elastic

Search
a new era

FinistDevs

David Pilato | @dadoonet

elastic

Search
a new era

David Pilato | @dadoonet

Commercial

FinistDevs

GDG Finistère

Elasticsearch

You Know, for Search

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Elasticsearch

APACHE LUCENE™

elastic

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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 not the droids you are looking for.

These are not the droids you are looking for.

"tokenizer": "standard"

These are not the droids you are looking for.

These
are
not
the
droids
you
are
looking
for

"filter": "**lowercase**"

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

"filter": "**stop**"

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

`"filter": "snowball"`

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

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
    }]}
```

Semantic
search
≠
Literal
matches

Elasticsearch

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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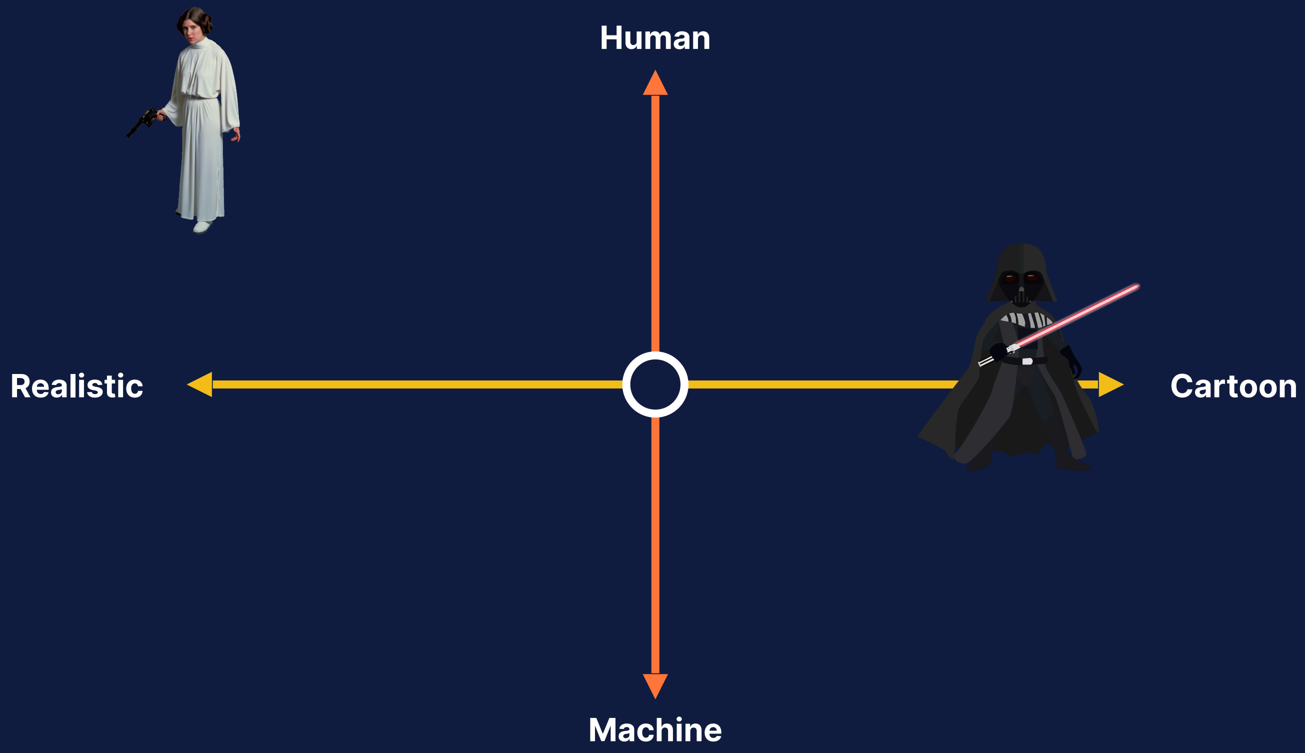
Embeddings represent your data

Example: 1-dimensional vector

Character	Vector
	[-1]
	[1]

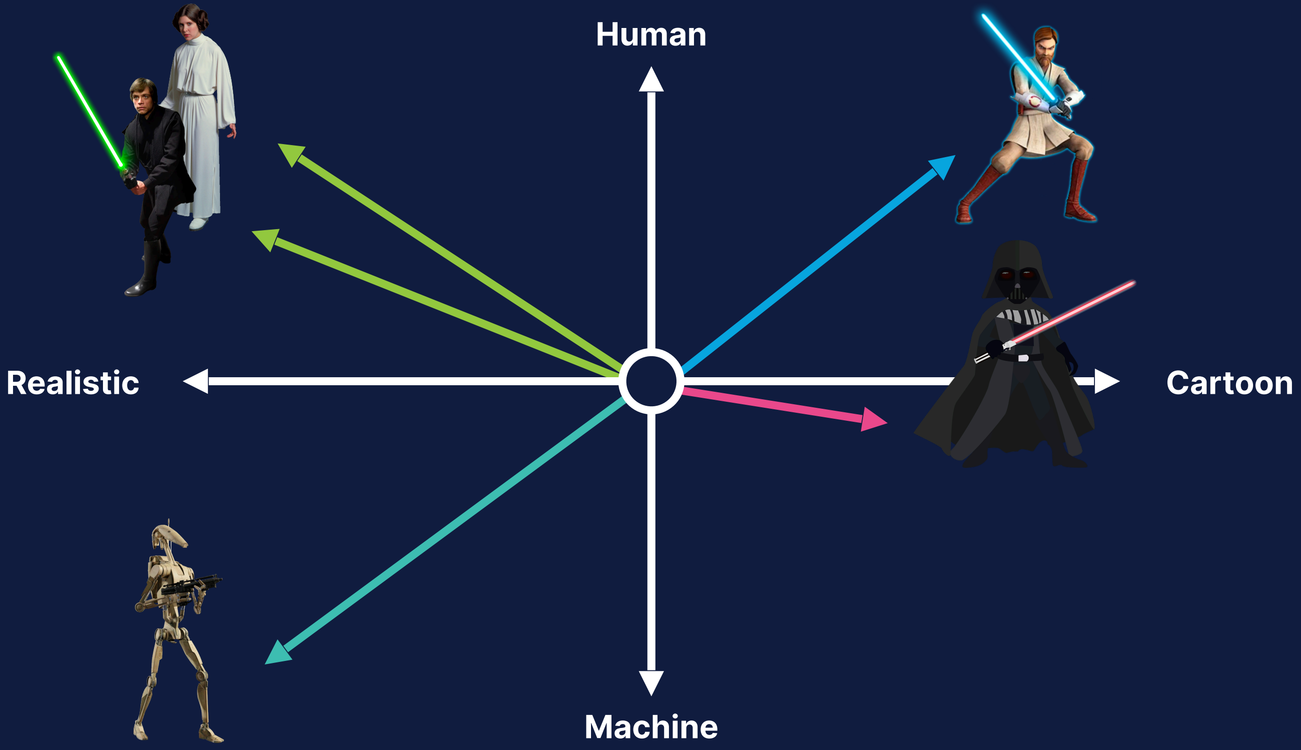
Multiple dimensions

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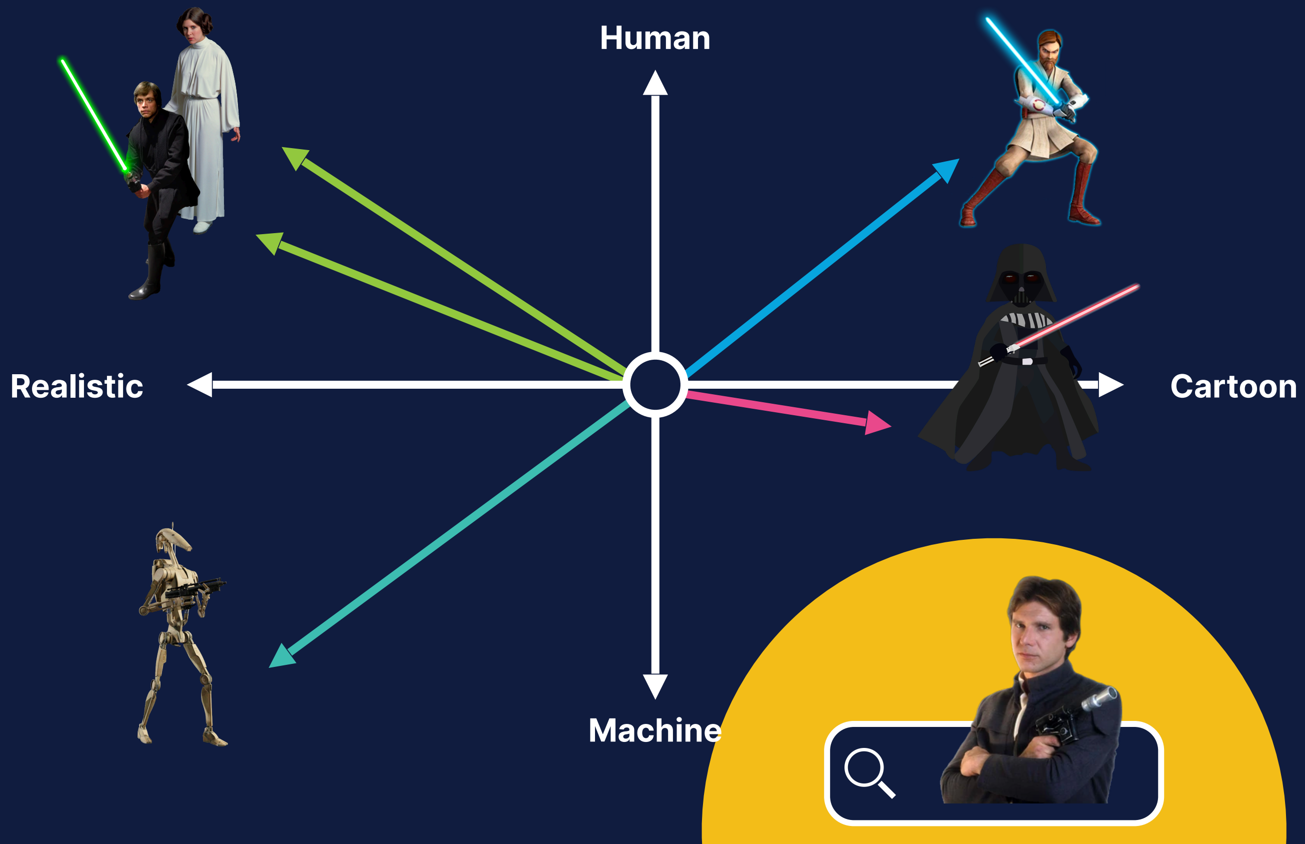
Vector search ranks objects
by similarity (~relevance) to the query



Rank	Result
Query	
1	
2	
3	
4	
5	

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How do you

index **vectors**?

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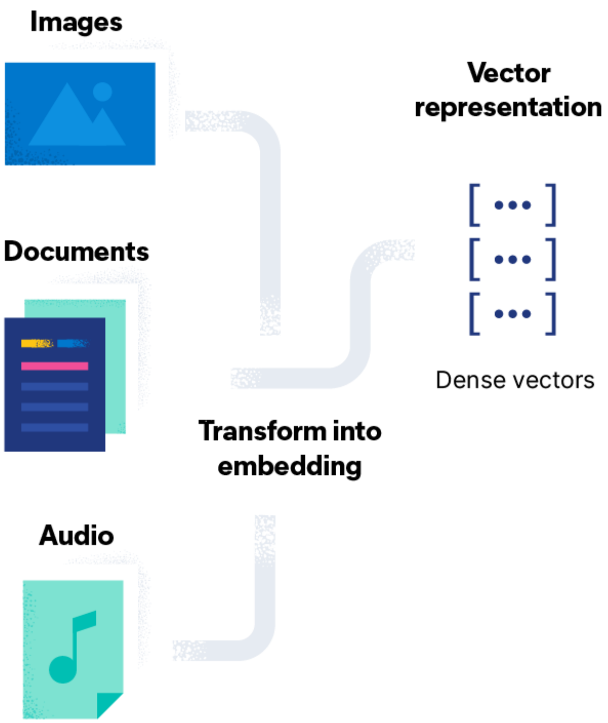
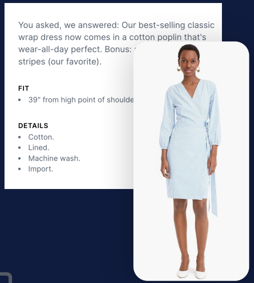
Architecture of Vector Search



`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

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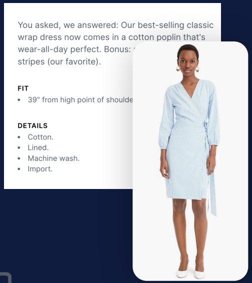

Source data

