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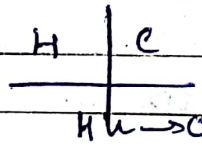
Web - Collection of docs.
Internet - Interconnected Network.
HTTP

WI → AI + Advanced IT.

Turing Test → In, AI, Turing Test is a method to determine whether a computer is Human Being.



Reverse Turing Test is:
Computer asks question eg: CAPTCHA

(1) Intelligent Web Page System
→ BI → CRM (Cust. Rel. Marketing) → Web Marketing / Service / Publishing

(2) Knowledge Network & Management.
→ Electronic Library.
→ Ontology engineering.
→ Semantic Web.

(3) Web Mining.
→ Multimedia data mining.
→ Text Mining.
→ Web based Ontology
→ Web log mining.
→ Web log structure.
→ Web warehousing

Index →
List of words / names / terms

Query → Text Indexing.

1) Documents
2) Tokenizing ~ Breaking Down Sentence.
3) Normalizing
4) Stemming ~ Root Word.
5) Stop Words. ~ Common Word.

Serial no.	term	Doc ID
1	bag.	1 → 2
2	ball	3 → 12
3	ball	1 → 12

Class Index
create(D) (populates list of documents) ← list of docs.
for d in D
(each document in D)
for w in d.
(each word in every document d)
i = index.lookup(w)
(check whether word w is present in index)
(if w is not present in index, lookup function returns -ve(1))

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if i<0

j = index.add(w)

(j will return to which position (or serial no.) the new word w is added to)

index.append(j, d.id);

(add the document id to the dict of doc id

4 cat [2]

else

index.append(d.id)

D1:

In the end it doesn't even matter

D2:

It might matter who knows

1) Tokenize.

Terms	DocID
In	1
the	1
end	1
it	1
doesn't	1
even	1
matter	1

Terms	DocID
It	1
might	1
matter	1
who	1
knows.	1

2) Sort & merge both lists.

Doesn't	1
and	1
even	1
In	1
It	1
It	2
knows	2
matter	1

Inverted Index.

Now, frequency comes into picture. Posting.

Dictionary.

Sl. no.	term	Docfq.	DocID list
1	Doesn't	1	1
2	and	1	1
3	In	1	1
4	It	2	1 → 2
5	knows.	1	2

Document frequency

Not Term frequency.

'It' twice in doc1

It	1	1

'It' twice in doc1 & 'It' once in doc 2.

It	2	1 → 2

Complexity

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'n' documents. 'm' words. 'w' words
(Total docs.) in index. per doc.

(1) complexity of reading every word

$$O(nw)$$

(2) for lookup function, at most 'm' words

$$O(\log m)$$

Assump: Structure used to store Term index is balanced Binary Tree

(3) One more function to append to docID the new document.

considering all of these, the Total Time complexity is : $O(nw \log m)$

I love pets
pets are good

I don't like
pets.

S1:

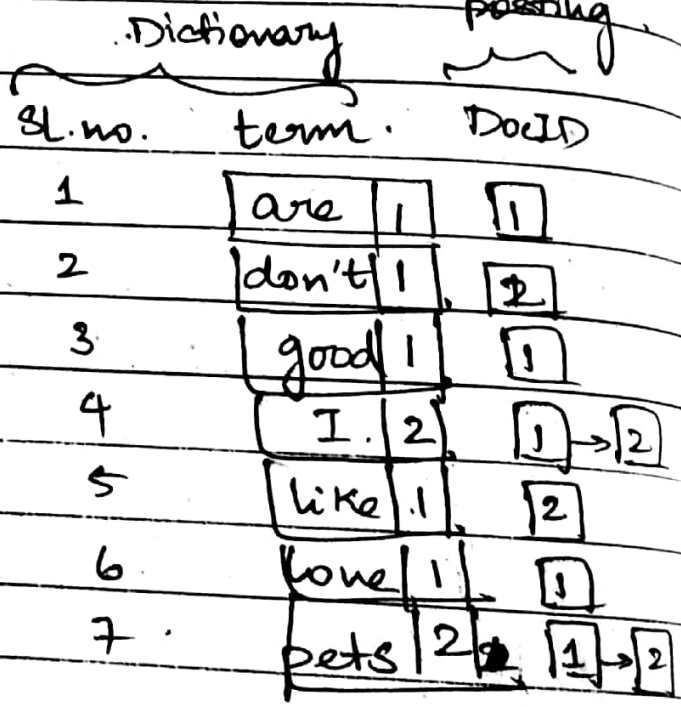
term	DocID
I	1
love	1
pets	1
pets	1
are	1
good	1

term	DocID
I	2
don't	2
like	2
pets.	2

S2:

