

Open Data Link

A dataset search engine for open data

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Open Data Link

- ▶ Dataset search engine for open data.
- ▶ Search methods:
 - ▶ Semantic keyword search
 - ▶ Joinable table search
 - ▶ Unionable table search

Motivation

- ▶ Governments and other organizations publish a lot of open data, but discovery is still difficult.
- ▶ Data scientists can identify ways to integrate datasets.
- ▶ Data publishers can see the wider context of their data.

Demo

Outline

System overview

Joinable table search

Unionable table search

Semantic Keyword Search

Future work

Outline

System overview

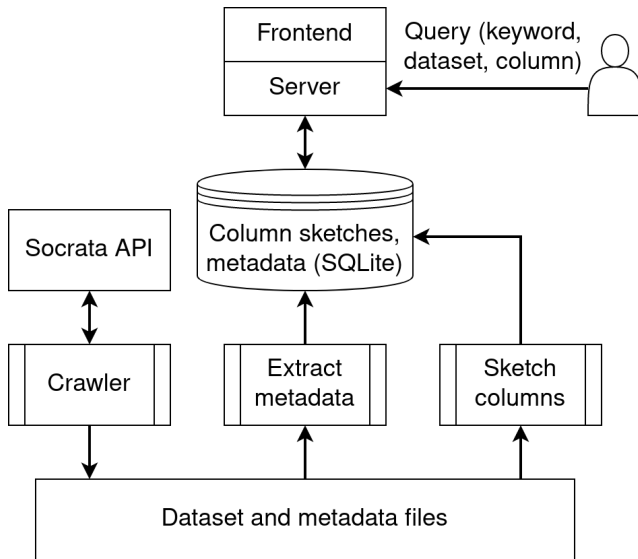
Joinable table search

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System overview



Dataset crawl

- ▶ 10k of 42k datasets on Socrata.
- ▶ 172k columns.
- ▶ Most datasets are small.
- ▶ Largest datasets have over 100 million rows.

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Joinable table search

JOIN

ACTION_SOUGHT	DEPARTMENT	CLIENT_ID	CLIENT_NAME	LOBBYIST_ID
AMENDMENT TO PLANNED DEVELOPMENT	TRANSPORTATION	2201517748	FRIEDMAN PROPERTIES	6842

	YEAR	LOBBYIST_ID	SALUTATION	FIRST_NAME	MIDDLE_INITIAL	LAST_NAME
DISCUSSED FY 2020 BUDGET	2011	3958	MR	STEPHEN		FORTINO
CONTRACT APPROVAL	2012	3789	MR	NEIL	A	PRITZ
CONSTRUCTION RELATED	2013	3773	MS.	ERICA	N.	BLAND
LANDMARKING, CLASS L APPROVALS AND RIGHT OF WAY ISSUES	2012	3964	MRS	MARY KAY		BONOMA
	2011	3764	MS	JENNIFER		CLARK
EVENT APPROVA	2013	4332	MR.	MICHAEL	J	PAULOS
ZONING APPROVALS	2014	3802	MR.	JAMES	L	TERMAN

Joinable table search

- ▶ Attributes are treated as sets.
- ▶ Sets are encoded with minhash data sketches.
- ▶ A table T is joinable with the query U if $\text{Containment}(X \in T, Q \in U) \geq t$.
- ▶ We use an LSH index for fast querying.

Minhash²

- ▶ Data sketch for estimating Jaccard similarity of sets.

$$J(S, T) = \frac{|S \cap T|}{|S \cup T|}$$

- ▶ A minhash signature is composed of the results of a number of minhashes.
- ▶ The probability that the minhashes for two sets are the same equals the Jaccard similarity of the sets¹.
- ▶ Minhash LSH hashes similar signatures to the same bucket.

¹Mining of Massive Datasets, Chapter 3.

²A. Broder, "On the Resemblance and Containment of Documents", Compression and Complexity of Sequences 1997.

LSH Ensemble³

- ▶ Set containment is a better measure for computing joinability.

$$C(Q, X) = \frac{|Q \cap X|}{|Q|}$$

- ▶ We can convert Jaccard similarity to containment, given the sizes of the domains.
- ▶ The size of the indexed domain is not constant, so domains are partitioned by cardinality.
- ▶ A minhash LSH index is constructed for each partition.

³Erkang Zhu, Fatemeh Nargesian, Ken Q. Pu, Renée J. Miller, “LSH Ensemble: Internet-Scale Domain Search”, VLDB 2016.