```
{
  "_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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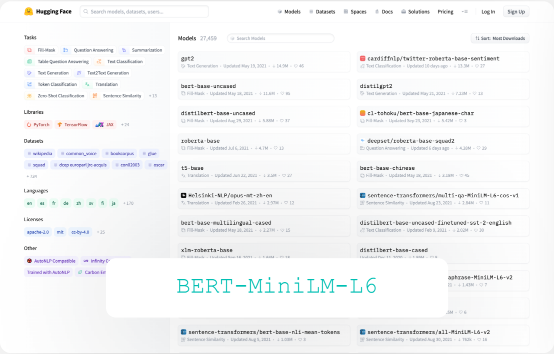
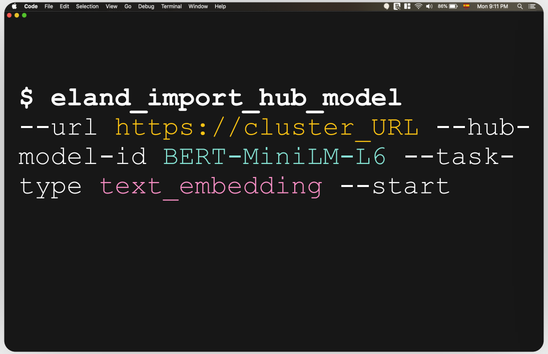
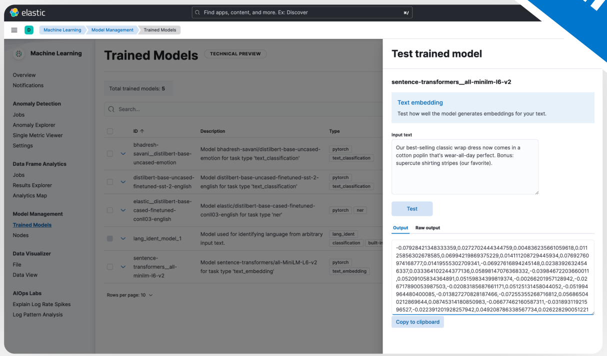
Eland Imports PyTorch Models







PyTorch → eland →

Select the appropriate model

Load it

Manage models

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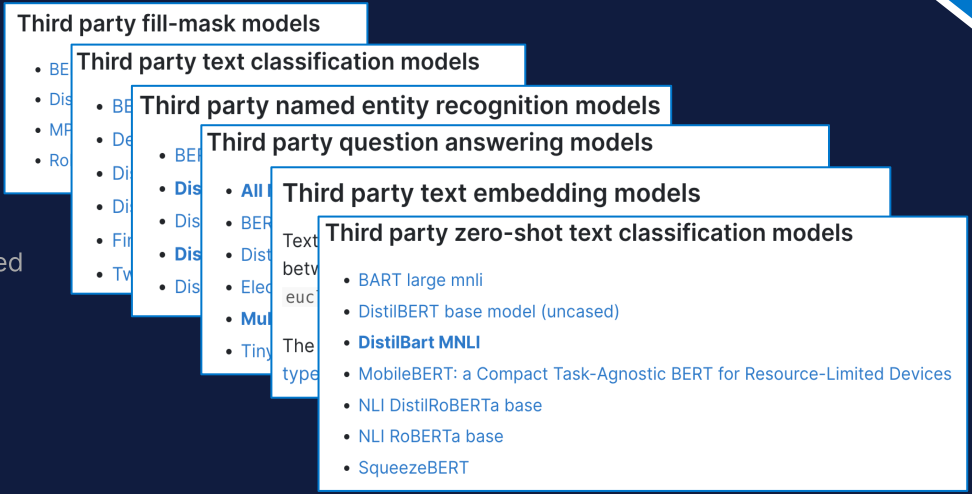
Elastic's range of supported NLP models