Term	ID
are	1
don't	2
good	1
I	1
I	2
like	2
love	1
Pets	1
pets	1
pets	2

S3:



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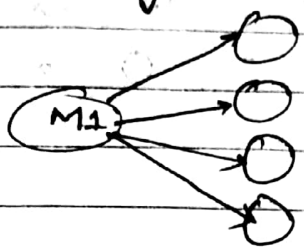
Web Intelligence :

Page Rank, Hyperlinks, Link Analysis.

(Q) How to tell if a mail account is a spam. account, without looking into contents.

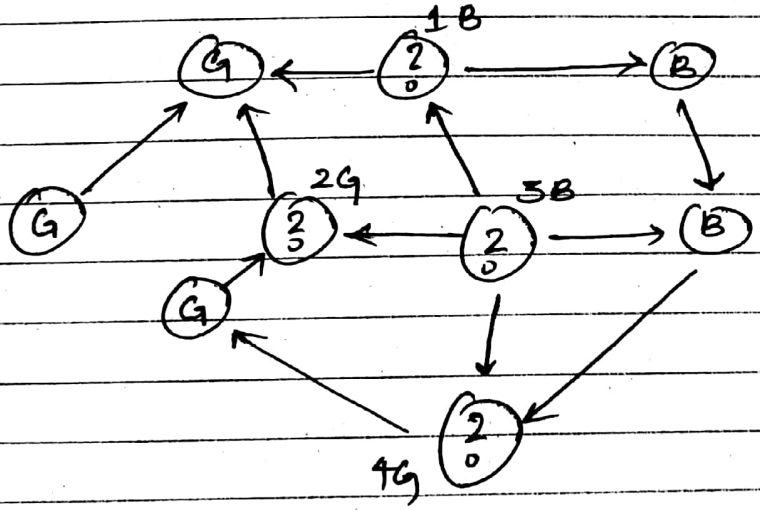
(A) No In-Link.



(1) No Good Node points to a bad node.

(2) If a node is pointing to a bad Node, then, it is bad.

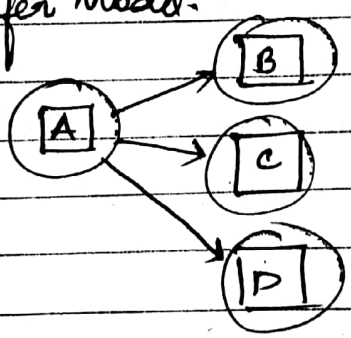
(3) If good nodes points to a Node, then, it is good.



Page Rank

Random Surfer Model.

Page Rank:



Prob = 1/n

n → No. of outlinks

Once you reach a node that has no outlink then, we use teleport operation

(1) Navigate to a different page

(2) Go Back

Teleport used when:

(1) Node has no outlink

(2) $0 < \alpha < 1$.

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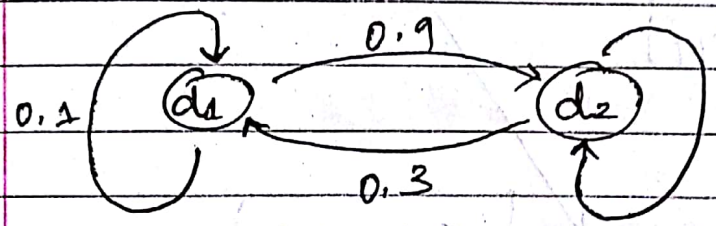
To convert Adjacency Matrix to TPM

(1) Divide each '1' in A by total no. of 1's in the row.
(2) Multiply resulting matrix by $1-\alpha$.
(3) Add α/N to every entry to the resulting matrix, to obtain



x_1 x_2

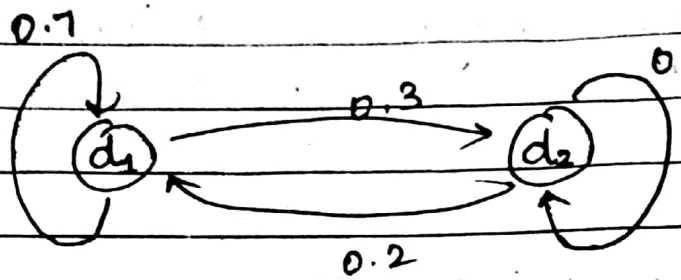
$P_t(d_1)$ $P_t(d_2)$.

