Similarity:

Retrieving Documents

Utkarsh Kulshrestha

Retrieving documents of interest

Document retrieval

- Currently reading article you like

Document retrieval

- Currently reading article you like
- Goal: Want to find similar article

Document retrieval

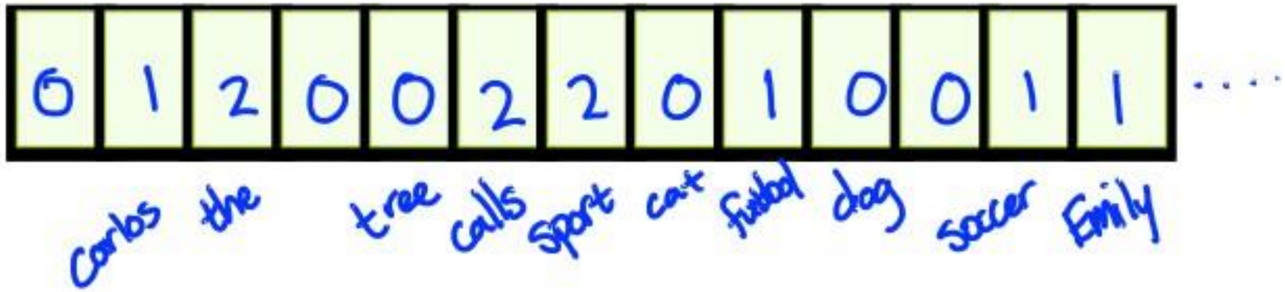
Challenges

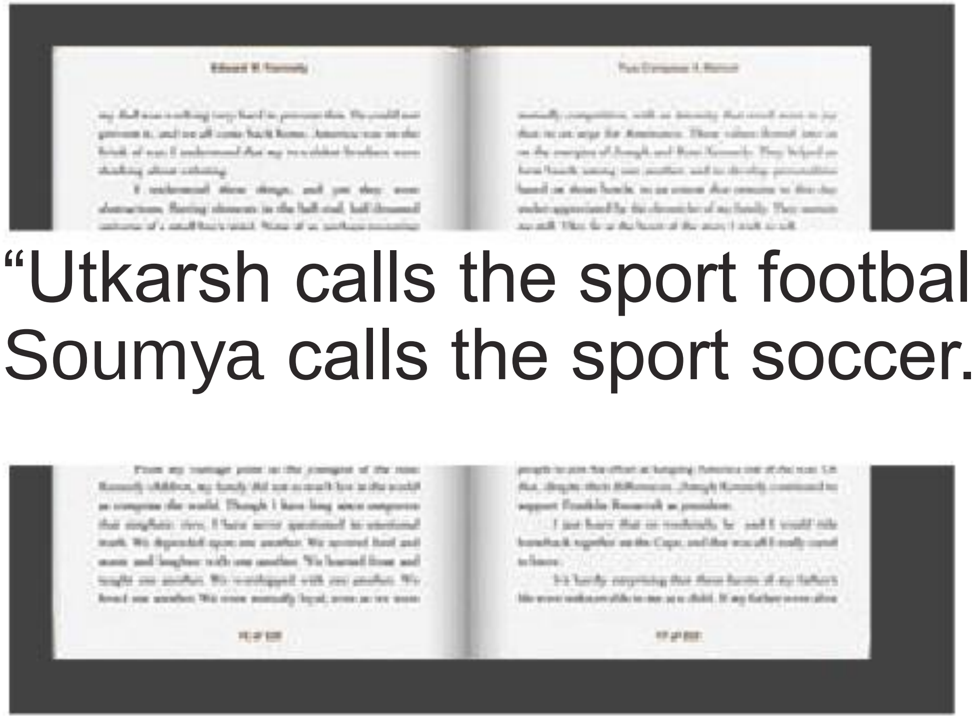
- How do we measure similarity?
- How do we search over articles?

Word count representation for measuring similarity

Word count document representation

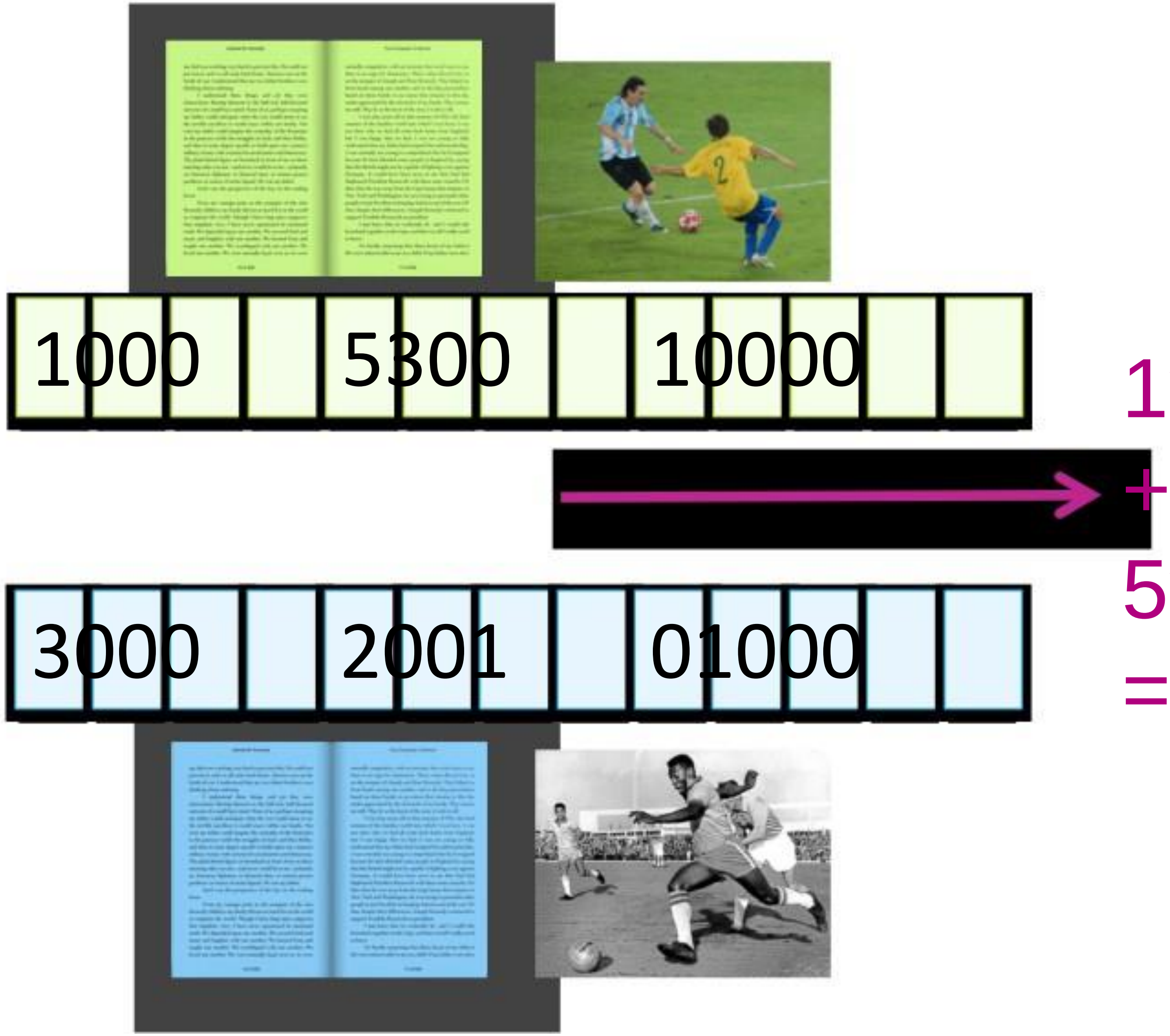
- Bag of words model
  - Ignore order of words
  - Count # of instances of each word in vocabulary





