Machine Learning System Design

Module 3: Building a Hotel Search Engine

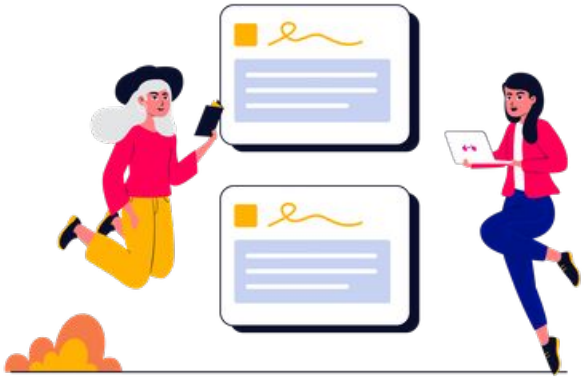
Hamza Farooq

Learning Outcomes

We will be covering topics on:

- Why is search so important?
- Understand the building blocks of search, again
- Sentence Transformers
- BM25, Bi-encoder, Cross-Encoders
- Cosine Similarity, again!
- Fitting all of this into a ML System
- Coding, lots of it, with API

A good search experience is key to a successful user journey



An estimated 50% of queries contain four or more words - search is no more just keyword based

Research shows that 68% of them are likely to never return to your site again.

62% of consumers will switch to a different brand or decide not to purchase from your brand at all after a bad customer experience — and poor site search is a bad customer experience.

Project Athena: Adding Semantic search to Hotel search

We want to build a hotel search using:

- Date check-in/check-out
- City
- Long text to get more granular choices such as:

```
Looking for a hotel in New York near Times Square with free breakfast and cheaper than $100 for 2nd June which is really kids friendly and has a swimming pool and I want to stay there for 8 days..
```

Sentence transformers

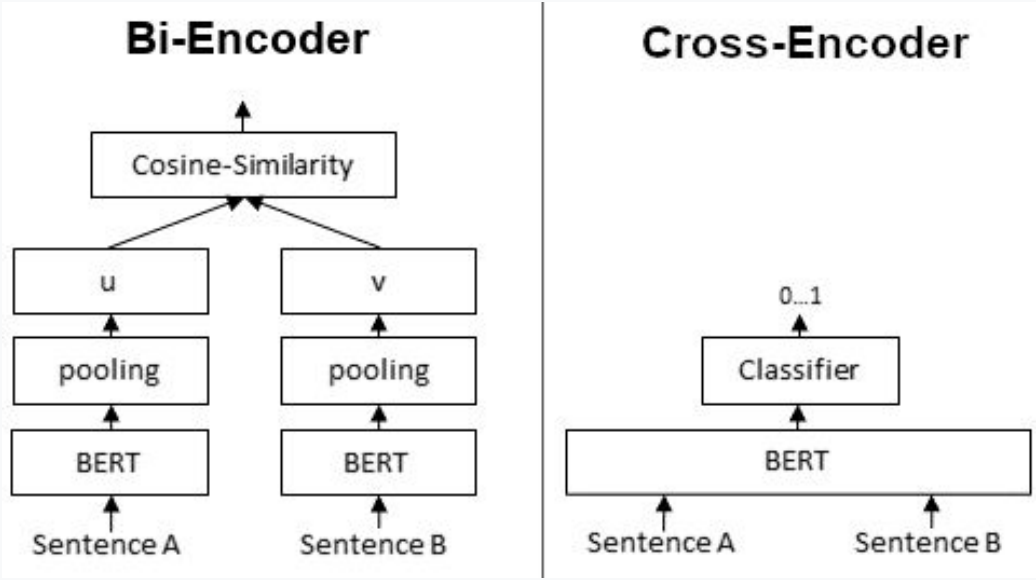
- Sentence transformers are models that encode the meaning of sentences using deep learning techniques.
- They transform sentences into fixed-length numerical representations called embeddings.
- Sentence embeddings capture semantic information and enable comparison and similarity calculations between sentences.
- A popular example is mpnet

