Powerful Full-Text Search with Elasticsearch

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@xeraa

elastic

Who uses a Database?

elastic

Who uses Search?

elastic

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elasticsearch

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Developer

Question https://sli.do/xeraa

Answer https://twitter.com/xeraa

Store

Apache Lucene
Elasticsearch

Example

These are not the droids you are looking for.

`html_strip` Char Filter

These are not the droids you are looking for.

`standard` Tokenizer

These are not the droids you are looking for

`lowercase` Token Filter

these are not the droids you are looking for

`stop` Token Filter

droids you looking

`snowball` Token Filter

droid you look

Setup

elastic cloud

https://cloud.elastic.co

docker

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Docker Compose

```yaml
---
version: '2'
services:
  kibana:
    image: docker.elastic.co/kibana/kibana:$ELASTIC_VERSION
    links:
      - elasticsearch
    ports:
      - 5601:5601

  elasticsearch:
    image: docker.elastic.co/elasticsearch/elasticsearch:$ELASTIC_VERSION
    volumes:
      - esdata1:/usr/share/elasticsearch/data
    ports:
      - 9200:9200

volumes:
  esdata1:
    driver: local
```

Analyze

```
GET /_analyze
{
  "analyzer": "english",
  "text": "These are not the droids you are looking for."
}
```

```
{
  "tokens": [
    {
      "token": "droid",
      "start_offset": 18,
      "end_offset": 24,
      "type": "<ALPHANUM>",
      "position": 4
    },
    {
      "token": "you",
      "start_offset": 25,
      "end_offset": 28,
      "type": "<ALPHANUM>",
      "position": 5
    },
    ...
  ]
}
```

```
GET /_analyze
{
  "char_filter": [
    "html_strip"
  ],
  "tokenizer": "standard",
  "filter": [
    "lowercase",
    "stop",
    "snowball"
  ],
  "text": "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
    },
    ...
  ]
}
```

Stop Words

a an and are as at be but by for if in into is it no not of on or such that the their then there these they this to was will with

https://github.com/apache/lucene-solr/blob/master/lucene/analysis/common/src/java/org/apache/lucene/analysis/en/EnglishAnalyzer.java#L45-L52

Always Use Stop Words?

To be, or not to be.

Languages

Arabic, Armenian, Basque, Brazilian, Bulgarian, Catalan, CJK, Czech, Danish, Dutch, English, Finnish, French, Galician, German, Greek, Hindi, Hungarian, Indonesian, Irish, Italian, Latvian, Lithuanian, Norwegian, Persian, Portuguese, Romanian, Russian, Sorani, Spanish, Swedish, Turkish, Thai

Language Rules

English: `Philipp's` → `philipp`

French: `l'église` → `eglis`

German: `äußerst` → `ausserst`

More Language Plugins

Core: ICU (Asian languages), Kuromoji (advanced Japanese), Phonetic, SmartCN, Stempel (Polish), Ukrainian

Community: Hebrew, Vietnamese, Network Address Analysis, String2Integer,...

Polish

To nie są droidy, których szukasz.

```
GET /_analyze
{
  "analyzer": "polish",
  "text": "To nie są droidy, których szukasz."
}
```

Polish

droid szukać

Polish with the English Analyzer

nie są droidi których szukasz

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Polish Stop Words

https://github.com/apache/lucene-solr/blob/master/lucene/analysis/stempel/src/resources/org/apache/lucene/analysis/pl/stopwords.txt

Detect Languages

https://github.com/spinscale/elasticsearch-ingest-langdetect

```
PUT /_ingest/pipeline/langdetect-pipeline
{
  "description": "A pipeline to detect languages",
  "processors": [
    {
      "langdetect": {
        "field": "quote",
        "target_field": "language"
      }
    }
  ]
}
```

```
GET /_ingest/pipeline/langdetect-pipeline/_simulate
{
  "docs": [
    {
      "_source": {
        "quote": "To nie są droidy, których szukasz."
      }
    }
  ]
}
```

```
{
  "docs" : [
    {
      "doc" : {
        "_index" : "_index",
        "_type" : "_type",
        "_id" : "_id",
        "_source" : {
          "language" : "pl",
          "quote" : "To nie są droidy, których szukasz."
        },
        "_ingest" : {
          "timestamp" : "2019-03-21T12:22:35.118896Z"
        }
      }
    }
  ]
}
```


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Another Example

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

Another Example

obi wan never told you what happen your father

Another Example

No. I am your father.

Another Example

i am your father

Inverted Index

	ID 1	ID 2	ID 3
am	0	0	1[2]
droid	1[4]	0	0
father	0	1[9]	1[4]
happen	0	1[6]	0
i	0	0	1[1]
look	1[7]	0	0
never	0	1[2]	0
obi	0	1[0]	0
told	0	1[3]	0
wan	0	1[1]	0
what	0	1[5]	0
you	1[5]	1[4]	0
your	0	1[8]	1[3]

To / The Index

```
PUT /starwars
{
  "settings": {
    "number_of_shards": 1,
    "analysis": {
      "filter": {
        "my_synonym_filter": {
          "type": "synonym",
          "synonyms": [
            "father,dad",
            "droid => droid,machine"
          ]
        }
      },
```

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```
    "analyzer": {
      "my_analyzer": {
        "char_filter": [
          "html_strip"
        ],
        "tokenizer": "standard",
        "filter": [
          "lowercase",
          "stop",
          "snowball",
          "my_synonym_filter"
        ]
      }
    }
  }
},
```

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```
"mappings": {
  "_doc": {
    "properties": {
      "quote": {
        "type": "text",
        "analyzer": "my_analyzer"
      }
    }
  }
}
}
```