"Utkarsh calls the sport football. Soumya calls the sport soccer."

Measuring similarity



1000 5300 10000

3000 2001 01000

1*3
+
5*2
= 13

Measuring similarity

1	0	0	0	5	3	0	0	1	0	0	0	0

0

0	0	1	0	0	0	9	0	0	6	0	4	0

Issues with word counts - Doc length

1	0	0	0	5	3	0	0	1	0	0	0	0

30002 00101000

Similarity = 13

2	0	0	0	10	6	0	0	2	0	0	0	0

60004 00202 000

Similarity = 52

Prioritizing important words with tf-idf

Issues with word counts - Rare words

Common words in doc: “the”, “player”, “field”, “goal”

Dominate rare words like: “futbol”, “Messi”

Document frequency

- What characterizes a rare word?
  - Appears infrequently in the corpus

- Emphasize words appearing in few docs
  - Equivalently, discount word *w* based on

    # of docs containing *w* in corpus

Important words

- Do we want only rare words to dominate???

- What characterizes an important word?
  - Appears frequently in document (common locally)
  - Appears rarely in corpus (rare globally)

- Trade off between local frequency and global rarity

TF-IDF document representation

- Term frequency - inverse document frequency (tf-idf)

TF-IDF document representation

- Term frequency - inverse document frequency (tf-idf)
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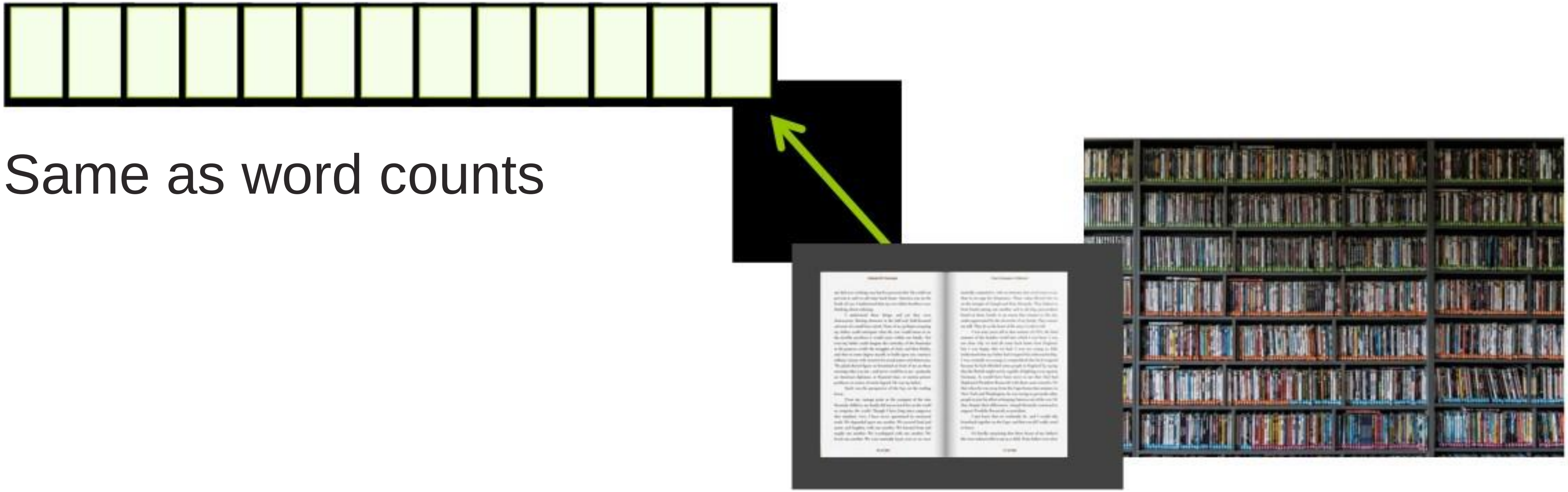
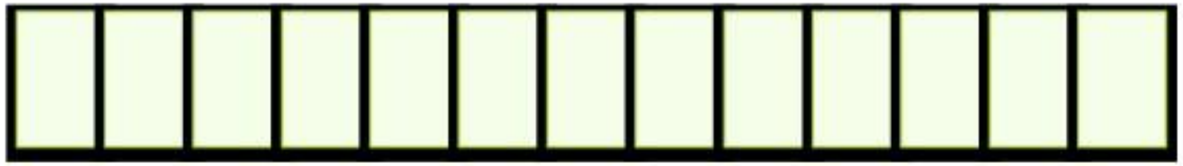


