Understanding Vector Databases

PyLadies Meetup NYC

elastic

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This talk is aimed for developers who may have some experience with machine learning but looking to skill up.

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This talk will explore the traditional "Classic" search, highlight its constraints, and provide an overview of vector databases.

Elasticsearch:
You Know, for Search

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elasticsearch

What's the well-known sentence of this scene in Star Wars?

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These are not the droids
you are looking for.

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```
GET /_analyze
{
  "char_filter": [ "html_strip" ],
  "tokenizer": "standard",
  "filter": [ "lowercase", "stop", "snowball" ],
  "text": "These are <em>not</em> the droids
           you are looking for."
}
```

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```
"char_filter": "html_strip"
```

```
These are <em>not</em> the droids you are
   looking for.
```

```
These are not the droids you are
   looking for.
```

elastic

```
"tokenizer": "standard"
```

These are not the droids you are looking for.

```
These
are
not
the
droids
you
are
looking
for
```

```
"filter": "lowercase"
```

These		these
are		are
not		not
the		the
droids		droids
you		you
are		are
looking		looking
for		for

elastic

```
"filter": "stop"
```

These		
are		
not		
the		
droids		droids
you		you
are		
looking		looking
for		

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```
"filter": "snowball"
```

droid**s**	droid
you	you
look**ing**	look

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```
These are <em>not</em> the droids you are looking for.


{ "tokens": [{
      "token": "droid",
      "start_offset": 27, "end_offset": 33,
      "type": "<ALPHANUM>", "position": 4
    },{
      "token": "you",
      "start_offset": 34, "end_offset": 37,
      "type": "<ALPHANUM>", "position": 5
    }, {
      "token": "look",
      "start_offset": 42, "end_offset": 49,
      "type": "<ALPHANUM>", "position": 7
    }]}
```

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PROS

- Fast and cheap
- Scalable
- Easy to understand

CONS

- Synonyms and homonyms
- Images, videos, audio
- User intent

Semantic Search:
Meaning, not literal matches

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X-wing starfighter squadron

What ships and crews do I need to destroy an almost finished death star?

Or is there a secret weakness?

Elasticsearch:
You Know, for Vector Search

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What do you need to get started with vector search?

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- Elasticsearch instance optimized for machine learning (8.13 or later)
- Python 3.8 (or later)
- Elasticsearch Python Client

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What is a vector database?

Why use vector search?

Vector search provides the foundation for implementing semantic search for text or similarity search for images, videos, or audio.

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A vector database allows you to find similar data quickly.