Synonyms

Index `synonym` **or query time** `synonym_graph`

```
GET /starwars/_mapping

GET /starwars/_settings
```

```
PUT /starwars/_doc/1
{
  "quote": "These are <em>not</em> the droids you are looking for."
}
PUT /starwars/_doc/2
{
  "quote": "Obi-Wan never told you what happened to your father."
}
PUT /starwars/_doc/3
{
  "quote": "<b>No</b>. I am your father."
}
```

```
GET /starwars/_doc/1

GET /starwars/_doc/1/_source
```

Multi Lingual

Index

```
PUT /starwars_en/_doc/1
```

Field

```
{ "quote_en": "...", "quote_de": "..." }
```

Search

```
POST /starwars/_search
{
  "query": {
    "match_all": { }
  }
}
```

```
{
  "took": 1,
  "timed_out": false,
  "_shards": {
    "total": 5,
    "successful": 5,
    "failed": 0
  },
  "hits": {
    "total": 3,
    "max_score": 1,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "2",
        "_score": 1,
        "_source": {
          "quote": "Obi-Wan never told you what happened to your father."
        }
      },
      ...
```


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```
POST /starwars/_search
{
  "query": {
    "match": {
      "quote": "droid"
    }
  }
}
```

```
{
  "took": 2,
  "timed_out": false,
  "_shards": {
    "total": 5,
    "successful": 5,
    "failed": 0
  },
  "hits": {
    "total": 1,
    "max_score": 0.39556286,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "1",
        "_score": 0.39556286,
        "_source": {
          "quote": "These are <em>not</em> the droids you are looking for."
        }
      }
    ]
  }
}
```


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```
POST /starwars/_search
{
  "query": {
    "match": {
      "quote": "dad"
    }
  }
}
```

```
...
  "hits": {
    "total": 2,
    "max_score": 0.41913947,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "3",
        "_score": 0.41913947,
        "_source": {
          "quote": "<b>No</b>. I am your father."
        }
      },
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "2",
        "_score": 0.39291072,
        "_source": {
          "quote": "Obi-Wan never told you what happened to your father."
        }
      }
    ]
  }
}
```


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```
POST /starwars/_doc/0/_explain
{
  "query": {
    "match": {
      "quote": "dad"
    }
  }
}
```

```
{
  "_index": "starwars",
  "_type": "_doc",
  "_id": "0",
  "matched": false
}
```

```
POST /starwars/_doc/1/_explain
{
  "query": {
    "match": {
      "quote": "dad"
    }
  }
}
```

```
{
  "_index": "starwars",
  "_type": "_doc",
  "_id": "1",
  "matched": false,
  "explanation": {
    "value": 0,
    "description": "no matching term",
    "details": []
  }
}
```

```
POST /starwars/_doc/2/_explain
{
  "query": {
    "match": {
      "quote": "dad"
    }
  }
}
```

```
{
  "_index": "starwars",
  "_type": "_doc",
  "_id": "2",
  "matched": true,
  "explanation": {
    ...
```

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```
POST /starwars/_search
{
  "query": {
    "match": {
      "quote": "machine"
    }
  }
}
```

```
{
  "took": 2,
  "timed_out": false,
  "_shards": {
    "total": 1,
    "successful": 1,
    "skipped": 0,
    "failed": 0
  },
  "hits": {
    "total": 1,
    "max_score": 1.2499592,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "1",
        "_score": 1.2499592,
        "_source": {
          "quote": "These are <em>not</em> the droids you are looking for."
        }
      }
    ]
  }
}
```


elastic

```
POST /starwars/_search
{
  "query": {
    "match_phrase": {
      "quote": "I am your father"
    }
  }
}
```

elastic

```
{
  "took": 3,
  "timed_out": false,
  "_shards": {
    "total": 5,
    "successful": 5,
    "failed": 0
  },
  "hits": {
    "total": 1,
    "max_score": 1.5665855,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "3",
        "_score": 1.5665855,
        "_source": {
          "quote": "<b>No</b>. I am your father."
        }
      }
    ]
  }
}
```

```
POST /starwars/_search
{
  "query": {
    "match_phrase": {
      "quote": {
        "query": "I am father",
        "slop": 1
      }
    }
  }
}
```

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```
{
  "took": 16,
  "timed_out": false,
  "_shards": {
    "total": 5,
    "successful": 5,
    "failed": 0
  },
  "hits": {
    "total": 1,
    "max_score": 0.8327639,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "3",
        "_score": 0.8327639,
        "_source": {
          "quote": "<b>No</b>. I am your father."
        }
      }
    ]
  }
}
```

```
POST /starwars/_search
{
  "query": {
    "match_phrase": {
      "quote": {
        "query": "I am not your father",
        "slop": 1
      }
    }
  }
}
```

elastic

```
{
  "took": 5,
  "timed_out": false,
  "_shards": {
    "total": 5,
    "successful": 5,
    "failed": 0
  },
  "hits": {
    "total": 1,
    "max_score": 1.0409548,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "3",
        "_score": 1.0409548,
        "_source": {
          "quote": "<b>No</b>. I am your father."
        }
      }
    ]
  }
}
```

```
POST /starwars/_search
{
  "query": {
    "match": {
      "quote": {
        "query": "van",
        "fuzziness": "AUTO"
      }
    }
  }
}
```