- Same as word counts

TF-IDF document representation

- Term frequency - inverse document frequency (tf-idf)
- Term frequency



- Inverse document frequency

$$\log \frac{\#\ \text{docs}}{1 + \#\ \text{docs using word}}$$

TF-IDF document representation

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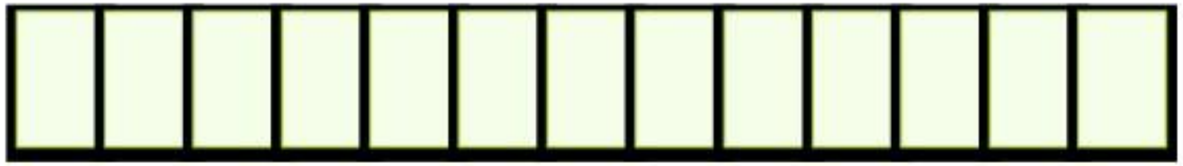


- Inverse document frequency

$$\log \frac{\#\ \text{docs}}{1 + \#\ \text{docs using word}}$$

word in many docs

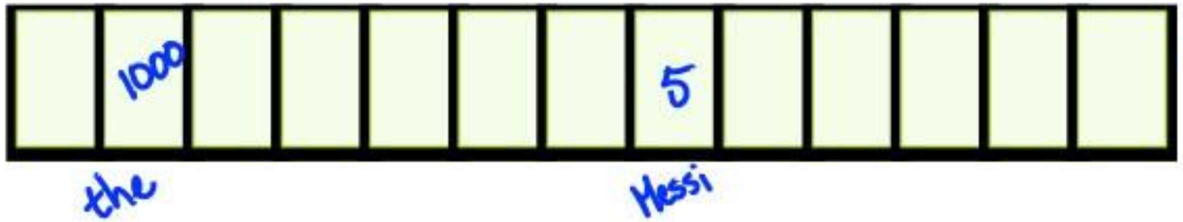
$$\log \frac{\text{large}\#}{1+\text{large}\#} \approx \log 1 = 0$$

rare word

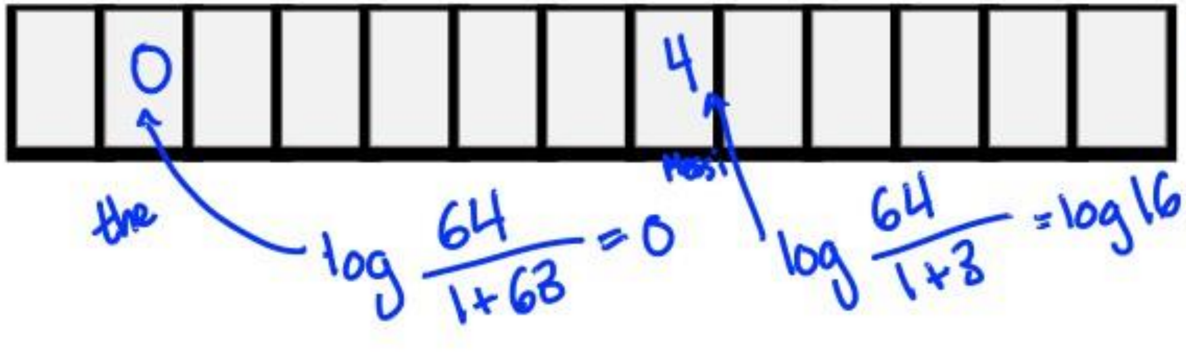
$$\log \frac{\text{large}\#}{1+\text{small}\#} \to \text{large}\#$$

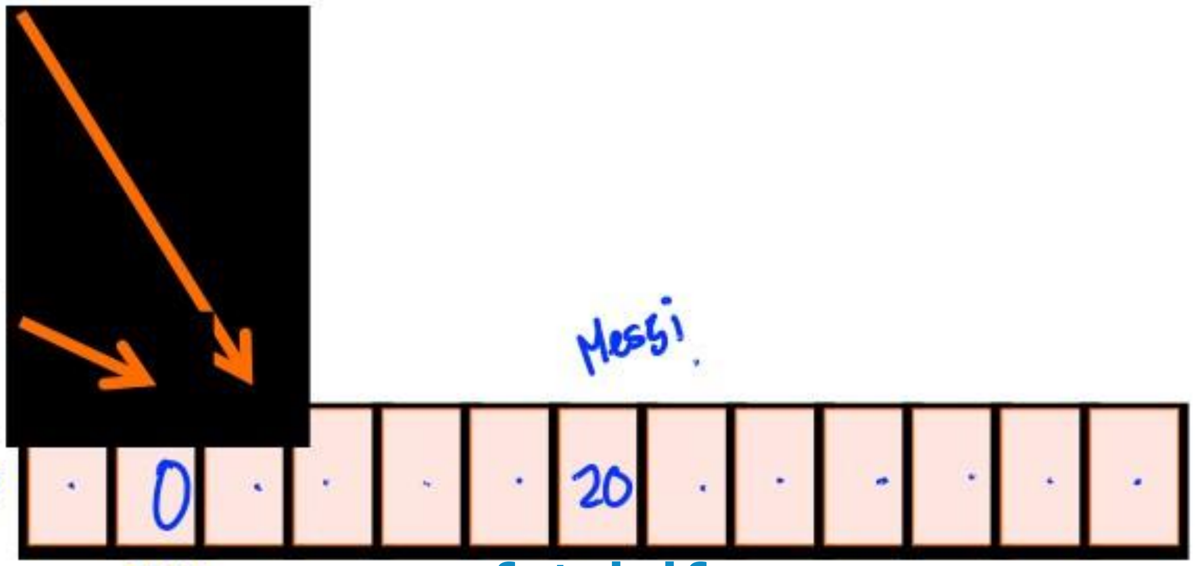
TF-IDF document representation

- Term frequency - inverse document frequency (tf-idf)
- Term frequency



- Inverse document frequency





tf * idf

Retrieving similar documents

Nearest neighbor search

- Query article:

- Corpus:

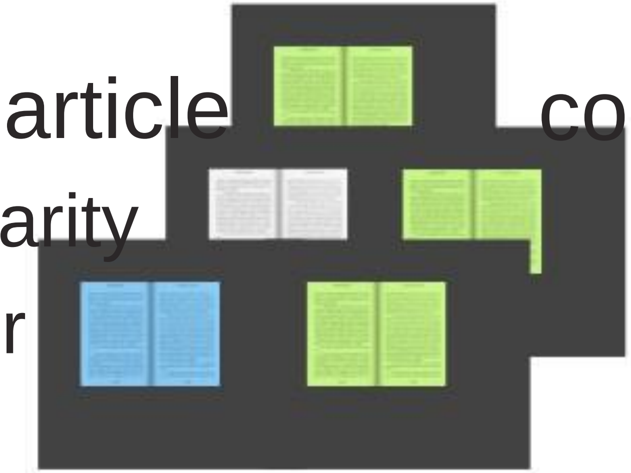
- Specify: Distance metric
- Output: Set of most similar articles

1 - Nearest neighbor

- Input: Query article

- Output: *Most* simila e

- Algorithm:
  - Search over each article corpus
    - Compute s = similarity
    - If s > Best_s, recor and set Best_s = s
  - Return



k - Nearest neighbor

- Input: Query article

- Output: *List of k* sim ticles

Clustering documents

Structure documents by topic

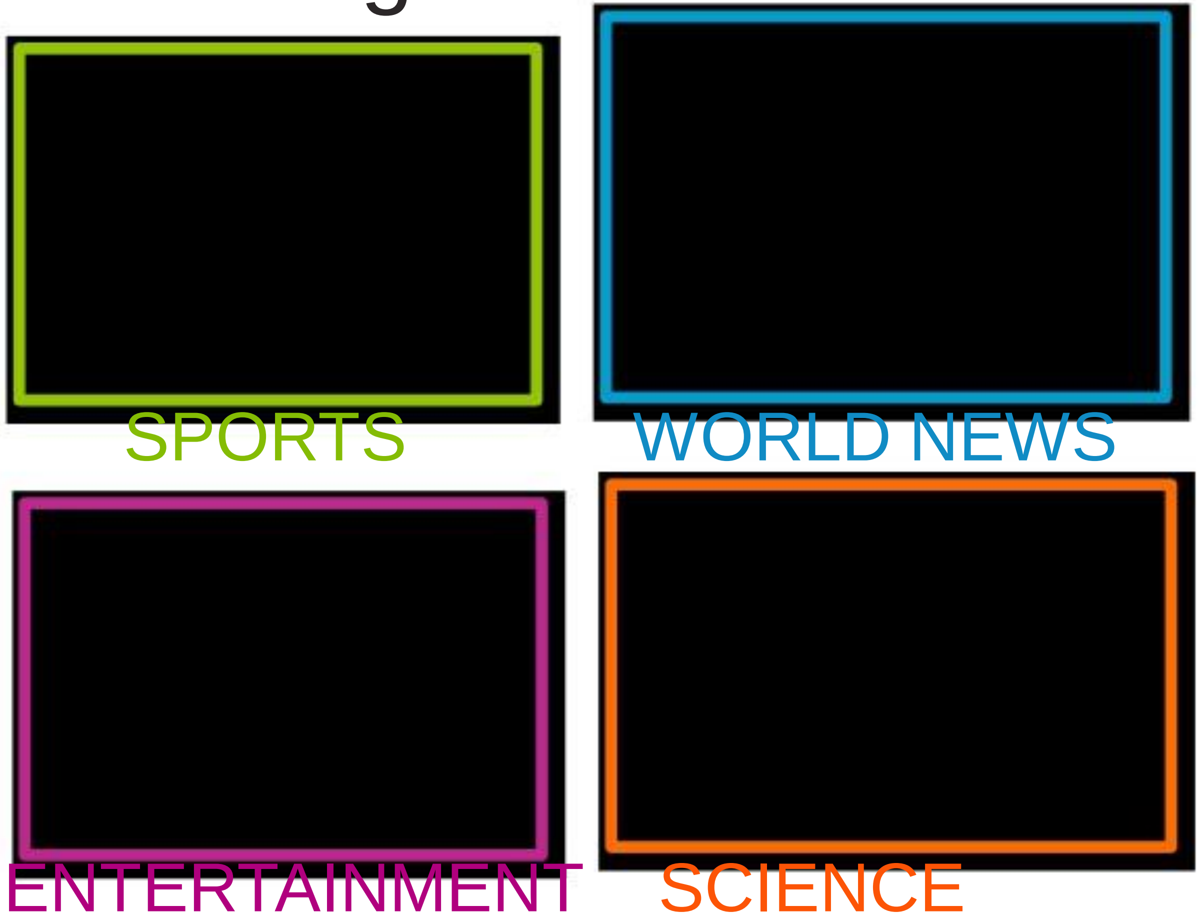
- Discover groups (*clusters*) of related articles

SPORTS

WORLD NEWS

What if some of the labels are known?

