elastic

La recherche
à l'ère de l'IA

David Pilato | @dadoonet

DevFest
TOULOUSE

openfeedback

Elasticsearch

You Know, for Search

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Elasticsearch

Lucene

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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."
}
```

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

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

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

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"tokenizer": "standard"

These are not the droids you are looking for.

These
are
not
the
droids
you
are
looking
for

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"filter": "**lowercase**"

These		**t**hese
are		are
not		not
the		the
droids	→	droids
you		you
are		are
looking		looking
for		for

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```
"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 not 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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Semantic
search
≠
Literal
matches

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You Know, for Search

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Elasticsearch

You Know, for **Vector** Search

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What is a **Vector**?

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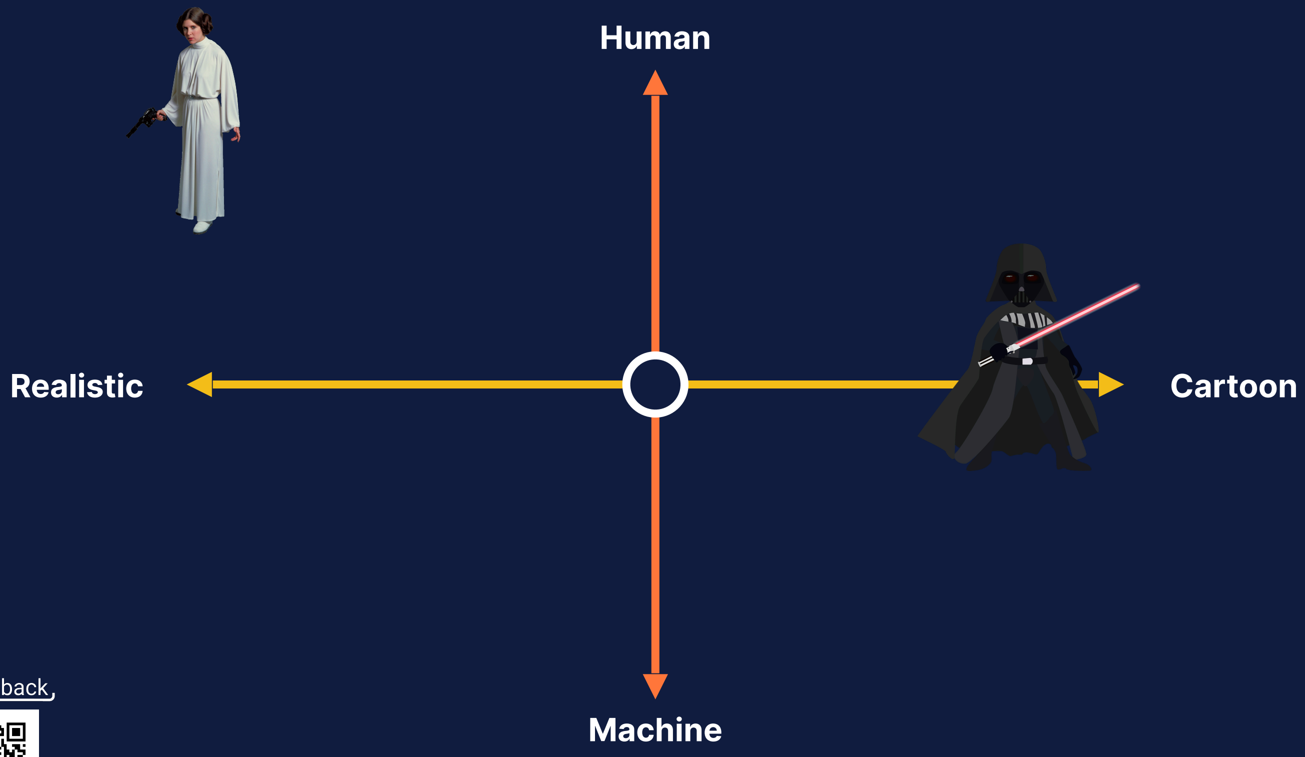
Embeddings represent your data

Example: 1-dimensional vector

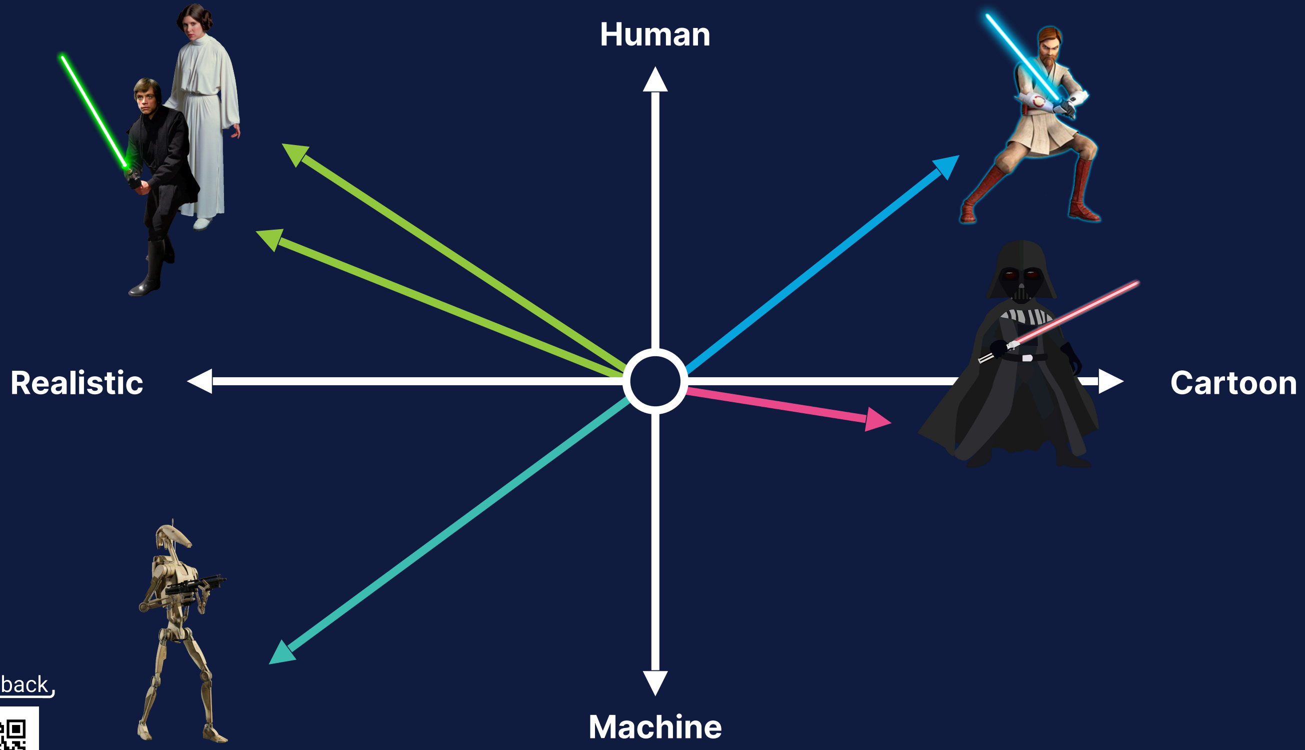
Character	Vector
	[-1]
	[1]

Multiple dimensions
represent different data aspects



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

Similar data
is grouped together



Character	Vector
	[-1.0, 1.0]
	[1.0, 0.0]
	[-1.0, 0.8]
	[1.0, 1.0]
	[-1.0, -1.0]

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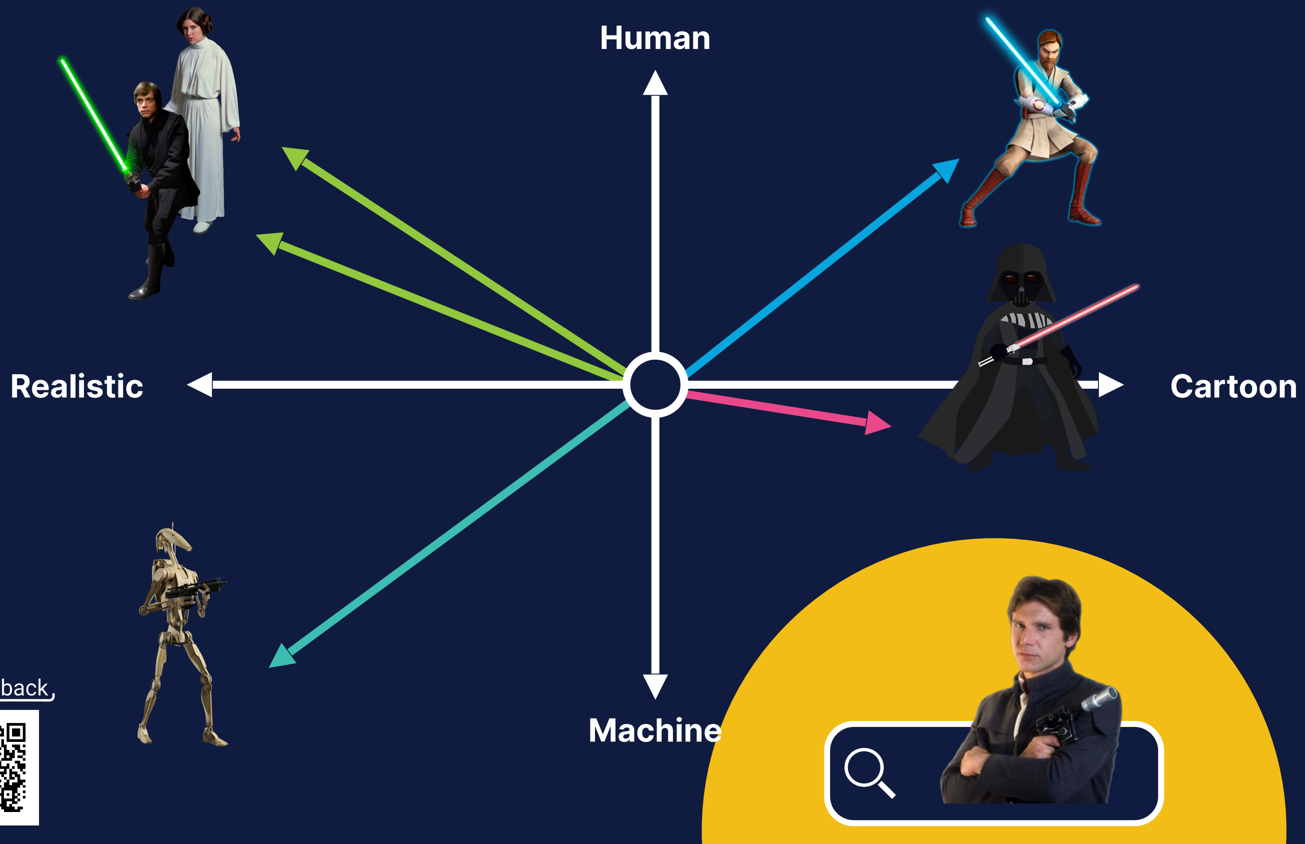
Vector search ranks objects
by similarity (~relevance) to the query



Rank	Result
Query	
1	
2	
3	
4	
5	

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How do you

index **vectors**?

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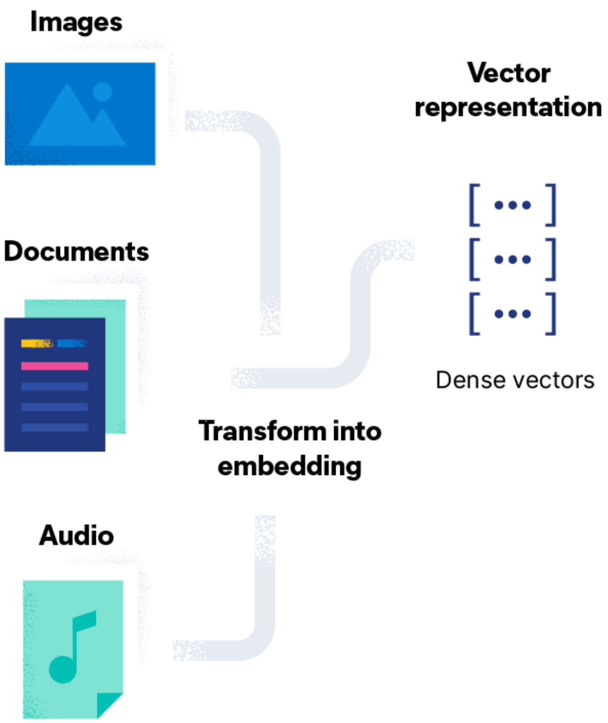
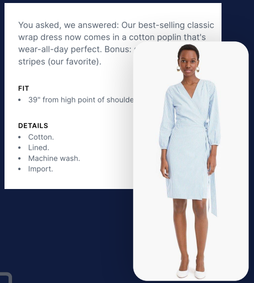
Architecture of Vector Search



dense_vector field type