```
{
  "took": 14,
  "timed_out": false,
  "_shards": {
    "total": 5,
    "successful": 5,
    "failed": 0
  },
  "hits": {
    "total": 1,
    "max_score": 0.18155496,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "2",
        "_score": 0.18155496,
        "_source": {
          "quote": "Obi-Wan never told you what happened to your father."
        }
      }
    ]
  }
}
```


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```
POST /starwars/_search
{
  "query": {
    "match": {
      "quote": {
        "query": "ovi-van",
        "fuzziness": 1
      }
    }
  }
}
```

```
{
  "took": 109,
  "timed_out": false,
  "_shards": {
    "total": 5,
    "successful": 5,
    "failed": 0
  },
  "hits": {
    "total": 1,
    "max_score": 0.3798467,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "2",
        "_score": 0.3798467,
        "_source": {
          "quote": "Obi-Wan never told you what happened to your father."
        }
      }
    ]
  }
}
```


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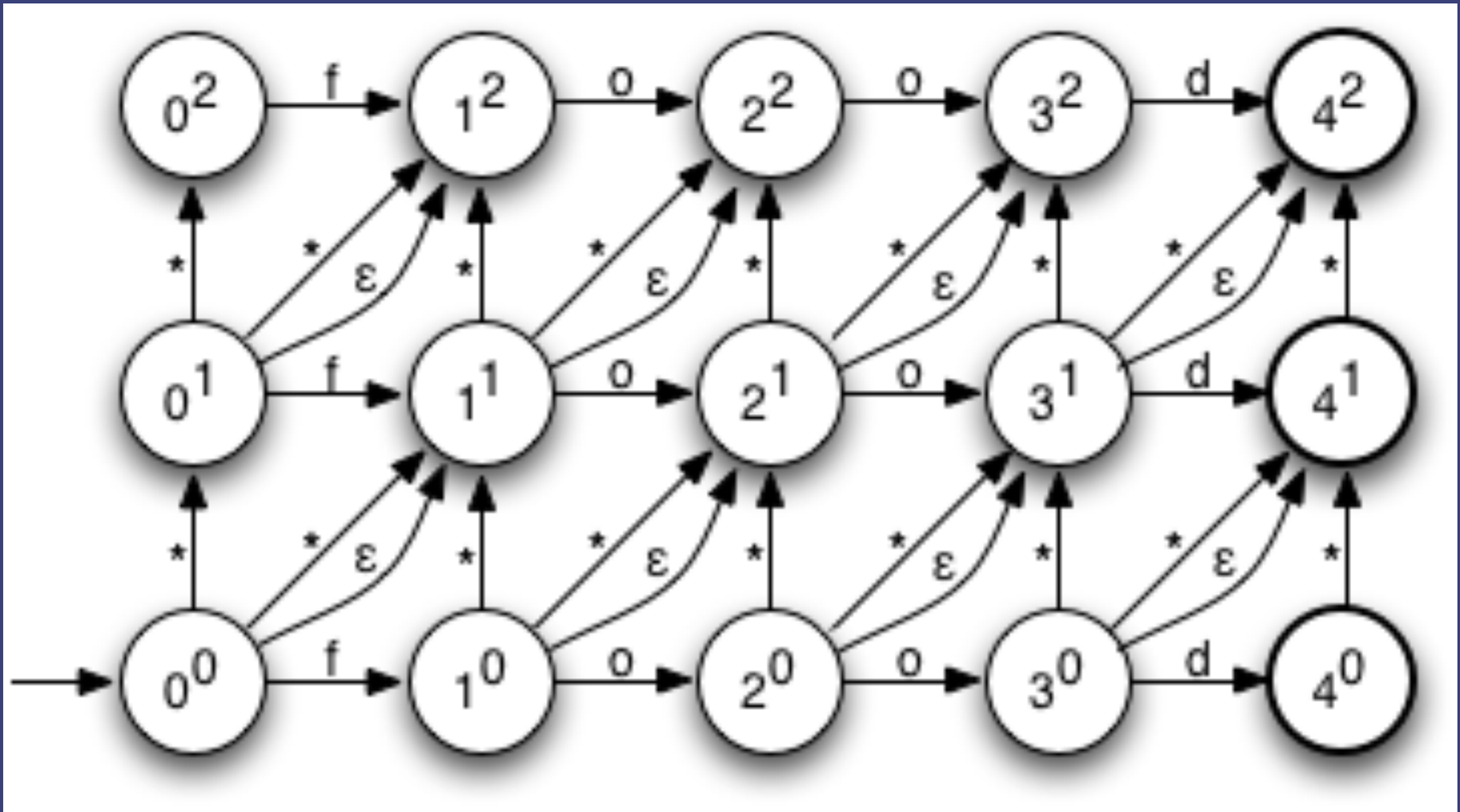
FuzzyQuery History

http://blog.mikemccandless.com/2011/03/lucenes-fuzzyquery-is-100-times-faster.html

Before: Brute force

Now: Levenshtein Automaton



http://blog.notdot.net/2010/07/Damn-Cool-Algorithms-Levenshtein-Automata

```
SELECT *
  FROM starwars
 WHERE quote LIKE "?an" OR
       quote LIKE "V?n" OR
       quote LIKE "Va?"
```

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Score

Term Frequency / Inverse Document Frequency (TF/IDF)