- **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



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

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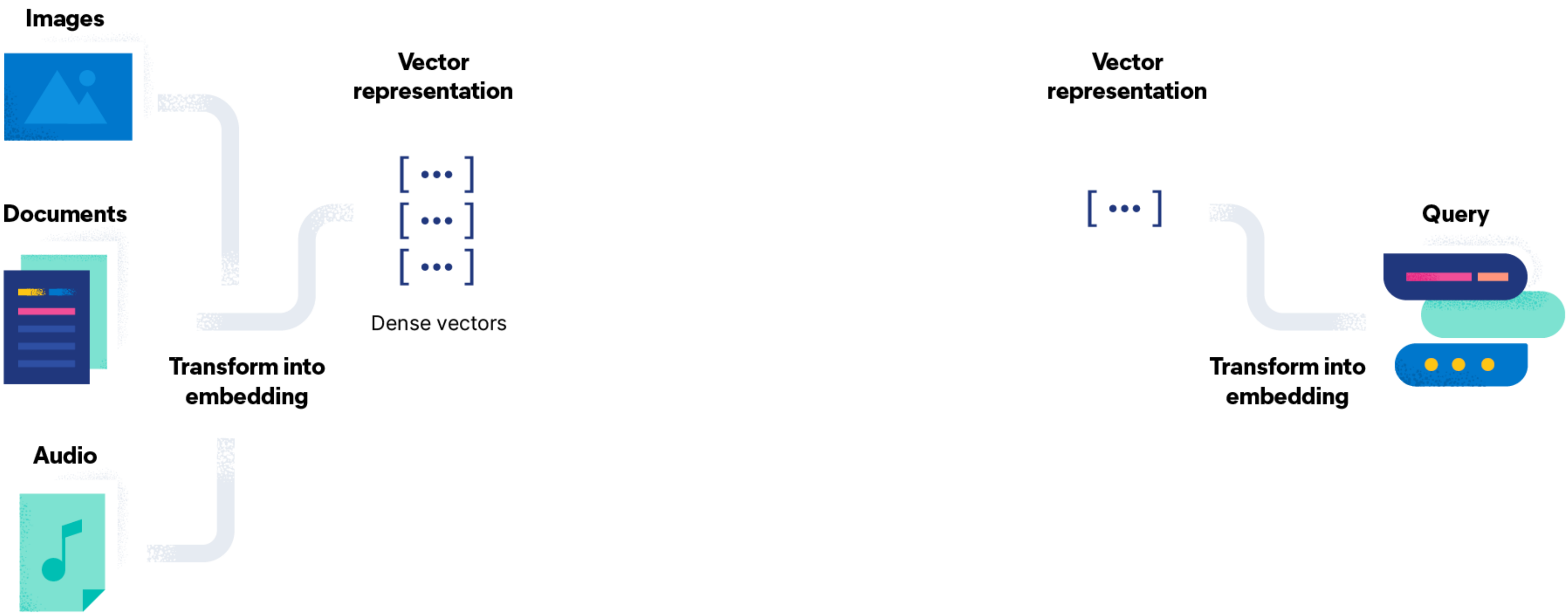
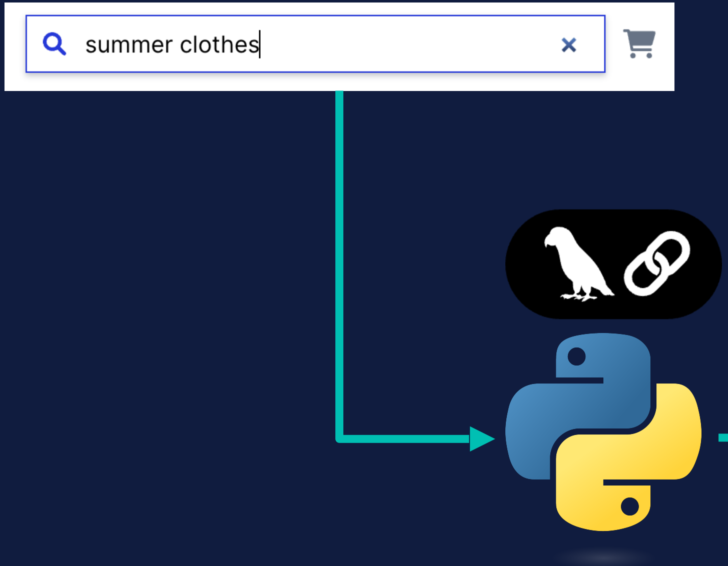
How do you

search vectors?