Neural-IR Models

Numerous architectures are available for ranking: representation-focused, interaction-focused, all-to-all interaction(cross encoder), and late interaction.

$$\sum_{i}^{n} IDF(q_i) \frac{f(q_i, D) * (k1 + 1)}{f(q_i, D) + k1 * (1 - b + b * \frac{fieldLen}{avgFieldLen})}$$

BM25



Source: https://www.sbert.net/examples/applications/cross-encoder/README.html

BM25

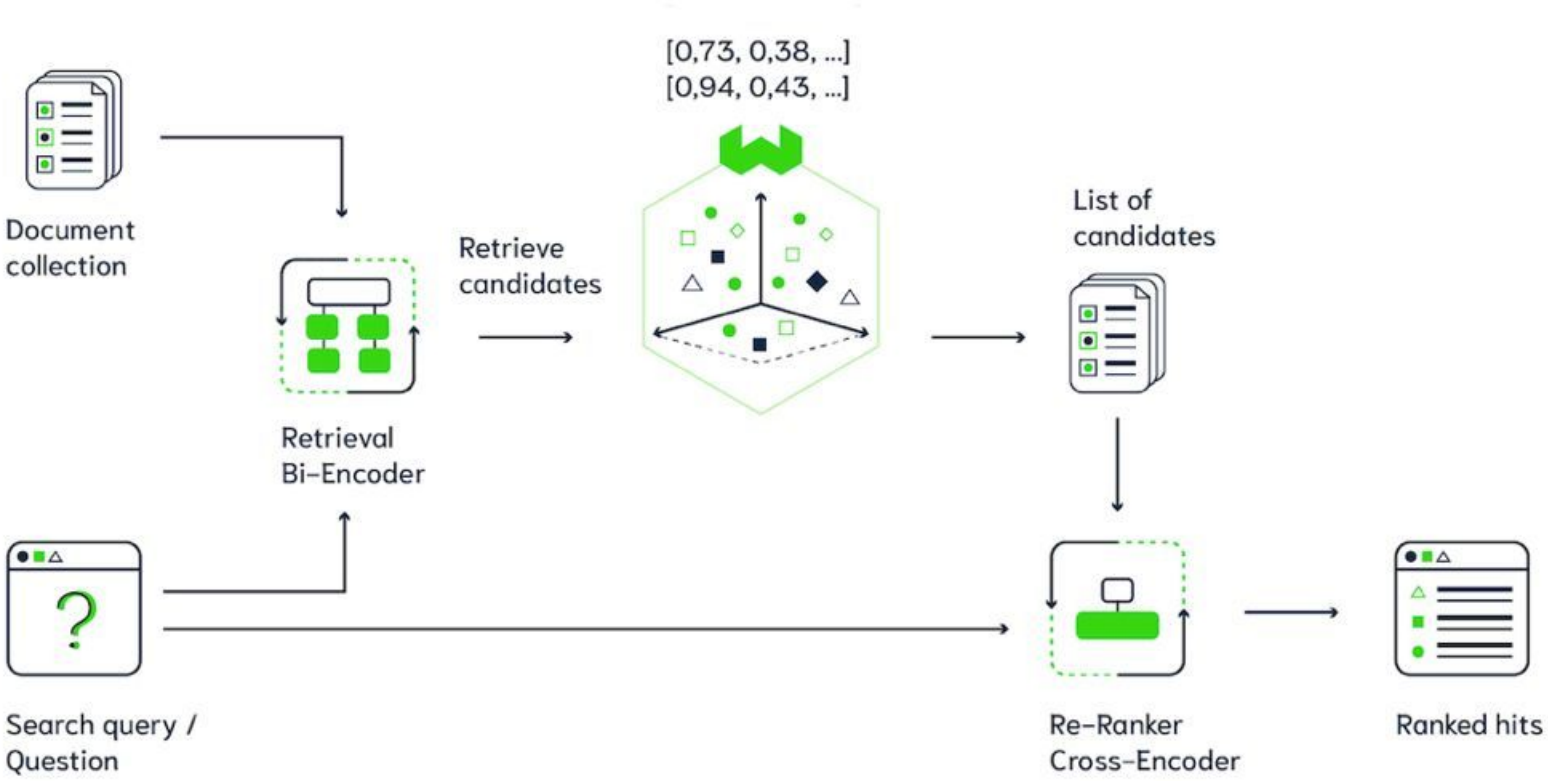
- BM25 stands for "Best Match 25" and is an information retrieval algorithm used to rank documents based on their relevance to a given query.
- It calculates a relevance score by considering the term frequency and document length in a collection of documents.