Search one term

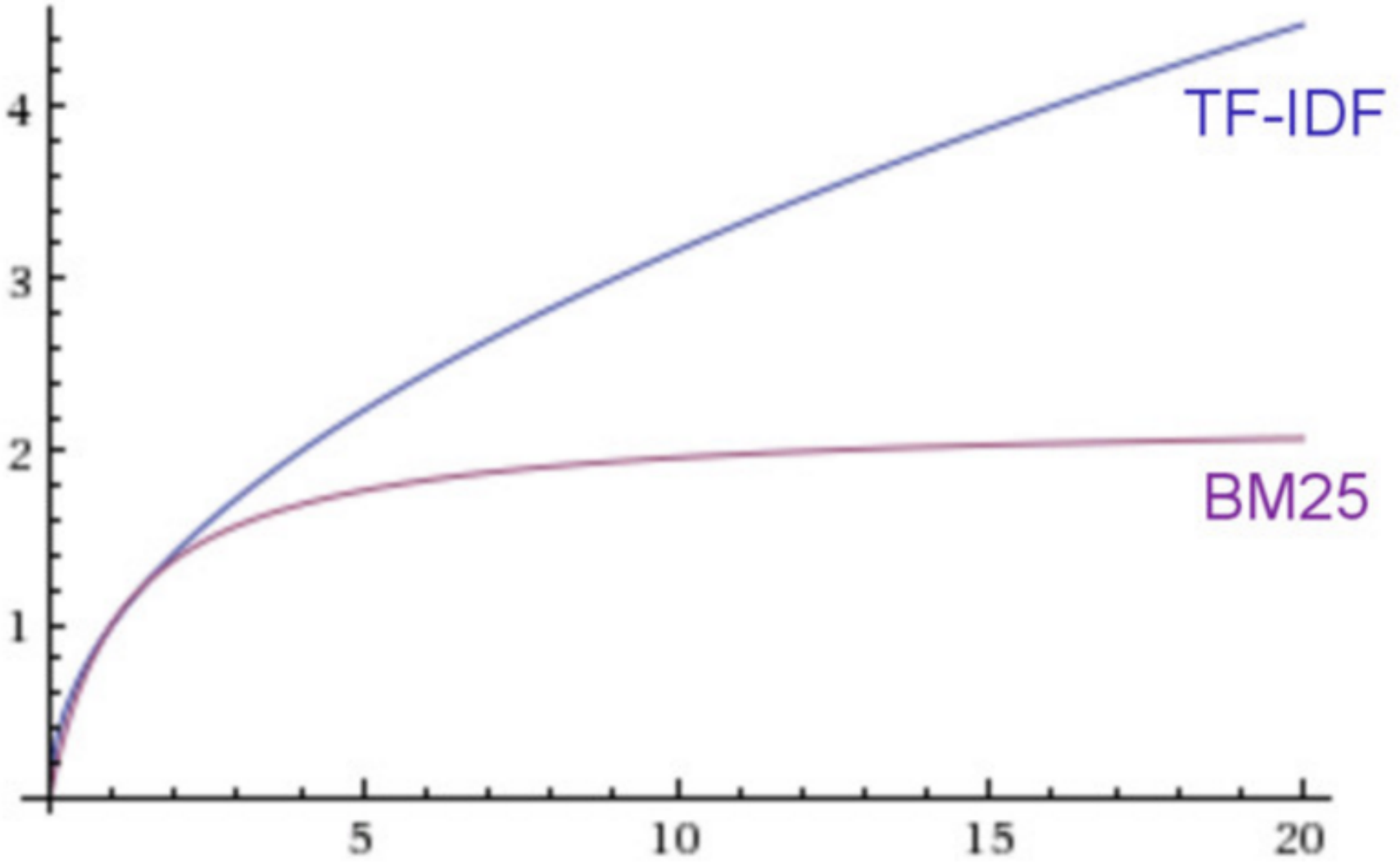
BM25

Default in Elasticsearch 5.0

https://speakerdeck.com/elastic/improved-text-scoring-with-bm25

Term Frequency

$$tf(t\ in\ d) = \sqrt{frequency}$$



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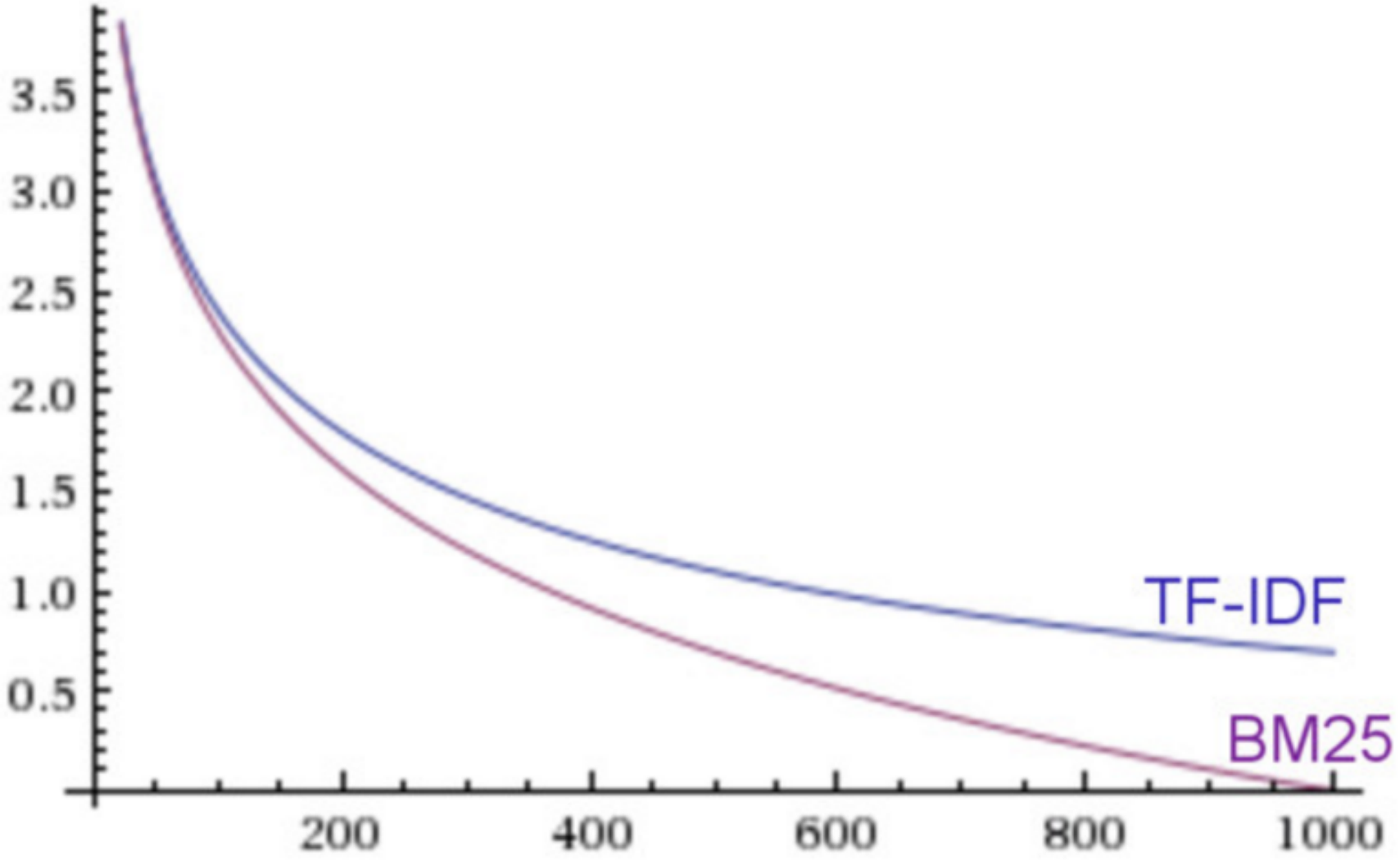
Inverse Document Frequency

