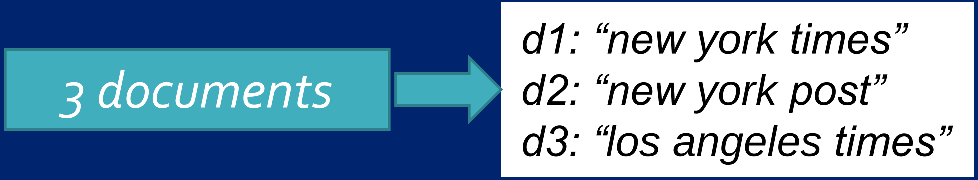
Vector Space Model

SDSC SAN DIEGO SUPERCOMPUTER CENTER

After this video you will be able to

- Explain the term “vector model”
- Describe the concepts of similarity function and similarity search
- Recognize that many document and image search engines use vector models and similarity search

Document Vector



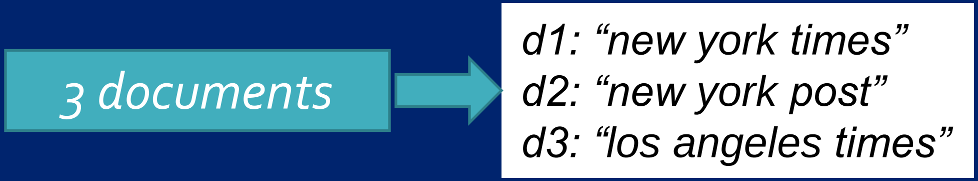
3 documents

d1: “new york times”
d2: “new york post”
d3: “los angeles times”

- Let’s create the term frequency matrix

	angeles	los	new	post	times	york
d1	0	0	1	0	1	1
d2	0	0	1	1	0	1
d3	1	1	0	0	1	0

Document Vector



3 documents

d1: “new york times”
d2: “new york post”
d3: “los angeles times”

- Inverse document frequency

TERM	*DOC-FREQUENCY*	*IDF*
angeles	*1*	$\log_2(3/1) = 1.584$
los	*1*	$\log_2(3/1) = 1.584$
new	*2*	$\log_2(3/2) = 0.584$
post	*1*	$\log_2(3/1) = 1.584$
times	*2*	$\log_2(3/2) = 0.584$
york	*2*	$\log_2(3/2) = 0.584$

The tf-idf matrix

TERM	*DOC-FREQUENCY*	*IDF*
angeles	*1*	$\log_2(3/1) = 1.584$
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	angeles	los	new	post	times	york
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d2	0	0	1	1	0	1
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The tf-idf matrix

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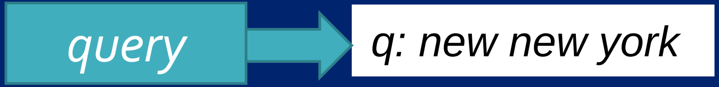
york	*2*	$\log_2(3/2) = 0.584$

	angeles	los	new	post	times	york	Length
d1	0	0	0.584	0	0.584	0.584	**1.011**
d2	0	0	0.584	1.584	0	0.584	**1.786**
d3	1.584	1.584	0	0	0.584	0	**2.316**

Length of d1 = sqrt(0.584^2+0.584^2+0.584^2)=1.011

Searching in Vector Space


query

q: new new york

- Max frequency of a term ("new") = 2
- Create the query vector

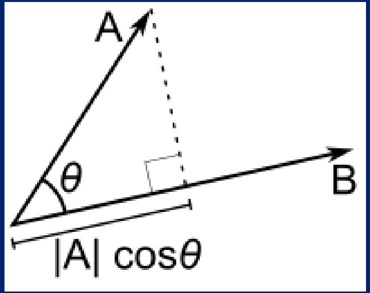
*Q [0 0 (2/2)*0.584=0.584 0 (1/2)*0.584=0.292 0]* ***length(q)=0.652***

- A similarity function between two vectors is a measure of how far they are apart

Similarity Function

- Many possible functions
- Cosine distance

$$similarity = \cos(\theta) = \frac{A \cdot B}{\|A\|\|B\|} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}}$$

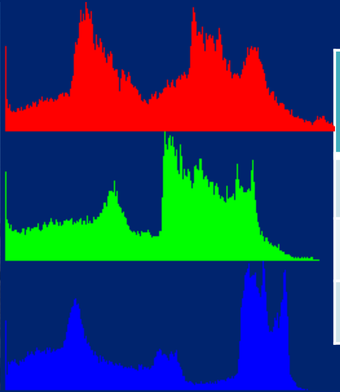


*cosSim(d1,q) = (0.584*0.584+0.584*0.292) / (1.011*0.652) = 0.776*
*cosSim(d2,q) = (0.584*0.584) / (1.786*0.652) = 0.292*
*cosSim(d3,q) = (0.584*0.292) / (2.316*0.652) = 0.112*

Query Term Weighting

- **Every query term may optionally be associated with a weighting term**
  - Q= York^1 times^2 post^5
    - wt(York) = 1/(1+2+5) = 1/8 = 0.125
    - wt(times) = 2/8 = 0.25
    - wt(post) = 5/8 = 0.625
  - Multiply the query vector with these weights
  - “new york post” ranks first

Image Search



	0-31	32-63	64-95	96-127	128-159	159-191	192-223	223-255
Red	0.04	0.12	0.23	0.06	0.24	0.12	0.13	0.06
Green	0.05	0.07	0.11	0.07	0.26	0.24	0.17	0.03
Blue	0.08	0.13	0.16	0.08	0.03	0.12	0.19	0.21