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)


```
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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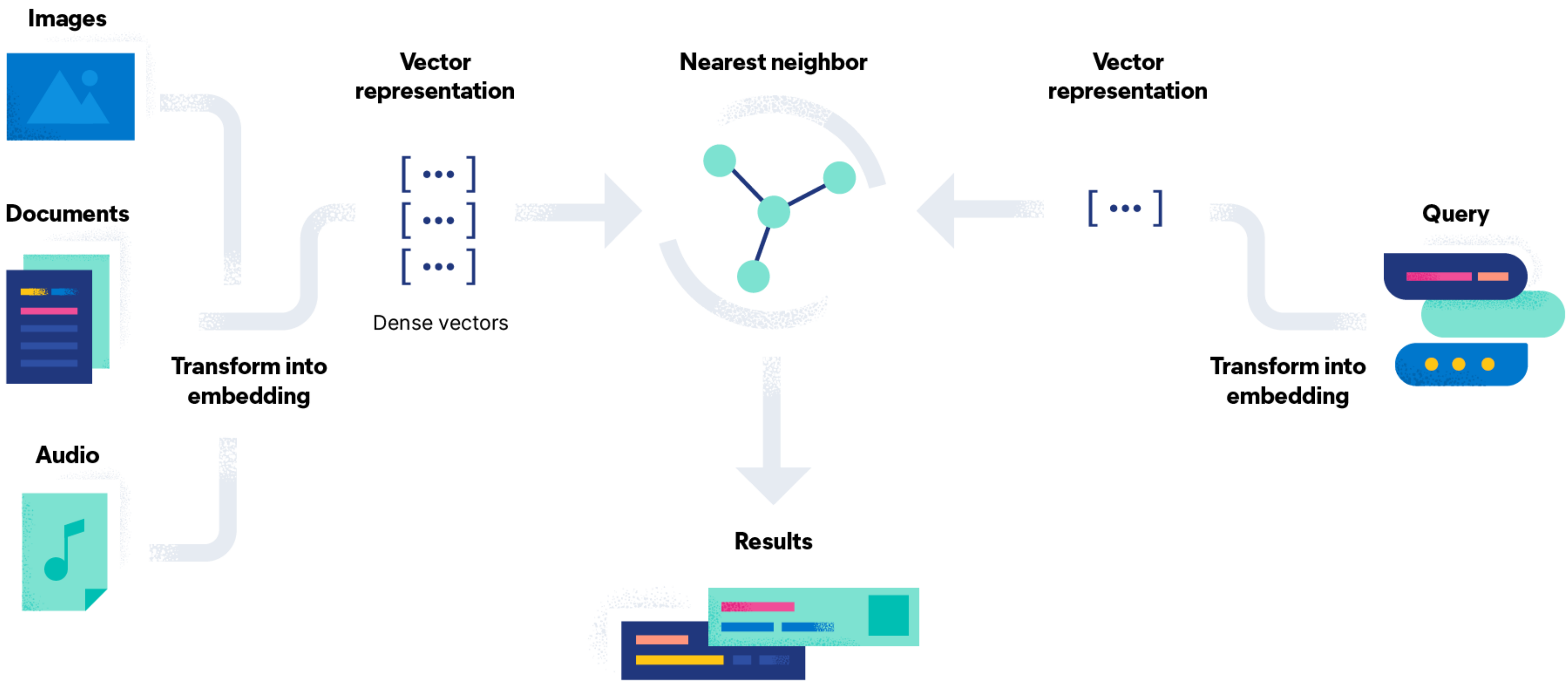
Architecture of Vector Search



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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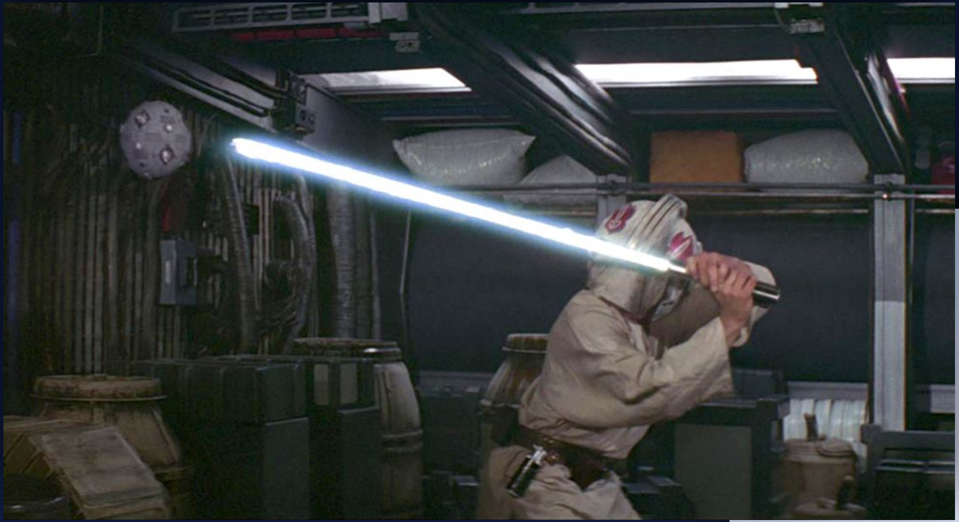
Problem

training vs actual use-case



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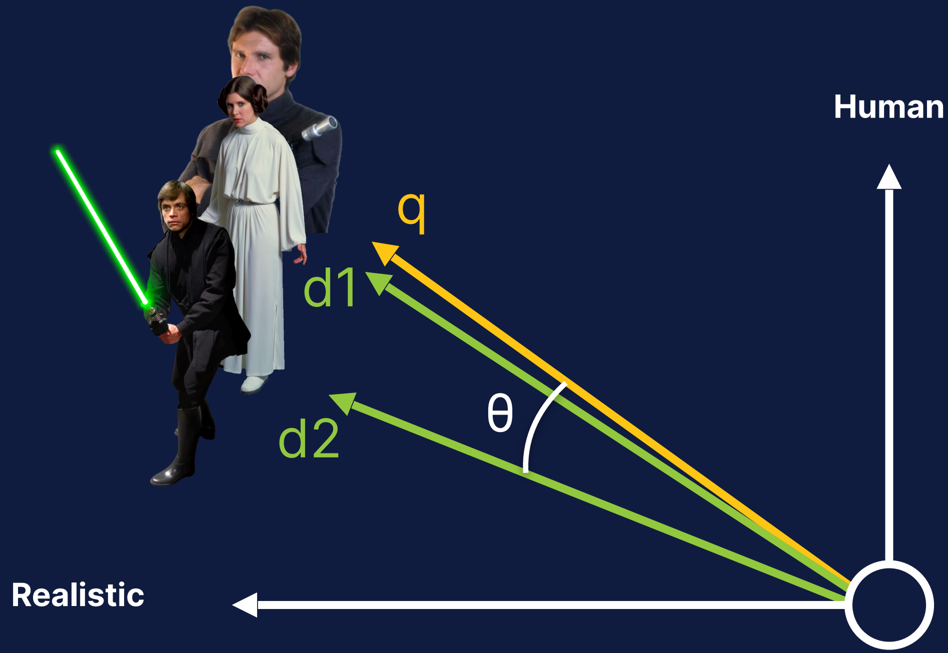
But how does it

really work?

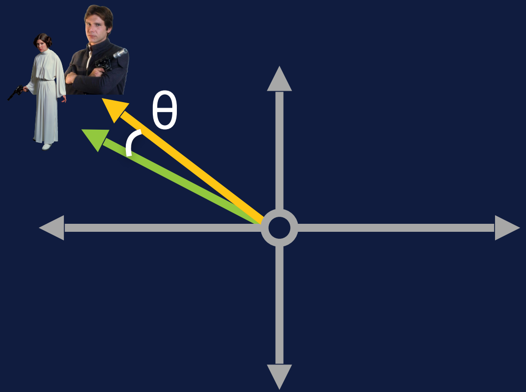
Similarity



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

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

Similarity: cosine (cosine)

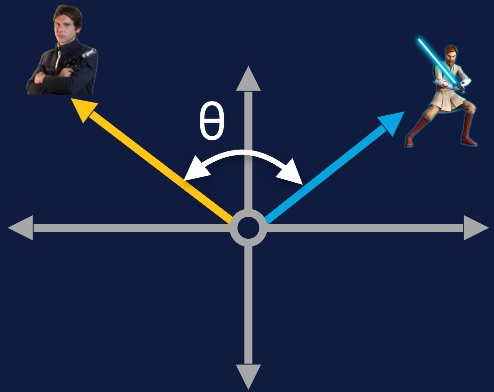


Similar vectors

θ close to 0

cos(θ) close to **1**

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

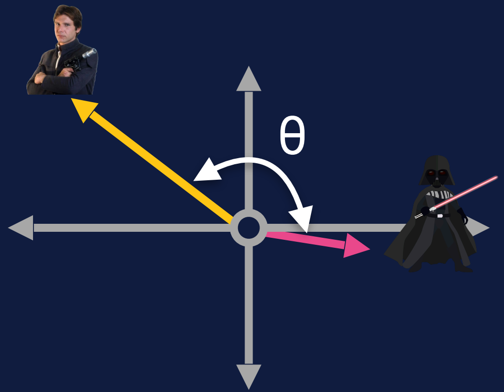


Orthogonal vectors

θ close to 90°

cos(θ) close to **0**

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



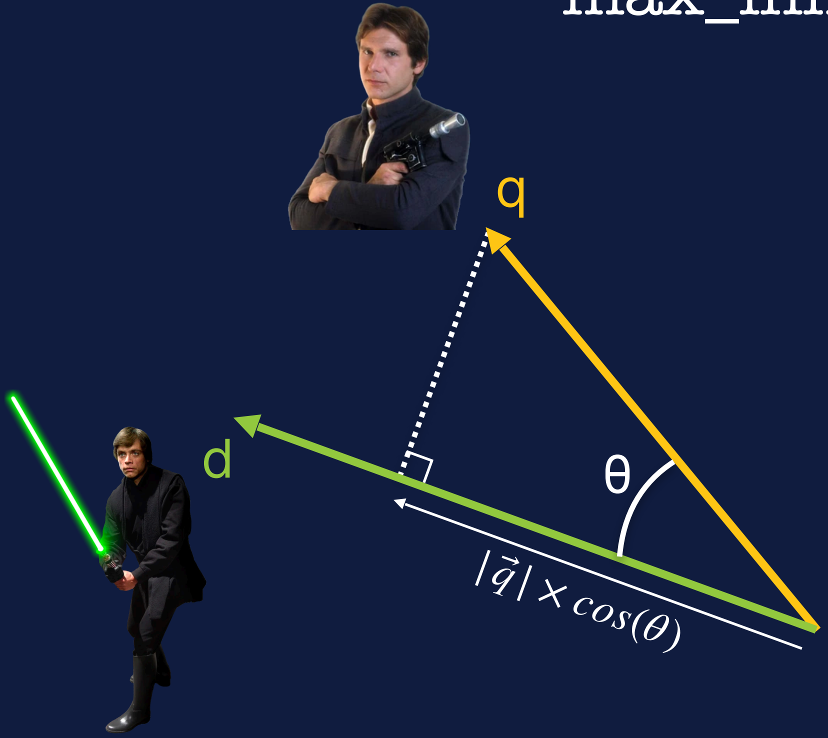
Opposite vectors

θ close to 180°

cos(θ) close to **-1**

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

Similarity: Dot Product (dot_product or max_inner_product)

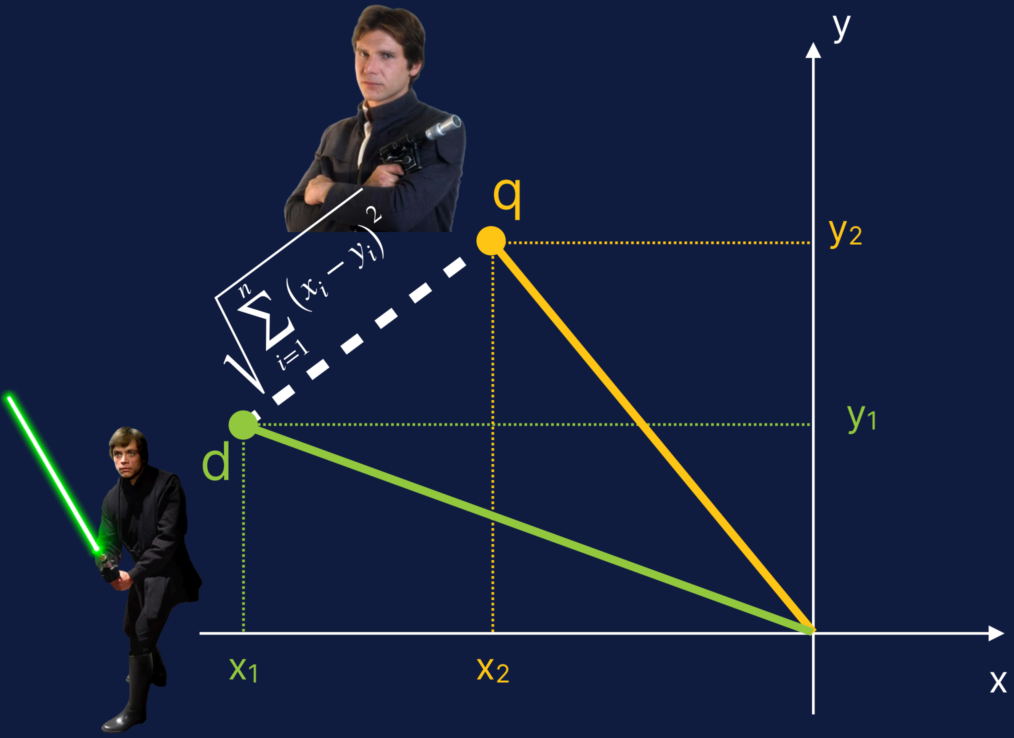


$$\vec{q} \times \vec{d} = |\vec{q}| \times cos(\theta) \times |\vec{d}|$$

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