$$idf(t) = 1 + log(\frac{numDocs}{docFreq + 1})$$



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Field-Length Norm

$$norm(d) = \frac{1}{\sqrt{numTerms}}$$

```
POST /starwars/_search?explain=true
{
  "query": {
    "match": {
      "quote": "father"
    }
  }
}
```

```
...
"_explanation": {
  "value": 0.41913947,
  "description": "weight(Synonym(quote:dad quote:father) in 0) [PerFieldSimilarity], result of:",
  "details": [
    {
      "value": 0.41913947,
      "description": "score(doc=0,freq=2.0 = termFreq=2.0\n), product of:",
      "details": [
        {
          "value": 0.2876821,
          "description": "idf(docFreq=1, docCount=1)",
          "details": []
        },
        {
          "value": 1.4569536,
          "description": "tfNorm, computed from:",
          "details": [
            {
              "value": 2,
              "description": "termFreq=2.0",
              "details": []
            },
            ...
```


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Score

0.41913947: i am your father

0.39291072: obi wan never told you what happen your father

Vector Space Model

Search multiple terms

Search your father

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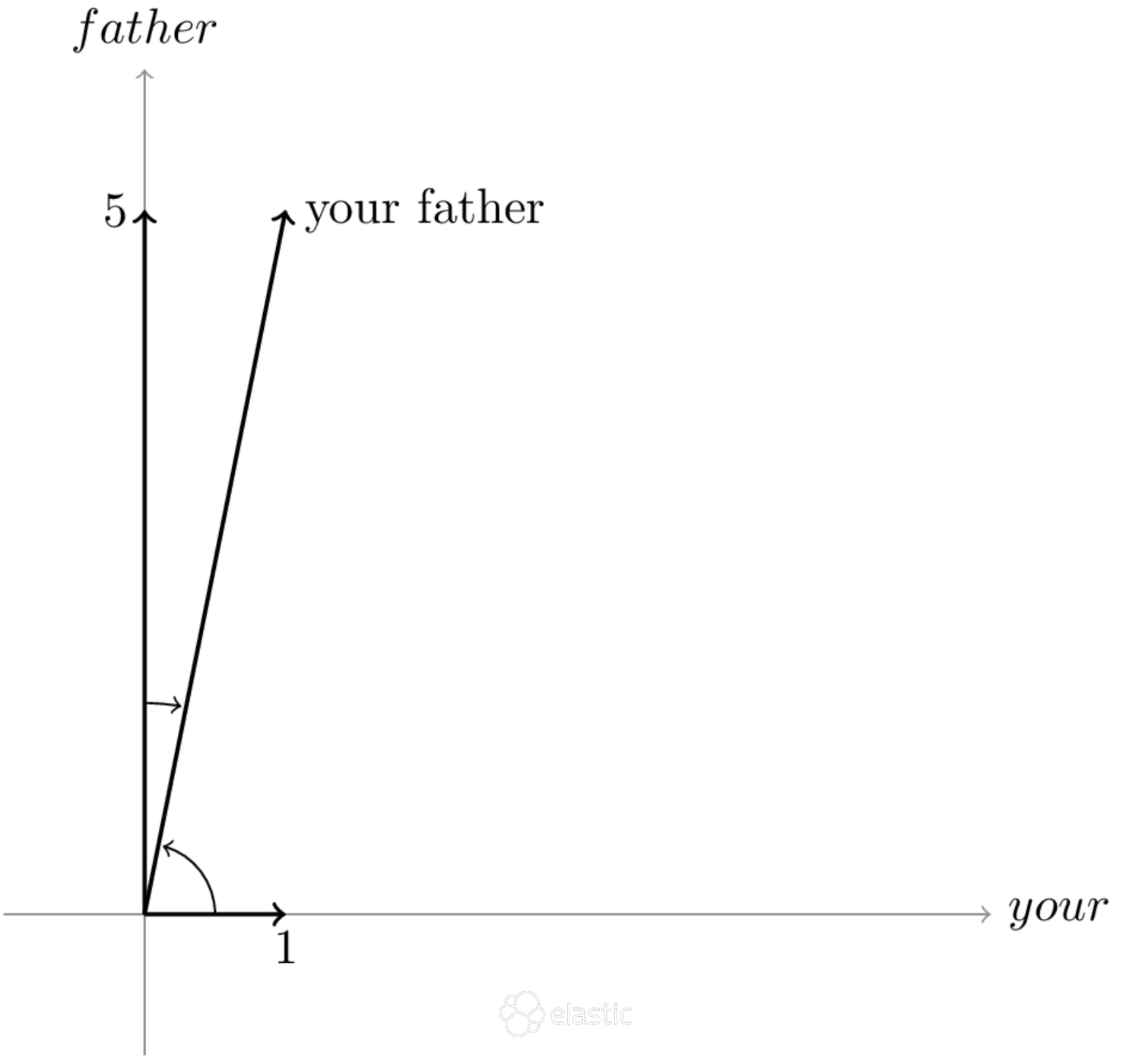
father
5
your father
your
1