$$[0.1] \begin{bmatrix} 0.1 & 0.9 \\ 0.3 & 0.7 \end{bmatrix}$$

$P_{11} = 0.1 \quad P_{12} = 0.9$
$P_{21} = 0.3 \quad P_{22} = 0.7$

0	1	0.3	0.7	$\vec{x}P$
0.3	0.7	0.24	0.76	$\vec{x}P^2$
0.24	0.76	0.252	0.748	$\vec{x}P^3$
0.252	0.748	0.2496	0.7504	$\vec{x}P^4$
...		...		
0.25	0.75	0.25	0.75	xP^5

Power Method.



I $\begin{matrix} & d1 & d2 \\ d1 \\ d2 \end{matrix}\begin{bmatrix} 1 & 0 \end{bmatrix}\begin{bmatrix} 0.7 & 0.3 \\ 0.2 & 0.8 \end{bmatrix}$ Ans = [0.4 0.6]

II $= \begin{bmatrix} 0.3 & 0.7 \end{bmatrix}\begin{bmatrix} 0.3 & 0.7 \\ 0.2 & 0.8 \end{bmatrix}$

$= 0.09 + 0.14 \quad 0.21 + 0.56$

$= [0.23 \quad 0.77]$

$\begin{bmatrix} 0.23 & 0.77 \end{bmatrix}\begin{bmatrix} 0.3 & 0.7 \\ 0.2 & 0.8 \end{bmatrix}$

III $\begin{bmatrix} 0.223 & 0.777 \end{bmatrix}\begin{bmatrix} 0.3 & 0.7 \\ 0.2 & 0.8 \end{bmatrix}$

$0.2223 \quad 0.7777$

$[0.2^2 \quad 0.77]$

$\begin{bmatrix} 1 & 0 \end{bmatrix}\begin{bmatrix} 0.7 & 0.3 \\ 0.2 & 0.8 \end{bmatrix}$ Ans = [0.4 0.6]

PageRank Vector = $\vec{\pi} = (\pi_1, \pi_2)$

$= (0.4, 0.6)$

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$$\pi = \pi \begin{bmatrix} 0.7 & 0.3 \\ 0.2 & 0.8 \end{bmatrix}$$

$$\pi = [x \quad y]$$

$$[x \quad y] = [x \quad y] \begin{bmatrix} 0.7 & 0.3 \\ 0.2 & 0.8 \end{bmatrix}$$

$$[x \quad y] = [0.7x + 0.2y \quad 0.3x + 0.8y$$

$$x = 0.7x + 0.2y$$

$$x + y = 1$$

(a) $0.3x = 0.2y$

$$y = \frac{3}{2}x$$

$$x + \frac{3}{2}x = 1$$

$$\frac{5x}{2} = 1$$

$$x = \frac{2}{5} = 0.4$$

(1) $\alpha = 0.4$ consider Graph

$1 \to 2$ $2 \to 1$ $2 \to 3$ $3 \to 2$

$4 \to 3$ $4 \to 2$ $4 \to 1$ $1 \to 3$

	1	2	3	4
1	0	1	1	0
2	1	0	1	0
3	0	1	0	0
4	1	1	1	0

Step1: Divide by total no. of 1's in row

$$\begin{bmatrix} 0 & 1/2 & 1/2 & 0 \\ 1/2 & 0 & 1/2 & 0 \\ 0 & 1/1 & 0 & 0 \\ 1/3 & 1/3 & 1/3 & 0 \end{bmatrix}$$

$\alpha = 0.4 \Rightarrow 1 - \alpha = 0.6$.