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

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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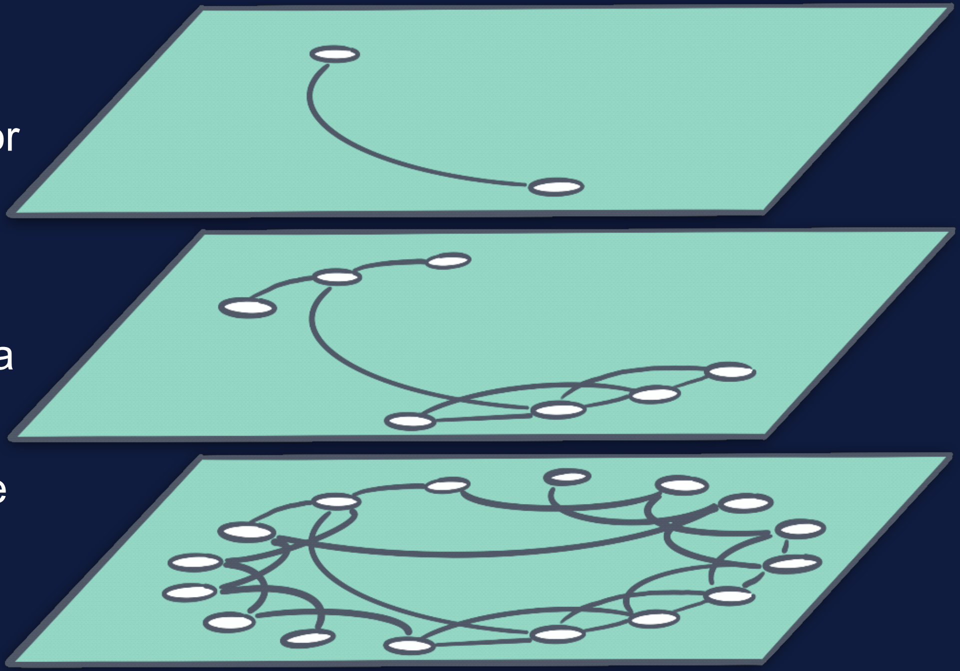
Brute Force

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

Scalar Quantization

Elasticsearch 8.14+ default

float32

Recall: High
Precision: High
Rescore: Likely Not Needed

Full RAM Required

int8

Recall: Good
Precision: Good
Oversampling: Moderate

Rescore: Reasonable

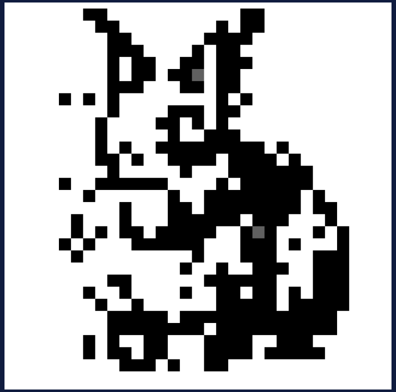
4X RAM Savings

int4

Recall: Low
Precision: Low
Oversampling: Needed

Rescore: may be slower

8X RAM Savings



bit

Recall: Bad
Precision: Bad
Oversampling: Needed

Rescore: Expensive and Limiting

32X RAM Savings

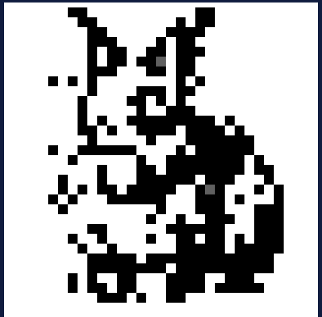
elastic

Scalar Quantization -> Better Binary Quantization

float32

int8

int4

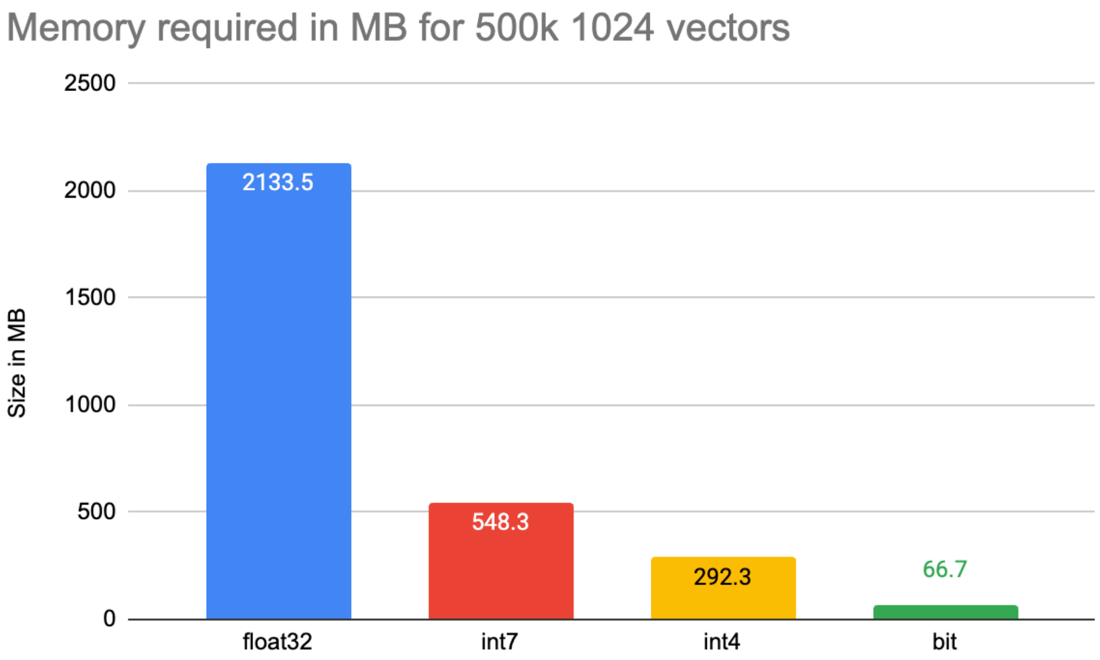


bit

BBQ*

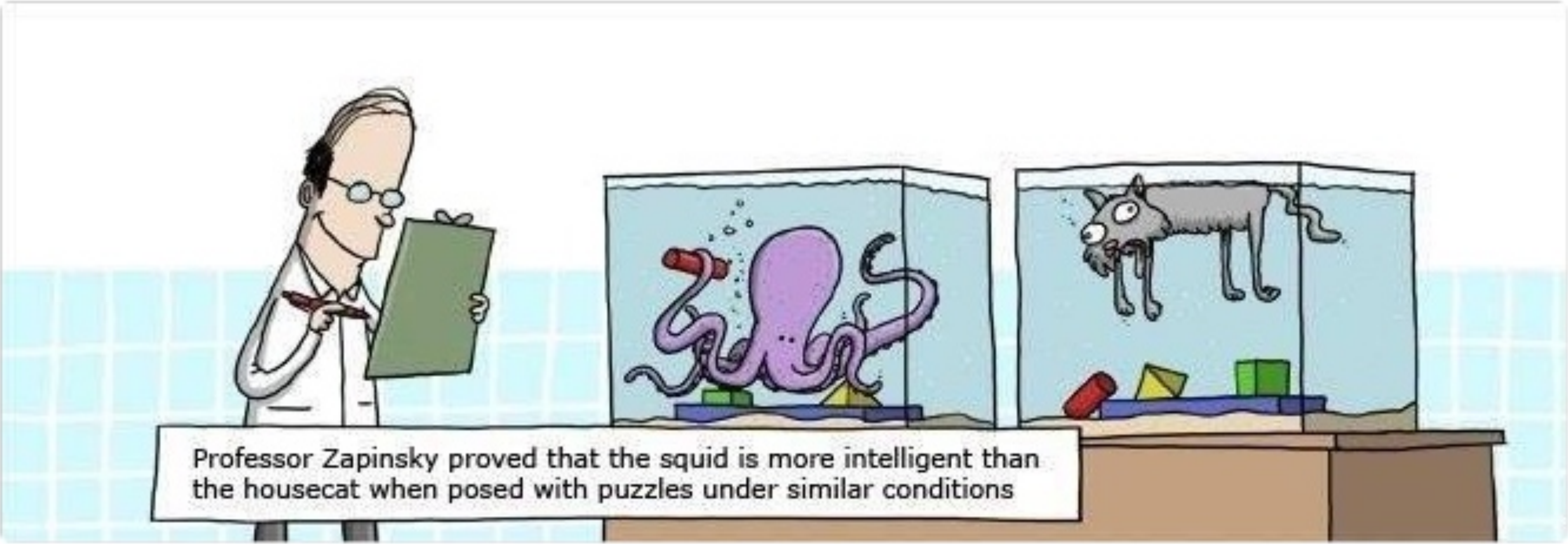
BBQ: 32X RAM savings.
Faster & more accurate than Product Quantization

Memory required



100M vectors?
Only 12GB!?! One single node.

Benchmarketing



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https://djdadoo.pilato.fr/

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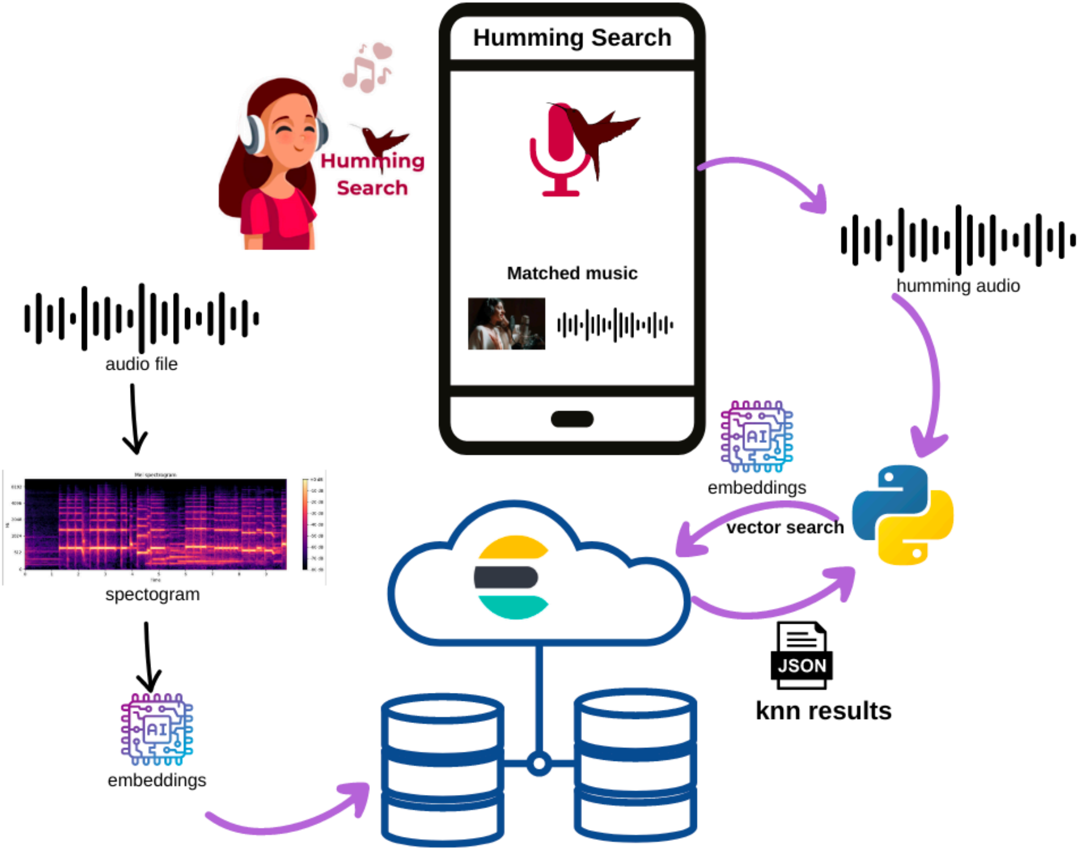

https://github.com/dadoonet/music-search/

Elasticsearch

You Know, for Hybrid Search

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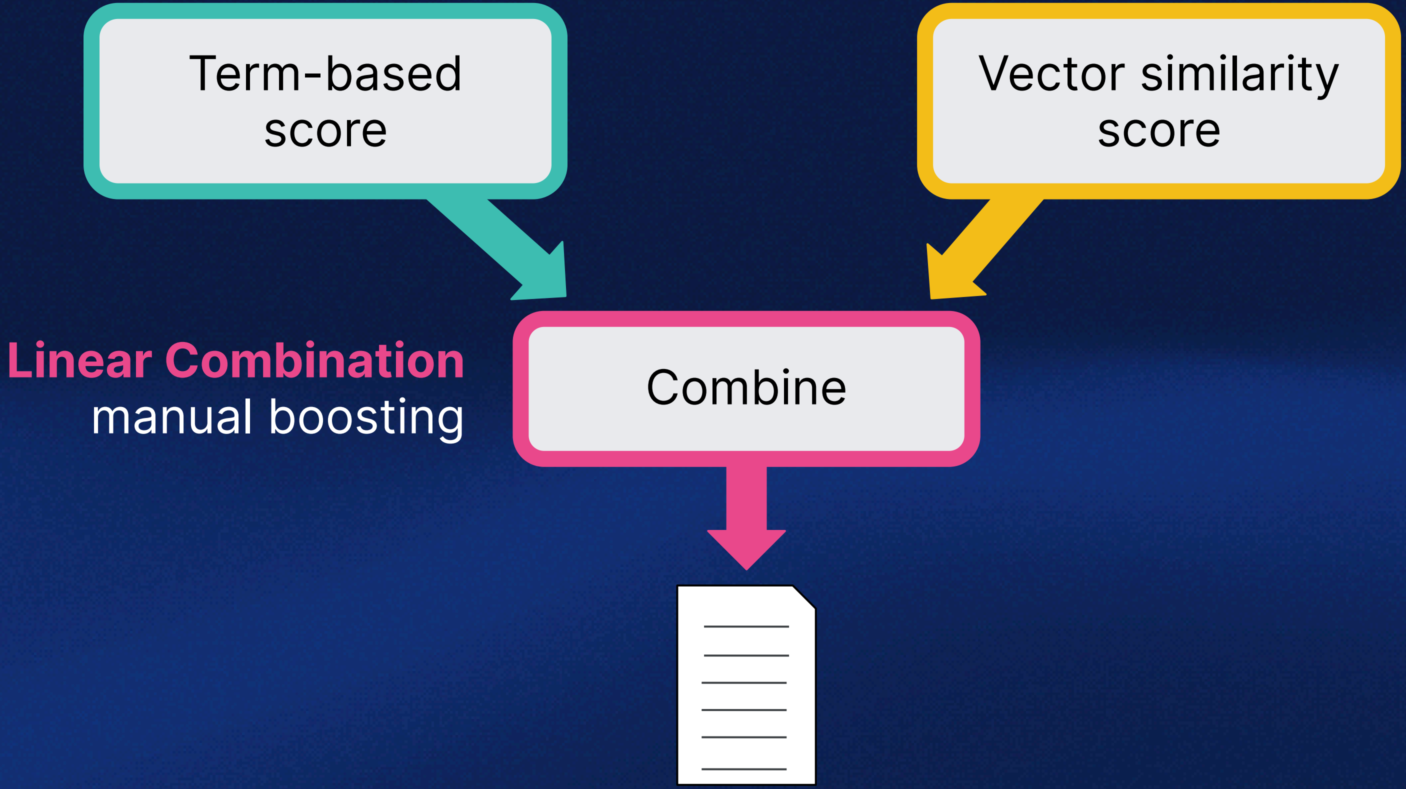
Hybrid scoring



