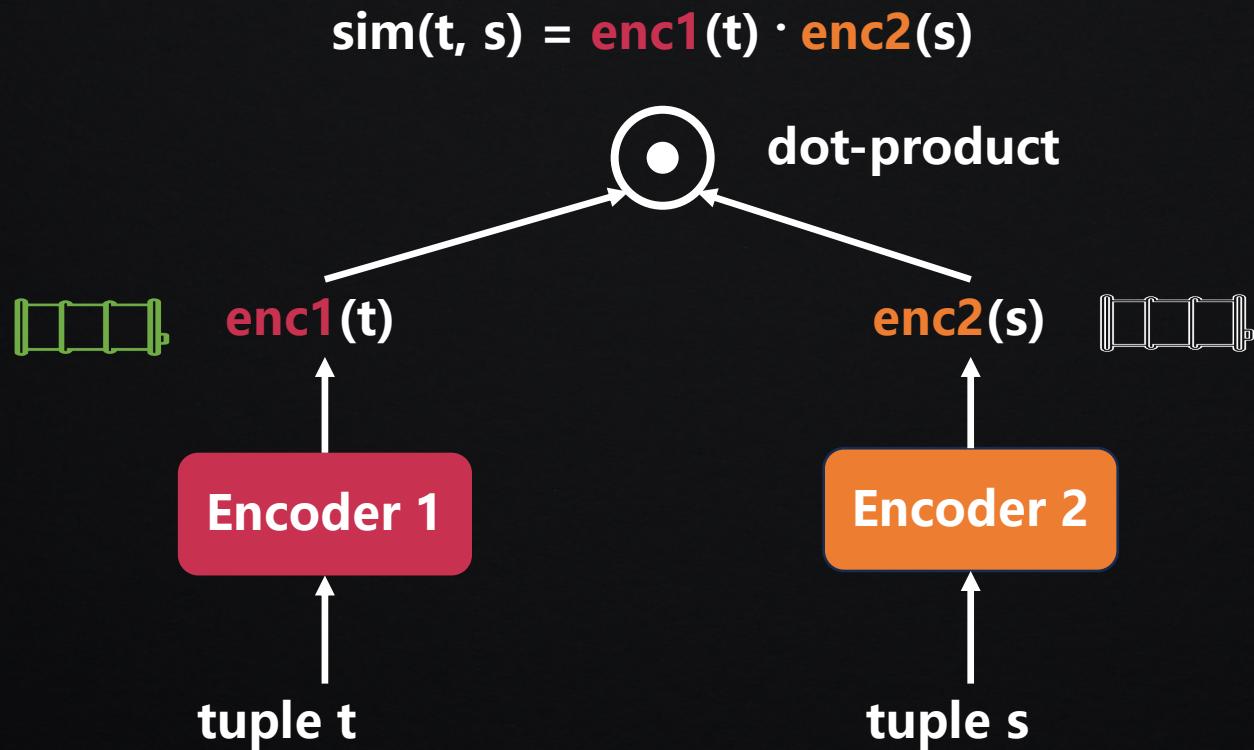
Retrieval

Dense Passage Retriever (DPR) for Text-Text



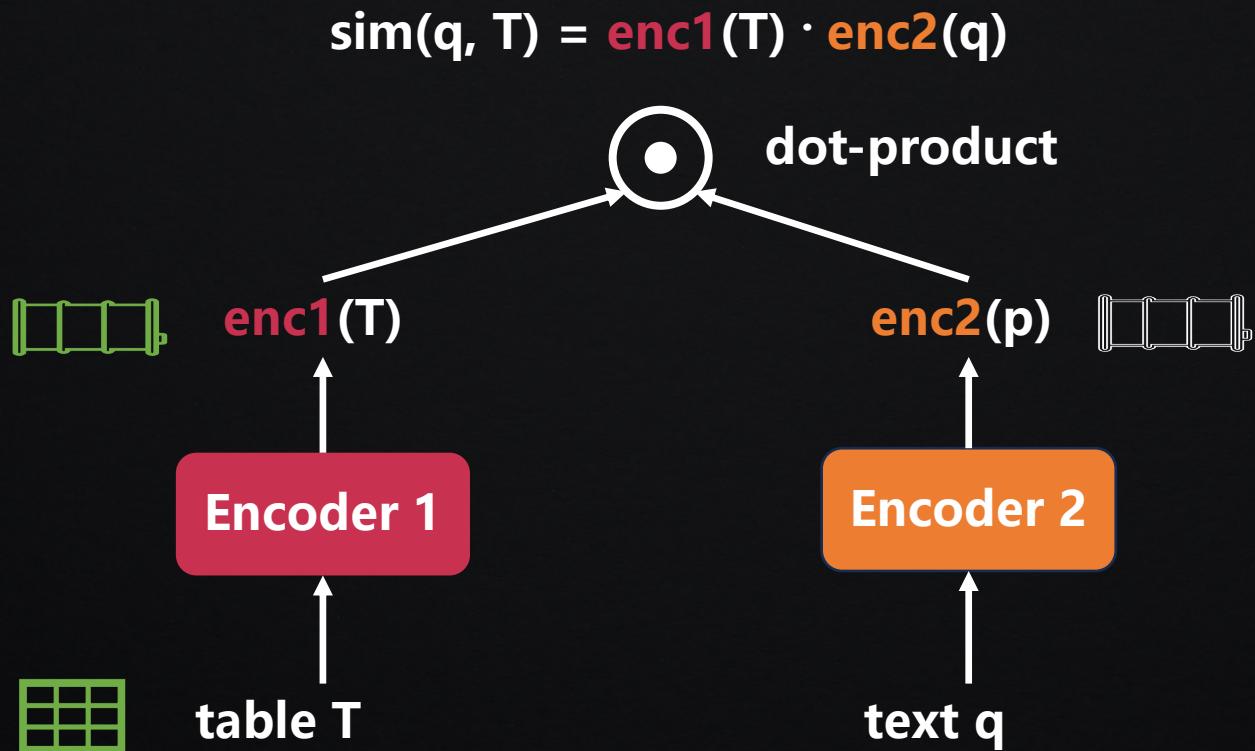
Retrieval

Dense Passage Retriever (DPR) for Tuple-Tuple