```
PUT ecommerce
{
  "mappings": {
    "properties": {
      "description": {
        "type": "text"
      }
      "desc_embedding": {
        "type": "dense_vector"
      }
    }
  }
}
```

Data Ingestion and Embedding Generation



Source data

POST ecommerce/_doc


```
{
  "_id":"product-1234",
  "product_name":"Summer Dress",
  "description":"Our best-selling…",
  "Price": 118,
  "color":"blue",
  "fabric":"cotton",
} "desc_embedding":[0.452,0.3242,…],
} "img_embedding":[0.012,0.0,…]
}
```


POST /ecommerce/_doc

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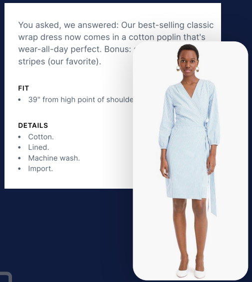
With Elastic ML



Source data

```
{
  "_id":"product-1234",
  "product_name":"Summer Dres
  "description":"Our best-sel
  "Price": 118,
  "color":"blue",
  "fabric":"cotton",
}
```

POST /ecommerce/_doc

ML Inference pipelines | Add inference pipeline

Inference pipelines will be run as processors from the Enterprise Search Ingest Pipeline

ml-inference-embedding-generation — Actions
Deployed | pytorch | text_embedding

ml-inference-emational-analysis — Actions
Deployed | pytorch | text_classification

Learn more about deploying ML models in Elastic