```
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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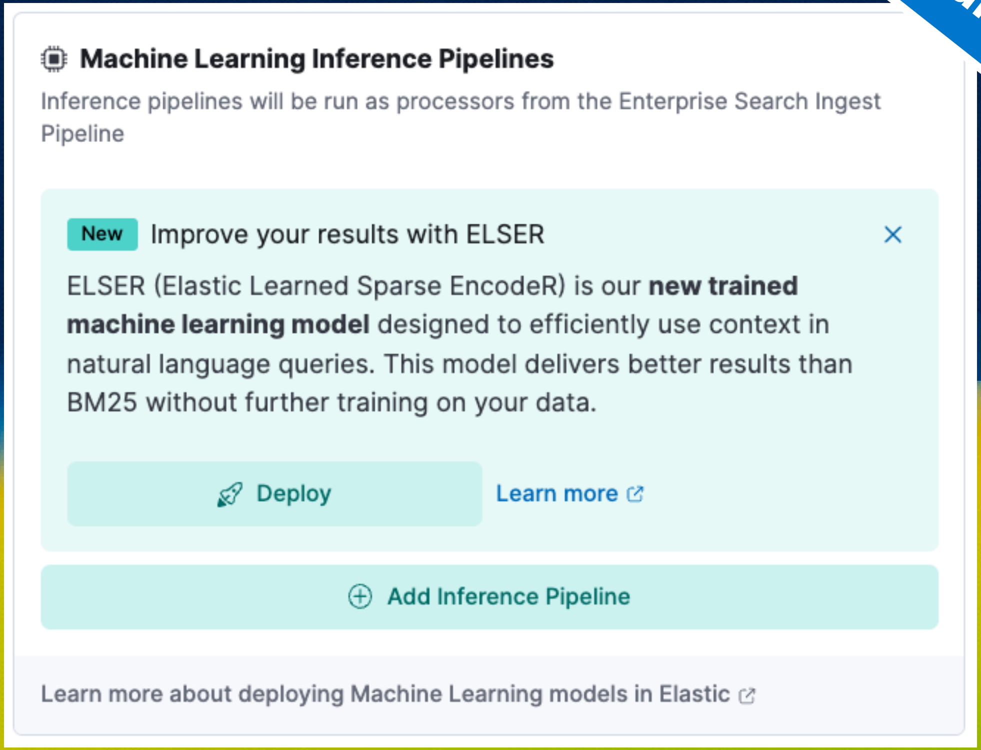
sparse_vector