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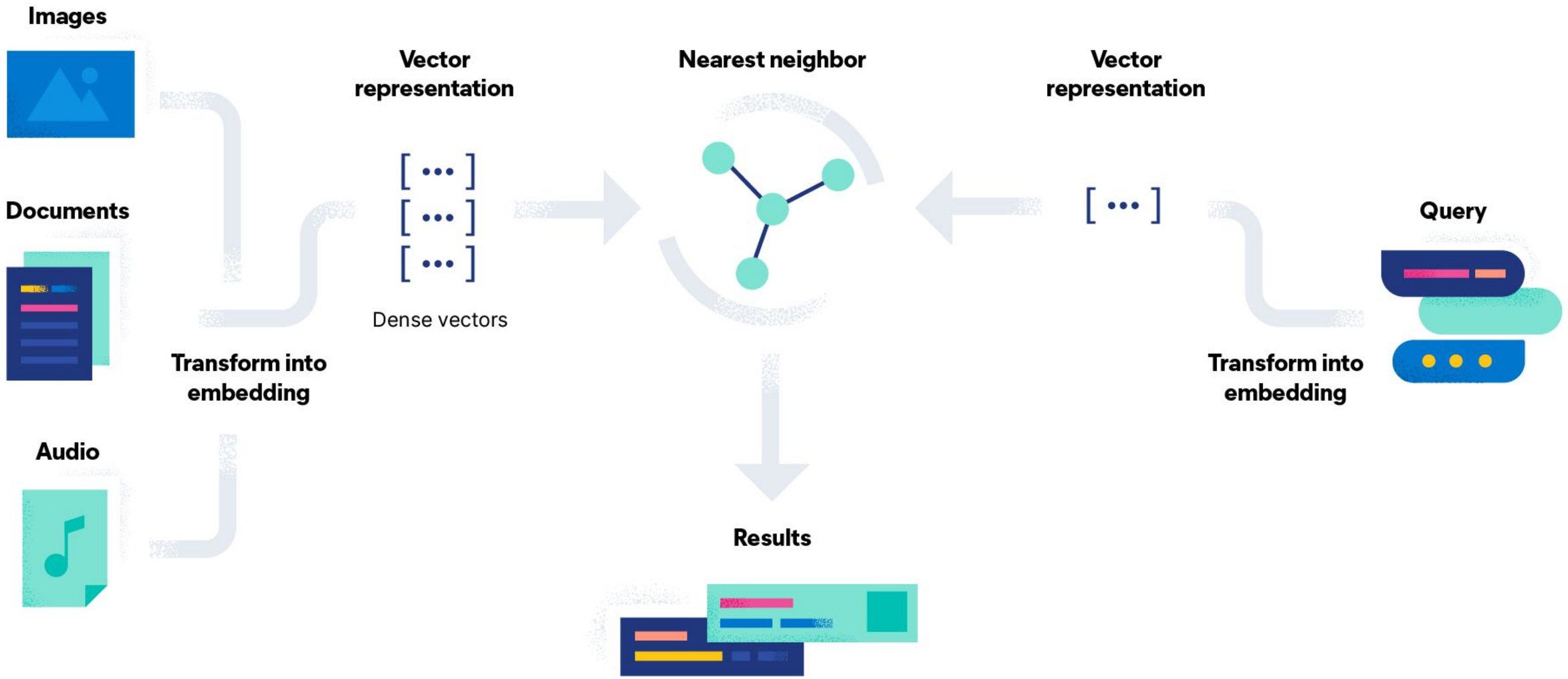
Searching in a vector database



What’s a vector?

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What are embeddings?

Embeddings leverage a machine learning model to translate text into numbers, allowing you to perform vector searches.

Embeddings represent your data

Example: 1-dimensional vector

Character	Vector
	[-1]
	[1]

