By Joaquin Delgado, PhD.
and Diana Hu

ML-Scoring

Where Search Meets Machine Learning

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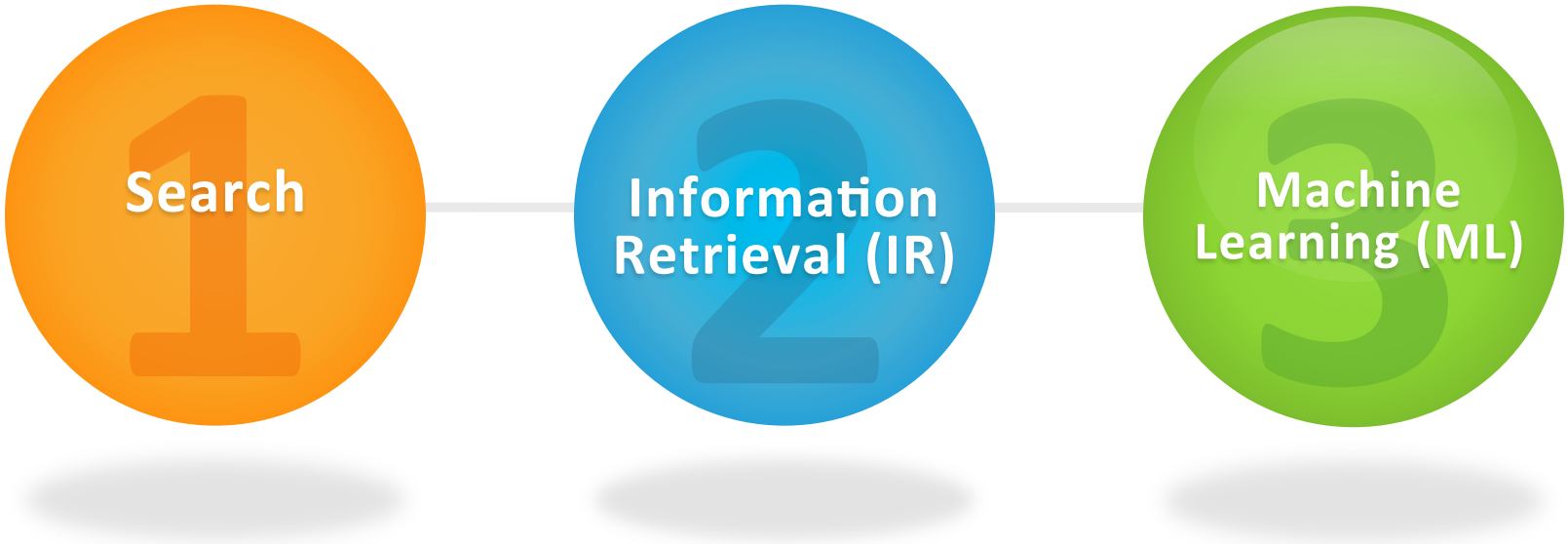
Finding Commonalities

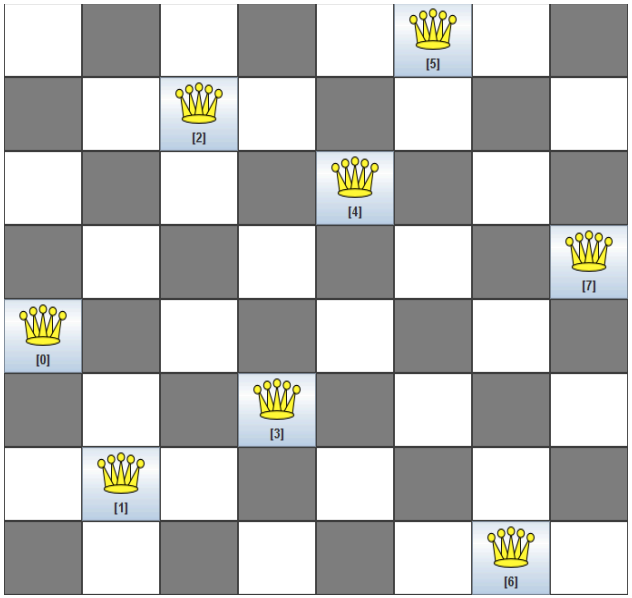


Can you map these to other things?