Not BM25 or (dense) vector

Sparse vector like BM25

Stored as inverted index



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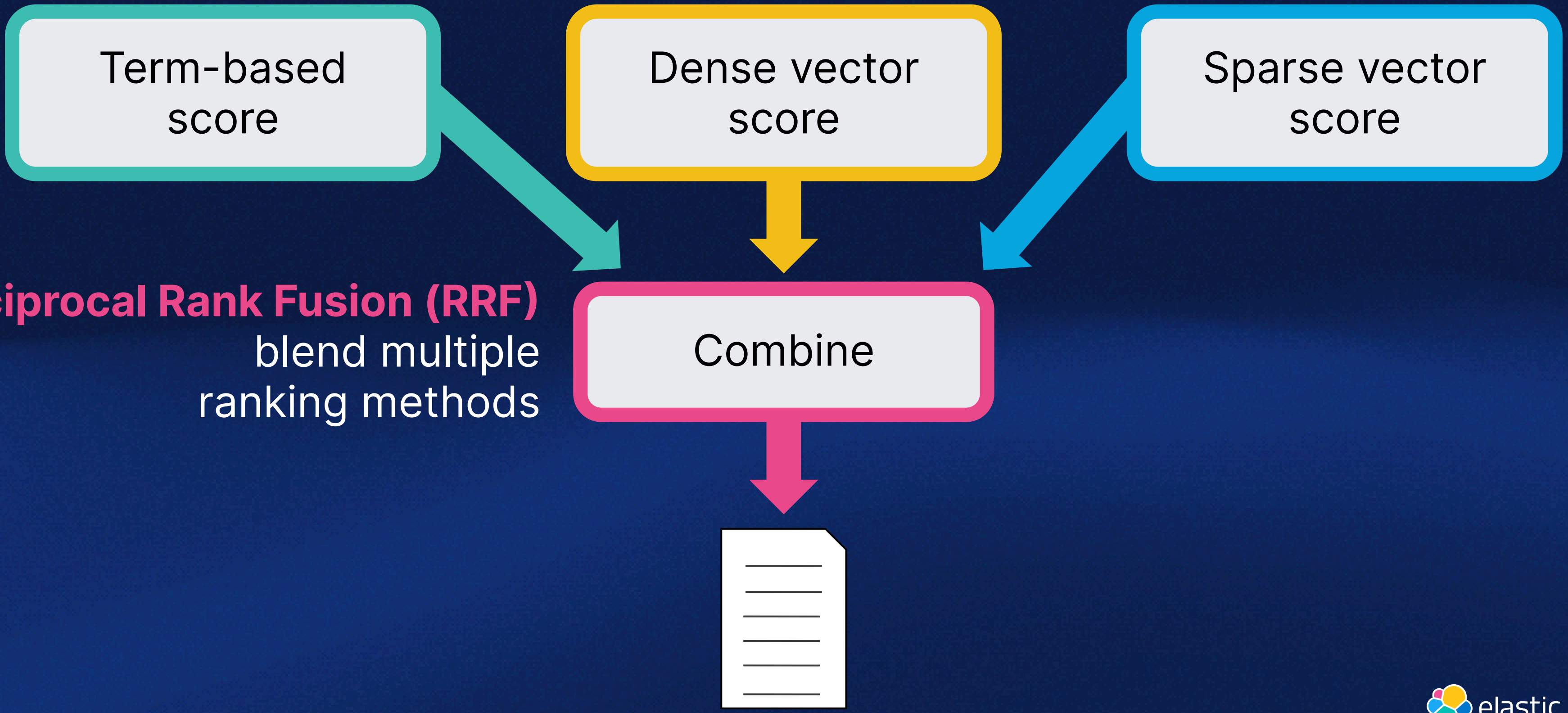
Hybrid ranking