- Training set of labeled docs



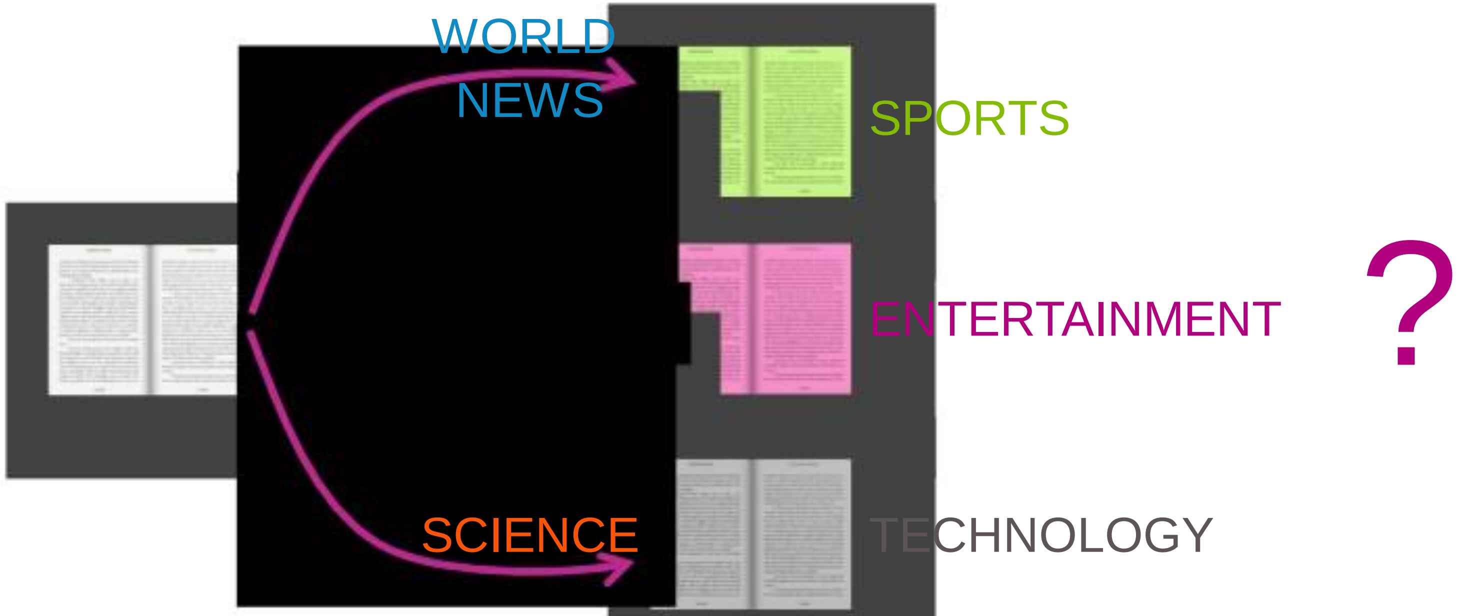
SPORTS

WORLD NEWS

ENTERTAINMENT

SCIENCE

Multiclass classification problem

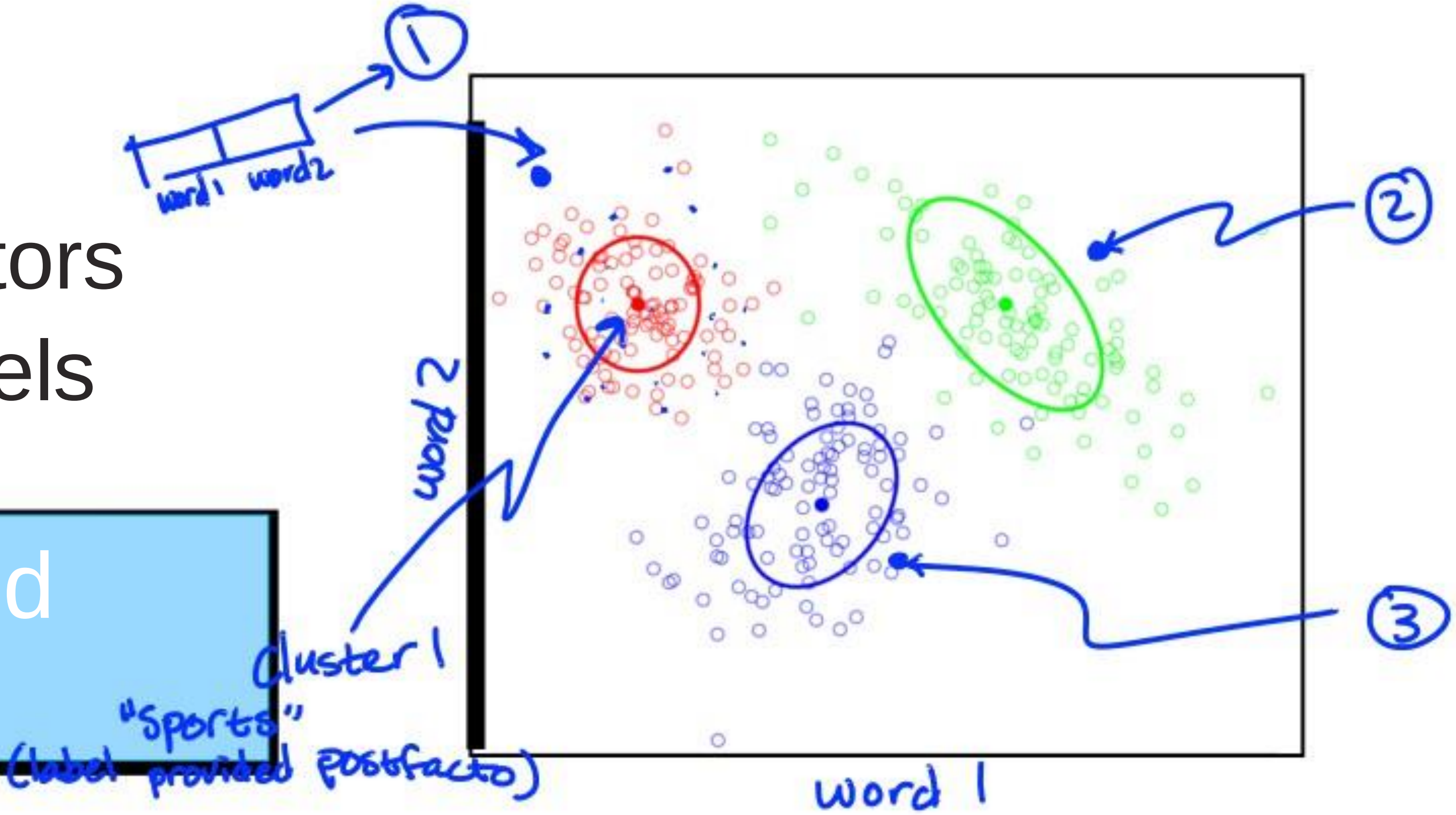


Example of
supervised learning

Clustering

- No labels provided
- Want to uncover cluster structure

- Input: docs as vectors
- Output: cluster labels

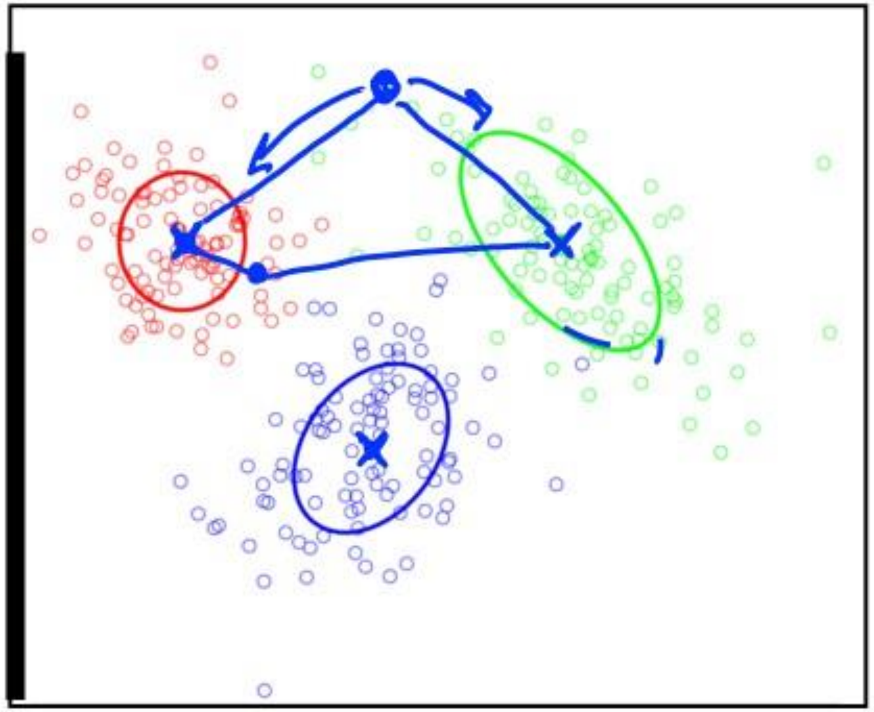


An unsupervised learning task

What defines a cluster?

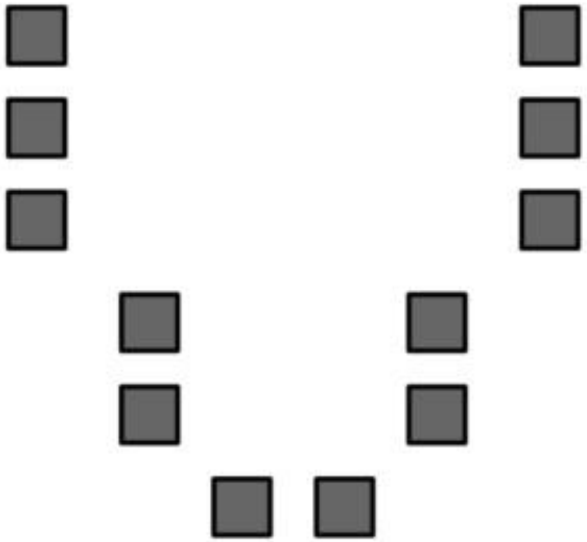
- Cluster defined by
  center & shape/spread

- Assign observation (doc) to cluster (topic label)