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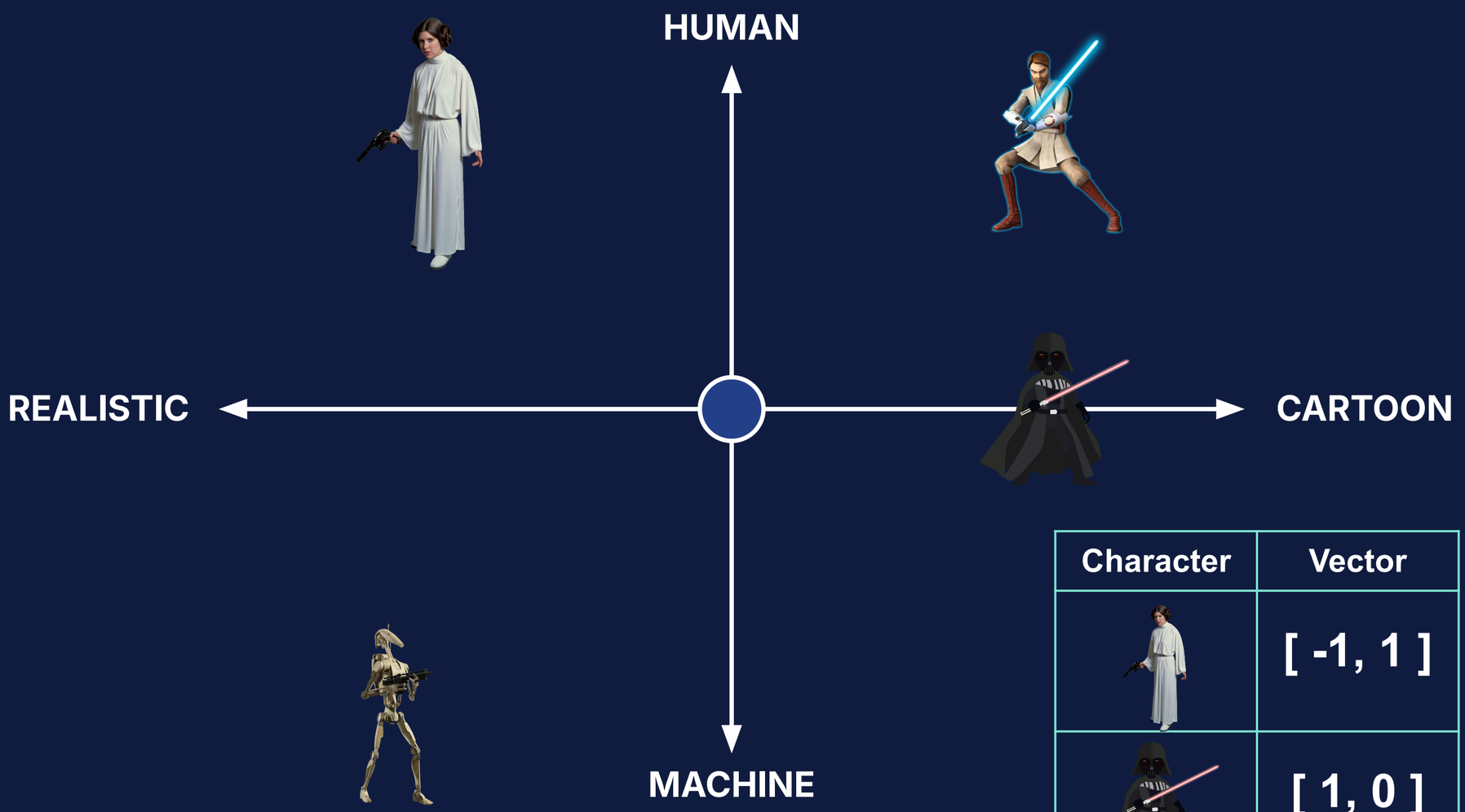
Multiple dimensions represent different data aspects



Character	Vector
	[-1, 1]
	[1, 0]