Search is a method for solving CSPs. The objective is to find all possible solutions (objects) that satisfy a set of constraints (query) on variables (fields). Optionally, scoring is used to rank results

Predicate Logic and Declarative Languages Rock!

Constraint Satisfaction Problem



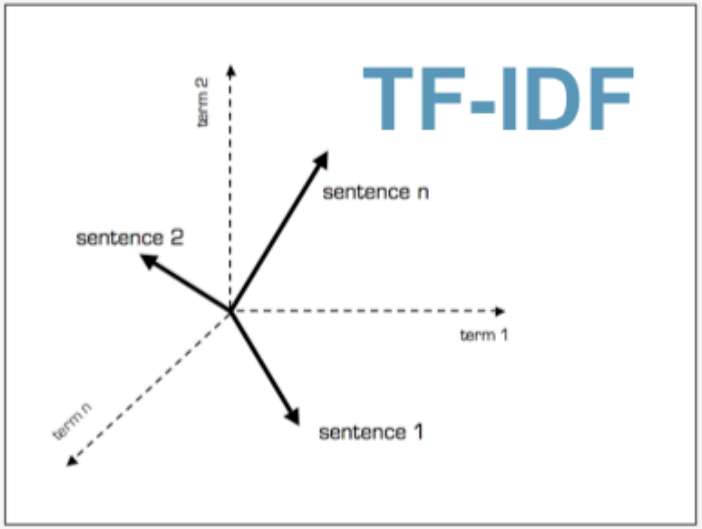
# Queens	# possible solutions	# feasible solutions	# optimal solutions	# optimal out of # possible
4	256 (4^4)	2	2	1 *out of* 128
8	8^8	64	64	1 *out of* 262144
16	16^16	14772512	14772512	1 out of 1248720872503
32	32^32	?	?	?
n	n^n	?	# fesasible	?

N-Queens Problem: Where to place N-Queens on a chessboard that don't interfere with (cannot capture) each other?

Information Retrieval is search + *relevance ranking* (scoring) applied to text documents and fields; often referred to as text or keyword search.

Have you heard of Bag-of-Words? Vector Space Representation? What about TF-IDF?

Ranking in the Vector Space Model



Language Model

$P(\text{optimization} \mid \text{search, engine}) >> P(\text{walking} \mid \text{search, engine})$

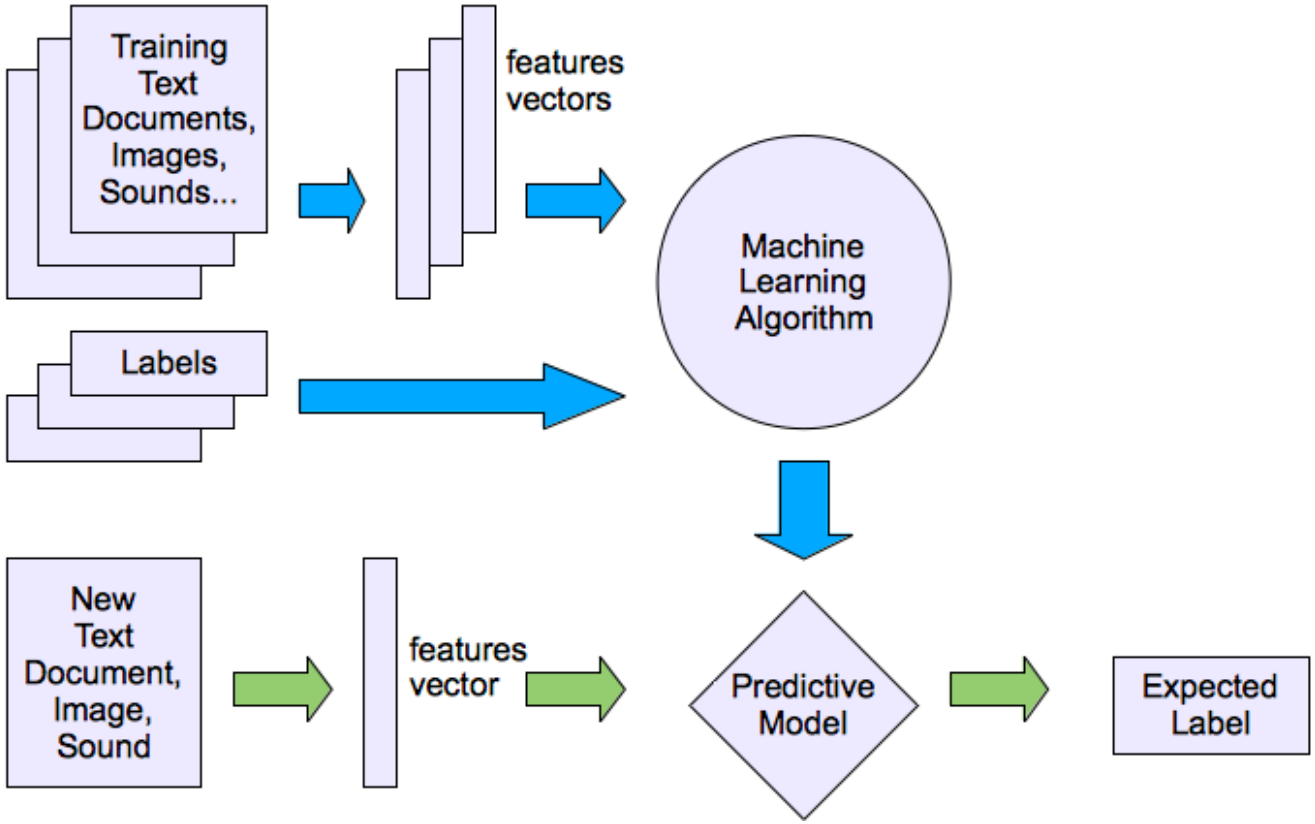
Probability Ranking Principle

$P(R = 1 \mid d, q)$ or $P(R = 0 \mid d, q)$

Machine Learning and in particular *supervised learning* refer to techniques used to learn how to classify or score previously unseen objects based on training data

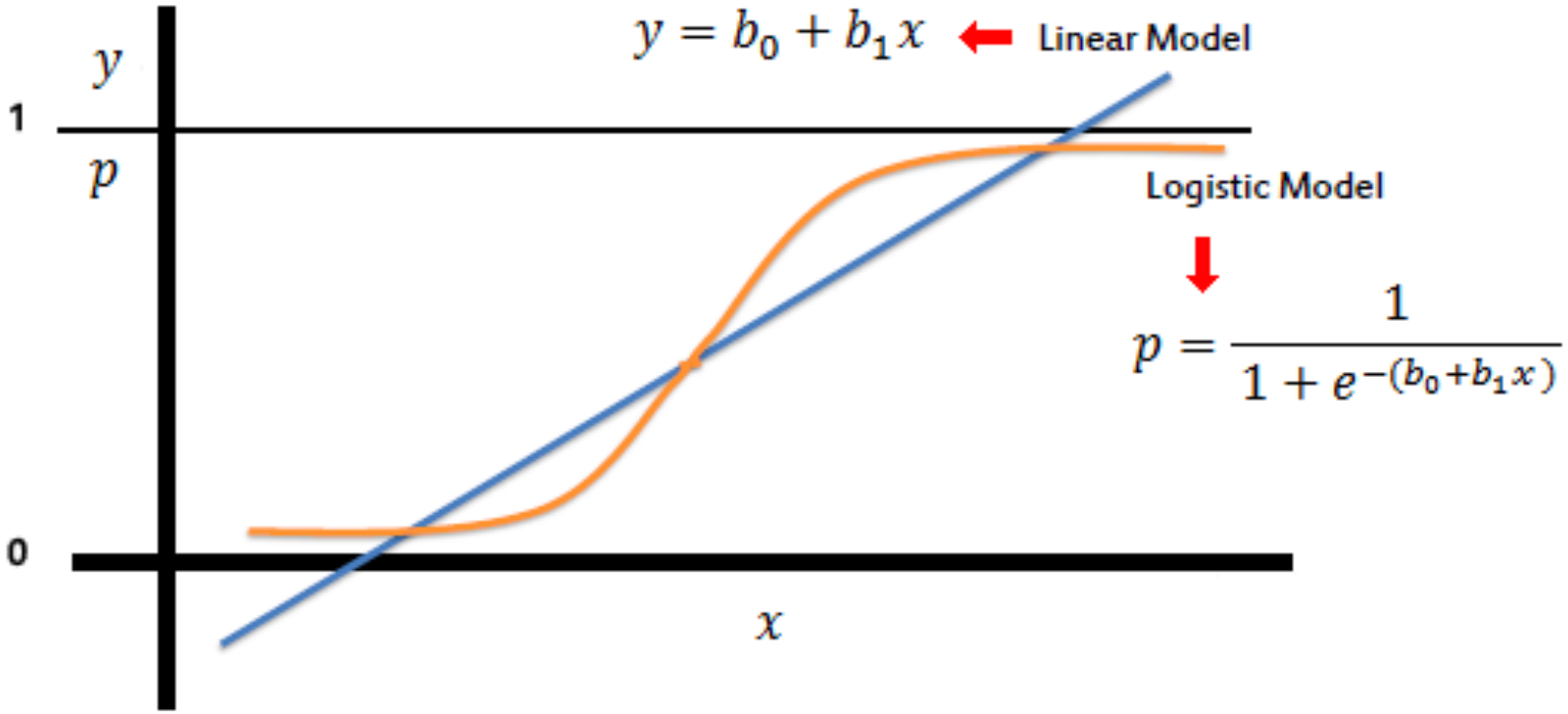
Inference and Generalization are the Key!