Coordination Factor

Reward multiple terms

Search for 3 terms

1 term: $X \cdot \frac{1}{3}$

2 terms: $(X + Y) \cdot \frac{2}{3}$

3 terms: $(X + Y + Z) \cdot \frac{3}{3}$

Practical Scoring Function

Putting it all together

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```
score(q,d)  =
            queryNorm(q)
          · coord(q,d)
          · Σ (
                tf(t in d)
              · idf(t)²
              · t.getBoost()
              · norm(t,d)
            ) (t in q)
```

Function Score

Script, weight, random, field value, decay (geo or date)

```
POST /starwars/_search
{
  "query": {
    "function_score": {
      "query": {
        "match": {
          "quote": "father"
        }
      },
      "random_score": {}
    }
  }
}
```

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Compare Scores

"100% perfect" vs a "50%" match

Don't do this. Seriously. Stop trying to think about your problem this way, it's not going to end well.

— https://wiki.apache.org/lucene-java/ScoresAsPercentages

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```
GET /starwars/_analyze
{
  "analyzer" : "my_analyzer",
  "text": "These are my father's machines."
}
```

```
{ "tokens": [
    {
      "token": "my",
      "start_offset": 10,
      "end_offset": 12,
      "type": "<ALPHANUM>",
      "position": 2
    },
    {
      "token": "father",
      "start_offset": 13,
      "end_offset": 21,
      "type": "<ALPHANUM>",
      "position": 3
    },
    {
      "token": "dad",
      "start_offset": 13,
      "end_offset": 21,
      "type": "SYNONYM",
      "position": 3
    },
    {
      "token": "machin",
      "start_offset": 22,
      "end_offset": 30,
      "type": "<ALPHANUM>",
      "position": 4
    }
] }
```

```
PUT /starwars/_doc/4
{
  "quote": "These are my father's machines."
}
```

```
POST /starwars/_search
{
  "query": {
    "match": {
      "quote": "my father machine"
    }
  }
}
```

```
"hits": {
  "total": 4,
  "max_score": 2.92523,
  "hits": [
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "4",
      "_score": 2.92523,
      "_source": {
        "quote": "These are my father's machines."
      }
    },
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "1",
      "_score": 0.8617505,
      "_source": {
        "quote": "These are <em>not</em> the droids you are looking for."
      }
    },
    ...
```


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2.92523 == 100%

```
DELETE /starwars/_doc/4

POST /starwars/_search
{
  "query": {
    "match": {
      "quote": "my father machine"
    }
  }
}
```

```
"hits": {
  "total": 3,
  "max_score": 1.2499592,
  "hits": [
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "1",
      "_score": 1.2499592,
      "_source": {
        "quote": "These are <em>not</em> the droids you are looking for."
      }
    },
    ...
```


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1.2499592 == 43% or 100%?

```
PUT /starwars/_doc/4
{
  "quote": "These droids are my father's father's machines."
}

POST /starwars/_search
{
  "query": {
    "match": {
      "quote": "my father machine"
    }
  }
}
```

```
"hits": {
  "total": 4,
  "max_score": 3.0068164,
  "hits": [
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "4",
      "_score": 3.0068164,
      "_source": {
        "quote": "These droids are my father's father's machines."
      }
    },
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "1",
      "_score": 0.89701396,
      "_source": {
        "quote": "These are <em>not</em> the droids you are looking for."
      }
    },
    ...
```


elastic

3.0068164 == 103%?

More Search

Highlighting

```
POST /starwars/_search
{
  "query": {
    "match": {
      "quote": "father"
    }
  },
  "highlight": {
    "type": "unified",
    "pre_tags": [
      "<tag>"
    ],
    "post_tags": [
      "</tag>"
    ],
    "fields": {
      "quote": {}
    }
  }
}
```

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```
...
"hits": {
  "total": 3,
  "max_score": 0.631961,
  "hits": [
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "4",
      "_score": 0.631961,
      "_source": {
        "quote": "These droids are my father's father's machines."
      },
      "highlight": {
        "quote": [
          "These droids are my <tag>father's</tag> <tag>father's</tag> machines."
        ]
      }
    },
...
```

Boolean Queries

`must` `must_not` `should` `filter`

```
POST /starwars/_search
{
  "query": {
    "bool": {
      "must": {
        "match": {
          "quote": "father"
        }
      },
      "should": [
        {
          "match": {
            "quote": "your"
          }
        },
        {
          "match": {
            "quote": "obi"
          }
        }
      ]
    }
  }
}
```

elastic

```
...
"hits": {
  "total": 3,
  "max_score": 2.117857,
  "hits": [
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "2",
      "_score": 2.117857,
      "_source": {
        "quote": "Obi-Wan never told you what happened to your father."
      }
    },
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "3",
      "_score": 1.3856719,
      "_source": {
        "quote": "<b>No</b>. I am your father."
      }
    },
    ...
```


elastic