  - Score under cluster is higher than others
  - Often, just more similar to assigned cluster center than other cluster centers



k-means

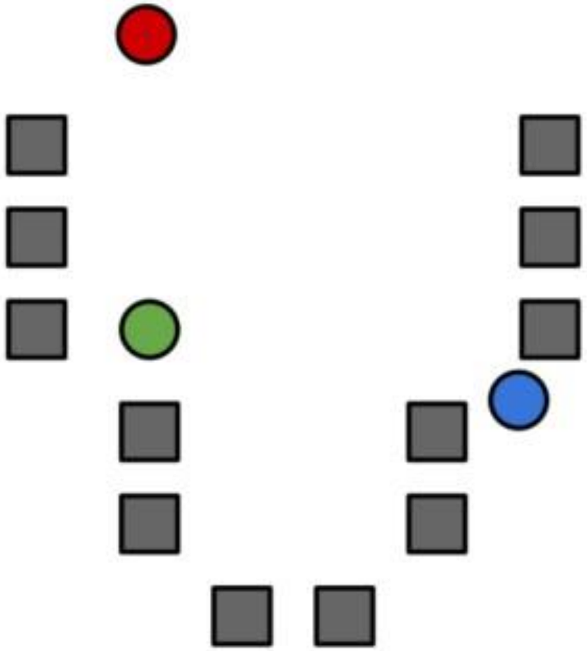
- Assume
  - Similarity metric = distance to cluster center (smaller better)



DATA
to
CLUSTER

k-means algorithm

0. Initialize cluster centers
1. Assign observations to closest cluster center
2. Revise cluster centers as mean of assigned observations
3. Repeat 1.+2. until convergence



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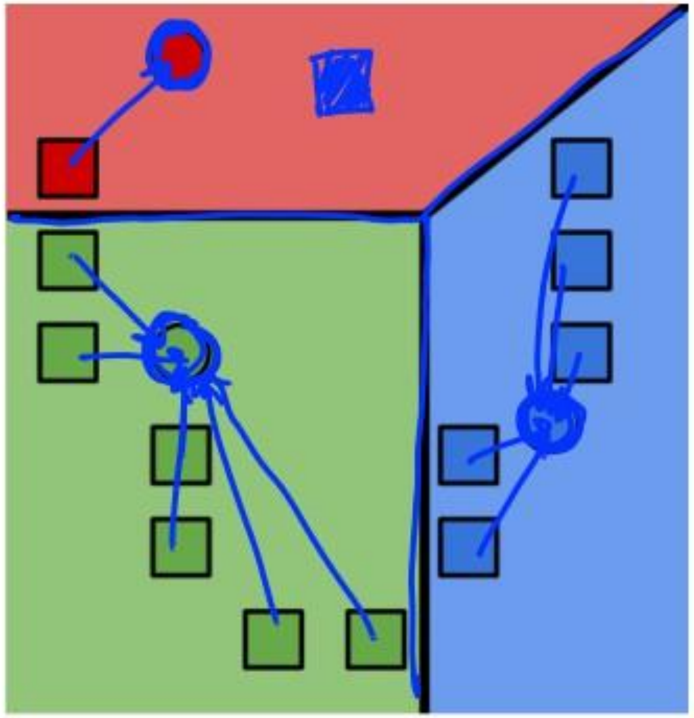