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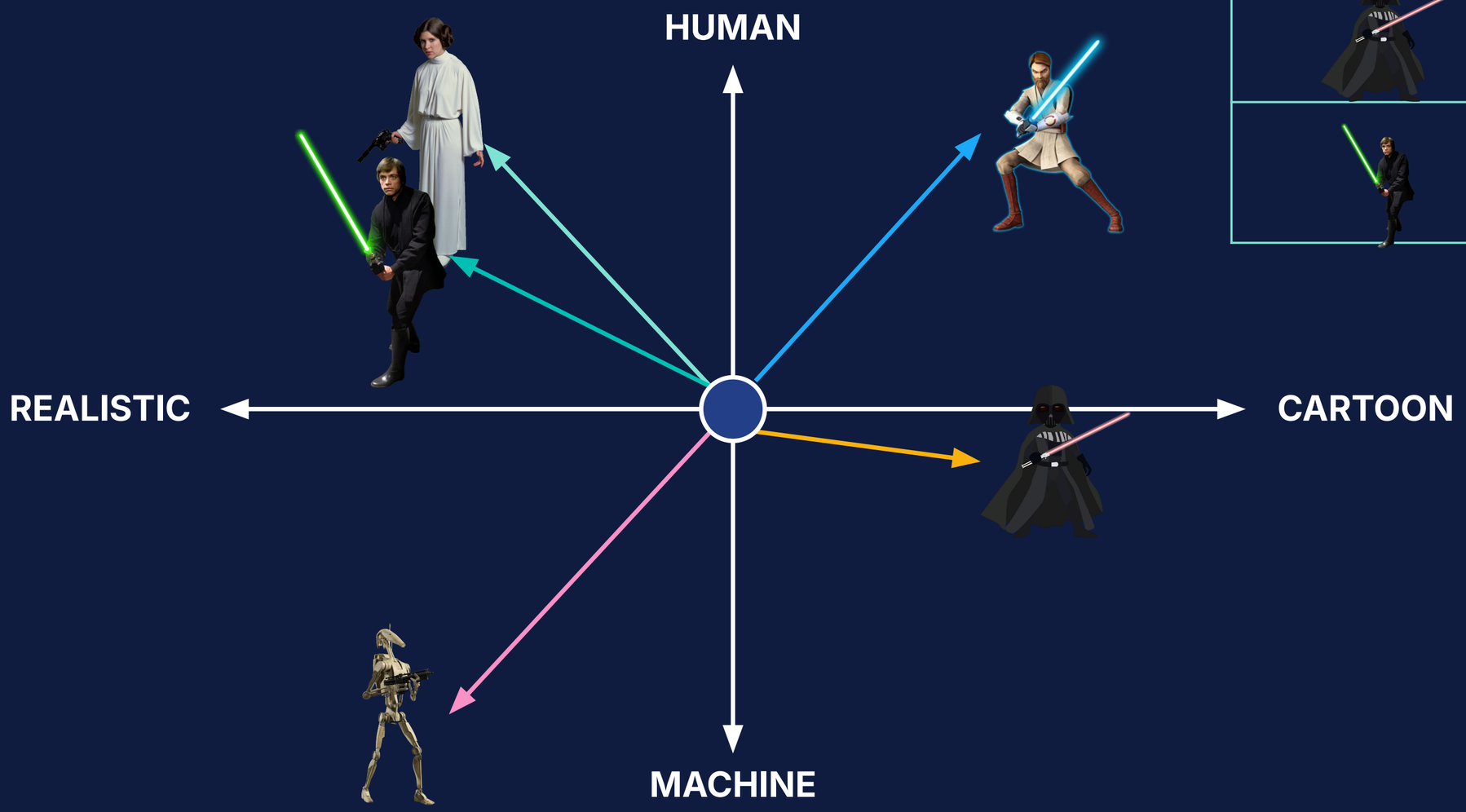
Similar data is grouped together



Character	Vector
	[-1.0, 1.0]
	[1.0, -0.1]
	[-1.0, 0.8]

