CHENNAI MATHEMATICAL INSTITUTE

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(Virtual Mode)

Researchers Beware! The Devil is in the (Mathematical) Models

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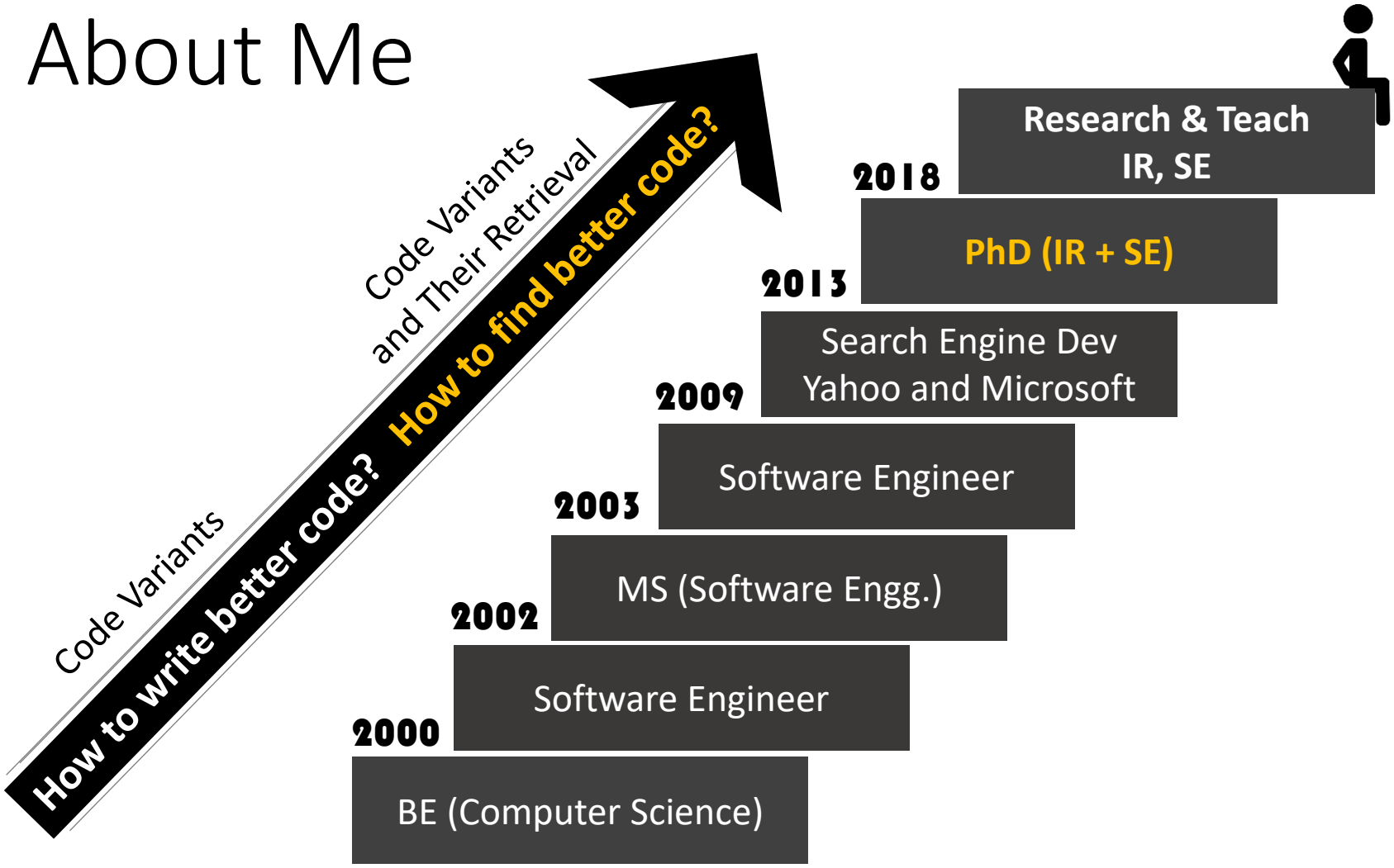
Two Day National Workshop on
An Insight into Mathematical Modelling in Information and Communication Engineering
Jointly Organized by Department of CSE and Department of Mathematics
Sri Sivasubramaniya Nadar College of Engineering

Mathematics, the science of structure, order, and relation that has evolved from elemental practices of counting, measuring, and describing the shapes of objects.
Britannica, https://www.britannica.com/science/mathematics.

About Me


Code Variants
How to write better code?
Code Variants
and Their Retrieval
How to find better code?
2000
BE (Computer Science)
2002
Software Engineer
2003
MS (Software Engg.)
2009
Software Engineer
2013
Search Engine Dev
Yahoo and Microsoft
2018
PhD (IR + SE)
Research & Teach
IR, SE

Agenda

Why should **Researchers** care for **Mathematics**?

Will Discuss	Will not Discuss
✓ Concepts	⦸ Details
✓ Illustrations	⦸ Definitions
✓ Intuitions	⦸ Formalism
✓ Purpose	⦸ Derivations
✓ Properties	⦸ Proofs

Three Stories
Relational Model in Databases,
Vector Space Models and **Probabilistic Models** in Search Engines