Reciprocal Rank Fusion (RRF)
blend multiple
ranking methods

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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

elastic

```
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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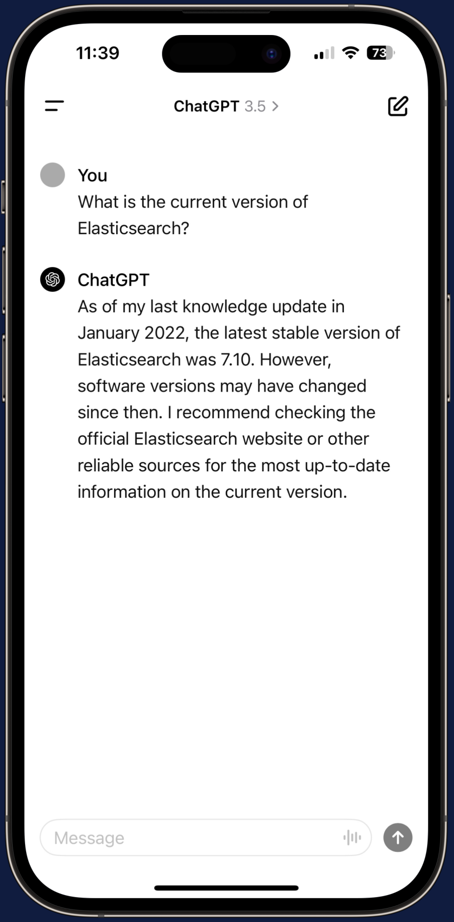
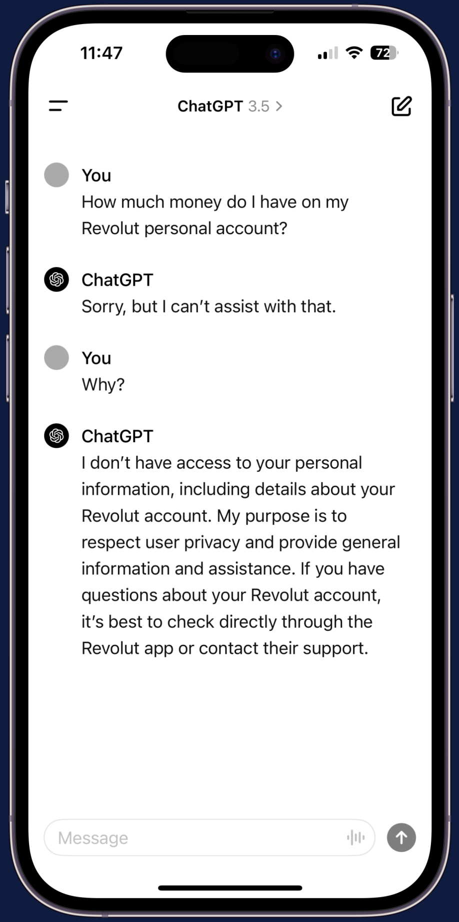
ChatGPT

Elastic and LLM


Gen AI
Search engines

LLM: opportunities and limits


11:39
73
ChatGPT 3.5 >
You
What is the current version of Elasticsearch?
ChatGPT
As of my last knowledge update in January 2022, the latest stable version of Elasticsearch was 7.10. However, software versions may have changed since then. I recommend checking the official Elasticsearch website or other reliable sources for the most up-to-date information on the current version.
Message


11:47
72
ChatGPT 3.5 >
You
How much money do I have on my Revolut personal account?
ChatGPT
Sorry, but I can't assist with that.
You
Why?
ChatGPT
I don't have access to your personal information, including details about your Revolut account. My purpose is to respect user privacy and provide general information and assistance. If you have questions about your Revolut account, it's best to check directly through the Revolut app or contact their support.
Message

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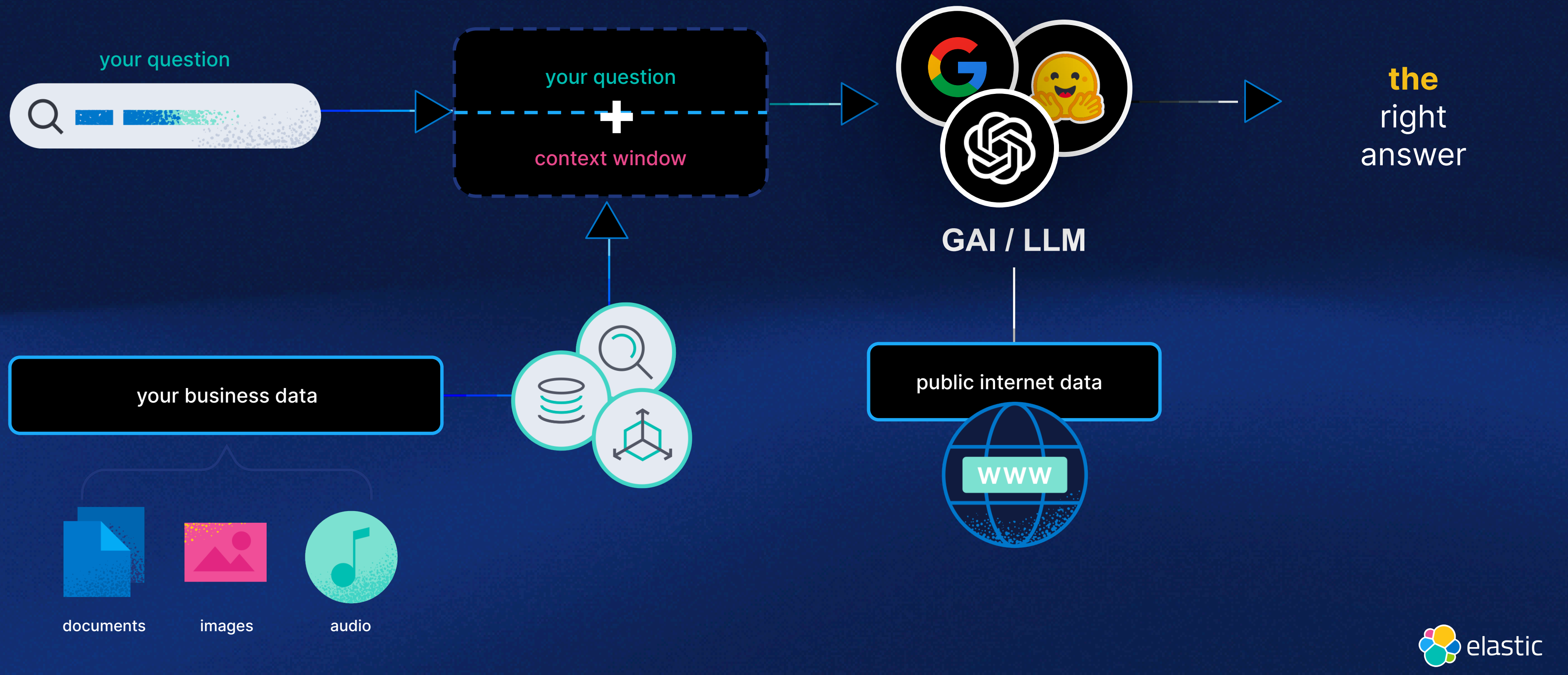
Retrieval Augmented Generation



Demo

Elastic Playground

elastic

me Home Online banking Enviroment setup

me Transaction search Financial summary Customer support

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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