```
{
  "_id":"product-1234",
  "product_name":"Summer Dress",
  "description":"Our best-selling…",
  "Price": 118,
  "color":"blue",
  "fabric":"cotton",
  "desc_embedding":[0.452,0.3242,…]
}
```

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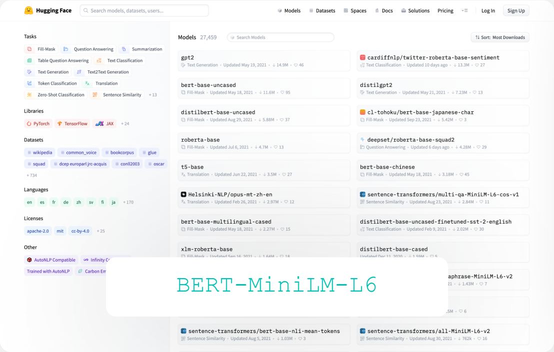
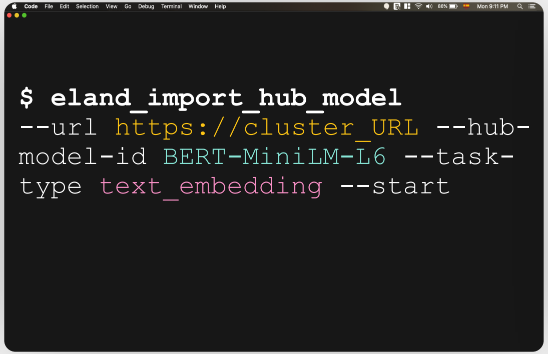
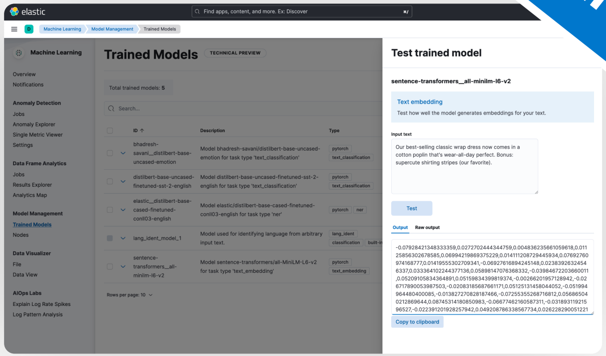
Eland Imports PyTorch Models







PyTorch

eland

Select the appropriate model

Load it

Manage models

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Elastic's range of supported NLP models

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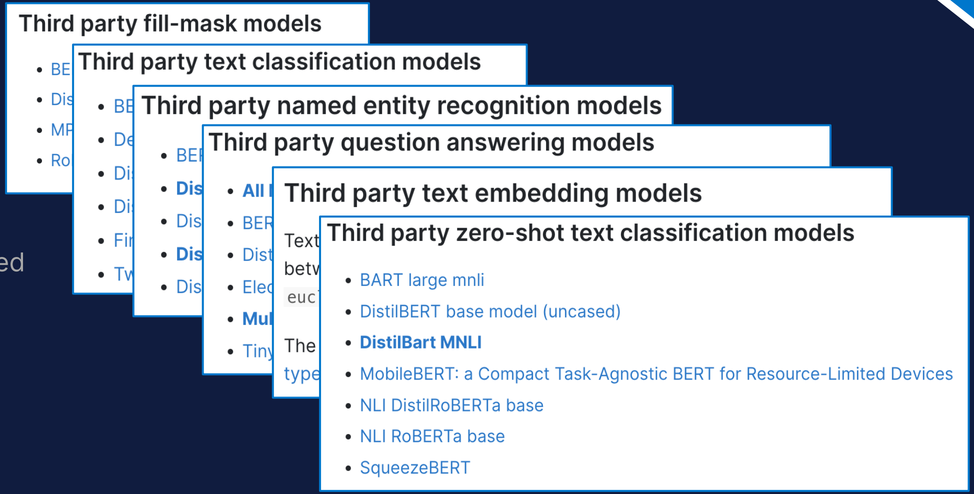
- **Fill mask model**
  Mask some of the words in a sentence and predict words that replace masks
- **Named entity recognition model**
  NLP method that extracts information from text
- **Text embedding model**
  Represent individual words as numerical vectors in a predefined vector space
- **Text classification model**
  Assign a set of predefined categories to open-ended text
- **Question answering model**
  Model that can answer questions given some or no context
- **Zero-shot text classification model**
  Model trained on a set of labeled examples, that is able to classify previously unseen examples



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Full list at: ela.st/nlp-supported-models

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How do you

search **vectors**?

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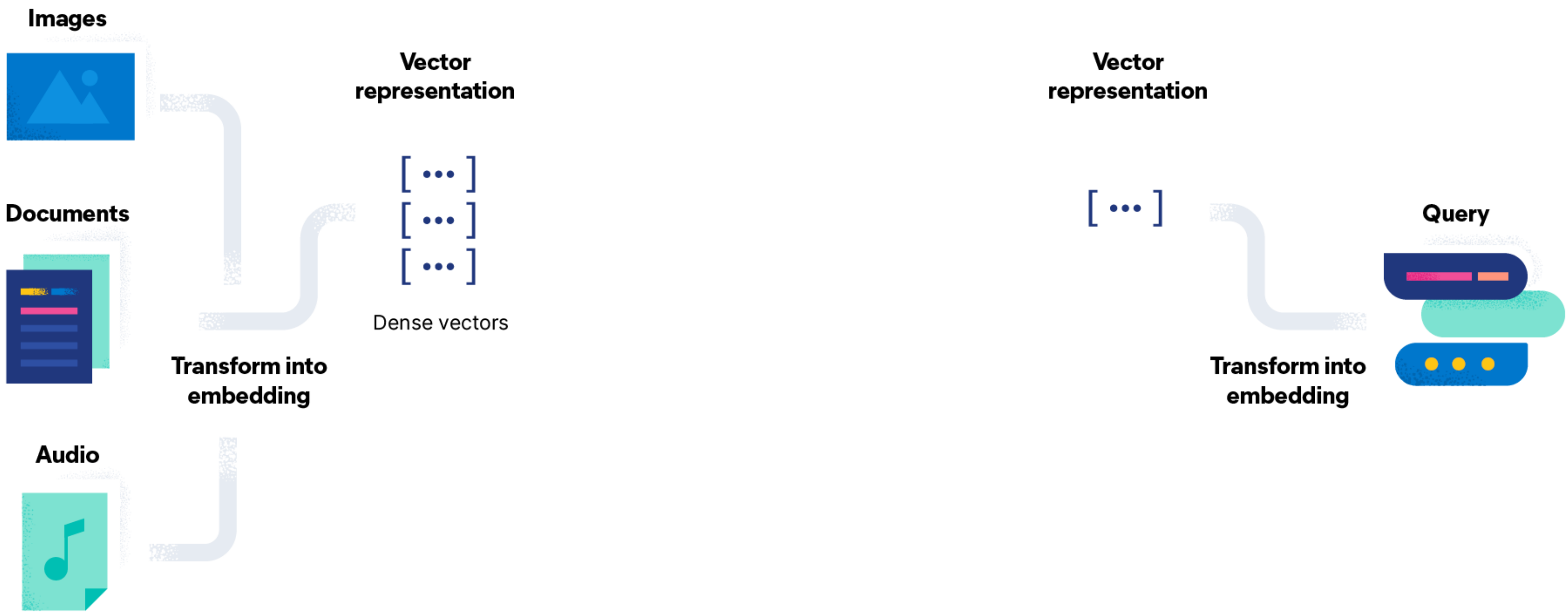
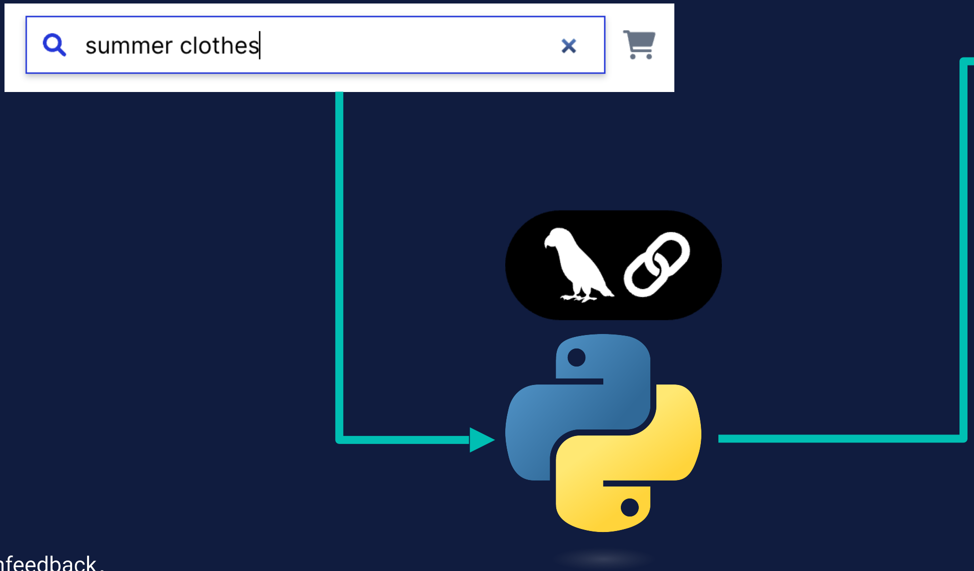
Architecture of Vector Search



knn query




```
GET ecommerce/_search
{
 "query" : {
    "bool": {
      "must": [{
         "knn": {
           "field": "desc_embbeding",
           "query_vector": [0.123, 0.244,...]



         }
      }],
      "filter": {
        "term": {
          "department": "women"
        }
      }
    }
  },
  "size": 10
}
```

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knn query (with Elastic ML)

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```
GET ecommerce/_search
{
 "query" : {
    "bool": {
      "must": [{
         "knn": {
           "field": "desc_embbeding",
           "query_vector_builder": {
             "text_embedding": {
               "model_text": "summer clothes",
               "model_id": <text-embedding-model>
             }
           }
         }
      }],
      "filter": {
        "term": {
          "department": "women"
        }
      }
    }
  },
  "size": 10
}
```

Transformer model

semantic_text field type

new in 8.15

```
PUT /_inference/text_embedding/e5-small-multilingual
{
    "service": "elasticsearch",
    "service_settings": {
       "num_allocations": 1,
       "num_threads": 1,
       "model_id": ".multilingual-e5-small_linux-x86_64"
    }
}
```

```
PUT ecommerce
{
  "mappings": {
    "properties": {
      "description": {
        "type": "text",
        "copy_to": [ "desc_embedding" ]
      }
      "desc_embedding": {
        "type": "semantic_text",
        "inference_id": "e5-small-multilingual"
      }
    }
  }
}
```

```
POST ecommerce/_doc
{
  "description": "Our best-selling…"
}
```

```
GET ecommerce/_search
{
  "query": {
    "semantic": {
      "field": "desc_embedding"
      "query" : "I'm looking for a red dress for a DJ party"
}}}
```

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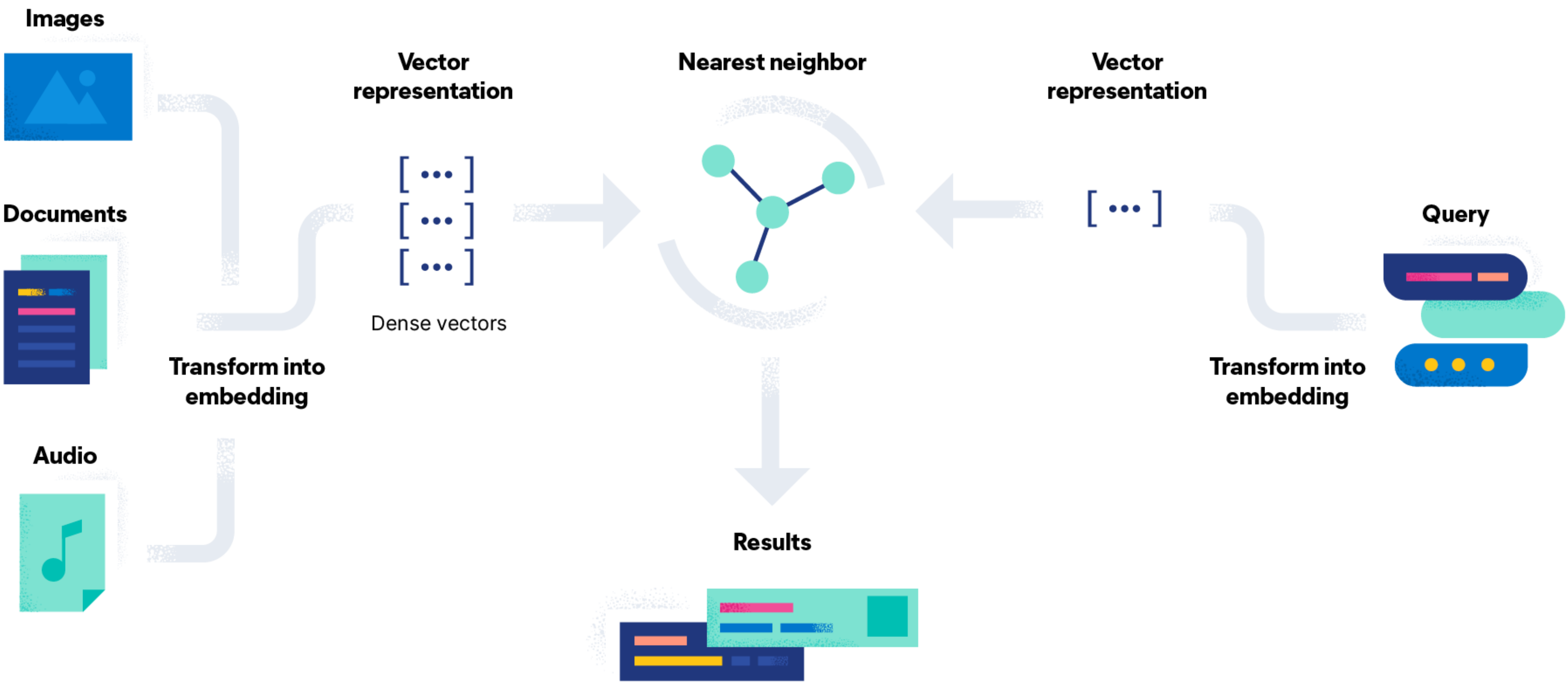
Architecture of Vector Search