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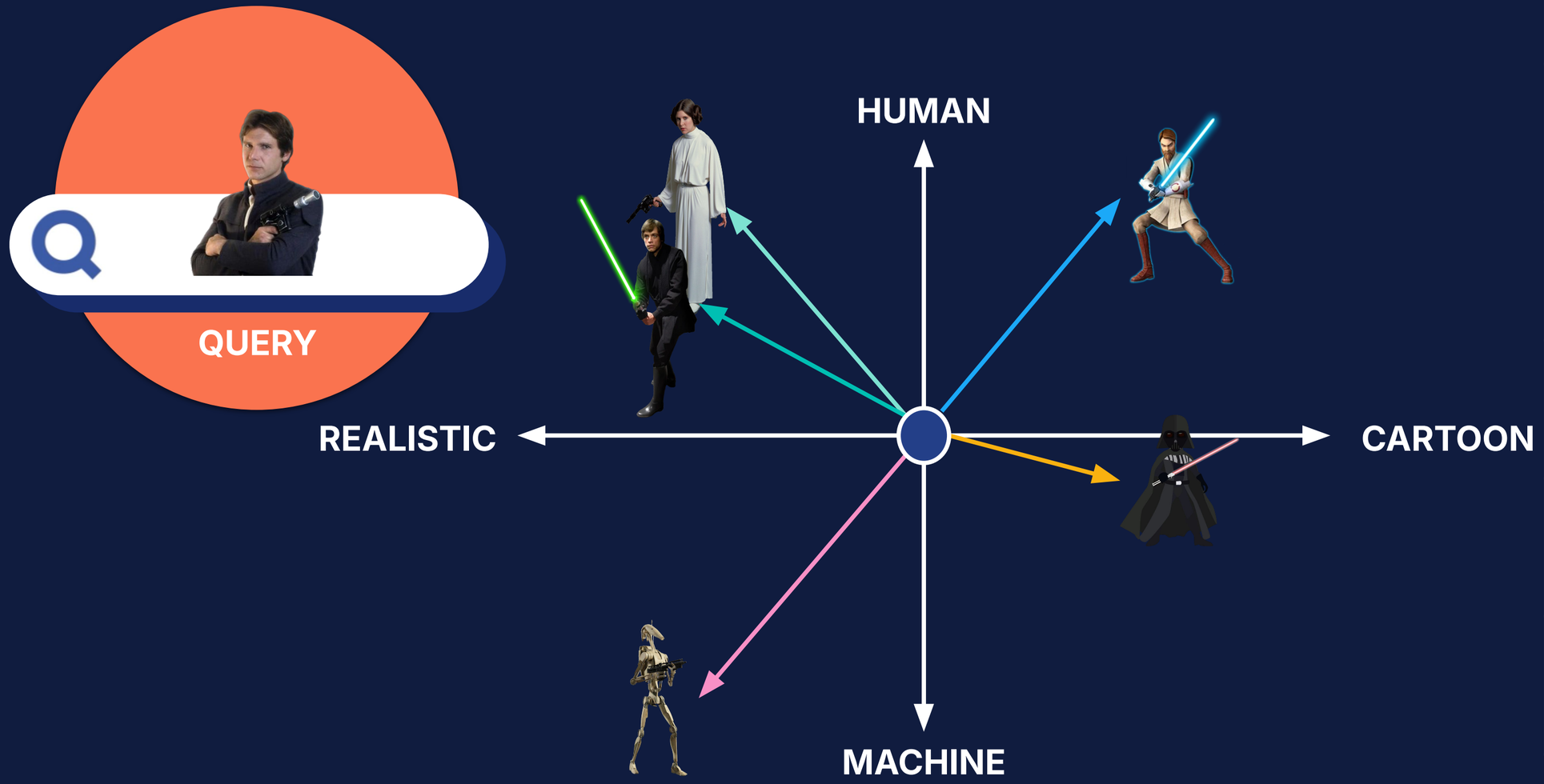
Vector search ranks objects by similarity (relevance) to the query



Relevance	Result
Query	
1	
2	
3	
4	
5	

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How to select a model?

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Choice of Embedding Model

Start with Off-the Shelf Models

- Text data: Hugging Face (like Microsoft’s E5)
- Images: OpenAI’s CLIP

Extend to Higher Relevance

- Apply hybrid scoring
- Bring Your Own Model: requires expertise + labeled data

What is chunking?

Chunking refers to the process of breaking content up.

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It is necessary for representing complex texts in vector embeddings.