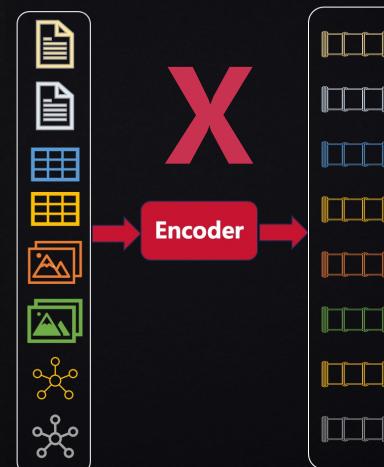
Retrieval

Dense Passage Retriever (DPR) for Text-Table



Retrieval over multi-modal data lakes

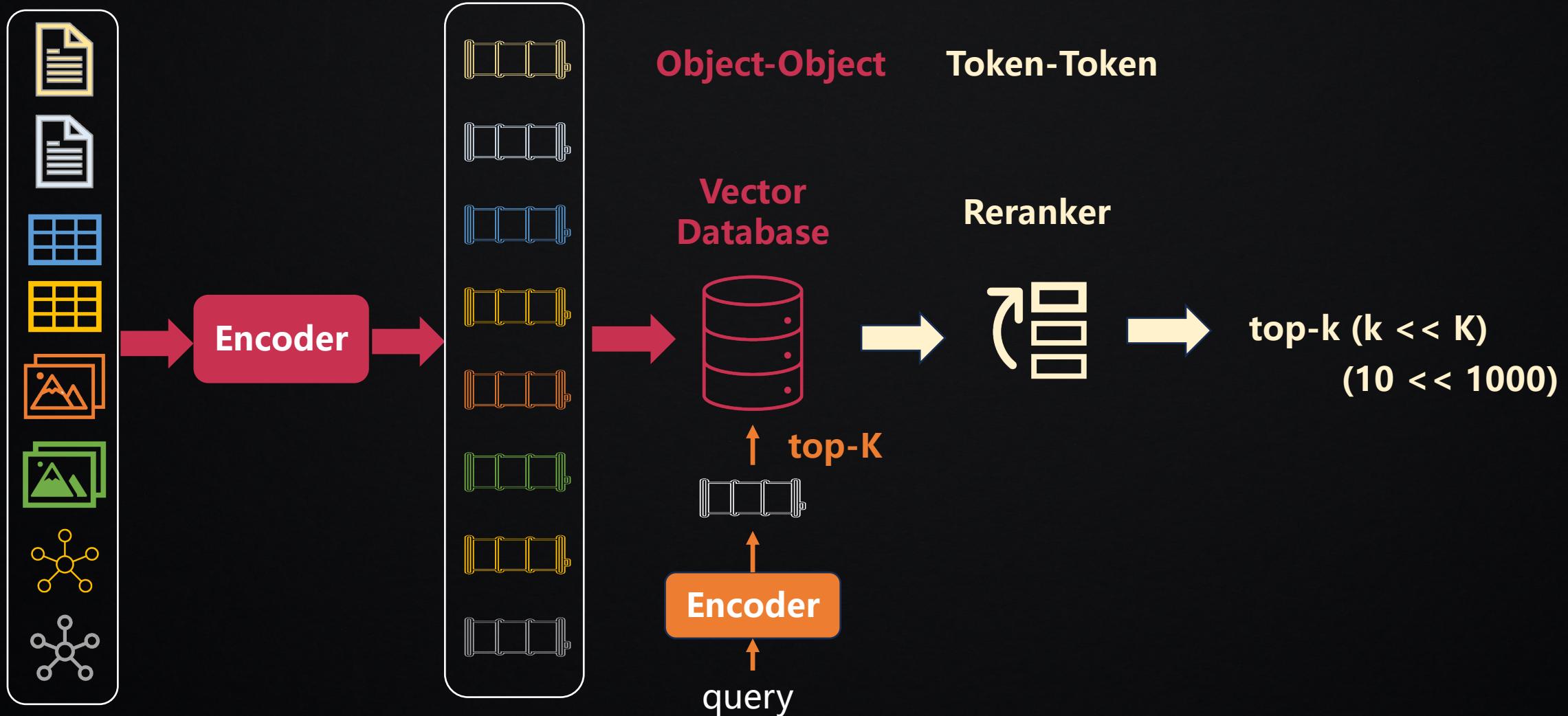
- We know (a little bit about) how to
 - align two encoders of the same/different data modalities
 - the main effort is to find positive/negative pairs
- We do not know how to
 - align multiple encoders
 - encode/index large tables
 - encode/index large graphs



Outline

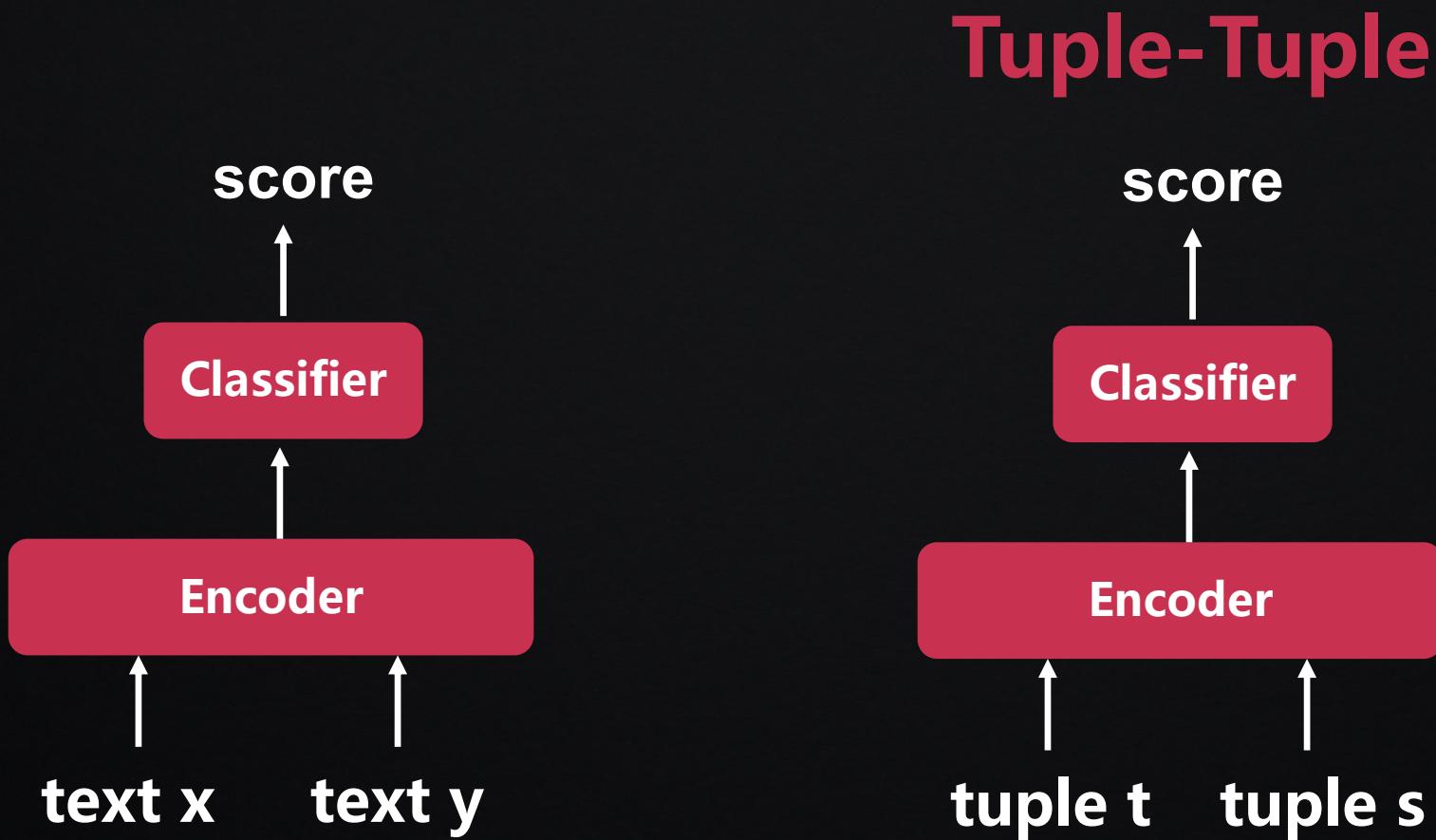
- **What:** Verify the outputs of LLMs (True/False)
- **How:** **Retrieval** **Rerank**
- **Results**
- **Opportunities**

Retrieval (Coarse-grained) -> Rerank (Fine-grained)



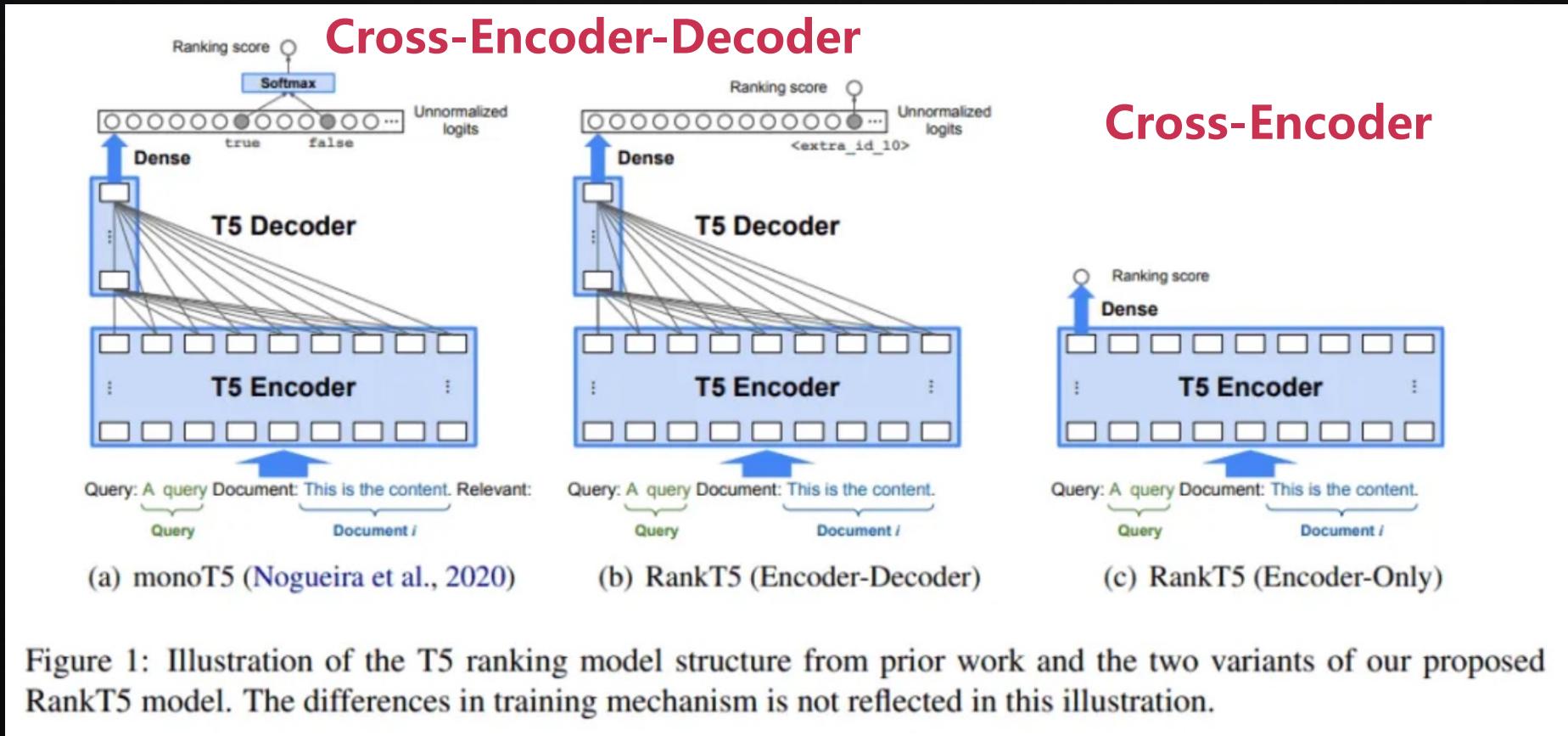
Rerank

Text-Text: Cross-Encoder (monoBERT)



Rerank

Text-Table: Cross-Encoder-Decoder (monoT5)



Note: Figure from the Google paper "RankT5: Fine-Tuning T5 for Text Ranking with Ranking Losses"

Outline

- **What:** Verify the outputs of LLMs (True/False)
- **How:** **Retrieval** **Rerank** **Verifier**



Outline

- **What: Verify the outputs of LLMs (True/False)**
- **How: retrieval, rerank, verifier**
- **Results**
- **Opportunities**

Verify Tuple(s) via retrieving Tuple and Text

 **Generated Tuple:** members of the 20th dáil

constituency	name	party
Clare	Brendan Daly	Fianna Fáil (generated value)

Retrieved Evidence and Verification

E1: Brendan Daly (2 February 1940 – 6 July 2023) was an Irish Fianna Fáil politician. He was a long-serving Teachta Dála(TD) for the Clare constituency, a government minister, and Senator.

Verification result: True. **Explanation:** The attribute 'party' value for Brendan Daly is Fianna Fáil, which matches with the claim.

Retrieved Evidence and Verification

E2: members of the 20th dáil

constituency	name	party
Tipperary South	Brendan Griffin	Fine Gael

Verification result: Not Related. **Explanation:** The evidence talks about the members of the 20th Dáil and the TDs elected by constituencies Tipperary South and Clare. It mentions Brendan Griffin as a member of the 20th Dáil from Tipperary South constituency, but it does not provide any information about Brendan Daly's party affiliation.

Verify Tuple(s) via retrieving Tuple and Text

Generative AI task: **tuple completion**

100 tuples with missing values

ChatGPT's accuracy in completion: **0.52**

Data lake: **13,796** textual files and 19,498 tables containing **269,622** tuples

Retrieval	Recall@3		Verifier	Accuracy
Tuple	0.99	both	ChatGPT	0.88
Text	0.58			

Verify Text using via retrieving Tables



Claim: In 1954 u.s. open (golf), the cash prize for tommy bolt, fred haas, and ben hogan was 960 in total.
(Ground Truth: a false claim that should be **Refuted**)

Retrieved Evidence and Verification

Table E1: 1954 u.s. open (golf)

I place	I player	I country	I score	I to par	I money	I
t1	led furgol	united states	71 + 70 + 71 + 72 = 284	+ 4	6000	I
t2	gene littler	united states	70 + 69 + 76 + 70 = 285	+ 5	3600	I
t3	lloyd mangrum	united states	72 + 71 + 72 + 71 = 286	+ 6	1500	I
t3	dick mayer	united states	72 + 71 + 70 + 73 = 286	+ 6	1500	I
t5	bobby locke	south africa	74 + 70 + 74 + 70 = 288	+ 8	960	I
t6	tommy bolt	united states	72 + 72 + 73 + 72 = 289	+ 9	570	I
t6	fred haas	united states	73 + 73 + 71 ÷ 72 = 289	+ 9	570	I
t6	ben hogan	united states	71 + 70 + 76 + 72 = 289	+ 9	570	I
t6	shelley mayfield	united states	73 + 75 + 72 + 69 = 289	+ 9	570	I
t6	billy joe patton (a)	united states	69 + 76 + 71 + 73 = 289	+ 9	10	I

Verification result: **Refuted.** **Explanation:** The cash prize for Tommy Bolt, Fred Haas, and Ben Hogan was \$570 each, totaling \$1710.

Table E2: 1959 u.s. open (golf)

I player	I country	I year (s)	I won	I total	I to par	I finish	I
ben hogan	united states	1948, 1950, 1951 , 1953	287	+ 7	t8		
cary middlecoff	united states	1949, 1956	294	+ 14	t19		
black fleck	united states	1955	294	+ 14	t19		
julius boros	united states	1952	297	+ 17	t28		
tommy bolt	united states	1958	301	+ 21	t38	V2:	

Verification result: **Not related.**

Verify Text using via retrieving Tables

A controlled study: **1,300** textual claims from TabFact benchmark

Retrieved from **19K Wikipedia Tables**

Verifier	Reference	Accuracy
ChatGPT		0.54
ChatGPT	Tables	0.91

Retrieval	Recall@5
Table	0.88

 →

Outline

- **What: Verify the outputs of LLMs (True/False)**
- **How: retrieval, rerank, verifier**
- **Results**
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Opportunities (DB)

1. Table learning using LLMs
2. Table reasoning using LLMs
3. Table retrieval (small tables, large tables, database tables)
4. Cross-modal data discovery (aligning multiple encoders)
5. Cross-modal matching
6. Cross-modal reranking
7. Cross-modal reasoning

Q & A