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

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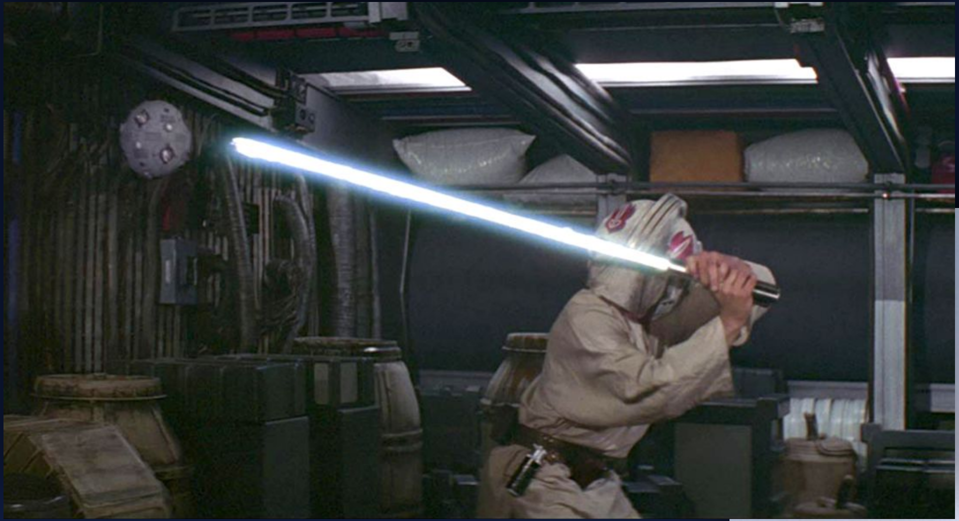
Problem

training vs actual use-case



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But how does it

really work?

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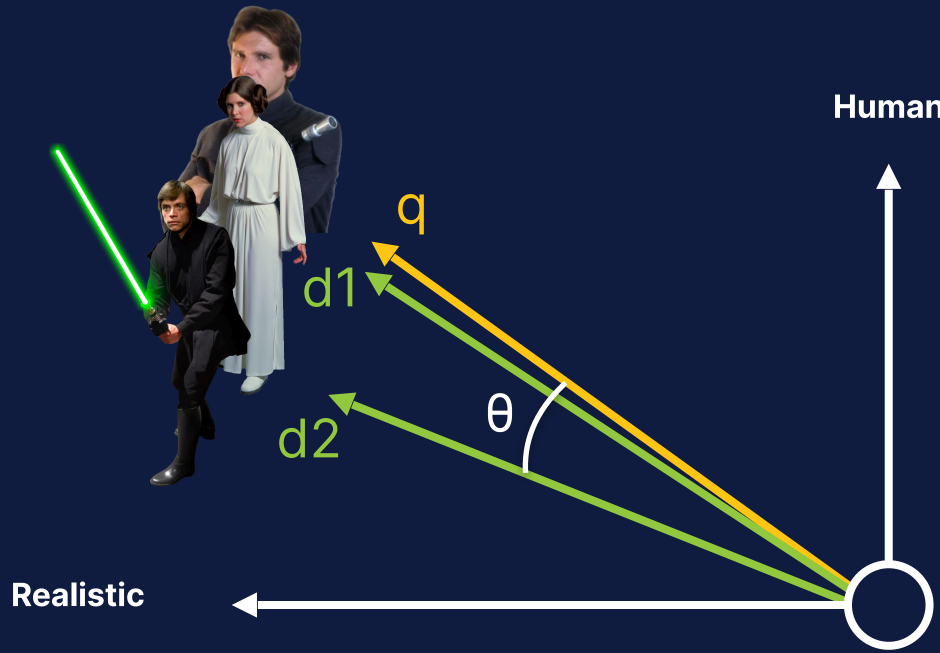
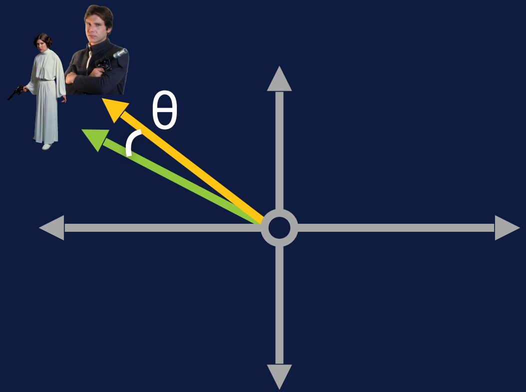
Similarity



$$\cos(\theta) = \frac{\vec{q} \times \vec{d}}{|\vec{q}| \times |\vec{d}|}$$

$$\_score = \frac{1 + \cos(\theta)}{2}$$

Similarity: cosine (cosine)

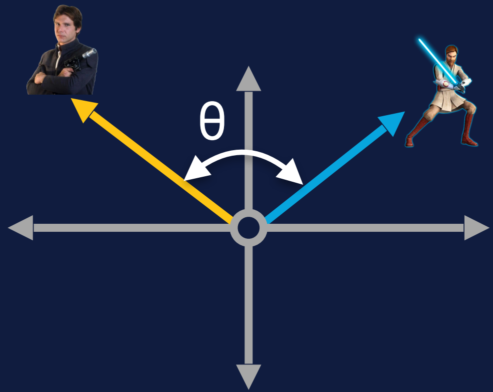


Similar vectors

θ close to 0

cos(θ) close to **1**

$$\_score = \frac{1+1}{2} = 1$$

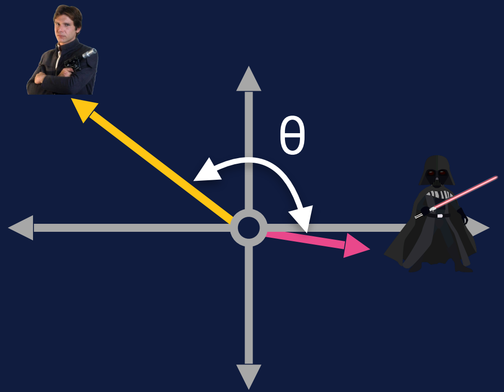


Orthogonal vectors

θ close to 90°

cos(θ) close to **0**

$$\_score = \frac{1+0}{2} = 0.5$$



Opposite vectors

θ close to 180°

cos(θ) close to **-1**

$$\_score = \frac{1-1}{2} = 0$$

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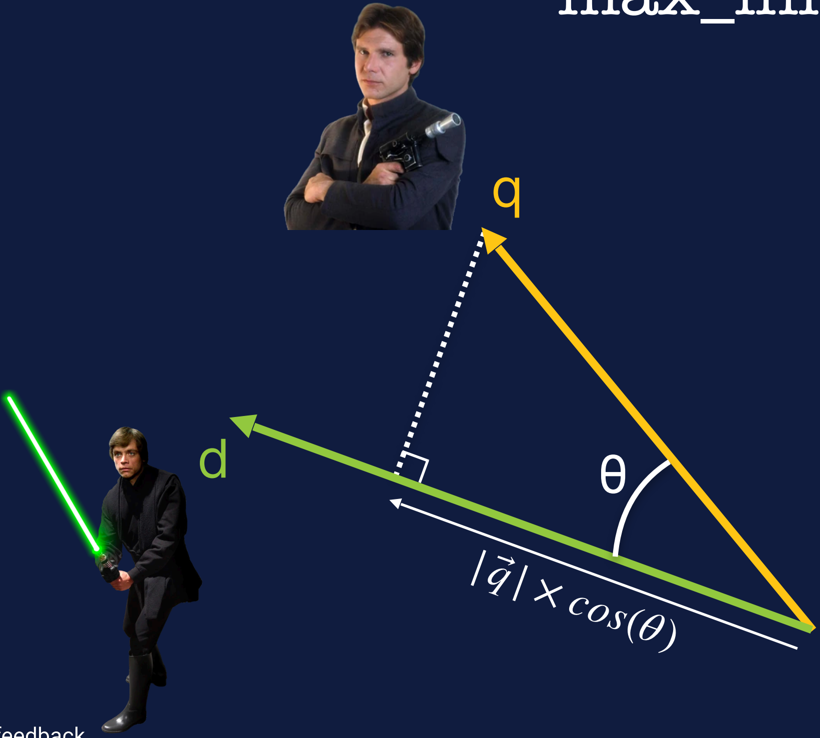
Similarity: Dot Product (dot_product or max_inner_product)