```
POST /starwars/_search
{
  "query": {
    "bool": {
      "filter": {
        "match": {
          "quote": "father"
        }
      },
      "should": [
        {
          "match": {
            "quote": "your"
          }
        },
        {
          "match": {
            "quote": "obi"
          }
        }
      ]
    }
  }
}
```

elastic

```
...
"hits": {
  "total": 3,
  "max_score": 1.6694657,
  "hits": [
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "2",
      "_score": 1.6694657,
      "_source": {
        "quote": "Obi-Wan never told you what happened to your father."
      }
    },
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "3",
      "_score": 0.8317767,
      "_source": {
        "quote": "<b>No</b>. I am your father."
      }
    },
```


elastic

Named Queries & `minimum_should_match`

```
POST /starwars/_search
{
  "query": {
    "bool": {
      "must": {
        "match": { "quote": "father" }
      },
      "should": [
        {
          "match": {
            "quote": { "query": "your", "_name": "quote-your" }
          }
        },
        {
          "match": {
            "quote": { "query": "obi", "_name": "quote-obi" }
          }
        },
        {
          "match": {
            "quote": { "query": "droid", "_name": "quote-droid" }
          }
        }
      ],
      "minimum_should_match": 2
    }
  }
}
```

elastic

```
...
  "hits": {
    "total": 1,
    "max_score": 2.117857,
    "hits": [
      {
        "_index": "starwars",
        "_type": "_doc",
        "_id": "2",
        "_score": 2.117857,
        "_source": {
          "quote": "Obi-Wan never told you what happened to your father."
        },
        "matched_queries": [
          "quote-obi",
          "quote-your"
        ]
      }
    ]
  }
}
```

Boosting

>1 increase, <1 decrease, <0 punish

<0 removed in 7.0

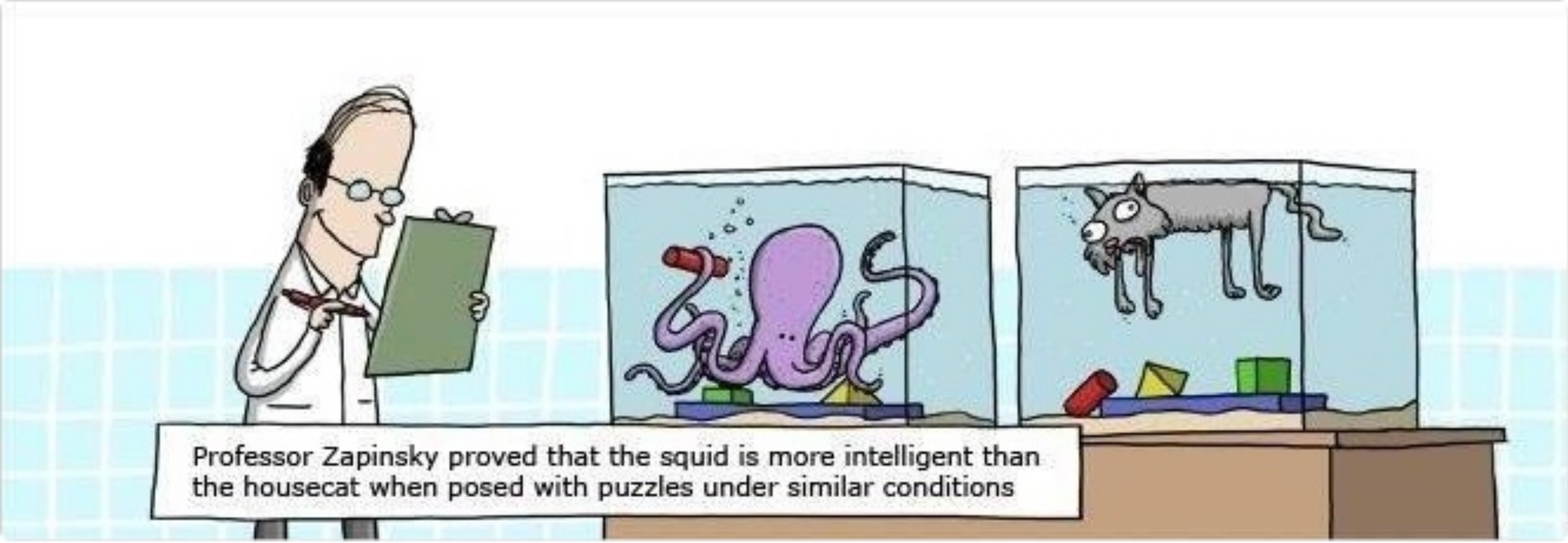
```
POST /starwars/_search
{
  "query": {
    "bool": {
      "must": {
        "match": {
          "quote": "father"
        }
      },
      "should": [
        {
          "match": {
            "quote": "your"
          }
        },
        {
          "match": {
            "quote": {
              "query": "obi",
              "boost": 3
            }
          }
        }
      ]
    }
  }
}
```

elastic