Bi-Encoder

- A bi-encoder is a type of neural network architecture used in natural language processing (NLP) tasks.
- It consists of two encoders: one for encoding the input query and another for encoding the input document.
- Each encoder independently encodes the input into a fixed-length representation, often called an embedding.

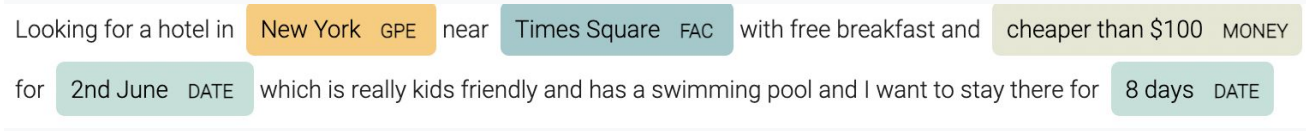
Cross-Encoder

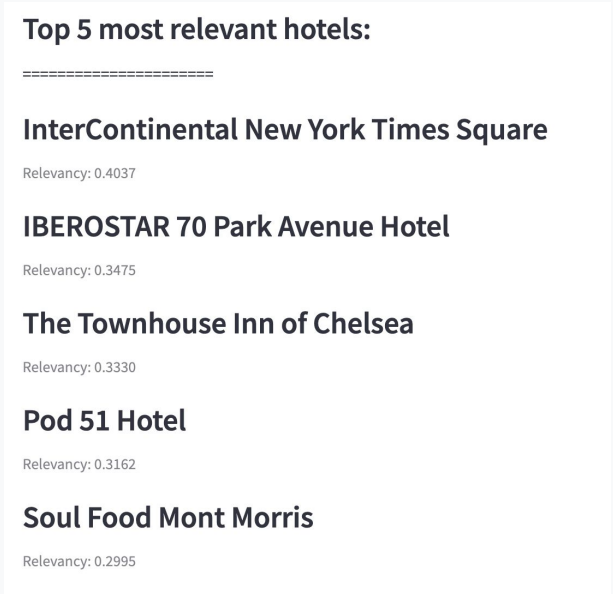
- A cross-encoder is another type of neural network architecture used in NLP tasks.
- It takes both the input query and document as a single input and encodes them into a fixed-length representation.
- Unlike the bi-encoder, the cross-encoder considers the interaction between the query and document when generating the representation.


[0,73, 0,38, ...]
[0,94, 0,43, ...]
Document collection
Retrieve candidates
List of candidates
Retrieval Bi-Encoder
Search query / Question
Re-Ranker Cross-Encoder
Ranked hits