$$\vec{q} \times \vec{d} = |\vec{q}| \times cos(\theta) \times |\vec{d}|$$

$$\_score_{float} = \frac{1 + dot\_product(q, d)}{2}$$

$$\_score_{byte} = \frac{0.5 + dot\_product(q, d)}{32768 \times dims}$$

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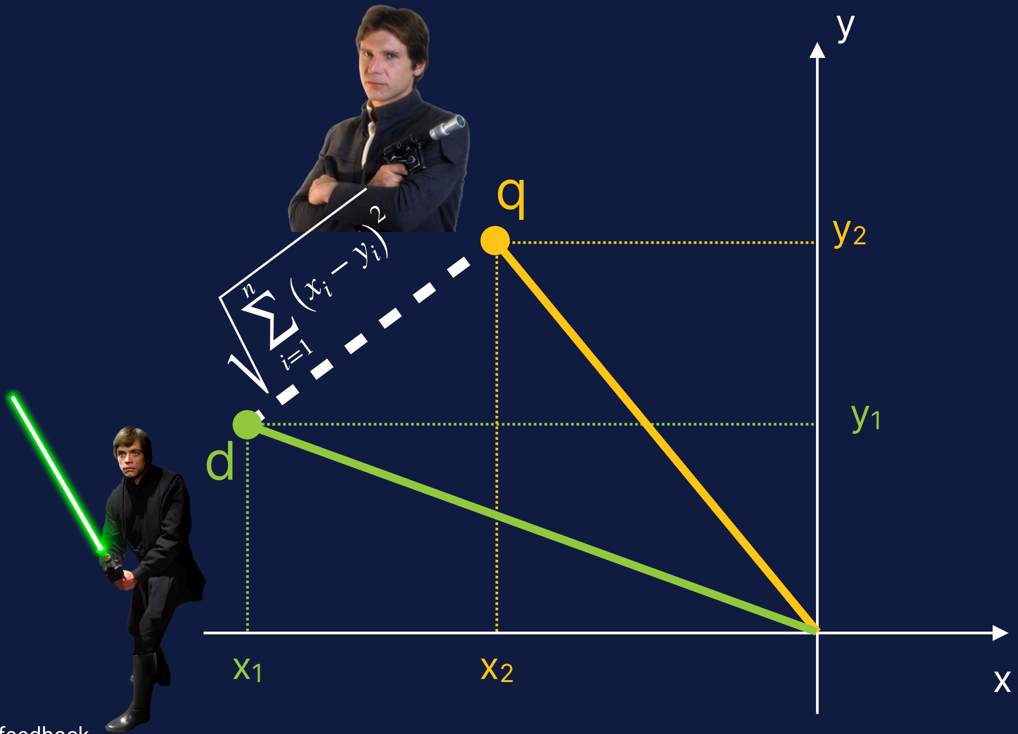
Similarity: Euclidean distance (l2_norm)



$$l2\_norm_{q,d} = \sqrt{\sum_{i=1}^{n}\left(x_i - y_i\right)^2}$$

$$\_score = \frac{1}{1 + (l2\_norm_{q,d})^2}$$

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Brute Force

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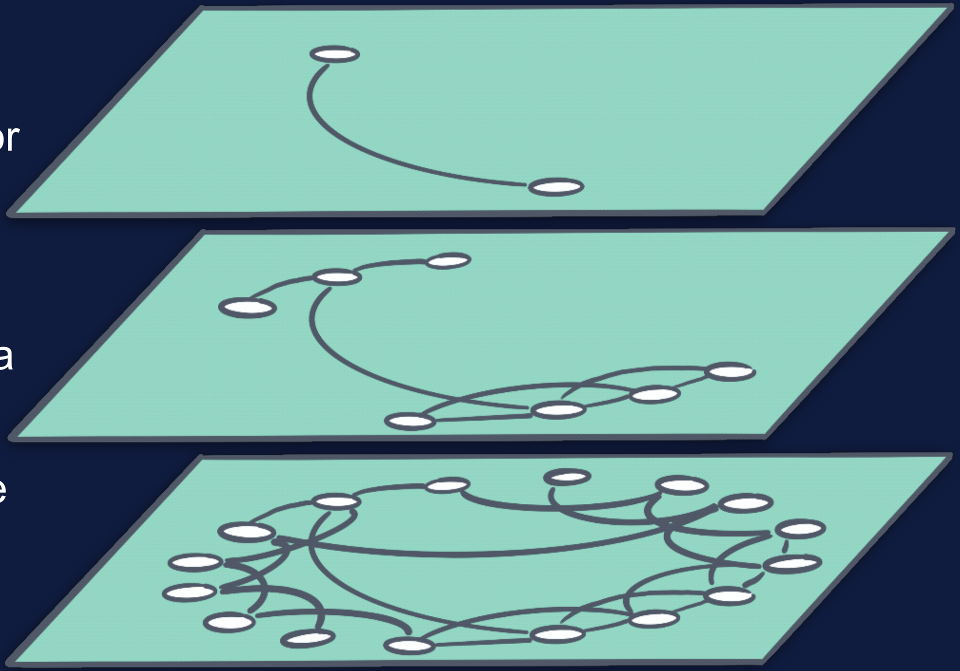
Hierarchical Navigable Small Worlds (HNSW)

One popular approach

- **HNSW:** a layered approach that simplifies access to the nearest neighbor
- **Tiered:** from coarse to fine approximation over a few steps
- **Balance:** Bartering a little accuracy for a lot of scalability
- **Speed:** Excellent query latency on large scale indices



Scaling Vector Search

Vector search

1. Needs lots of memory
2. Indexing is slower
3. Merging is slow

* Continuous improvements in Lucene + Elasticsearch

Best practices

1. Avoid searches during indexing
2. Exclude vectors from _source
3. Reduce vector dimensionality
4. Use byte rather than float

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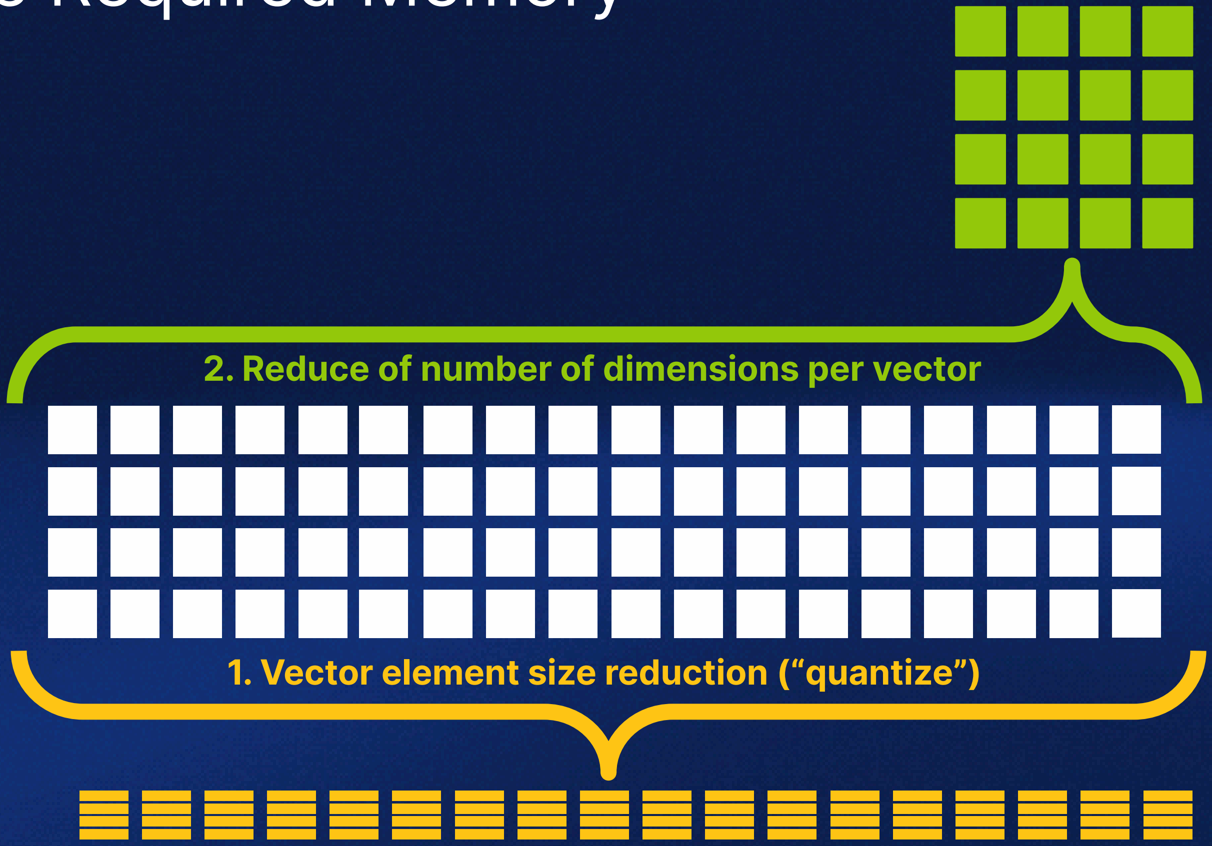
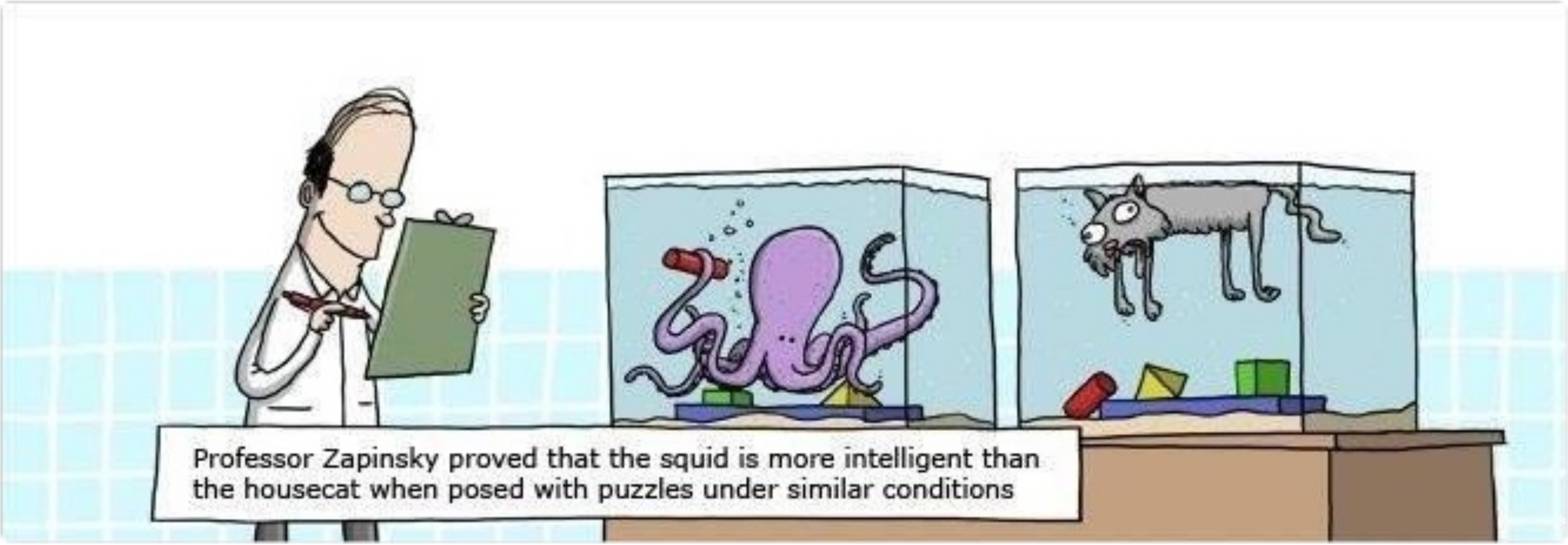
Reduce Required Memory



Benchmarketing



https://djdadoo.pilato.fr/

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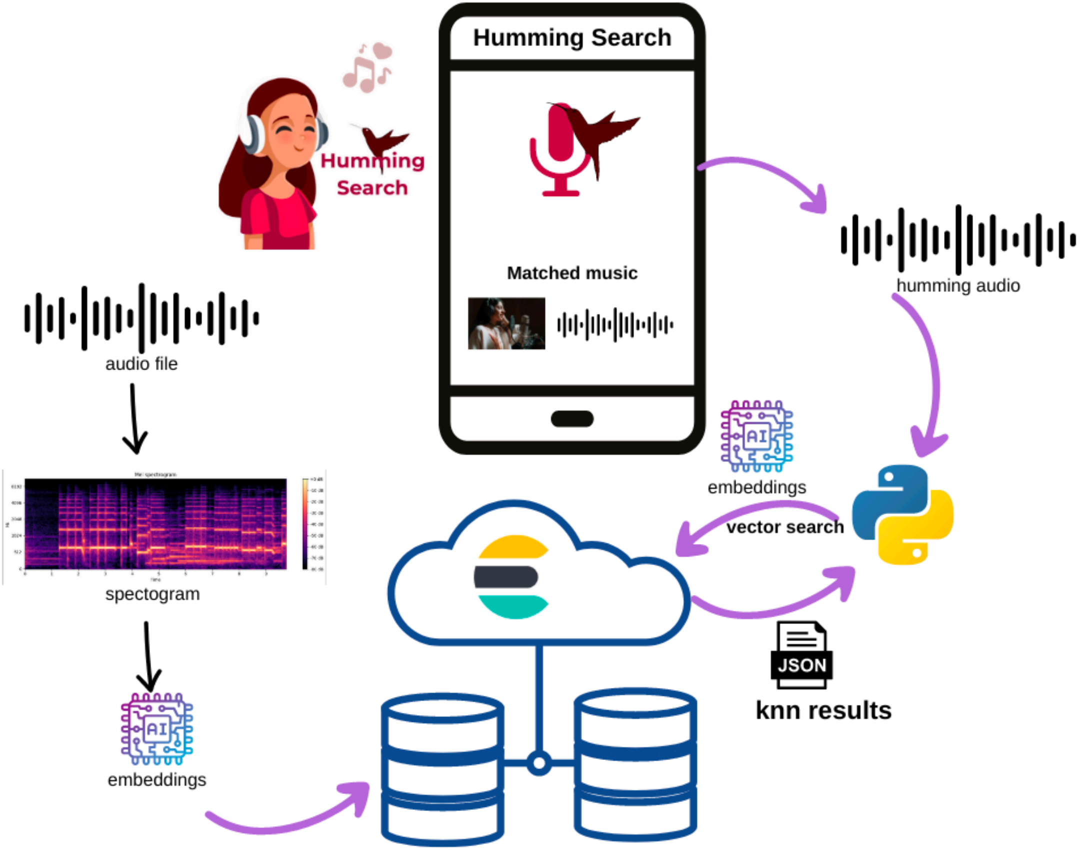

https://github.com/dadoonet/music-search/

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Elasticsearch

You Know, for **Hybrid** Search

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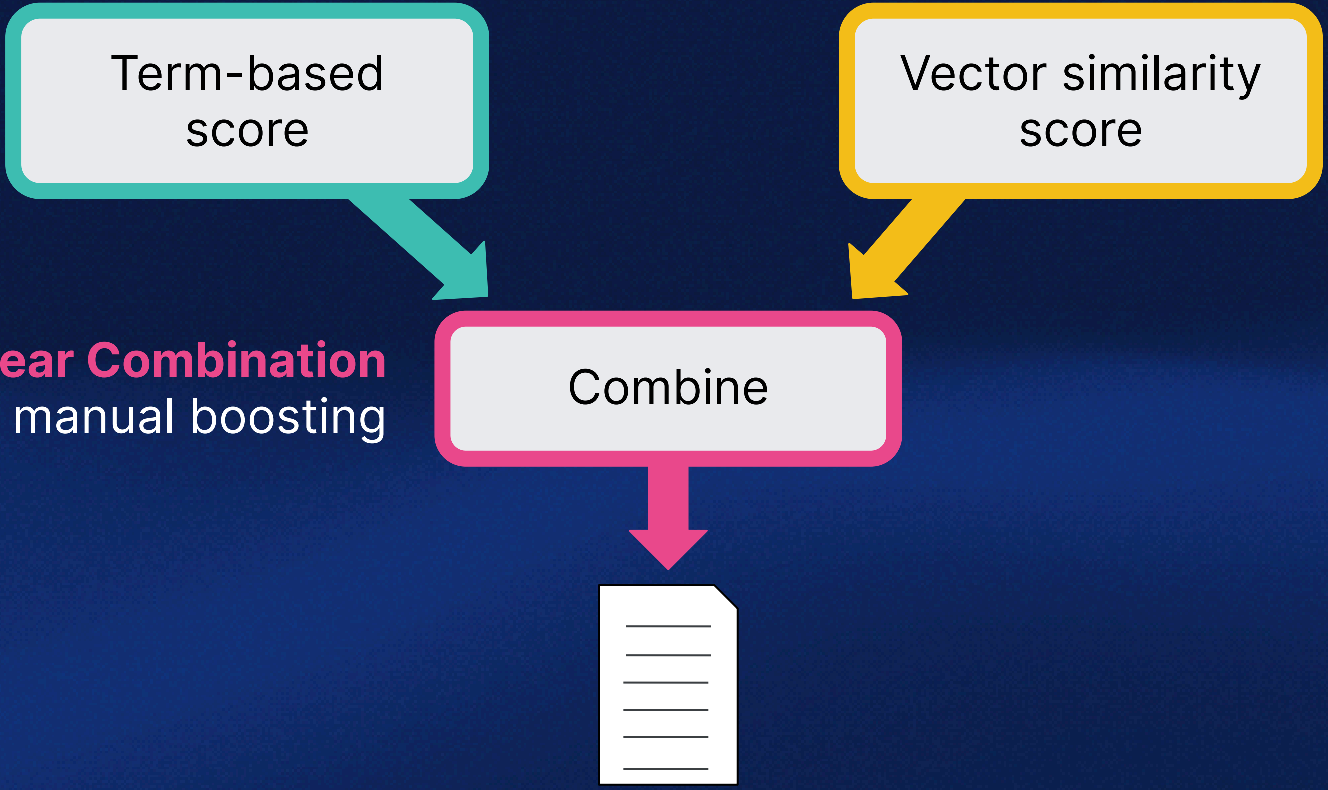
Hybrid scoring



Linear Combination
manual boosting

```
GET ecommerce/_search
{
  "query" : {
    "bool" : {
      "must" : [{
        "match": {
          "description": {
            "query": "summer clothes",
            "boost": 0.1
          }
        }
      },{
        "knn": {
          "field": "desc_embbeding",
          "query_vector": [0.123, 0.244,...],
          "boost": 2.0,
          "filter": {
            "term": {
              "department": "women"
            }
          }
        }
      }],
      "filter" : {
        "range" : { "price": { "lte": 30 } }
      }
    }
  }
}
```

summer clothes

pre-filter

post-filter

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```
PUT starwars
{
  "mappings": {
    "properties": {
      "text.tokens": {
        "type": "sparse_vector"
      }
    }
  }
}
```

"These are not the droids you are looking for.",

"Obi-Wan never told you what happened to your father."

```
GET starwars/_search
{
   "query":{
      "sparse_vector": {
        "field": "text.tokens",
        "query_vector": { "lucas": 0.50047517,
                          "ship": 0.29860738,
                          "dragon": 0.5300422,
                          "quest": 0.5974301, ... }
      }
   }
}
```

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ELSER

Elastic **L**earned **S**parse Encod**ER**

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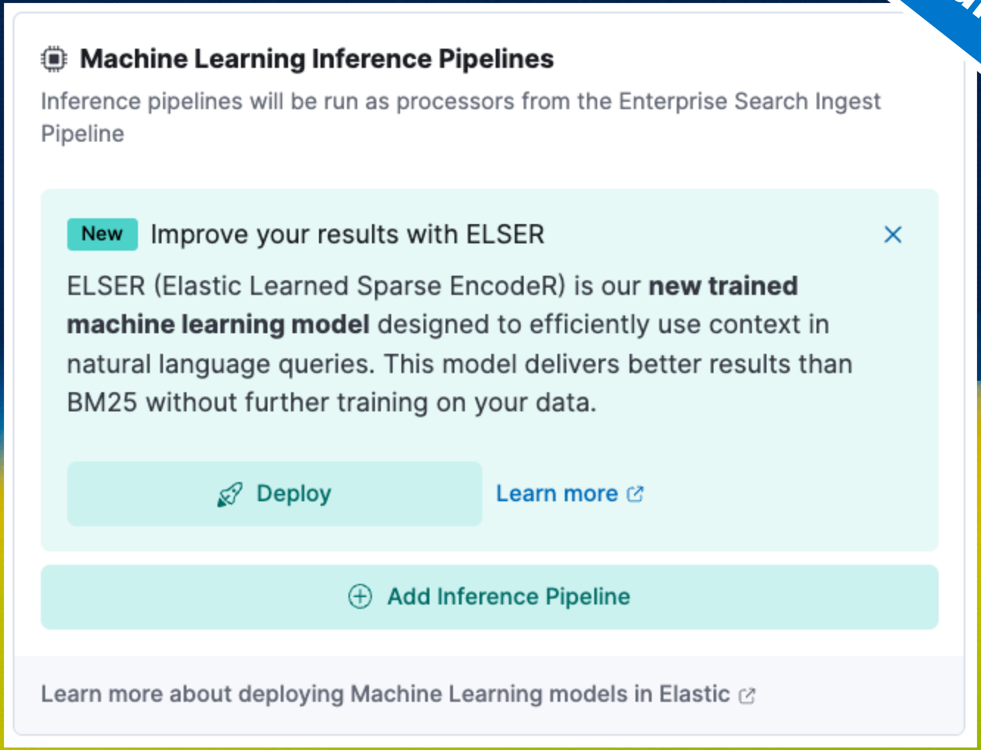
sparse_vector

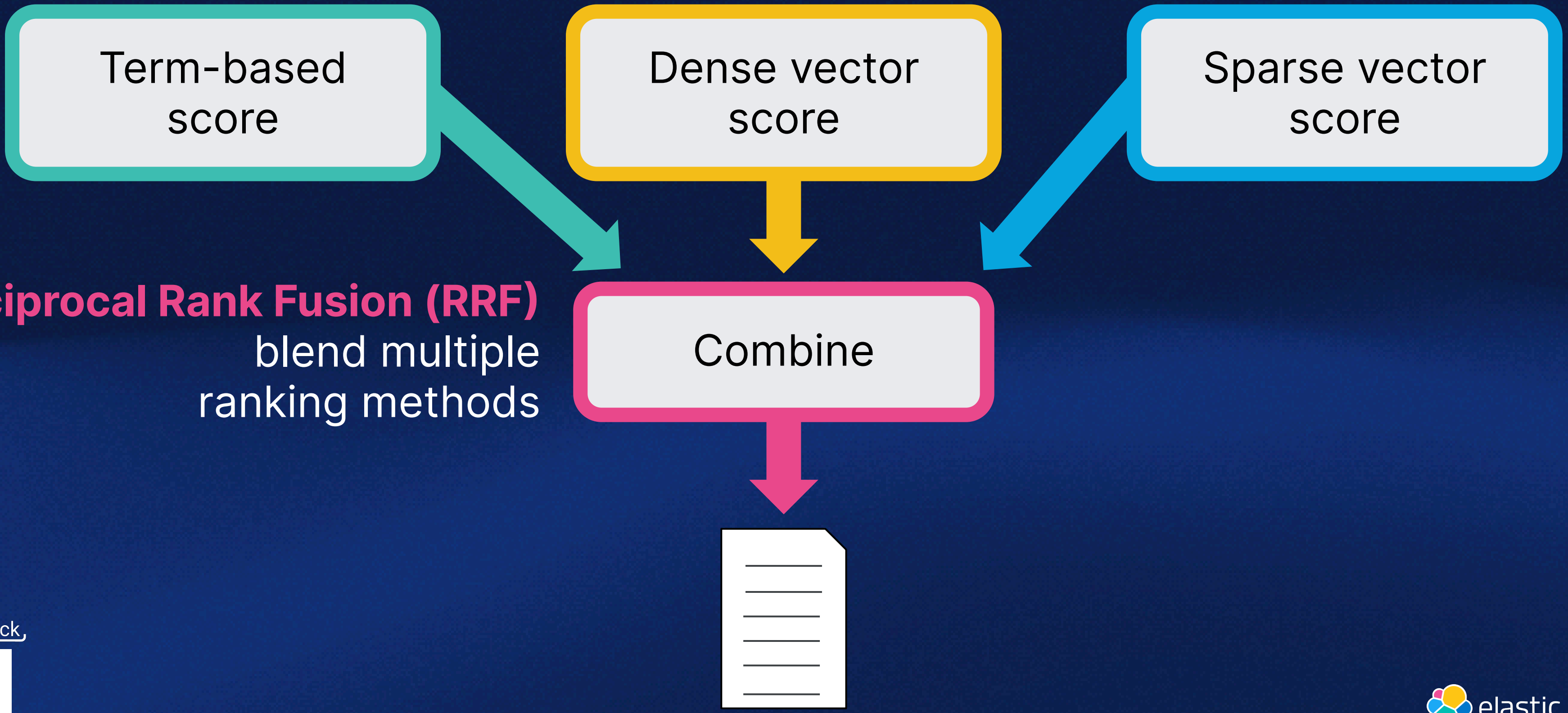
Not BM25 or (dense) vector

Sparse vector like BM25

Stored as inverted index



Hybrid ranking



Reciprocal Rank Fusion (RRF)
blend multiple ranking methods

Reciprocal Rank Fusion (RRF)

$$RRFscore(d \in D) = \sum_{r \in R} \frac{1}{k + r(d)}$$

D - set of docs
R - set of rankings as permutation on 1..|D|
k - typically set to 60 by default

Dense Vector			
Doc	Score	r(d)	k+r(d)
A	1	1	61
B	0.7	2	62
C	0.5	3	63
D	0.2	4	64
E	0.01	5	65

BM25			
Doc	Score	r(d)	k+r(d)
C	1,341	1	61
A	739	2	62
F	732	3	63
G	192	4	64
H	183	5	65

Doc	RRF Score
A	1/61 + 1/62 = 0,0325
C	1/63 + 1/61 = 0,0323
B	1/62 = 0,0161
F	1/63 = 0,0159
D	1/64 = 0,0156