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```
helpers.bulk(es, actions, pipeline="text-embedding", chunk_size=1000)
```

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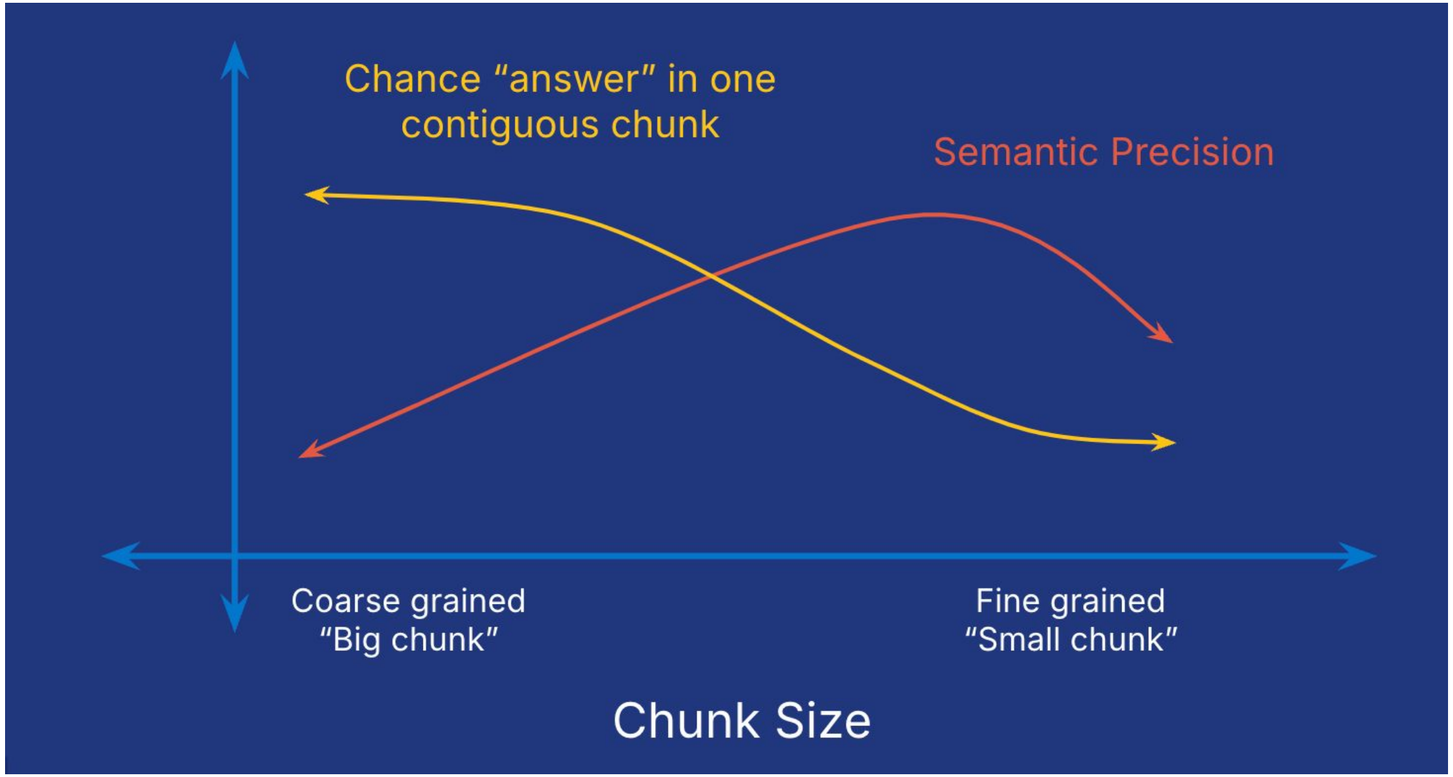
Impact of chunk size



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How and when to run a hybrid search?

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Demo

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Demo

https://www.elastic.co/search-labs/blog/elastic-vector-database-practical-example

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Let’s take a look at the book data

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Pipeline

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```
import json
from getpass import getpass

from elasticsearch import Elasticsearch, helpers
from sentence_transformers import SentenceTransformer
```

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```
cloud_endpoint = getpass("Elastic deployment Cloud Endpoint: ")
cloud_api_key = getpass("Elastic deployment API Key: ")
INDEX_NAME = "books-pipeline"

es = Elasticsearch(
    hosts=cloud_endpoint,
    api_key=cloud_api_key,
)
```

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```
resp = es.ingest.put_pipeline(
    id="text-embedding",
    description="converts book description text to a vector",
    processors=[
        {
            "inference": {
                "model_id": "sentence-transformers__msmarco-minilm-l-12-v3",
                "input_output": [
                    {
                        "input_field": "book_description",
                        "output_field": "description_embedding",
                    }
                ],
            }
        }
    ],
    on_failure=[
        {
            "set": {
                "description": "Index document to 'failed-<index>'",
                "field": "_index",
                "value": "failed-{{{_index}}}",
            }
        },
        {
            "set": {
                "description": "Set error message",
                "field": "ingest.failure",
                "value": "{{_ingest.on_failure_message}}",
            }
        },
    ],
)

print(resp)
```