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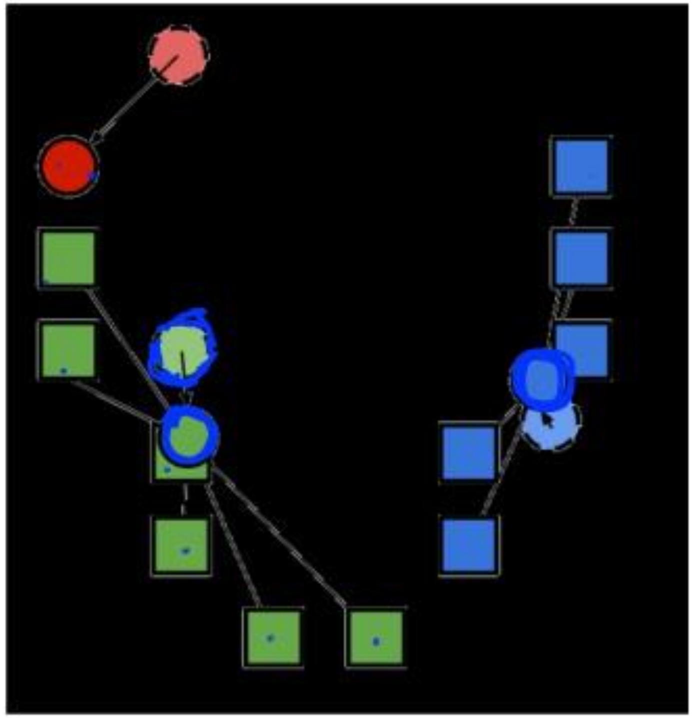

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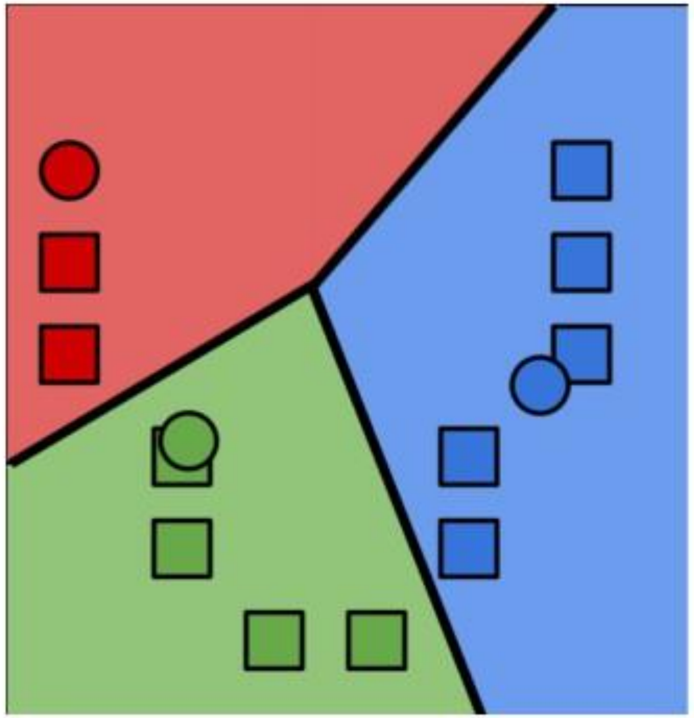


Other examples

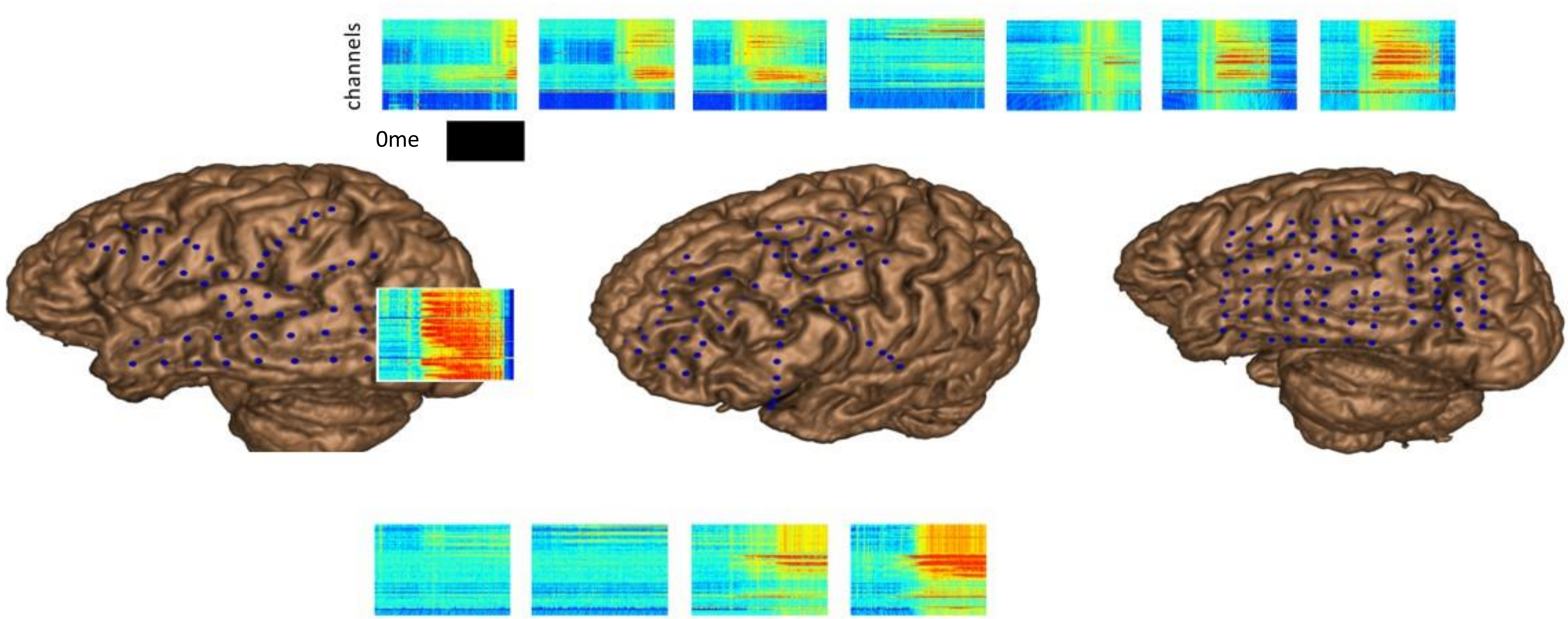
Clustering images

- For search, group as:
  - Ocean
  - Pink flower
  - Dog
  - Sunset
  - Clouds
  - …

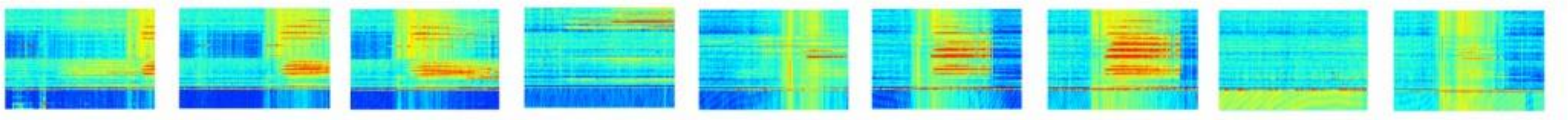
Grouping patients by medical condition

- Better characterize subpopulations and diseases

Example: Patients and seizures are diverse



Cluster seizures by observed time courses



Products on Amazon

- Discover product categories

es

“baby”

- Or discovering groups of users

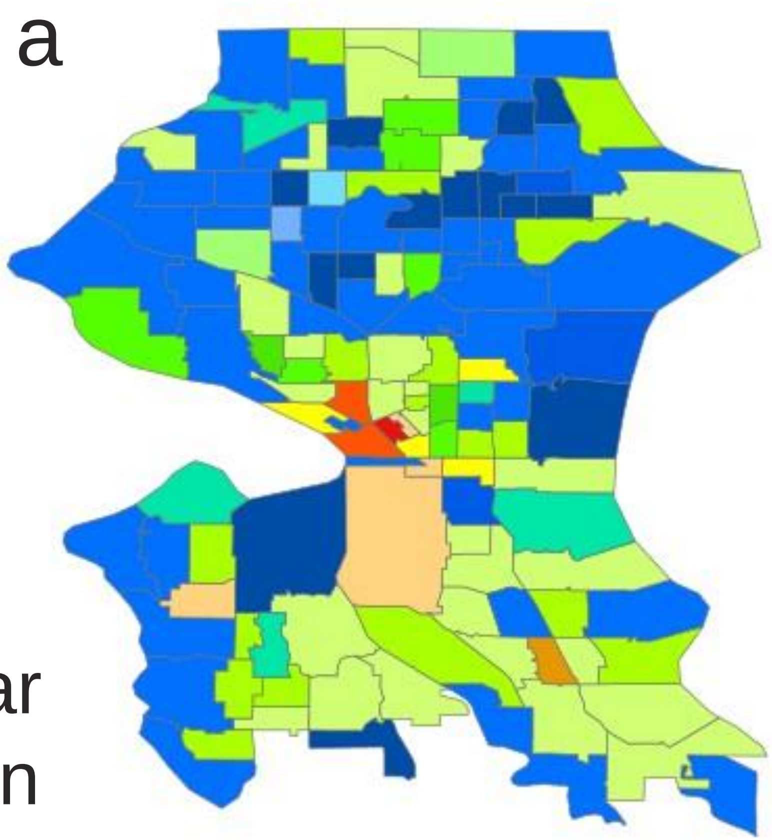
Structuring web search results

- Search terms can have multiple meanings
- Example: “cardinal”

- Use clustering to structure output

Discovering similar neighborhoods

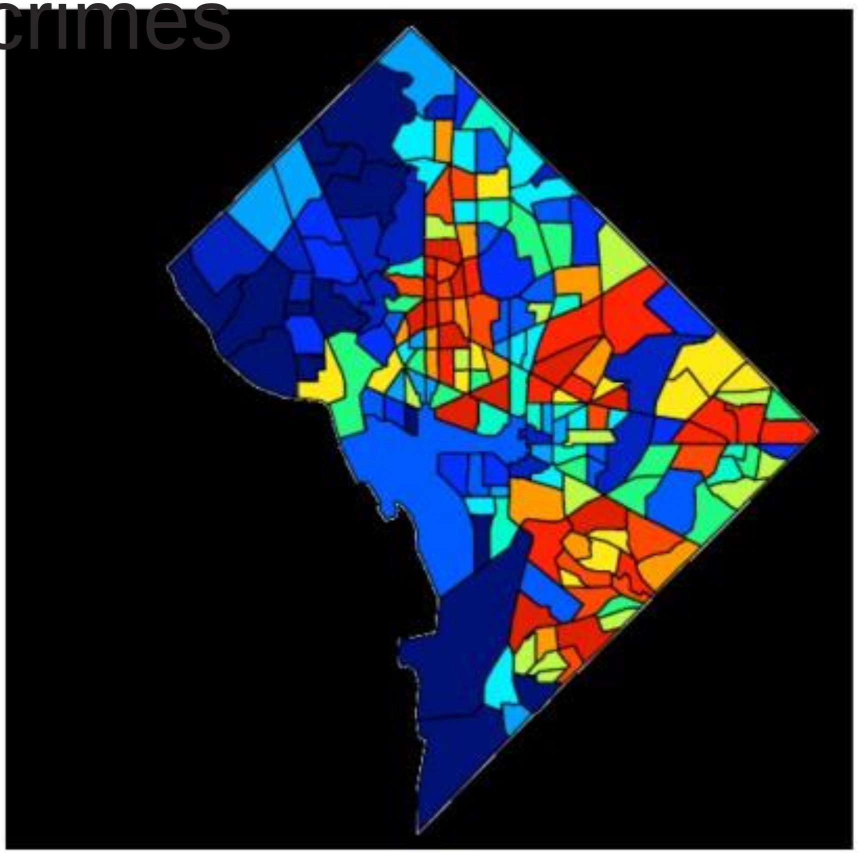
- Task 1: Estimate price at a small regional level
- Challenge:
  - Only a few (or no!) sales in each region per month
- Solution:
  - Cluster regions with similar trends and share information within a cluster



City of Seattle

Discovering similar neighborhoods

- Task 2: Forecast violent crimes to better task police
- Again, cluster regions an share information!
- Leads to improved predi compared to examining region independently



Washington, DC

Summary for clustering and similarity

What you can do now…

- Describe ways to represent a document (e.g., raw word counts, tf-idf,…)
- Measure the similarity between two documents
- Discuss issues related to using raw word counts
  - Normalize counts to adjust for document length
  - Emphasize important words using tf-idf
- Implement a nearest neighbor search for document retrieval
- Describe the input (unlabeled observations) and output (labels) of a clustering algorithm
- Determine whether a task is supervised or unsupervised
- Cluster documents using k-means (algorithmic details to come…)
- Describe other applications of clustering

THANK YOU !!!!

ANY QUESTIONS ?????