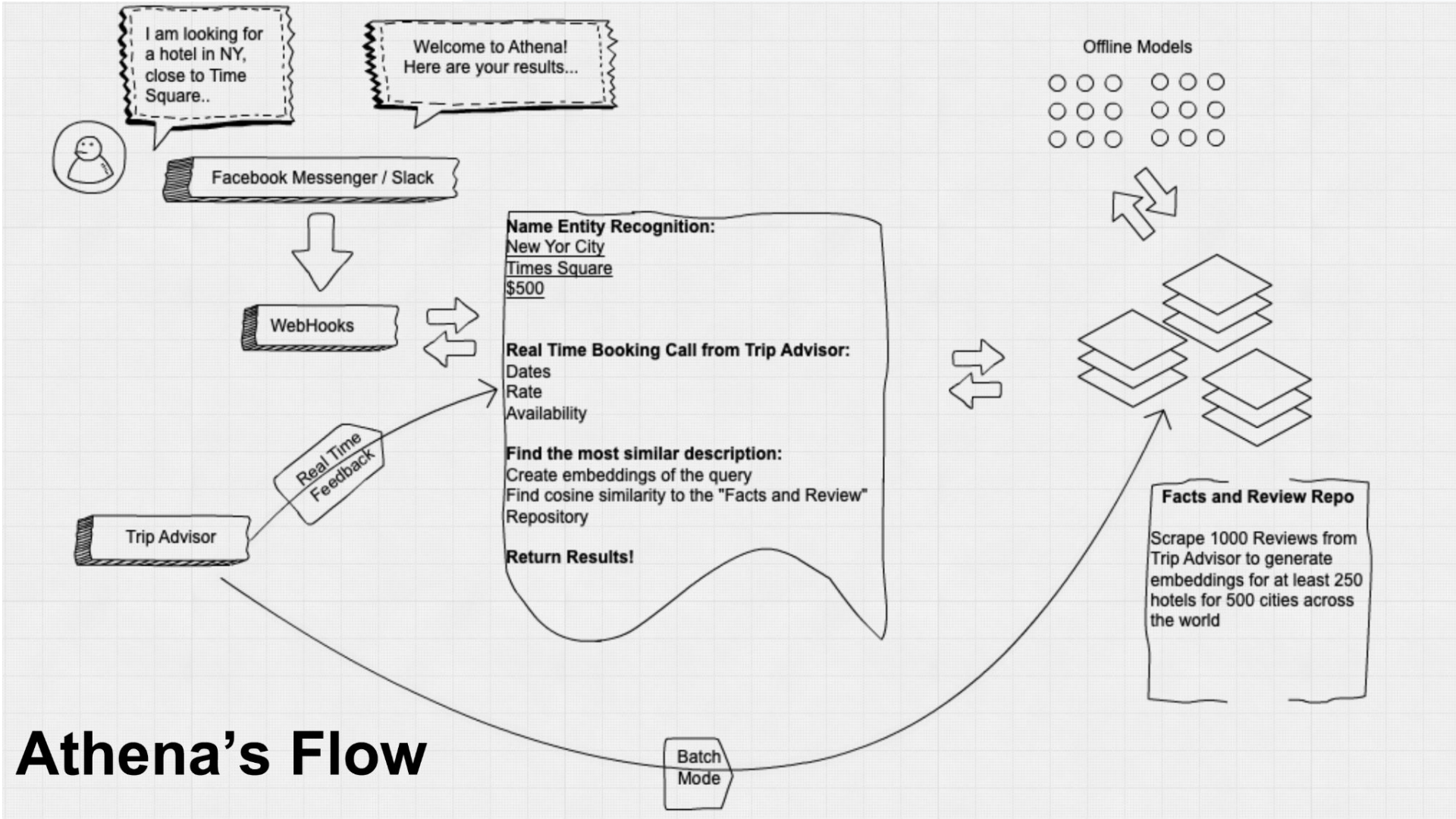
The result...

```
Looking for a hotel in New York near Times Square with
free breakfast and cheaper than $100 for 2nd June which
is really kids friendly and has a swimming pool and I
want to stay there for 8 days..
```