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```
mappings = {
    "mappings": {
        "properties": {
            "book_title": {"type": "text"},
            "author_name": {"type": "text"},
            "rating_score": {"type": "float"},
            "rating_votes": {"type": "integer"},
            "review_number": {"type": "integer"},
            "book_description": {"type": "text"},
            "genres": {"type": "keyword"},
            "year_published": {"type": "integer"},
            "url": {"type": "text"},
        }
    }
}
# Delete any previous index
es.indices.delete(index=INDEX_NAME)
es.indices.create(index=INDEX_NAME, body=mappings)
print(f"Index '{INDEX_NAME}' created.")
```

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```python
file_path = "../data/books.json"
with open(file_path, "r") as file:
    books = json.load(file)

# create an array of index actions, with each element holding one document
actions = [
    {"_index": INDEX_NAME, "_id": book.get("id", None), "_source": book}
    for book in books
]

try:
    helpers.bulk(es, actions, pipeline="text-embedding", chunk_size=1000)
    print(f"Successfully added {len(actions)} books into the '{INDEX_NAME}' index.")

except helpers.BulkIndexError as e:
    print(f"Error occurred while ingesting books: {e}")
    print(e.errors)
```

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What is RAG?

Retrieval-augmented generation (RAG) integrates external information retrieval into generating responses by Large Language Models (LLMs).

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Vector Databases vs RAG

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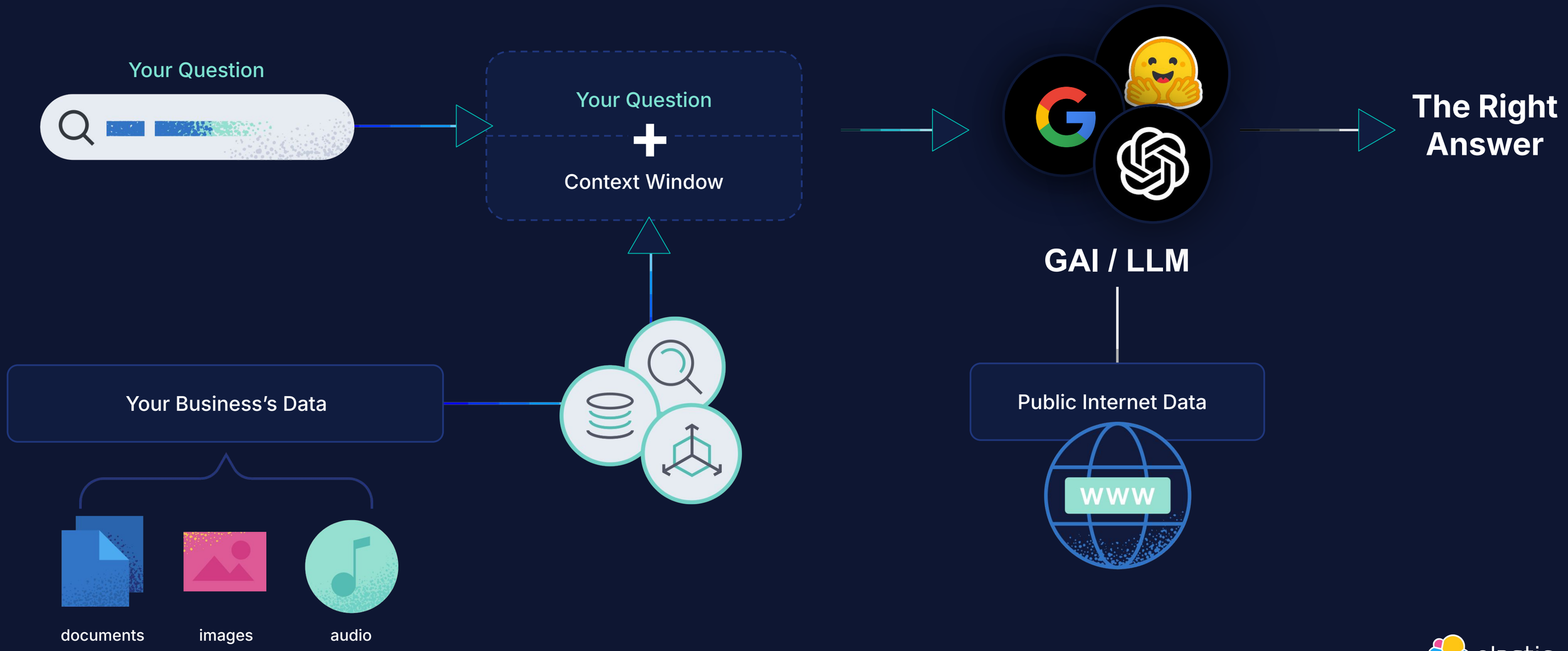
Retrieval Augmented Generation