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Unionable table search

UNION



Candidate Name	Source Type	Source Name	Date	Amount
Abbett, Richard	Candidate	Abbett, Richard	09/29/2016	20.00
Abercrombie, Neil	Other Entity	Facebook, Inc.	04/01/2014	65.16
Aiona, Sam	Candidate	Aiona, Sam	06/30/2015	6415.49

Candidate Name	Contributor Type	Contributor Name	Date	Amount	
Ige, David	Individual	Ohuri, Yoshiko	09/11/2014	99.05	.00
Ige, David	Individual	Perry, Nolan	10/13/2014	50.00	
Herkes, Robert	Individual	Nip, Celeste	02/04/2008	200.00	
Hannemann, Mufi	Individual	Murakami, Ross R.	04/15/2008	500.00	.00
Hannemann, Mufi	Individual	Dinsmore, Jeffrey C.	07/20/2009	1000.00	.00
Hooser, Gary	Individual	SHERMAN, WENDY L.	06/10/2010	500.00	
Hannemann, Mufi	Individual	Miyashiro, Alton K.	10/09/2014	2000.00	.00
Hannemann, Mufi	Individual	Konishi, Glen S.	07/22/2010	150.00	.33
Hong, Ted	Individual	Malasek, Vojtech	10/29/2008	4000.00	
Hannemann, Mufi	Individual	Takara, Russell H.	09/08/2008	1000.00	
Hokama, Riki	Individual	Matsuda, Eric	06/25/2013	225.00	
Hannemann, Mufi	Individual	McIntyre, Gregory T.	06/30/2007	250.00	
Ige, David	Individual	Lincoln, Faye	11/10/2014	500.00	

Unionable table search

- ▶ The LSH Ensemble index is queried for each column of the query table.
- ▶ Candidate tables are those that appear in $\geq 40\%$ of the joinability queries.
- ▶ Candidates are ranked by alignment: the fraction of candidate columns that are unionable with a query column.

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Semantic Keyword Search

- ▶ Problem: Given a list of keywords, return top-k similar datasets
- ▶ Motivation: Data scientists want a simple way to find new and insightful datasets

Our Approach

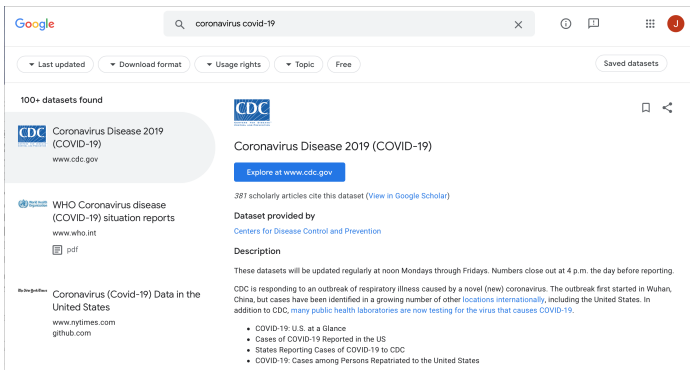
- ▶ Search on the metadata, not on the data in the dataset
 - ▶ Data in dataset is too noisy
- ▶ Metadata that we have:
 - ▶ Dataset description
 - ▶ Column description
 - ▶ Datasets tags

Our Approach (Cont.)

- ▶ Use semantic similarity
 - ▶ Example: Fish & Seafood
 - ▶ Example: Coronavirus & Respiratory System

Others Approach

► Google Dataset Search



The screenshot shows the Google Dataset Search interface. At the top, the search bar contains 'coronavirus covid-19'. Below the search bar, there are filters for 'Last updated', 'Download format', 'Usage rights', 'Topic', and 'Free'. A 'Saved datasets' button is on the right. The results section shows '100+ datasets found'. The first result is 'Coronavirus Disease 2019 (COVID-19)' from the CDC, with a link to 'www.cdc.gov'. The second result is 'WHO Coronavirus disease (COVID-19) situation reports' from 'www.who.int', with a PDF icon. The third result is 'Coronavirus (Covid-19) Data in the United States' from 'www.nytimes.com' and 'github.com'. The main content area for the CDC dataset is expanded, showing the CDC logo, the title 'Coronavirus Disease 2019 (COVID-19)', a button to 'Explore at www.cdc.gov', and a link to '387 scholarly articles cite this dataset (View in Google Scholar)'. It also lists the 'Dataset provided by' as 'Centers for Disease Control and Prevention' and includes a 'Description' section stating that the datasets are updated regularly and provides a list of four specific datasets.

Google coronavirus covid-19

Last updated Download format Usage rights Topic Free Saved datasets

100+ datasets found

CDC Coronavirus Disease 2019 (COVID-19)
www.cdc.gov

WHO WHO Coronavirus disease (COVID-19) situation reports
www.who.int
pdf

nytimes.com github.com Coronavirus (Covid-19) Data in the United States
www.nytimes.com
github.com

CDC Coronavirus Disease 2019 (COVID-19)
Explore at www.cdc.gov

387 scholarly articles cite this dataset ([View in Google Scholar](#))

Dataset provided by
[Centers for Disease Control and Prevention](#)

Description
These datasets will be updated regularly at noon Mondays through Fridays. Numbers close out at 4 p.m. the day before reporting.

CDC is responding to an outbreak of respiratory illness caused by a novel (new) coronavirus. The outbreak first started in Wuhan, China, but cases have been identified in a growing number of other [locations internationally](#), including the United States. In addition to CDC, [many public health laboratories are now testing for the virus that causes COVID-19](#).

- COVID-19: U.S. at a Glance
- Cases of COVID-19 Reported in the US
- States Reporting Cases of COVID-19 to CDC
- COVID-19: Cases among Persons Repatriated to the United States

System Overview

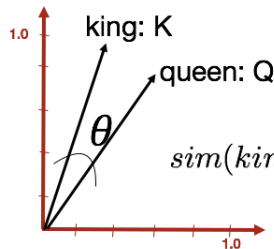
- ▶ FastText: word in dataset's metadata \rightarrow embedding vector
- ▶ SimHash: embedding vector \rightarrow bit vector
- ▶ Locality Sensitive Hashing (LSH): build index on the bit vector of each word

- ▶ Word in dataset's metadata -> embedding vector
- ▶ Embedding vector represent the semantics of words
- ▶ Embedding vectors are learned from wikipedia articles

⁴A. Joulin, E. Grave, P. Bojanowski, T. Mikolov, *Bag of Tricks for Efficient Text Classification*

FastText (Cont.)

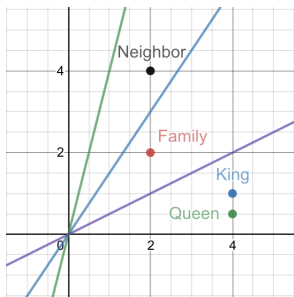
- ▶ closeness or similarity of vectors := Cosine-Similarity
- ▶ Closer a pair of vectors, closer the semantics of the two words
- ▶ Example: King and Queen have high cosine similarity



$$\text{sim}(\text{king}, \text{queen}) = \text{Cosine}(\theta) = \frac{\vec{K} \cdot \vec{Q}}{\|\vec{K}\| \cdot \|\vec{Q}\|}$$

Simhash

- ▶ Embedding Vector \rightarrow Bit Vector
- ▶ Word: [puple, blue, green]
 - ▶ Neighbor: [1, 1, 0]
 - ▶ Family: [1, 0, 0]
 - ▶ King: [0, 0, 0]
 - ▶ Queen: [0, 0, 0]



Locality Sensitive Hashing (LSH)

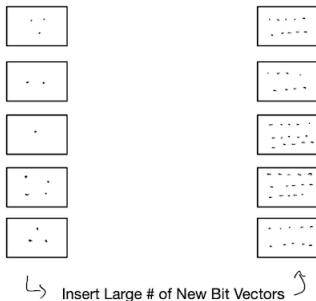
- ▶ Underlying data structure: Hash Table
 - ▶ Predefined # of buckets
- ▶ Insert SimHashed embedding vectors into hash table
- ▶ Collisions in hash table buckets are candidate pairs.

SimHash LSH (Cont.)

- ▶ Predefined # of hash tables
- ▶ Query each hash table for M candidates
 - ▶ $M \geq k$
- ▶ Order M candidates into a top-k list by the cosine similarity of embedding vectors

Problem with SimHash LSH

- ▶ The # of hash tables and # of buckets in each hash table must be **hand tuned**
- ▶ Must be retuned when data size significantly changes



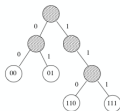
LSH Forest⁵

- ▶ Underlying data structure: Prefix Tree or Trie
- ▶ Similar to LSH
 - ▶ Predefined # of prefix trees
 - ▶ Ascend each prefix tree for M candidates
 - ▶ $M \geq k$

⁵Mayank Bawa, Tyson Condie, and Prasanna Ganesan. 2005. *LSH forest: self-tuning indexes for similarity search*

LSH Forest (Cont.)

- ▶ Variable length hashing in prefix tree solves LSH's problems



- ▶ Add Bit Vector: $[0, 0, 1, \dots]$



- ▶ Prefix Tree expands and contracts to account for # of embedding vectors
 - ▶ Thus, no hand tuning

Review

- ▶ FastText: Word in Metadata -> Embedding vector
- ▶ SimHash: Embedding Vector -> Bit Vector
- ▶ LSH Forest: Index on Bit Vectors

Answering Queries

- ▶ Query the index with each keyword in the keyword list
- ▶ Add the results to a list
- ▶ Rank datasets by how often they appear in the list

Problems

- ▶ No semantic relationships **between** words
 - ▶ Example: Keyword List := “traffic violations”
 - ▶ Produces good results for “traffic” and “violations”, but not “traffic violations”

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- ▶ Improve ability to see semantic relationships between words
- ▶ Organize datasets into a directory structure
- ▶ Use semantic similarity of column names in unionable table search.
- ▶ Similar dataset search based on metadata similarity.
- ▶ Keyword search over data values.