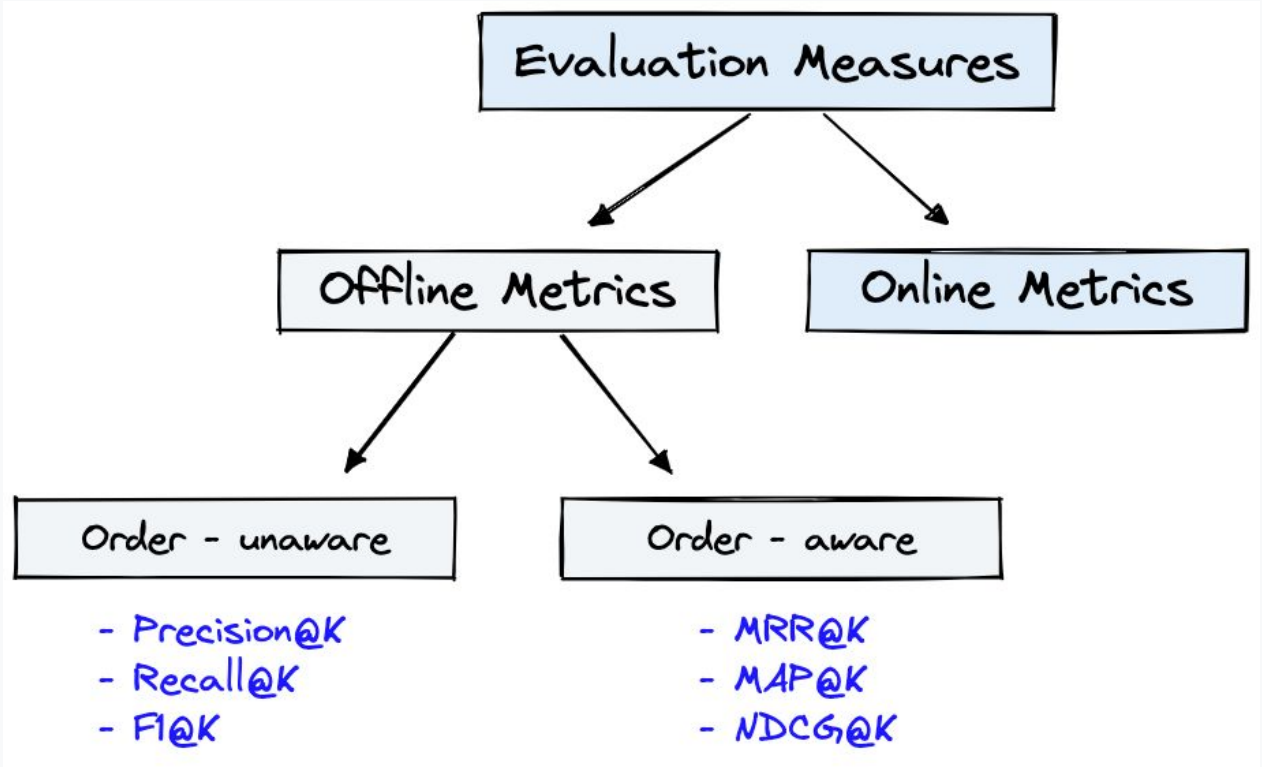




https://hamzafarooq-hotelfinder-paris-newer-ntdhf9.streamlitapp.com/


I am looking for a hotel in NY, close to Time Square..
Welcome to Athena! Here are your results...
Offline Models
Facebook Messenger / Slack
WebHooks
Name Entity Recognition:
New Yor City
Times Square
$500
Real Time Booking Call from Trip Advisor:
Dates
Rate
Availability
Find the most similar description:
Create embeddings of the query
Find cosine similarity to the "Facts and Review" Repository
Return Results!
Real Time Feedback
Trip Advisor
Facts and Review Repo
Scrape 1000 Reviews from Trip Advisor to generate embeddings for at least 250 hotels for 500 cities across the world
Batch Mode
Athena's Flow

Evaluation Criteria

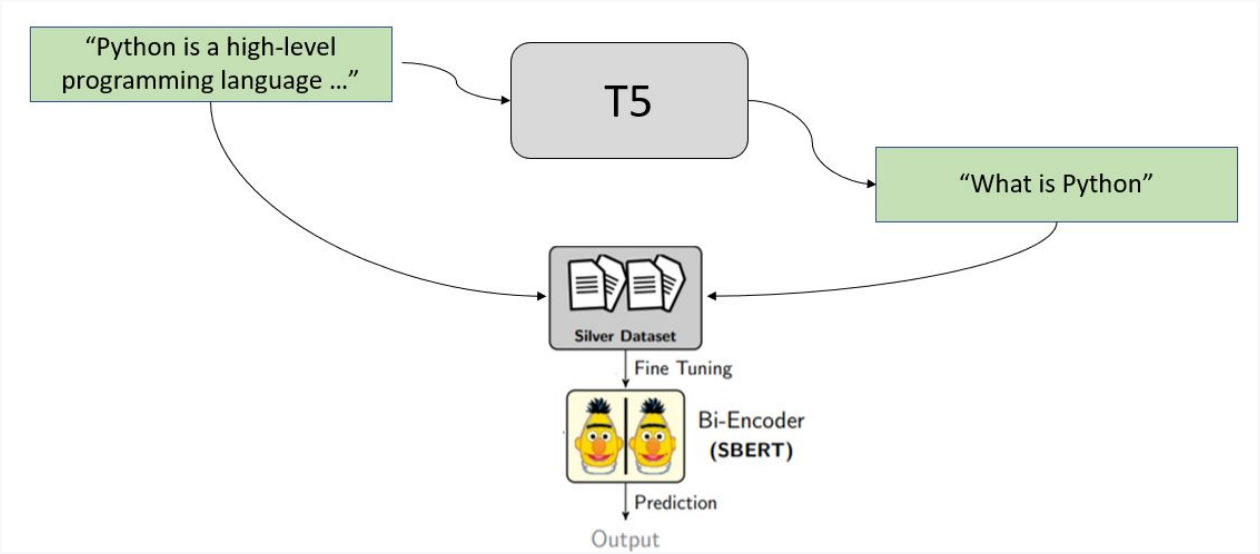


Source:

https://www.pinecone.io/learn/offline-evaluation/

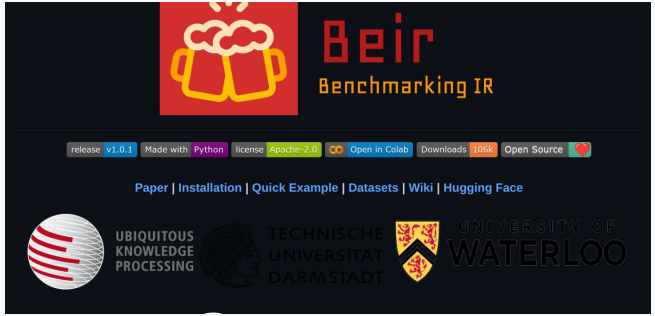
What happens when we don't have ground truth?

Creating ground-truth from scratch

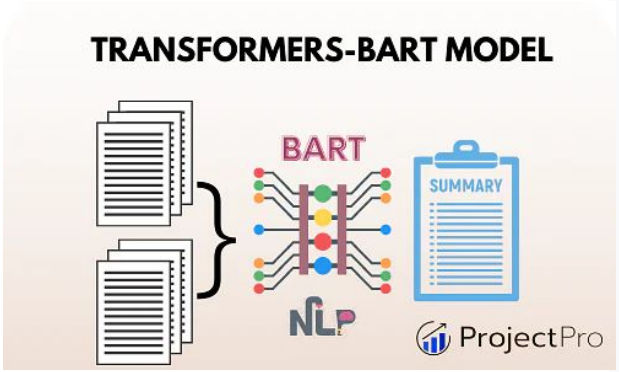


BEIR: A Heterogenous Benchmark for Zero-shot Evaluation of Information Retrieval Models

Nandan Thakur, Nils Reimers, Andreas Rücklé, Abhishek Srivastava, Iryna Gurevych



Summarization



Demo

- BART is a sequence-to-sequence model trained as a denoising autoencoder.
- A fine-tuned BART model can take a text sequence (for example, English) as input and produce a different text sequence at the output (for example, French).
- This type of model is relevant for machine translation question-answering, text summarization or sequence classification
- Also, given two or more sentences, evaluates whether the sentences are logical extensions or are logically related to a given statement.