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Elastic's playground

A low-code interface for you to explore LLMs

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es_client = elasticsearch.Elasticsearch(
getpass.getpass("Host: "),
api_key=getpass.getpass("API Key: "),
)

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```
embedding = OpenAIEmbeddings(model="text-embedding-3-large")
elastic_vector_search = ElasticsearchStore(
    index_name="vr_tour_data",
    es_connection=es_client,
    embedding=embedding,
)
```

```
translated_texts = df['translated_text'].tolist()
combined_text = "\n".join(translated_texts)
text_splitter = CharacterTextSplitter(chunk_size=1100, chunk_overlap=0)
docs = text_splitter.split_documents([Document(page_content=combined_text)])
```

Next steps

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Search Labs

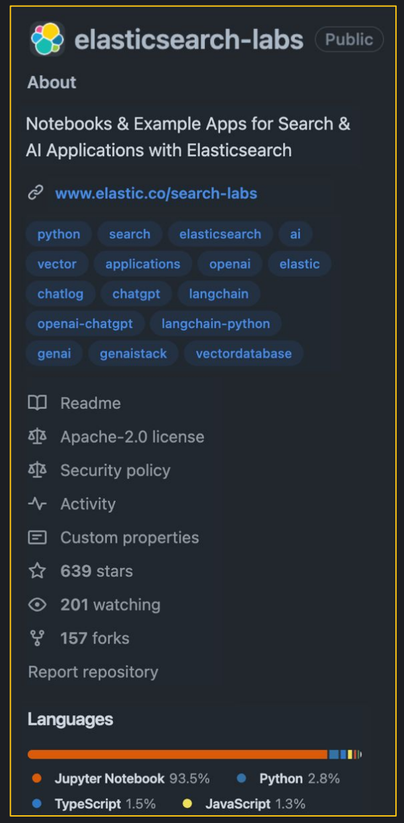
ML Research December 1, 2023

RAG evaluation metrics: A journey through metrics

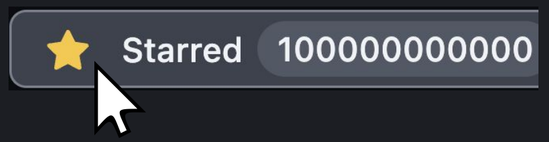
Explore RAG evaluation metrics like BLEU score, ROUGE score, PPL, BARTScore, and more. Discover...

By: **Quentin Herreros**, **Thomas Veasey** and **Thanos Papaoikonomou**

elastic.co/**search-labs**



github.com/elastic/**elasticsearch-labs**



Tutorials
GitHub Example Code
Integrations
Blogs

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ElasticON is back!

ElasticON New York

Nov. 13, 2024

Manhattan Center

https://www.elastic.co/events/elasticon/new-york-city

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Elastic Contributors

This community program is designed to recognize and reward the hard work of our awesome contributors. Join this friendly competition and earn points for:

Code contributions | Presentations | Video tutorials | Event organization
Translations | Technical Q&A | Written content | Content validation

The top contributors will win cool prizes such as **Elastic trainings**, **certificate exams, cloud credits** and more. Check out the rules on our website and start submitting today!

elastic.co/community/contributor

The current cycle runs from February 1st 2024 to January 31st 2025

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Get involved

The community would love to hear from you!

If you have a cool use case to share at a meetup, please let us know! We would love to make that happen.

And if your company would like to host a meetup - we have user groups in other cities as well, please let us know.

Send an email to meetups@elastic.co or ully@elastic.co

Let me know if this talk inspires you to build anything. I'm @JessicaGarson on most platforms.

If you have any questions on our Discuss forums and the community Slack channel.

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Thank you!
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