```
...
"hits": {
  "total": 3,
  "max_score": 4.2368493,
  "hits": [
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "2",
      "_score": 4.2368493,
      "_source": {
        "quote": "Obi-Wan never told you what happened to your father."
      }
    },
    {
      "_index": "starwars",
      "_type": "_doc",
      "_id": "3",
      "_score": 1.3856719,
      "_source": {
        "quote": "<b>No</b>. I am your father."
      }
    },
    ...
```


elastic

Performance


Professor Zapinsky proved that the squid is more intelligent than the housecat when posed with puzzles under similar conditions

elastic

ONE MILLION
DOCUMENTS
memegenerator.net

Conclusion

Indexing

Formatting

Tokenize

Lowercase, Stop Words, Stemming

Synonyms

elastic

Scoring

Term Frequency

Inverse Document Frequency

Field-Length Norm

Vector Space Model

Advanced Queries

Highlighting

Boolean

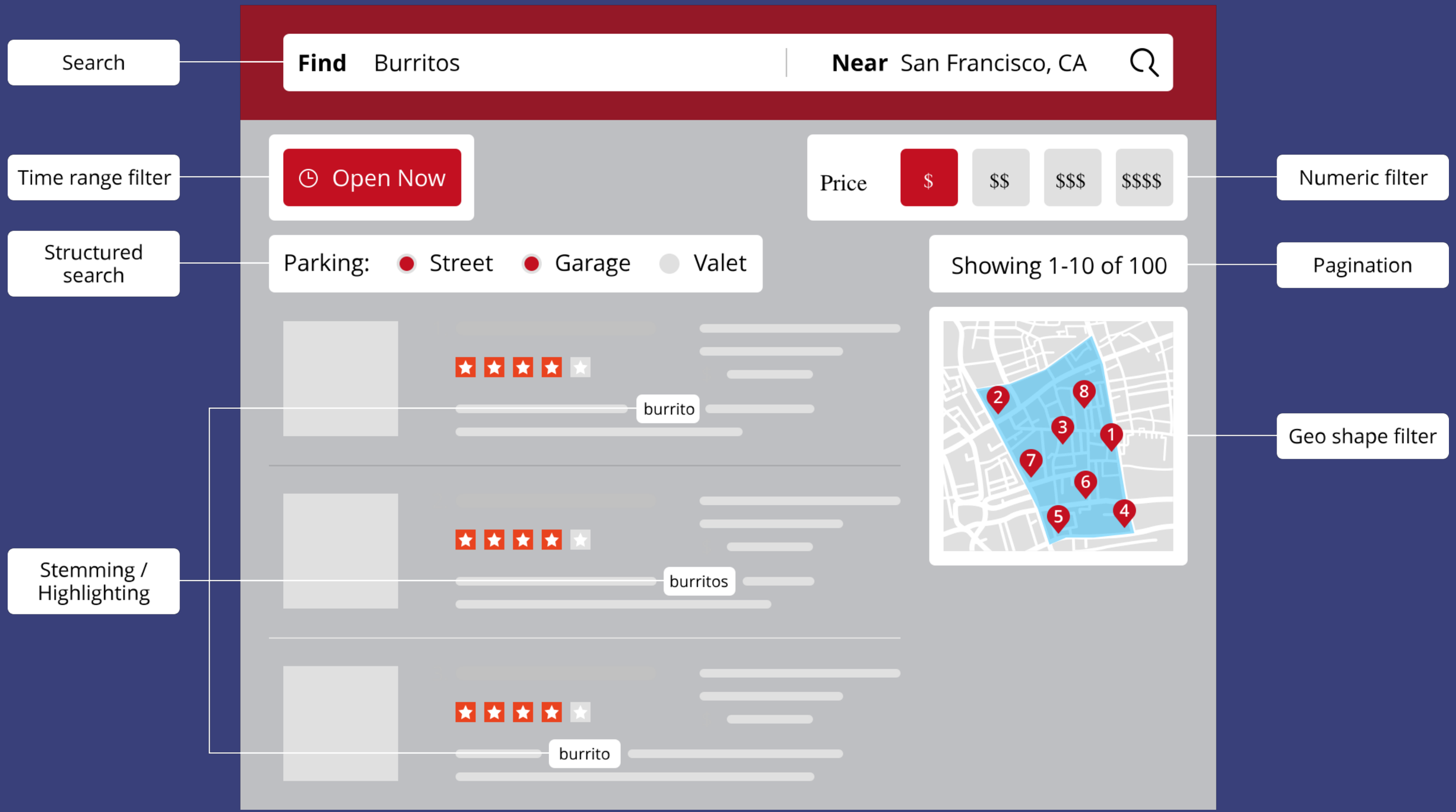
Boost

Performance

elastic

app search

https://www.elastic.co/blog/elastic-app-search-beta-released


Search
Find Burritos
Near San Francisco, CA
Time range filter
Open Now
Price
$
$$
$$$
$$$$
Numeric filter
Structured search
Parking: Street Garage Valet
Showing 1-10 of 100
Pagination
burrito
burritos
burrito
Geo shape filter
Stemming / Highlighting

rent-a-car

Overview
Analytics
Query Tester

MANAGE
Content
Fields
API Logs

RELEVANCE
Weights
Boosts

SEARCH SETTINGS
Pinned Results
Synonyms

← View all queries

Result Pins for "sedan"

sedan | full-size | + Add Alias

Promoted Results

	ID	SCORE	
1	710766	0.991	vehicle_type ⇒ sedan model_make_id ⇒ BMW 335i model_trim ⇒ M Trim model_drive ⇒ RWD
2	310465	1.359	vehicle_type ⇒ sedan model_make_id ⇒ To model_trim ⇒ EX model_drive ⇒
3	007891	1.143	vehicle model mod
4	36		

sedan

PROMOTED

BMW 335i
$126.05 Per day
Dealer ★★★★☆
Unlimited Mileage
1.2 mi

Toyota Camry
$126.05 Per day
Dealer ★★☆☆☆
625 Free Miles
.8 mi

Nissan Altima
$126.05 Per day
Dealer ★★★☆☆
Unlimited Mileage
1.4 mi

Lexus IS350
$126.05 Per day
Dealer ★★☆☆☆
Unlimited Mileage
2.1 mi

Thank You

Questions & Stickers

Philipp Krenn

@xeraa

elastic