Aspect-based Sentiment Analysis

Utilize transformers and other ML models to generate sentiment for various aspects of an entity

@misc{YangL2022,
  title = {PyABSA: Open Framework for Aspect-based Sentiment Analysis},
  author = {Yang, Heng and Li, Ke},
  doi = {10.48550/ARXIV.2208.01368},
  url = {https://arxiv.org/abs/2208.01368},
  keywords = {Computation and Language (cs.CL), FOS: Computer and information sciences, FOS: Computer and information sciences},
  publisher = {arXiv},
  year = {2022},
  copyright = {arXiv.org perpetual, non-exclusive license}
}

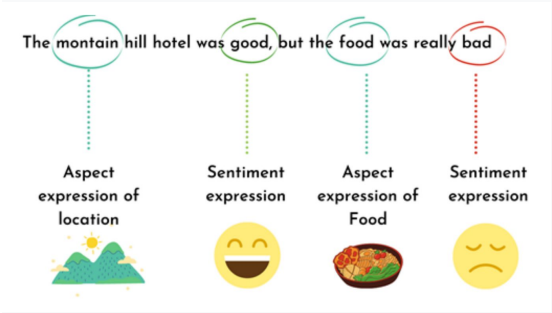
Consider these reviews:

Friendly and accommodating staff helpful with transportation, restaurants and directions. Great location for all activities. Easy walk to Louvre. Breakfasts exceeded expectations. Mattress was too soft to my liking.

The reception was friendly and professional and speedy. The room was ready and perfect. The bed was very comfortable and the air conditioning was silent and potent. The free afternoon tea was amazing and open until 2am. The breakfast was one of the very best you could find in Paris

The room was awesome

Stayed here for two nights after a work trip in the city. I made an error in my booking and the hotel were very gracious and sorted it out for me. Kindly offered breakfast on the morning of my arrival. Very good selection for breakfast. Excellent location and fab staff would recommend




```
{'staff': ['Positive', 'Positive'],
 'location': ['Positive', 'Positive'],
 'Breakfasts': ['Positive'],
 'Mattress': ['Negative'],
 'reception': ['Positive'],
 'room': ['Positive', 'Positive'],
 'bed': ['Positive'],
 'air conditioning': ['Positive'],
 'afternoon tea': ['Positive'],
 'breakfast': ['Positive', 'Positive']}
```

Keyword creation using Transformers

KeyPhraseTransformer is built on T5 Transformer architecture, trained on 500,000 training samples to extract important phrases/topics/themes from text of any length.

Source: https://github.com/Shivanandroy/KeyPhraseTransformer

- *hotel staff were very helpful and friendly.*
- *i was very happy with the room and bathroom.*
- *i was very happy with my stay at the hotel.*
- *i would highly recommend this hotel to anyone who is looking for a place to stay.*
- *hotel staff is very friendly and helpful.*
- *i was so happy to stay at this hotel... it was amazing!*
- *louvre and many other locations*
- *hotel staff were very friendly and helpful.*
- *breakfast and afternoon snacks*
- *i know where i will be staying on our next trip to paris*

Query Intent Models

Queries need special handling and interpretation due to their tendency to be short and to often imply more than they state explicitly

Supreme Reflective Speckled Down Jacket

Water resistant reflective poly with printed graphic, down filled quilted baffles and taffeta lining….

attribute augmentation

id:
product_type:
brand:
price:
audience:
review_score:
color:
material:
durability:
design pattern:
fit:
water repellent:
…

price:
audience:
review_score:
color:
material:
durability:
design pattern:
…

durability:
design pattern:
…

The attribute augmentation layer auto generates a new layer of attributes from product picture, title & description and reviews

embeddings

water resistant orange down jacket supreme..|

query intent

Product Type: Jacket
Color: Orange
Brand: Supreme
Water Repellent: Yes

Use knn model to reduce the sample space

similarity measure

Use a combination of BM25 with Bi-Encoder and Cross-Encoders

embeddings

Homework

- Implement similar hotel search engine for Miami hotels - feel free to apply any of the methods mentioned for retrieval and additional methods to improve your modeling
- Submission is a colab notebook

Thank you.

Appendix