```
GET index/_search
{
  "retriever": {
    "rrf": {
     "retrievers": [{
          "standard" { "query": {
              "match": {...}
            }
          }
        },{
          "standard" { "query": {
              "sparse_vector": {...}
            }
          }
        },{
          "knn": { ... }
        }
      ]
    }
  }
}
```

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Hybrid Ranking

⬇

BM25f

+

Sparse Vector

+

Dense Vector

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ChatGPT

Elastic and LLM

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Gen AI
Search engines
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LLM: opportunities and limits

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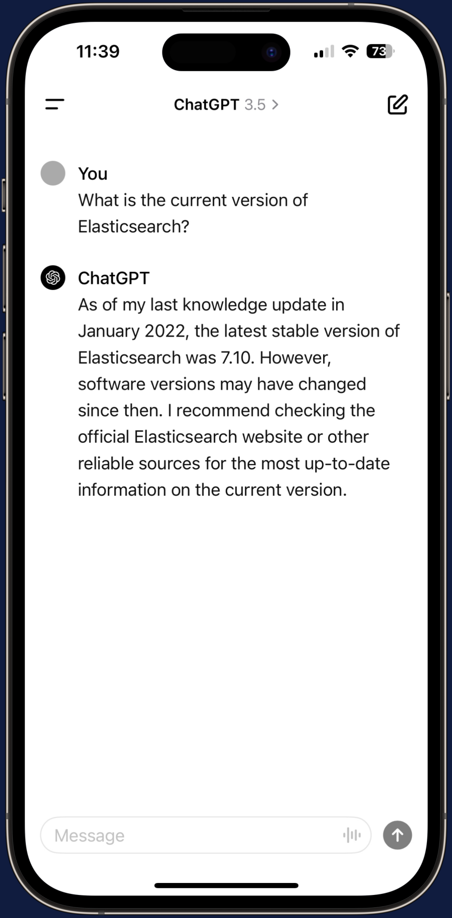

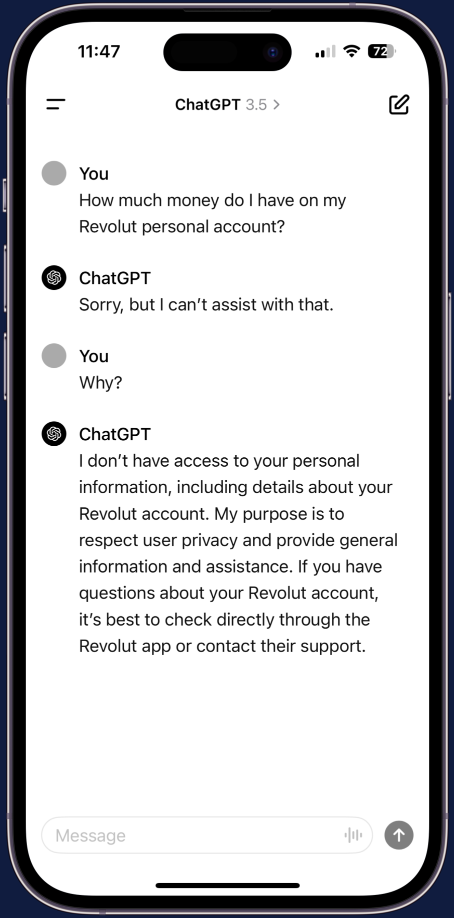

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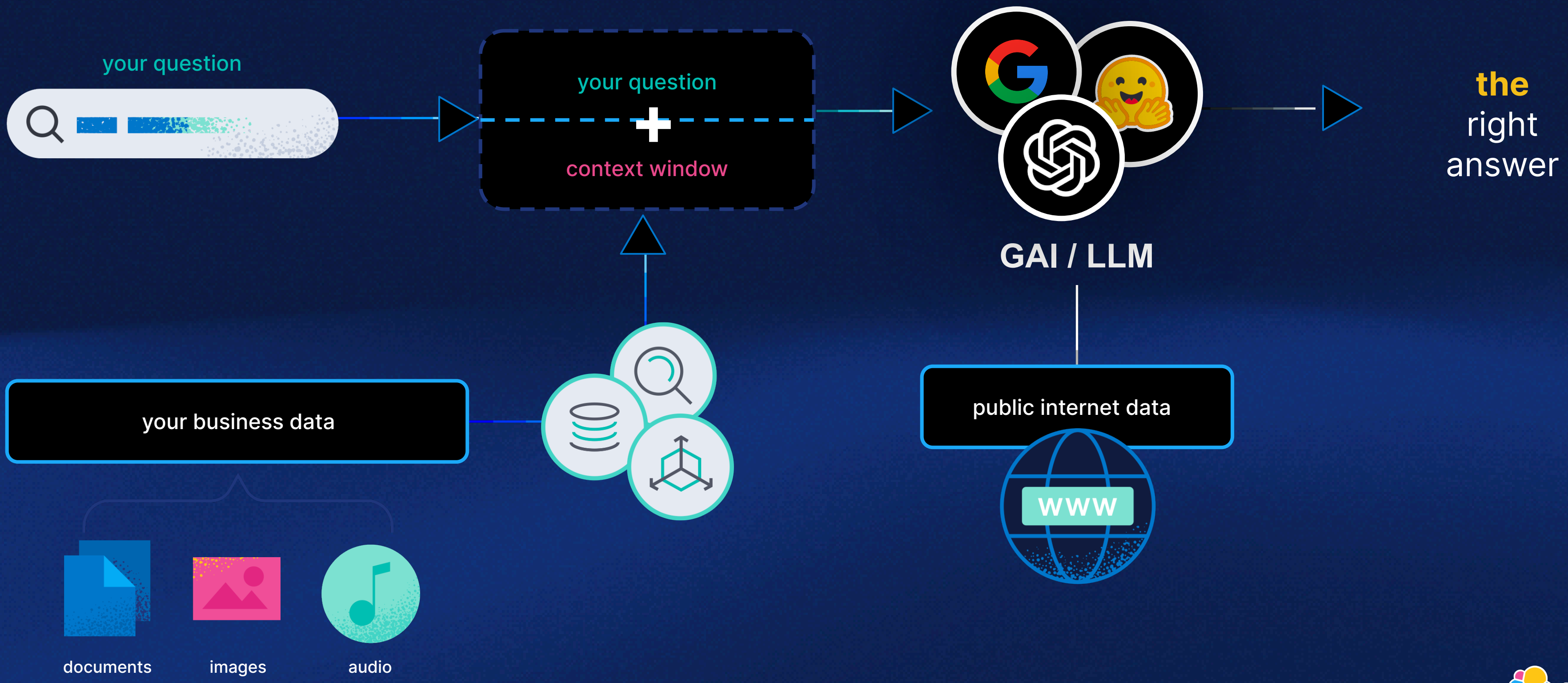
Retrieval Augmented Generation



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Demo

Elastic Playground

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me Transaction search Financial summary Customer support

Home | Online banking | Enviroment setup

Search your transactions:

This search is not enabled by Elastic and reflects the kind of functionality available to customers today.

Submit

Date	Account	Description	Value	Opening balance	Closing balance
18/06/24	EL03-130981-Transmission	Inbound payment made from EL03-130981-Transmission, St.james's Plac (STJ): 864dce1b-bb95-47d5-87dd-7d02f3b10c3f	7419.0	-825.0	6594.0
18/06/24	EL03-130981-Transmission	Purchase at merchant: Southeastern Grocers, LLC, location: Fayetteville,AR	82.0	6594.0	6512.0
18/06/24	EL03-130981-Transmission	Purchase at merchant: Müller Holding Ltd. & Co. KG, location: Glendale,AZ	188.0	6512.0	6324.0
17/06/24	EL03-130981-Transmission	Payment made from EL03-130981-Transmission to Elwood Erickson, Mitie Grp. (MTO): d37085fc-1382-4593-9cb8-26e5526bd9a0	533.0	20.0	-513.0
17/06/24	EL03-130981-Transmission	Payment made from EL03-130981-Transmission to Classie Johns, Barclays (BARC): 75b603a2-1c1b-45e9-a7ec-4a551bf98a8d	312.0	-513.0	-825.0
16/06/24	EL03-130981-Transmission	Purchase at merchant: E-MART Inc., location: Fayetteville,AR	31.0	51.0	20.0
14/06/24	EL03-130981-Transmission	Purchase at merchant: Dick's Sporting Goods, Inc., location: Montgomery,AL	182.0	329.0	147.0
14/06/24	EL03-130981-Transmission	Purchase at merchant: Valor Holdings Co., Ltd., location: Louisville,KY	96.0	147.0	51.0
13/06/24	EL03-130981-Transmission	Purchase at merchant: The Save Mart Companies, location:	34.0	363.0	329.0

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Elasticsearch

You Know, for Semantic Search

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La recherche à l'ère de l'IA

David Pilato | @dadoonet

DevFest TOULOUSE

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