Story 1

Evolution of RDBMS and SQL

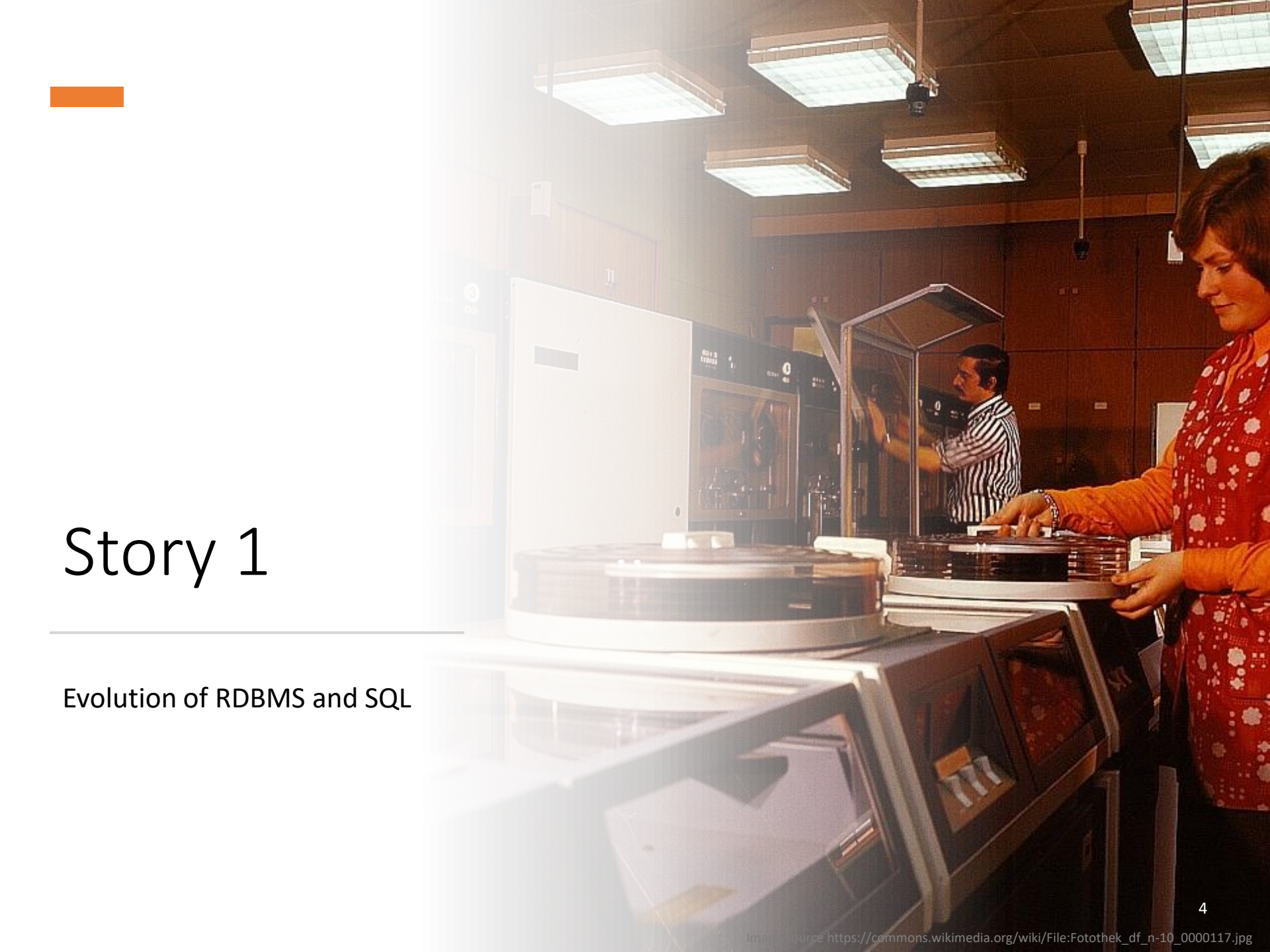


Image source https://commons.wikimedia.org/wiki/File:Fotothek_df_n-10_0000117.jpg

Interrelated “Data” as a Relation

The Relational Model

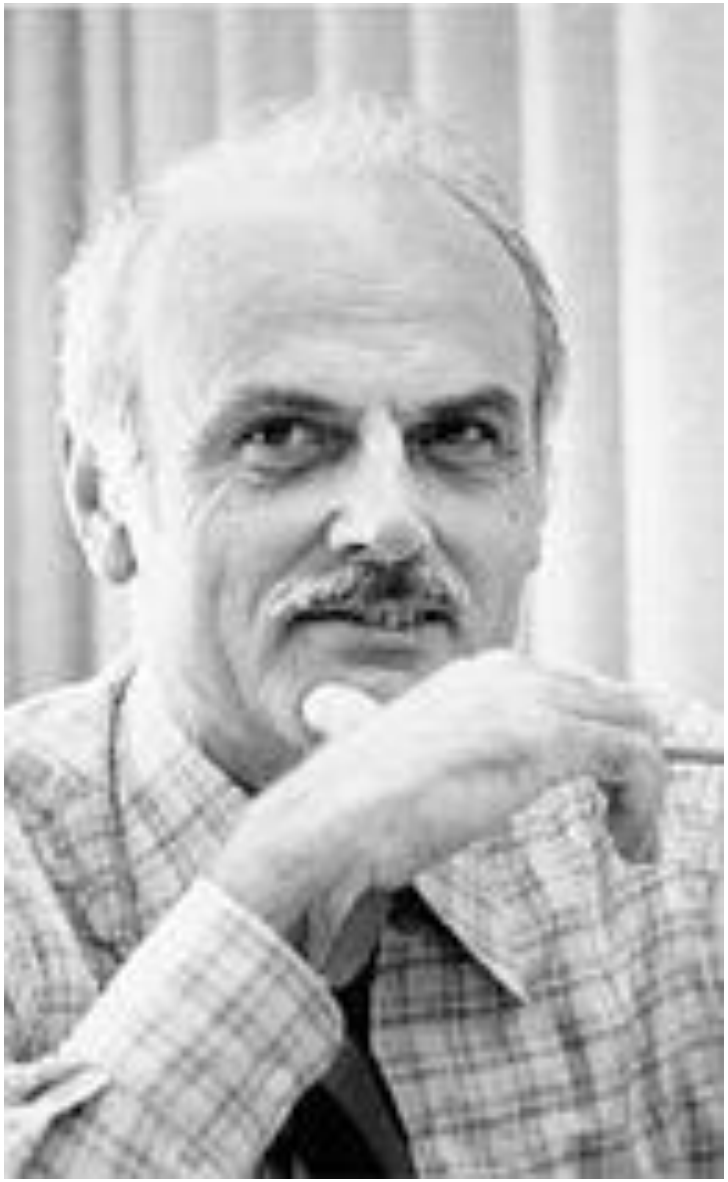
Edgar F. Codd

PhD in Computer Science

Winner of the Turing Award

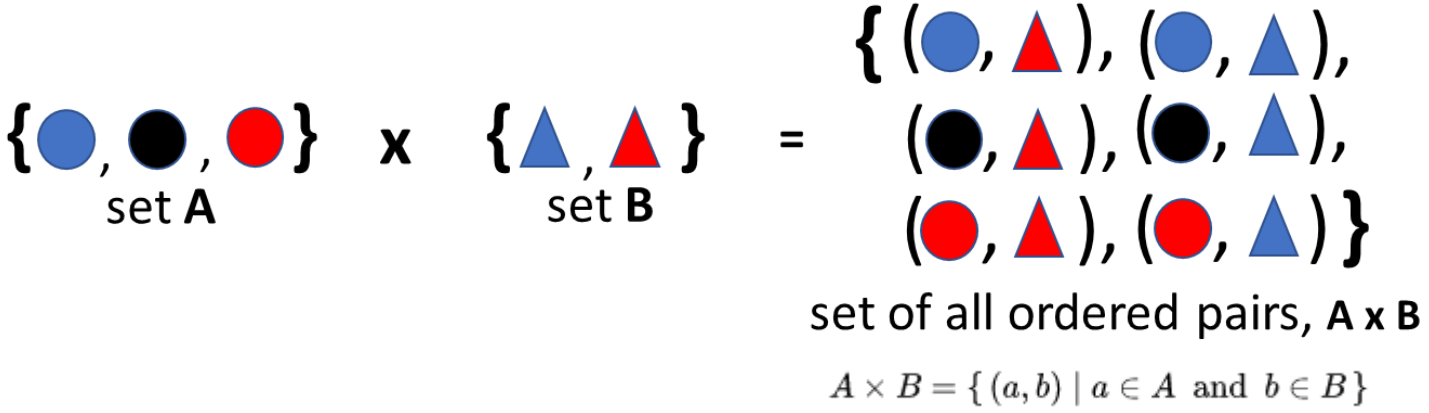
“He made other valuable contributions to computer science, but the relational model, a very influential general theory of data management, remains his most mentioned, analyzed and celebrated achievement.”

– Wikipedia.



The “Relation” from Math Textbook

- A relation R from a set A to set B is a subset of the cartesian product A x B.