Step(2) Multiply the resulting matrix by $1-\alpha$

$$[0.6] \begin{bmatrix} 0 & 0.5 & 0.5 & 0 \\ 0.5 & 0 & 0.5 & 0 \\ 0 & 1 & 0 & 0 \\ 0.33 & 0.33 & 033 & 0 \end{bmatrix}$$

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$$\begin{bmatrix} 0 & 0.3 & 0.3 & 0 \\ 0.3 & 0 & 0.3 & 0 \\ 0 & 0.6 & 0 & 0 \\ 0.198 & 0.198 & 0.198 & 0 \end{bmatrix}$$

Step (3): Add α/n to everything:

$\alpha = 0.4 \quad N = 4$

$N \rightarrow$ Total no. of nodes.

$$\begin{bmatrix} 0.1 & 0.4 & 0.4 & 0.1 \\ 0.4 & 0.1 & 0.4 & 0.1 \\ 0.1 & 0.7 & 0.1 & 0.1 \\ 0.3 & 0.3 & 0.3 & 0.1 \end{bmatrix}$$

↕ TPM from Adjacency Matrix

Now, to get PageRank

$$\begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} 0.1 & 0.4 & 0.4 & 0.1 \\ 0.4 & 0.1 & 0.4 & 0.1 \\ 0.1 & 0.7 & 0.1 & 0.1 \\ 0.3 & 0.3 & 0.3 & 0.1 \end{bmatrix}$$

#PageRank

more → human memory.

"Google & the mind"

Psychological.

(1) Word-Word Association

formed semantic network

web-graphs => hyperlink

(2) Algorithm:

Ends up retrieving a bunch of words of words

Search works better for a semantic network as compared to a web graph

(Q) Is human memory same as Google Indexing

(A) No.

- Human mind is poor at recalling facts.
- " " needs context
- fuzzy
- sparse

Searching: Structured Data: complex in nature.

LSH: Locality Sensitive Hashing

(Q) Given 2 network assignments, how to find if they have been plagiarized.

(A) Document Similarity.

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Shingling : A common technique of representing sets.

LSH → Locality Sensitive Hashing.

General idea of LSH →
Hashing items such that similar items fall into the same bin.

Starting point = Similar docs → Similar sets

hard part → Arranging similar items such that they fall into the same bin

Starting point = Similar docs → Similar sets.

Applications of set similarities :

(1) Grouping of docs, pages with similar content
→ topic

(2) Netflix → Recommending.

(3) Movie fans.

(4) Entropy Matching.

Applications of Document Similarity:

(1) Mirror Sites

(2) Plagiarism.

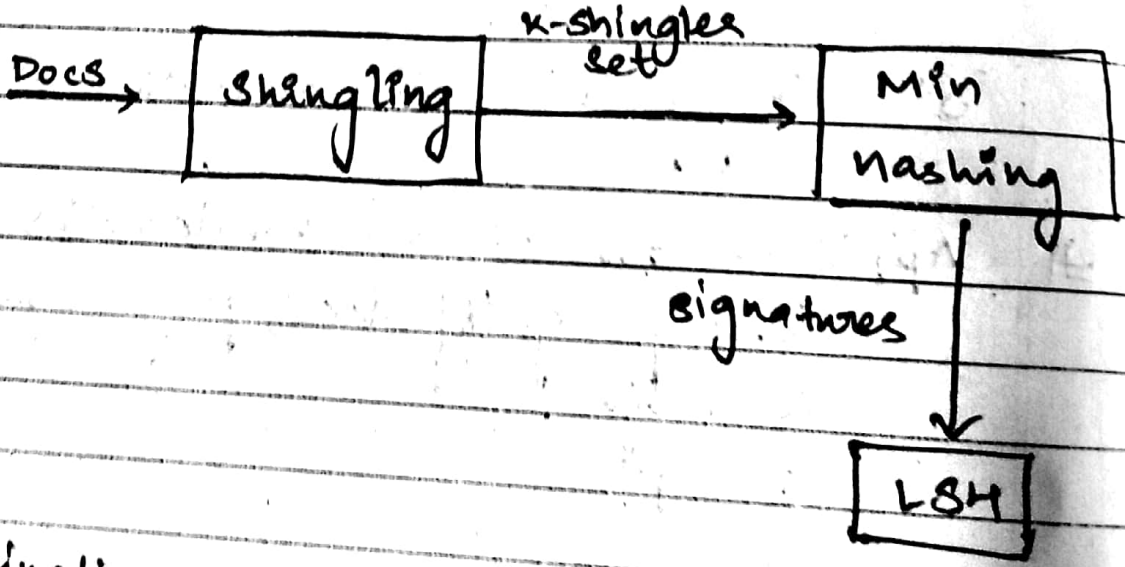
(3) e-news.

Calculate Similarity

1) Shingling.