Generating a Predictive Model from Supervised Learning



Expected labels are generated for a classification task; instead this same process can be used to learn and generate a score (also called a *regression task*)

Example of ML Algorithm: Logistic Regression



Examples of Other Search-based Systems

- Database Systems
- AI Systems
- E-Commerce Systems
- Recommender Systems
- Advertising Systems

Search Engines : The Big Hammer!

- Search engines are largely used to solve non-IR search problems, and here is why:
  - Widely Available
  - Fast and Scalable
  - Integrates well with existing data stores (SQL and No-SQL)

But Are We Using the Right Tool?

- **Search Engines** were originally designed for IR.
- More complex non-IR search tasks sometimes require a **two phase approach**

Information Retrieval based Scoring

Ranking Formula

Called Lucene Similarity

Score of a document for a given query

Normalized doc length, shorter docs are more likely to be relevant than longer docs

$$score_{q,d} = norm(q) \times \sum_{t\ in\ q} \sqrt{tf_{t,d}} \times idf_t^2 \times norm(d,field) \times boost(t)$$

Can be ignored (was an attempt to make query scores comparable across indices, it's there for backward compatibility)

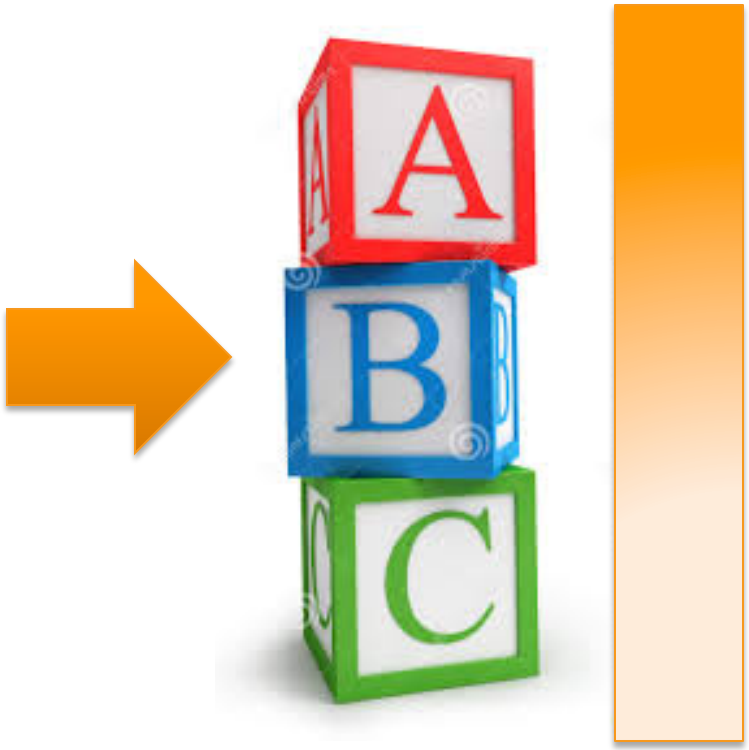
Core TF/IDF weight

Boost of query term t

Complex Scoring: Two Phase Approach

Filter

Rank

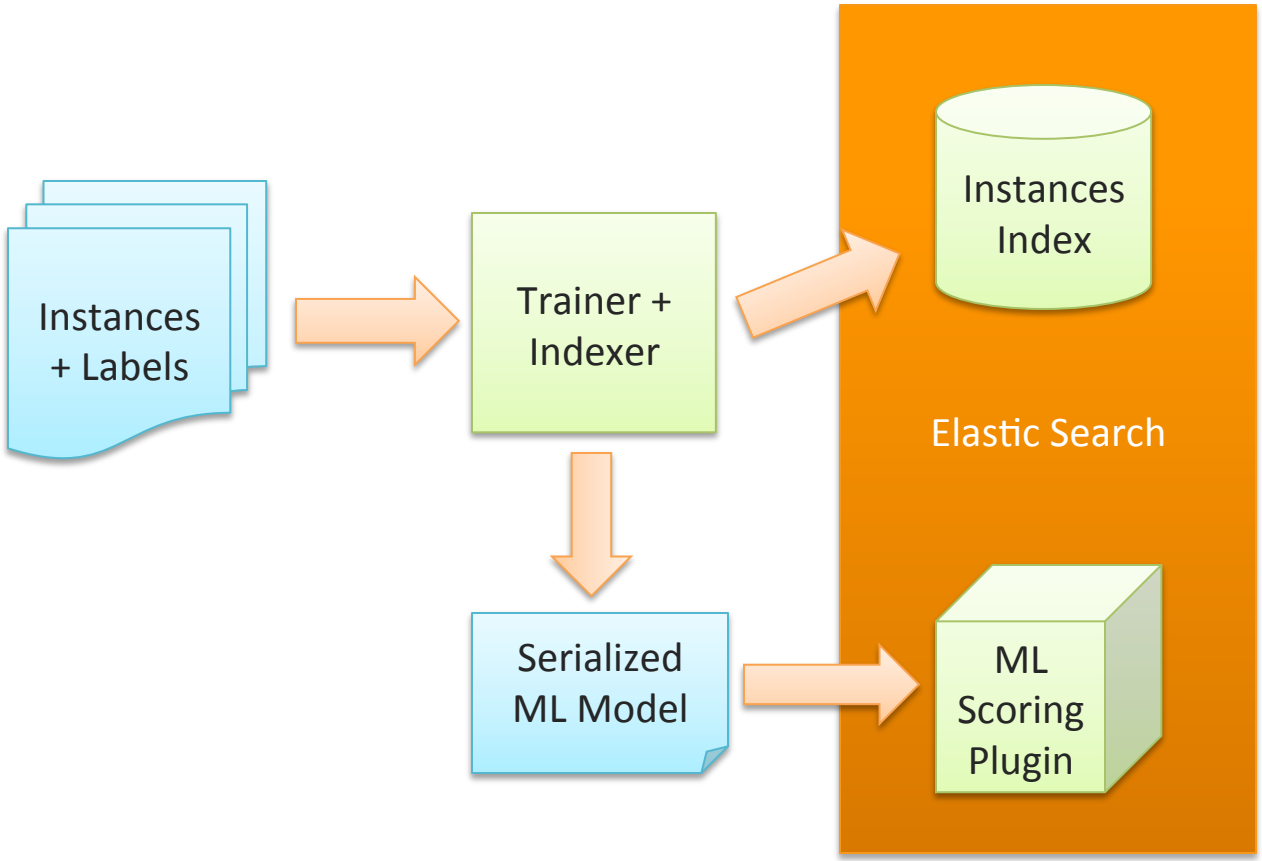


What is ML-Scoring?

- Create an Elastic Search (ES) document index of instances
- Train a supervised learning ML model from a subset of instances + labels
- Generate a ES plugin that uses the ML model to srore documents

An Open Source POC!

Introducing ML-Scoring



Search Predictor (ML-Scoring) Query

```
{
  "query": {
    "function_score": {
      "query": {
        "match_all": {}
      },
      "functions": [
        {
          "script_score": {
            "script": "search-predictor",
            "lang": "native",
            "params": {}
          }
        }
      ],
       "boost_mode": "replace"
    }
  }
}
```

Support for Various ML Libraries

Only Linear Models for now…

https://github.com/sdhu/elasticsearch-prediction

Potential Issues

- Performance
  - It may be a problem if the search space is very large and/or the computation too intensive
- Operations
  - Code running on a key infrastructure
  - Versioning and binary compatibility

Questions?