Let’s say a relation exists between the reds

Relation RedShapes =

A Relation

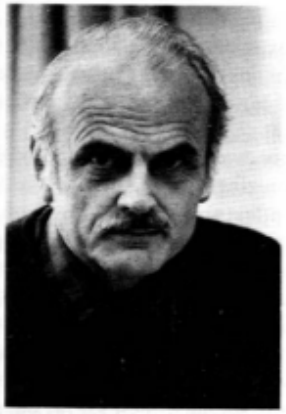
- Let the set, id = {1,2,3}
- Let the set, name = {vv, sd}
- What is id x name?
- We have a relation if we assign a sequential id to each name.

id	name
1	sd
2	vv

id	name
1	sd
1	vv
2	sd
2	vv
3	sd
3	vv

The 1981 ACM Turing Award Lecture

Delivered at ACM '81, Los Angeles, California, November 9, 1981



The 1981 ACM Turing Award was presented to Edgar F. Codd, an IBM Fellow of the San Jose Research Laboratory, by President Peter Denning on November 9, 1981 at the ACM Annual Conference in Los Angeles, California. It is the Association's foremost award for technical contributions to the computing community.

Codd was selected by the ACM General Technical Achievement Award Committee for his "fundamental and continuing contributions to the theory and practice of database management systems." The originator of the relational model for databases, Codd has made further important contributions in the development of relational algebra, relational calculus, and normalization of relations.

Edgar F. Codd joined IBM in 1949 to prepare programs for the Selective Sequence Electronic Calculator. Since then, his work in computing has encompassed logical design of computers (IBM 701 and Stretch), managing a computer center in Canada, heading the development of one of the first operating systems with a general multiprogramming capability, contributing to the logic of self-reproducing automata, developing high level techniques for software specification, creating and extending the relational approach to database management, and developing an English analyzing and synthesizing subsystem for casual users of relational databases. He is also the author of *Cellular Automata*, an early volume in the ACM Monograph Series.

Codd received his B.A. and M.A. in Mathematics from Oxford University in England, and his M.Sc. and Ph.D. in Computer and Communication Sciences from the University of Michigan. He is a Member of the National Academy of Engineering (USA) and a Fellow of the British Computer Society.

The ACM Turing Award is presented each year in commemoration of A. M. Turing, the English mathematician who made major contributions to the computing sciences.

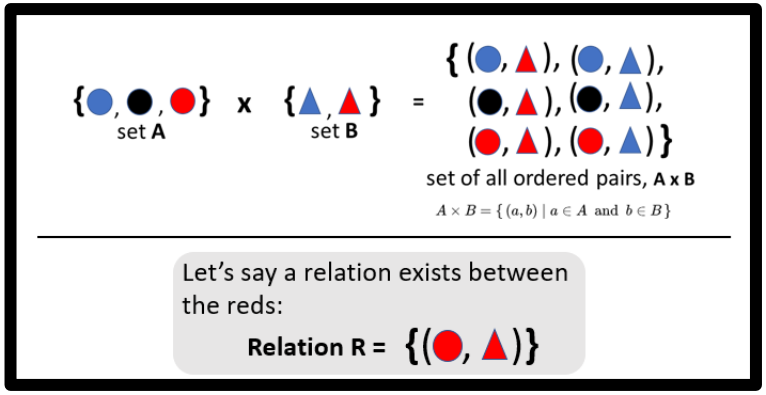
Relational Database: A Practical Foundation for Productivity

E. F. Codd
IBM San Jose Research Laboratory

https://dl.acm.org/doi/pdf/10.1145/1283920.1283937?download=true

Story So Far…

What is a Relation?



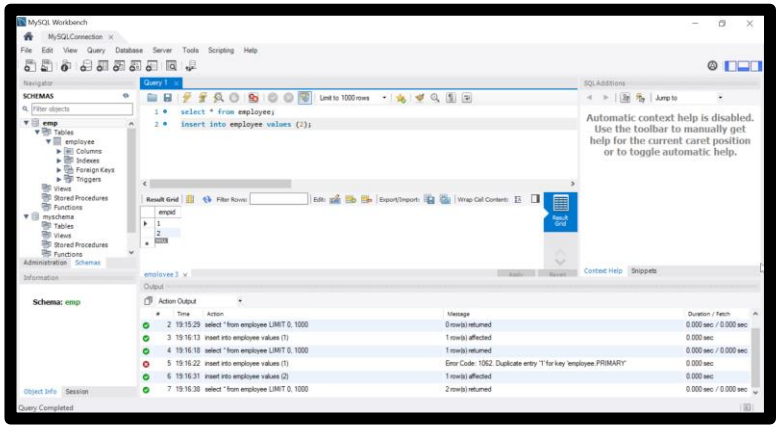
Relational Data Model

id	name
1	sd
1	vv
2	sd
2	vv
3	sd
3	vv

Vs

id	name
1	sd
2	vv

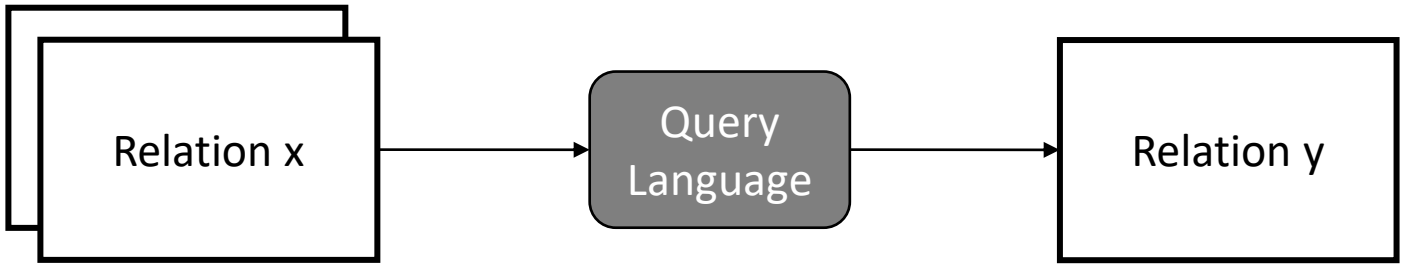
MySQL – An RDBMS



Attendance **relation**
{(1,1), (2,1)}
is same as the table

	studentid	sessionid
▶	1	1
	2	1

Query Languages



Procedural Language
Relational Algebra

Popular Language
SQL

Select Operation

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

(a) The *instructor* table

- Relational Algebra

$$\sigma_{\text{dept_name=“Physics”}}(\text{instructor})$$

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
33456	Gold	Physics	87000

Project Operation

- Notation: $\Pi_{A1, A2,..,Ak}(r)$ where A_i are attribute names

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
58583	Califieri	History	62000
83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

(a) The *instructor* table

- Example of projection:

$$\Pi_{ID, name, salary}(instructor)$$

Projection

$\Pi_{ID,\ name,\ salary}\ (instructor)$

ID	*name*	*dept_name*	*salary*
22222	Einstein	Physics	95000
12121	Wu	Finance	90000
32343	El Said	History	60000
45565	Katz	Comp. Sci.	75000
98345	Kim	Elec. Eng.	80000
76766	Crick	Biology	72000
10101	Srinivasan	Comp. Sci.	65000
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83821	Brandt	Comp. Sci.	92000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
76543	Singh	Finance	80000

(a) The *instructor* table

ID	*name*	*salary*
10101	Srinivasan	65000
12121	Wu	90000
15151	Mozart	40000
22222	Einstein	95000
32343	El Said	60000
33456	Gold	87000
45565	Katz	75000
58583	Califieri	62000
76543	Singh	80000
76766	Crick	72000
83821	Brandt	92000
98345	Kim	80000

Union, Selection and Projection

- $\Pi_{course_id}(\sigma_{semester=\text{“Fall”} \wedge year=2009}(section)) \cup \Pi_{course_id}(\sigma_{semester=\text{“Spring”} \wedge year=2010}(section))$

course_id	sec_id	semester	year	building	room_number	time_slot_id
BIO-101	1	Summer	2009	Painter	514	B
BIO-301	1	Summer	2010	Painter	514	A
CS-101	1	Fall	2009	Packard	101	H
CS-101	1	Spring	2010	Packard	101	F
CS-190	1	Spring	2009	Taylor	3128	E
CS-190	2	Spring	2009	Taylor	3128	A
CS-315	1	Spring	2010	Watson	120	D
CS-319	1	Spring	2010	Watson	100	B
CS-319	2	Spring	2010	Taylor	3128	C
CS-347	1	Fall	2009	Taylor	3128	A
EE-181	1	Spring	2009	Taylor	3128	C
FIN-201	1	Spring	2010	Packard	101	B
HIS-351	1	Spring	2010	Painter	514	C
MU-199	1	Spring	2010	Packard	101	D
PHY-101	1	Fall	2009	Watson	100	A

course_id
CS-101
CS-315
CS-319
CS-347
FIN-201
HIS-351
MU-199
PHY-101

Modern day SQL

```
select … from … where …
Union
select … from … where …
```

ARTICLE

A relational model for unstructured documents

Author: A. Salminen Authors Info & Affiliations

Publication: SIGIR '87: Proceedings of the 10th annual international ACM SIGIR conference on Research and development in information retrieval • November 1987 • Pages 196–207 • https://doi.org/10.1145/42005.42028

ARTICLE

Semantics of extended relational model for managing uncertain information

Authors: V. S. Alagar, F. Sadri, J. N. Said Authors Info & Affiliations

Publication: CIKM '95: Proceedings of the fourth international conference on Information and knowledge management • December 1995 • Pages 234–240 • https://doi.org/10.1145/221270.221578

RESEARCH-ARTICLE

On the Optimization of Recursive Relational Queries: Application to Graph Queries

Authors: Louis Jachiet, Pierre Genevès, Nils Gesbert, Nabil Layaida Authors Info & Affiliations

Publication: SIGMOD '20: Proceedings of the 2020 ACM SIGMOD International Conference on Management of Data • June 2020 • Pages 681–697 • https://doi.org/10.1145/3318464.3380567

Story 2

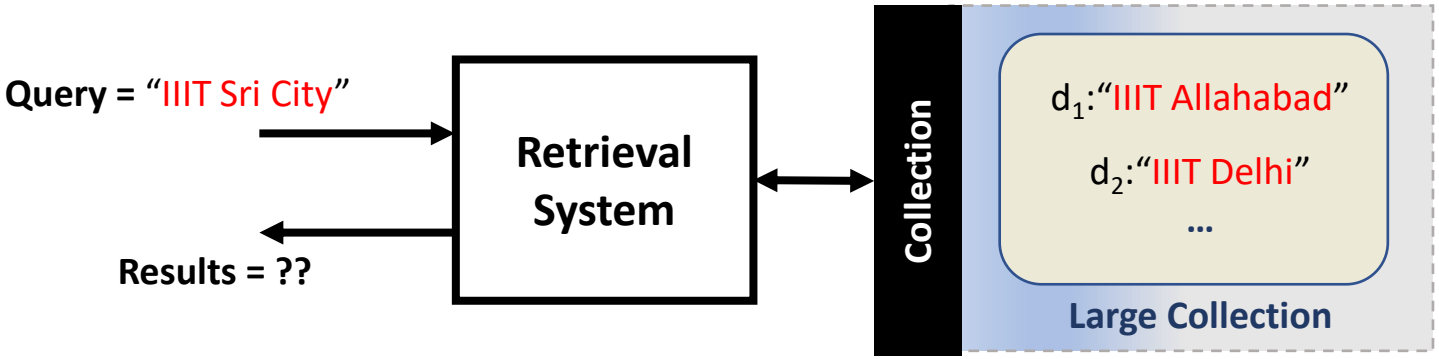
Models in Search Engines

Image Source
https://philbradley.typepad.com/phil_bradleys_weblog/2016/02/100-search-engines-logos-image-for-you-to-use.html

Simple Retrieval Problem

- Say, we have a **collection** with 5 **documents**, each having the following contents
  - d1: IIIT ALLAHABAD
  - d2: IIIT DELHI
  - d3: IIIT GUWAHATI
  - d4: IIIT KANCHIPURAM
  - d5: IIIT SRI CITY
- Assume, the **Query** is
  - IIIT SRI CITY
- Which **document** will you match and why?

The Problem: How to Build a Retrieval System?



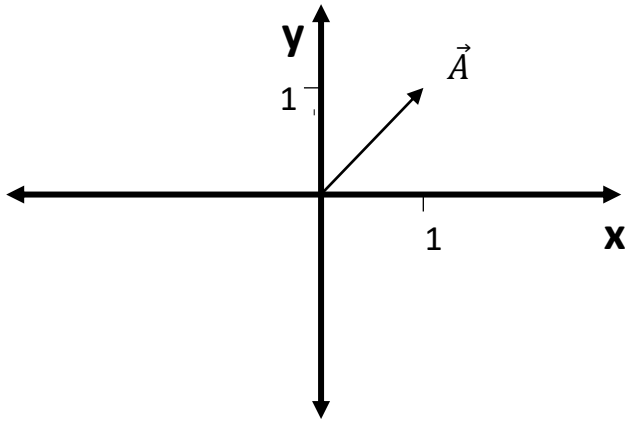
One (bad) Approach

- First match the **term** IIIT.
  - Filter out documents that contain this term.
- Next match the **term** Sri.
  - Filter out documents that contain this term.
- Next match the **term** City.
  - Filter out documents that contain this term.

Three iterations!
Quiz: Can we do better?

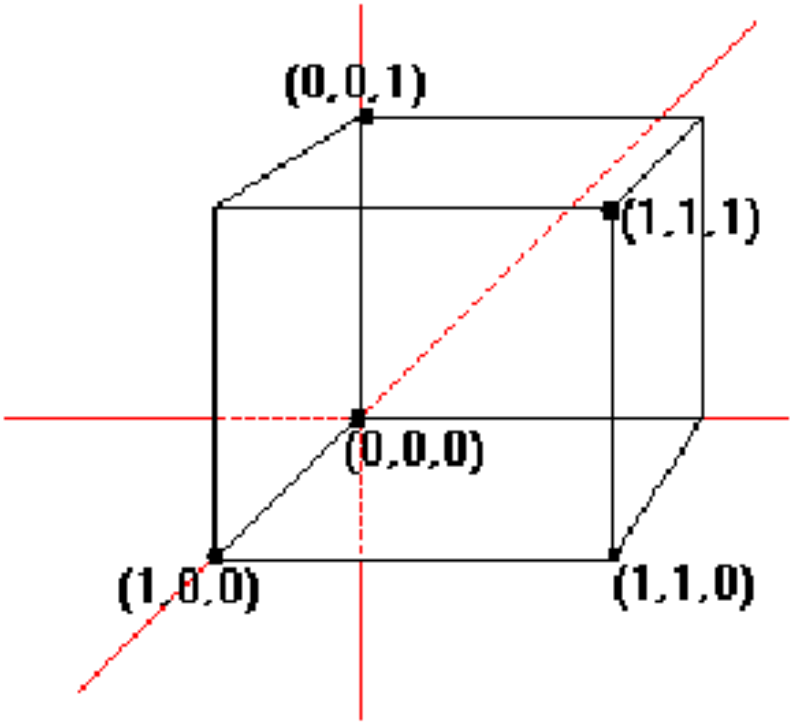
Vector

- Geometric entity which has magnitude and direction



$\vec{A}$ is fixed at (0,0)

What is (1,1,1) ?

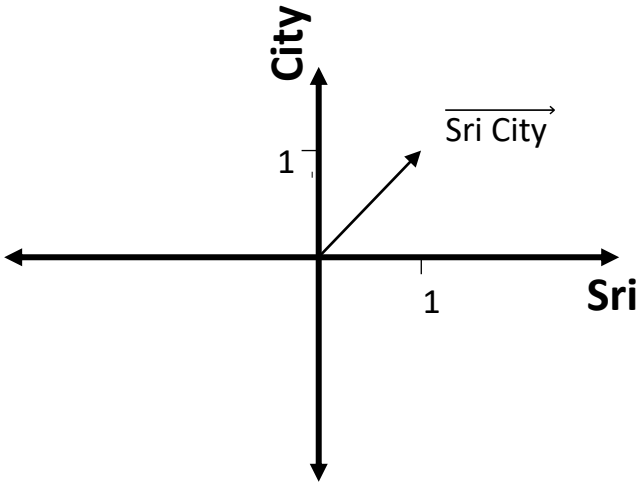


Remember!

A number is just a mathematical object. We give meaning to it!

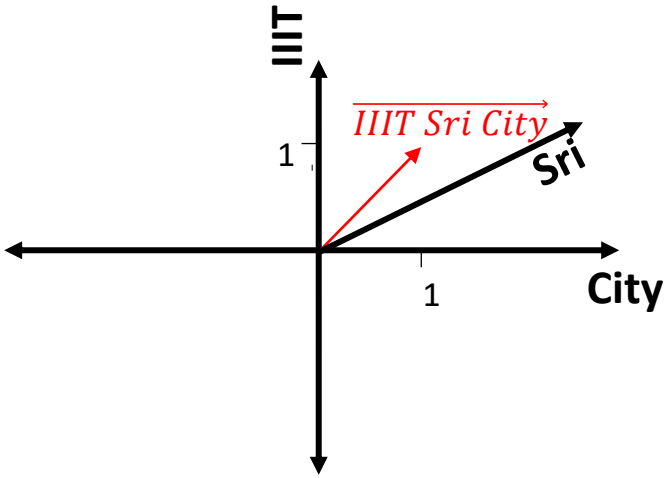
Sentences are Vectors

- “Sri City” as a vector



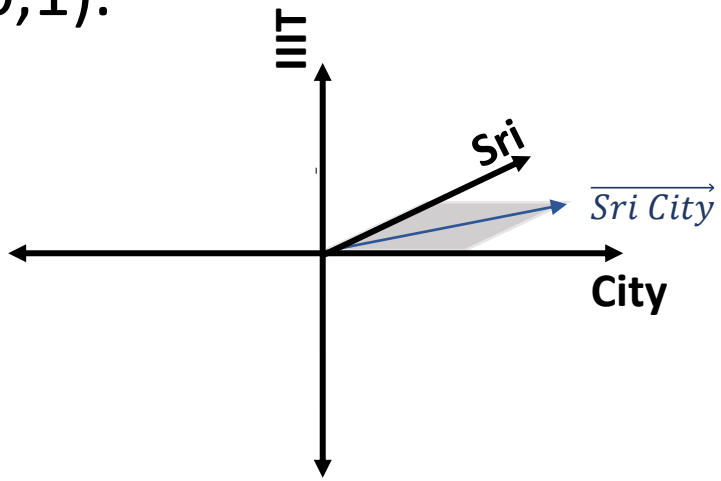
Sentences are Vectors

- "IIIT Sri City" is a 3-dimensional vector



Sentences are Vectors

- On this 3D space, “Sri City” vector will lie on the x (City) and z (Sri) plane. If (x,y,z) denotes the vector, “Sri City” is (1,0,1).



Natural Language Phrases as Vectors

Let query q = "IIIT Sri City".

Let document, d_1 = "IIIT Sri City" and d_2 = "IIIT Delhi".

	IIIT	Sri	City	Delhi
q	1	1	1	0
d_1	1	1	1	0
d_2	1	0	0	1

q = (1,1,1,0), d_1= (1,1,1,0) and d_2 = (1,0,0,1)

Quiz

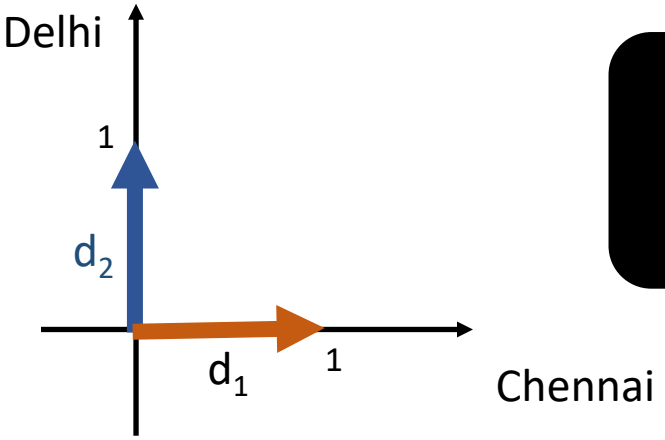
- Considering the following vectors:

	IIIT	Sri	City	Delhi
q	1	1	1	0
d_1	1	1	1	0
d_2	1	0	0	1

- What is the Natural Language (NL) equivalent of (0,1,1,0) ?
- What is the vector for Delhi?

Similarity Score

- Assume, we have the following two documents:
  - d_1 = “Chennai”
  - d_2 = “Delhi”
- On a scale of 0 – 1, how similar are d_1 and d_2?
- What is the angle between d_1 and d_2 vectors?



Can we express similarity as a function of the angles?

0 – 90 to 1 – 0: How?

	0°	30°	45°	60°	90°
sin	0	1/2	1/√2	√3/2	1
cos	1	√3/2	1/√2	1/2	0
tan	0	1/√3	1	√3	Not defined

Back to Trigonometry: Dot Product

- If a and b are non-unit vectors, what is the cosine of angle between them (cos Θ)?

$$\mathbf{a} \cdot \mathbf{b} = \|\mathbf{a}\| \, \|\mathbf{b}\| \cos(\theta)$$

(or)

$$\cos(\theta) = \frac{\mathbf{a} \cdot \mathbf{b}}{\|\mathbf{a}\| \, \|\mathbf{b}\|}$$

Example

Let query q = "BITS Pilani".

Let document, d_1 = "BITS Pilani Goa Campus" and d_2 = "IIIT Delhi".

	BITS	Pilani	Goa	Campus	IIIT	Delhi
q	1	1	0	0	0	0
d_1	1	1	1	1	0	0
d_2	0	0	0	0	1	1

In our VSM, q = (1,1,0,0,0,0), d_1= (1,1,1,1,0,0) and d_2 = (0,0,0,0,1,1)

similarity(d_1, q) = $\frac{d_1.q}{||d_1||\,||q||} = \frac{1.1 + 1.1}{\sqrt{1^2+1^2+1^2+1^2}\,\sqrt{1^2+1^2}} = 0.71.$

similarity(d_2, q) = $\frac{d_2.q}{||d_2||\,||q||} = 0.$

An Assumption

More frequent appearance of a query term implies higher document relevance.

Which of the Following are Sets?

- {1, 2, 3, 4, 5, 6, 5, 7, 8, 9, 10, 11, 12, 13}
- {A, B, C, D, E, F, G, H, I, I, J, K, L, M, N, O}
- {apple, banana, orange, apple, banana, orange}

Vadivelu, a popular tamil actor

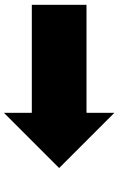
Bag

- {1, 2, 3, 4, 5, 6, 5, 7, 8, 9, 10, 11, 12, 13}
- {A, B, C, D, E, F, G, H, I, I, J, K, L, M, N, O}
- {apple, banana, orange, apple, banana, orange}

Set of Words Representation

- "IIIT Sri City" → {IIIT, Sri, City}
- "IIIT Sri City, Sri City" → {IIIT, Sri, City}

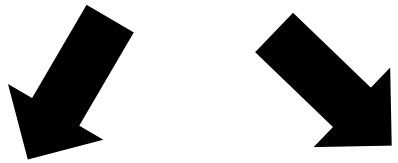
(Assuming, we ignore the punctuations)



	IIIT	Sri	City
q	1	1	1

Bag of Words Representation

- "IIIT Sri City" → {IIIT, Sri, City}
- "IIIT Sri City, Sri City" → [IIIT, Sri, Sri, City, City]



IIIT Sri City

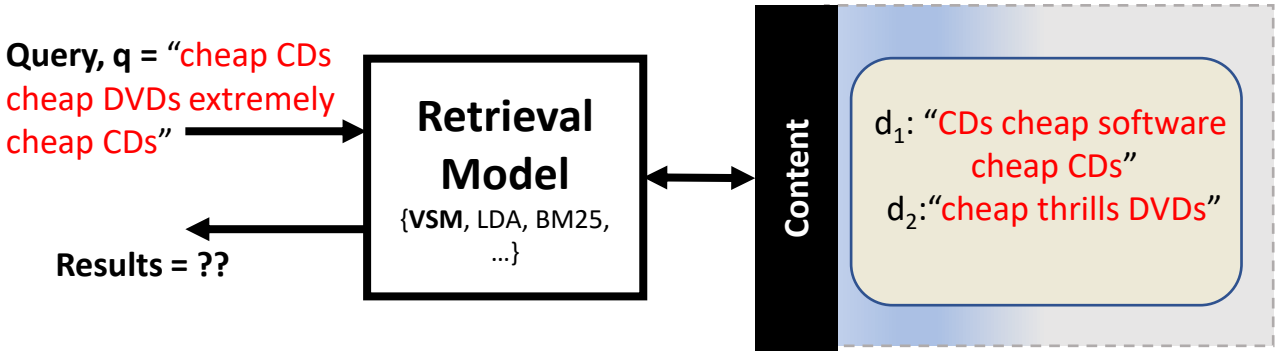
	IIIT	Sri	City
q	1	1	1

IIIT Sri City, Sri City

	IIIT	Sri	City
q	1	2	2

Leads to different vectors

Which Document to Retrieve?



	cheap	CDs	DVDs	extremely	software	thrills
q	3	2	1	1	0	0
d_1	2	2	0	0	1	0
d_2	1	0	1	0	0	1

$sim(q,d_1) = 0.86$

$sim(q,d_2) = 0.59$

Example taken from Manning's IR Book (https://nlp.stanford.edu/IR-book/pdf/irbookonlinereading.pdf)

RESEARCH-ARTICLE

word2vec, node2vec, graph2vec, X2vec: Towards a Theory of Vector Embeddings of Structured Data

Author: Martin Grohe Authors Info & Affiliations

Publication: PODS'20: Proceedings of the 39th ACM SIGMOD-SIGACT-SIGAI Symposium on Principles of Database Systems • June 2020 • Pages 1–16 • https://doi.org/10.1145/3375395.3387641

RESEARCH-ARTICLE

CC2Vec: distributed representations of code changes

Authors: Thong Hoang, Hong Jin Kang, David Lo, Julia Lawall Authors Info & Affiliations

Publication: ICSE '20: Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering • June 2020 • Pages 518–529 • https://doi.org/10.1145/3377811.3380361

ARTICLE

The basic ideas in neural networks

Authors: David E. Rumelhart, Bernard Widrow, Michael A. Lehr Authors Info & Affiliations

Publication: Communications of the ACM • March 1994 • https://doi.org/10.1145/175247.175256

Story 3

A Probabilistic Model

Photo by Scott Graham on Unsplash

The Law – Robert M. Coates

From the book, “The World of Mathematics – Volume IV”.

Triborough Bridge, NY, USA.
(aka Robert F. Kennedy Bridge)

Late 1940s, NY: *No other bridge or main highway was affected, and though the two preceding nights had been equally balmy and moonlit, on both of these the bridge traffic had run close to* ***normal****.*

And then, one day…

It just looked as if ***everybody*** *in Manhattan who owned a car had decided to drive out to Long Island that evening.*

No Reason!

Sergeant: “I kept askin’ them” he said, “Is there night football somewhere that we don’t know about? Is it the races you’re goin’ to?”

But the funny thing was half the time they’d be askin’ me. “What’s the crowd for, Mac?” they would say. And I’d just look at them.

If normal things stop happening, if we lose regularities in life, our planet could become unlivable!

Time for Action

- At this juncture, it was inevitable that Congress should be called on for action.

- Senator said, "*You can control it*". Re-education and reforms were decided upon. He said, (we need to lead people back to) "*the basic regularities, the homely* ***averageness*** *of the American way of life*".

The Law of Large Numbers

Known as the Fundamental theorem of Probability

The average of the results obtained from a large number of trials should be close to the expected value, and will tend to become closer as more trials are performed.

Probabilistic Retrieval

- Information Need: Taj Mahal
- Let a query q be “Taj”
- Let the results be:
  - d1: Taj
  - d2: Taj Mahal
  - d3: Taj Tea
- Two judges were asked to provide relevance judgments:

Document	Judge 1	Judge 2
Taj	R	N
Taj Mahal	R	R
Taj Tea	N	N

Probability of Relevance

- Documents **can** have probability of being relevant and of being non-relevant at the same time.
- Example:
  - Documents in our collection :

Document	P(R=0|d,q)	P(R=1|d,q)
Taj	0.5	0.5
Taj Mahal	?	?
Taj Tea	?	?

R = 0 ➔ Non-Relevant
R = 1 ➔ Relevant

Probability of Relevance

- Documents **can** have probability of being relevant and of being non-relevant at the same time.
- Example:
  - Documents in our collection :

Document	P(R=0|d,q)	P(R=1|d,q)
Taj	0.5	0.5
Taj Mahal	0	1
Taj Tea	1	0

R = 0 ➔ Non-Relevant
R = 1 ➔ Relevant

Probability Ranking Principle

Rank documents by the probability of relevance, $P(R=1|q,d)$ $R \in \{0,1\}$

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R = 0 ➔ Non-Relevant
R = 1 ➔ Relevant

Search Result:
1. Taj Mahal
2. Taj
3. Taj Tea

Bayes Optimal Decision Rule

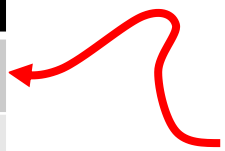
d is relevant if
$P(R=1|d,q) > P(R=0|d,q)$

Document	P(R=0|d,q)	P(R=1|d,q)
Taj	0.5	0.5
Taj Mahal	0	1
Taj Tea	1	0

Search Result:
1. Taj Mahal

Predicting Relevance

Document	P(R=0|d,q)	P(R=1|d,q)
Taj	0.5	0.5
Taj Mahal	0	1
Taj Tea	1	0



This is user given relevance.

Can we estimate/predict relevance based on term occurrence ?

Predicting Relevance

- You may use labeled set from judges (or mined from clicklogs)
- You may assume query and document as set of words.

Query	Document	Relevance
q1 = (x1,x2,…)	d1 = (..xi, xj,…)	1
q1	d2	1
q1	d3	0
q2	d1	0
q2	d2	0
q2	d3	1

This is user given relevance.

Can we estimate/predict relevance ?

Binary Independence Model (BIM)

- Each document is a binary vector of terms.
- Occurrence of terms is mutually independent.

$$P(R = 1|d, q) = \frac{P(d|R = 1, q)P(R = 1|q)}{P(d|q)}$$

Bayes Rule

Quiz

$$P(R = 1|d, q) = \frac{P(d|R = 1, q)P(R = 1|q)}{P(d|q)}$$

Bayes Rule

- P(d=Taj|R=1,q) = ?
- P(R=1|q) = ?
- P(d|q) = ?

Document	P(R=0|d,q)	P(R=1|d,q)
Taj	0.5	0.5
Taj Mahal	0	1
Taj Tea	1	0

Quiz

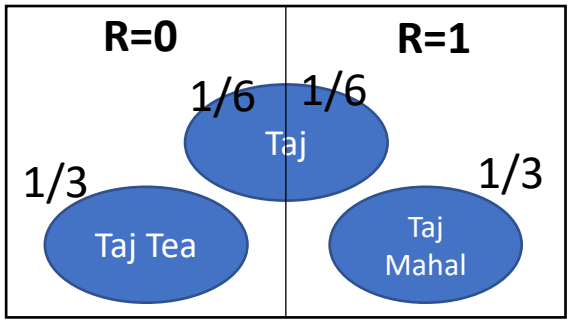
$$P(R = 1|d, q) = \frac{P(d|R = 1, q)P(R = 1|q)}{P(d|q)}$$

Bayes Rule

- P(d=Taj|R=1,q) = 1/3
- P(R=1|q) = 1/2
- P(d=Taj|q) = 1/3

P(R=1|d=Taj,q) = (1/3)(1/2)/(1/3) = ½

Document	P(R=0|d,q)	P(R=1|d,q)
Taj	0.5	0.5
Taj Mahal	0	1
Taj Tea	1	0



Predicting Relevance

- Odds of Relevance is easier to calculate

Constant term.

$$O(R|\vec{x},\vec{q}) = \frac{P(R=1|\vec{x},\vec{q})}{P(R=0|\vec{x},\vec{q})} = \frac{\frac{P(R=1|\vec{q})P(\vec{x}|R=1,\vec{q})}{P(\vec{x}|\vec{q})}}{\frac{P(R=0|\vec{q})P(\vec{x}|R=0,\vec{q})}{P(\vec{x}|\vec{q})}} = \frac{P(R=1|\vec{q})}{P(R=0|\vec{q})} \cdot \frac{P(\vec{x}|R=1,\vec{q})}{P(\vec{x}|R=0,\vec{q})}$$

- In BIM, we assume that the term occurrence is mutually independent

$$\frac{P(\vec{x}|R=1,\vec{q})}{P(\vec{x}|R=0,\vec{q})} = \prod_{t=1}^{M} \frac{P(x_t|R=1,\vec{q})}{P(x_t|R=0,\vec{q})} = \prod_{t:x_t=1} \frac{P(x_t=1|R=1,\vec{q})}{P(x_t=1|R=0,\vec{q})} \cdot \prod_{t:x_t=0} \frac{P(x_t=0|R=1,\vec{q})}{P(x_t=0|R=0,\vec{q})}$$

$$= \prod_{t:x_t=q_t=1} \frac{p_t}{u_t} \cdot \prod_{t:x_t=0,q_t=1} \frac{1-p_t}{1-u_t}$$

Retrieval Status Value

Not document specific.
Constant for a query.

$$\prod_{t:x_t=q_t=1} \frac{p_t(1-u_t)}{u_t(1-p_t)} \cdot \prod_{t:q_t=1} \frac{1-p_t}{1-u_t}$$

RSV = $$\prod_{t:x_t=q_t=1} \frac{p_t(1-u_t)}{u_t(1-p_t)}$$

RSV is used for ranking documents.

ARTICLE

Probabilistic model for contextual retrieval

Authors: Ji-Rong Wen, Ni Lao, Wei-Ying Ma Authors Info & Affiliations

Publication: SIGIR '04: Proceedings of the 27th annual international ACM SIGIR conference on Research and development in information retrieval • July 2004 • Pages 57–63 • https://doi.org/10.1145/1008992.1009005

Using Term Location Information to Enhance Probabilistic Information Retrieval

Authors: Baiyan Liu, Xiangdong An, Jimmy Xiangji Huang Authors Info & Affiliations

Publication: SIGIR '15: Proceedings of the 38th International ACM SIGIR Conference on Research and Development in Information Retrieval • August 2015 • Pages 883–886 • https://doi.org/10.1145/2766462.2767827

RESEARCH-ARTICLE

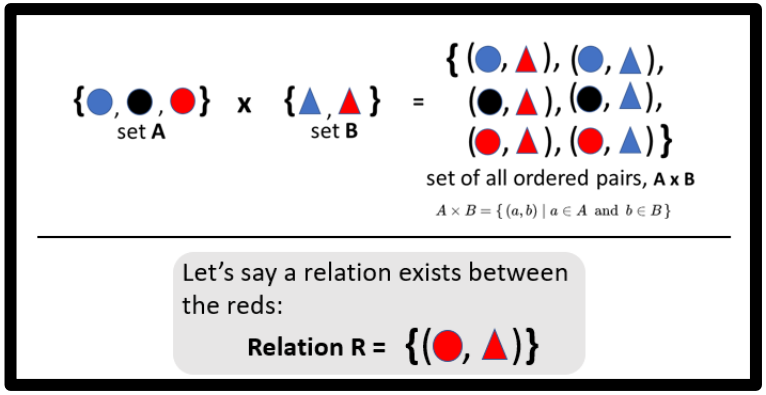
Probabilistic Topic Models for Text Data Retrieval and Analysis

Author: ChengXiang Zhai Authors Info & Affiliations

Publication: SIGIR '17: Proceedings of the 40th International ACM SIGIR Conference on Research and Development in Information Retrieval • August 2017 • Pages 1399–1401 • https://doi.org/10.1145/3077136.3082067

Summary: Relational Model

What is a Relation?



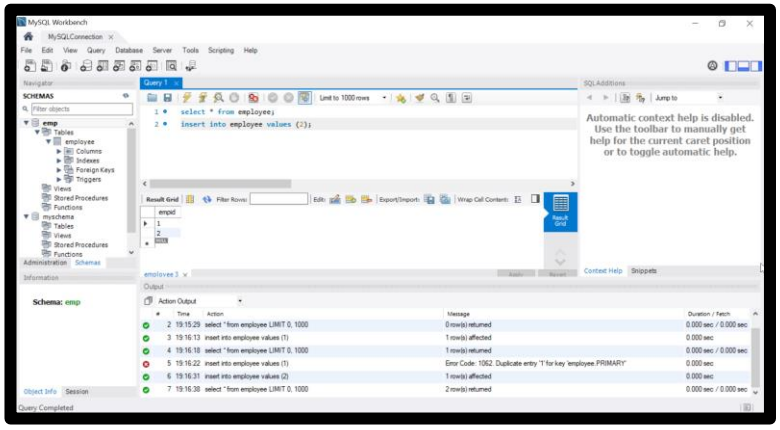
Relational Data Model

id	name
1	sd
1	vv
2	sd
2	vv
3	sd
3	vv

Vs

id	name
1	sd
2	vv

MySQL – An RDBMS

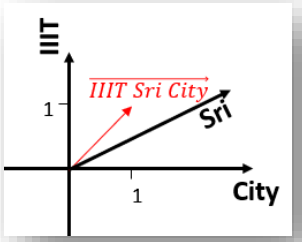


Attendance **relation**
{(1,1), (2,1)}
is same as the table

	studentid	sessionid
▶	1	1
	2	1

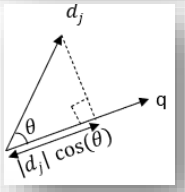
Summary: Vector Space Model

Model Documents as Vectors



Compute Similarity

$$\cos(\theta) = \frac{d_j . q}{||d_j||\ ||q||}$$



A Worked-Out Example

Query, q = "cheap CDs cheap DVDs extremely cheap CDs"

Retrieval Model {VSM, LDA, BM25, ...}

Results = ??

Content

d_1: "CDs cheap software cheap CDs"

d_2:"cheap thrills DVDs"

	cheap	CDs	DVDs	extremely	software	thrills	
q	3	2	1	1	0	0	
d_1	2	2	0	0	1	0	← $sim(q,d_1) = 0.86$
d_2	1	0	1	0	0	1	← $sim(q,d_2) = 0.59$

Summary: Probabilistic Model

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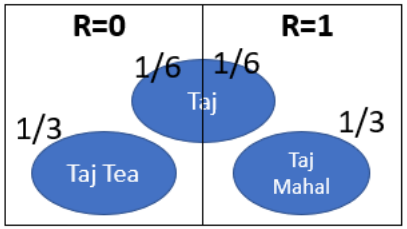
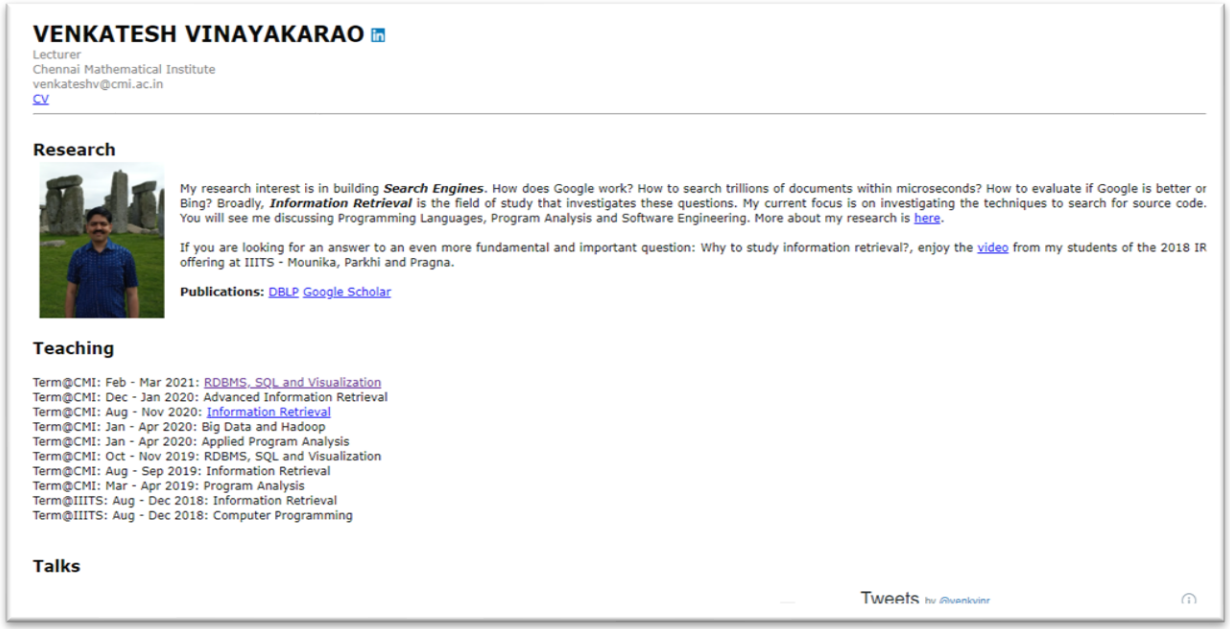


RSV = $$\prod_{t:x_t=q_t=1} \frac{p_t(1-u_t)}{u_t(1-p_t)}$$

RSV is used for ranking documents.



VENKATESH VINAYAKARAO

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CV

Research

My research interest is in building ***Search Engines***. How does Google work? How to search trillions of documents within microseconds? How to evaluate if Google is better or Bing? Broadly, ***Information Retrieval*** is the field of study that investigates these questions. My current focus is on investigating the techniques to search for source code. You will see me discussing Programming Languages, Program Analysis and Software Engineering. More about my research is here.

If you are looking for an answer to an even more fundamental and important question: Why to study information retrieval?, enjoy the video from my students of the 2018 IR offering at IIITS - Mounika, Parkhi and Pragna.

Publications: DBLP Google Scholar

Teaching

Term@CMI: Feb - Mar 2021: RDBMS, SQL and Visualization
Term@CMI: Dec - Jan 2020: Advanced Information Retrieval
Term@CMI: Aug - Nov 2020: Information Retrieval
Term@CMI: Jan - Apr 2020: Big Data and Hadoop
Term@CMI: Jan - Apr 2020: Applied Program Analysis
Term@CMI: Oct - Nov 2019: RDBMS, SQL and Visualization
Term@CMI: Aug - Sep 2019: Information Retrieval
Term@CMI: Mar - Apr 2019: Program Analysis
Term@IIITS: Aug - Dec 2018: Information Retrieval
Term@IIITS: Aug - Dec 2018: Computer Programming

Talks

Tweets

Thank You

venkateshv@cmi.ac.in

This slide deck is available at http://vvtesh.co.in/.

The Blind Men and the Elephant

The First approached the Elephant,
And happening to fall
Against his broad and sturdy side,
At once began to bawl:
"God bless! but the Elephant
Is very like a wall!"

The Second, feeling of the tusk,
Cried, "Ho! what have we here
So very round and smooth and sharp?
To me 'tis mighty clear
This wonder of an Elephant
Is very like a spear ! "

The third approached the animal,
And happening to take
The squirming trunk within his hands,
Thus boldly up and spake:
"I see," quoth he, "the Elephant
Is very like a Snake!"

The Fourth reached out an eager hand,
And felt about the knee.
"What most this wondrous beast is like
Is mighty plain," quoth he;
" 'Tis clear enough the Elephant
Is very like a tree!"

-from *An Introduction to Mathematical Modeling* (Dover Books on Computer Science)