(2) Min-Hashing.

(3) LSH.



Shingling: set of k-sensitive words

2K abcab → {ab, bc, ca, ~~2K~~}

↑
Set

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Shingles & Doc Similarity

→ most of the shingles.

→ 2 shingles (inter-changing paragraph)

Min Hashing:

→ Jaccard similarity

→ Signature Matrix

*

$$JC \rightarrow sim(C_1, C_2) = |C_1 \cap C_2| / |C_1 \cup C_2|$$

Rows → universal elements:

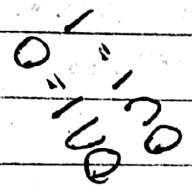
Cols → sets

$JC = A/(A+B+C)$

C1	C2	
0	1	
1	0	
1	1	*
0	0	
1	1	*
0	1	

2/5

	C1	C2
A	1	1
B	1	0
C	0	1
D	0	0



Maturity level of an organization refers to the ability of an org for continuous improvement in a particular

Min Hashing :

Element	S_1	S_2	S_3	S_4
b	0	0	1	0
e	0	0	1	0
a	1	0	0	1
d	1	0	1	1
c	0	1	0	1

$h(S_1) = a$

$h(S_2) = e$

$h(S_3) = b$

$h(S_4) = a$

Row	c_1	c_2
1	1	0
2	0	1
3	1	1
4	1	0
5	0	1

$h(x) = x \bmod 5$

$g(x) = (2x + 1) \bmod 5$

Minhash Signature Matrix

JC = 1/5

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	Sig 1	Sig 2
h(x)	∞	∞
g(x)	∞	∞

h(1) = 1
g(1) = 3

	Sig 1	Sig 2
h(1)=1	1	∞
g(1)=3	3	∞
h(2)=2	1	2
g(2)=0	3	0
h(3)=3	1	2
g(3)=2	2	0
h(4)=4	1	2
g(4)=4	2	0
h(5)=0	1	0
g(5)=1	2	0

Raw	S_1	S_2	S_3	S_4	
0	1	0	0	1	$h_1(x) = (x+1) \bmod 5$
1	0	0	1	0	$h_2(x) = (3x+1) \bmod 5$
2	0	1	0	1	
3	1	0	1	1	
4	0	0	1	0	

S_1	S_2	S_3	S_4	~~h(x)~~
∞	∞	∞	∞	$h_1(0) = 1$
∞	∞	∞	∞	$h_2(0) = 1$

$h_1(0)=1$ 1 ∞ ∞ 1

$h_2(0)=2$ 1 ∞ ∞ 1

$h_1(1)=2$ 1 ∞ 2 1

$h_2(1)=4$ 1 ∞ 4 1

$h_1(2)=3$ 1 3 2 1

$h_2(2)=2$ 1 2 4 1

$h_1(3)=4$ 1 3 2 1

$h_2(3)=0$ 0 2 0 0

$h_2(4)=0$ 1 3 0 1

$h_2(4)=3$ 0 2 0 0

$Sim(S_1, S_4) =$

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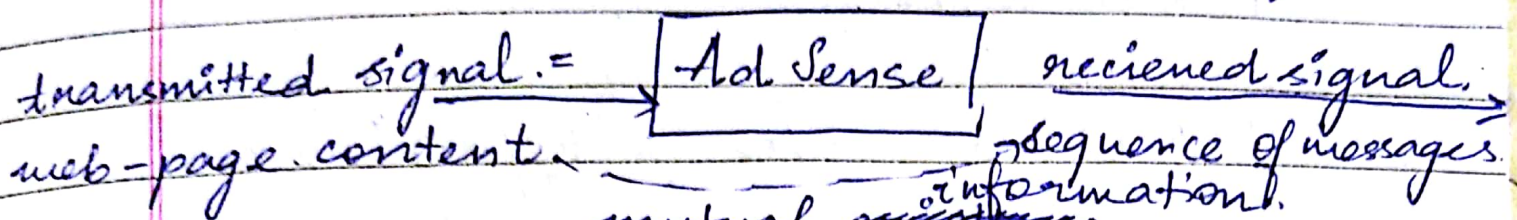
0	0	1	0	1	$h_1(x) = (2x+1) \bmod 6$
1	0	1	0	0	$h_2(x) = (3x+2) \bmod 6$
2	1	0	0	1	$h_3(x) = (3x+2) \bmod 6$
3	0	0	1	0	
4	0	0	1	1	
5	1	0	0	0	

	S_1	S_2	S_3	S_4
$h_1(0)=1$	∞	1	∞	1
$h_2(0)=2$	∞	2	∞	2
$h_3(0)=2$	∞	2	∞	2
$h_1(1)=3$	∞	1	∞	1
$h_2(1)=5$	∞	2	∞	2
$h_3(1)=1$	∞	1	∞	2
$h_1(2)=5$	5	1	∞	1
$h_2(2)=2$	2	2	∞	2
$h_3(2)=0$	0	1	∞	0
$h_1(3)=1$	5	1	1	1
$h_2(3)=5$	2	2	5	2
$h_3(3)=5$	0	1	5	0
$h_1(4)=3$	5	1	1	1
$h_2(4)=2$	2	2	2	2
$h_3(4)=4$	0	1	4	0
$h_1(5)=5$	5	1	1	1
$h_2(5)=5$	2	2	2	2
$h_3(5)=3$	0	1	4	0

$2/3 = 66\%$.
kind of similar

Adsense, Keywords & mutual information



Advertising Messages

Inverse Search.

pages to keywords.

query words to pages.

Tf-Idf.

- How important a word is
- Tf-idf increases proportionality to the number of times.
- Rarer words make better keywords

2 ways to search (or show ads)

(1) Search based on keyword

(2) & Inverse Search

(Based on imp word in website)

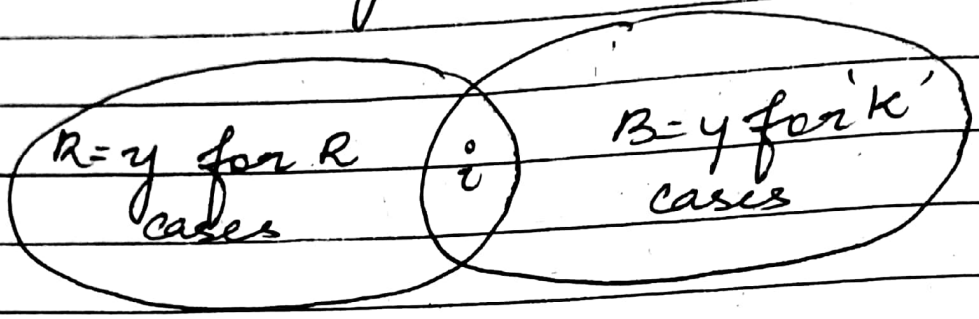
$P(B/R) = i/n$

$P(R) = n/n$

$P(R \text{ and } B) = i/n = (i/n) * (n/n)$

$P(B,R) = P(B/R) \cdot P(R)$

This is Baye's rule.



$P(B,R) = P(B/R) \cdot P(R)$

$= P(R/B) \cdot P(B)$

⇒

Types of prob:

- → Conditional. $P(x_1/x_2)$
- → Posterior $P(x/x_1)$
- → Apriori $P(x_1)\ P(x_2)\ P(x)$

Independence:

$i/c = n/n \equiv i/n = c/n$

$P(R) = n/n \quad P(C) = c/n$

$P(R/C) = i/c \quad P(C/R) = i/n$

R & C are independent

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(Q) Machine A & B produce produce 10% & 90% effectively. of the prod of component. intended for motor industry. From the experience, it is known that prob. that A produces a defective comp is 0.01
B -> defective component -> 0.05
Pick random comp
find the prob. that it was made by A or by B.

Prob (A) = (produced by A)

$P(A) = 0.1$ $P(D|A) = 0.01$
$P(B) = 0.9$ $P(D|B) = 0.05$

$$P(A|D) = \frac{P(D|A).P(A)}{P(D|A).P(A) + P(D|B).P(B)}$$

$= 0.02.$

Language & Information

transmitted signal. = meaning	language	recieved signal spoken / written word

Language is redundant.
Language tries to maintain "uniform information density"

- Besides Tf-idf.
  - keyword is present in how many docs.
  - semantics of a word.
  - bipartite graph.

- Machine learning.

Prediction using conditional probability

Sentiment Analysis:

Lib

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limiting physical.
Internal control.

Mutual information:

double summation.

$$I(F,B) = \sum_{f,b} p(f,b) \log \frac{p(f,b)}{p(f)\,p(b)}$$

Limitations of ML: