# INTRODUCTION TO DATA SCIENCE

This lecture is based on course by E. Fox and C. Guestrin, Univ of Washington

12/01/2022

WFAiS UJ, Informatyka Stosowana I stopień studiów

# Retrieving documents of interest

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





# Retrieving documents of interest

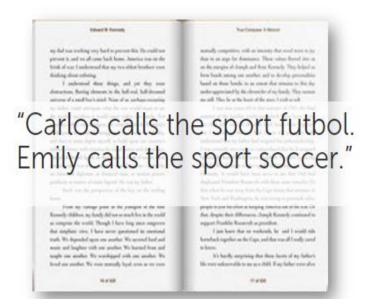
## Challenges

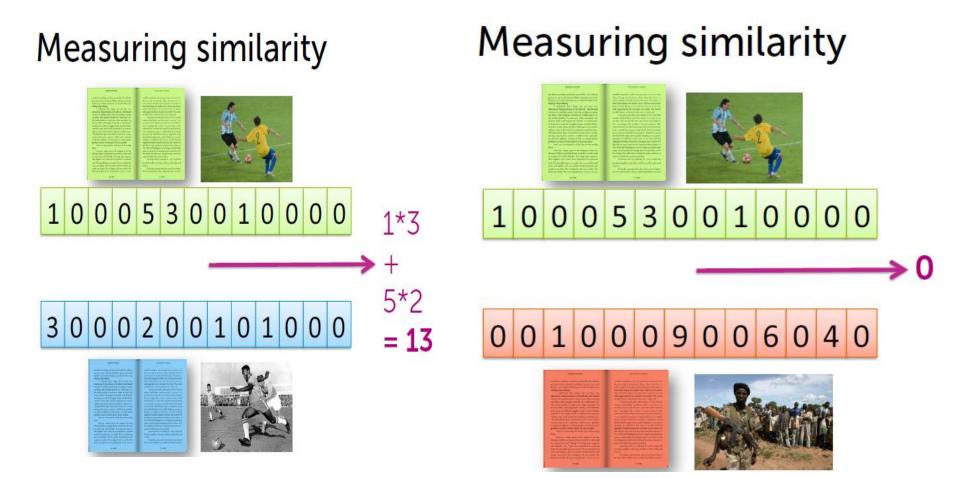
- How do we measure similarity?
- How do we search over articles?



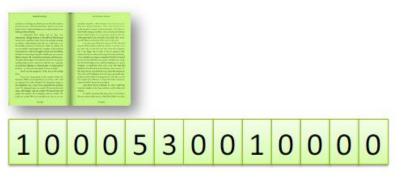
- Bag of words model
  - Ignore order of words
  - Count # of instances of each word in vocabulary

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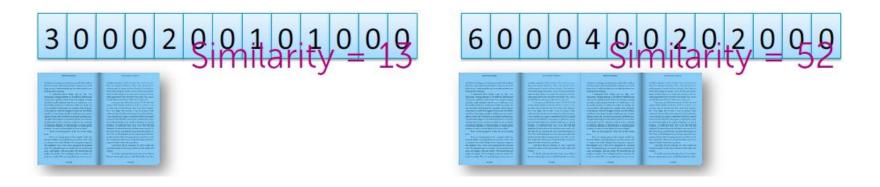


#### Issues with word counts - Doc length

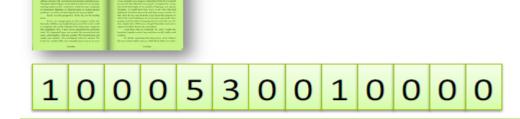


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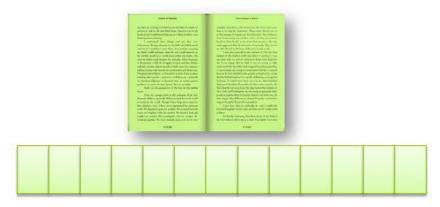
#### Solution = normalize



$$\sqrt{(1^2 + 5^2 + 3^2 + 1^2)}$$

#### Prioritizing important words

#### Issues with word counts – Rare words



Common words in doc: "the", "player", "field", "goal" Dominate rare words like: "futbol", "Messi"

### Prioritizing important words

### **Document frequency**

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

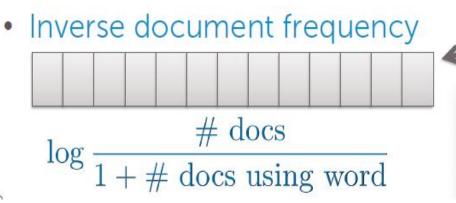
### Prioritizing important words

#### 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)
- Term frequency

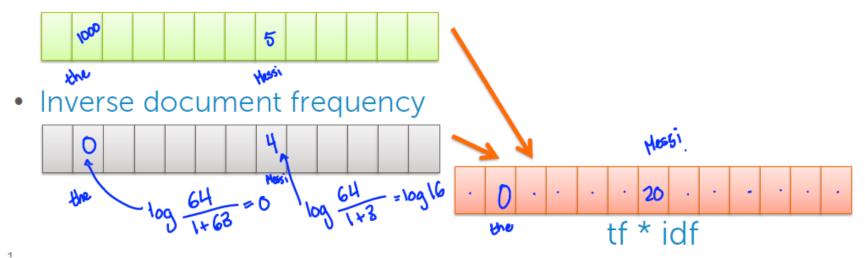




## **TF-IDF document representation**

#### **TF-IDF** document representation

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



# Retrieving similar documents

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#### Nearest neighbor search

- Query article:
- Corpus:

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



# Retrieving similar documents

#### 1 – Nearest neighbor

Input: Query article



- Output: Most similar article
- Algorithm:
  - Search over each article 📃 in corpus
    - Compute **s = similarity(**
    - If s > Best\_s, record and set Best\_s = s





# Retrieving similar documents

### k – Nearest neighbor

- Input: Query article
- Output: List of k similar articles



# Structure documents by topics

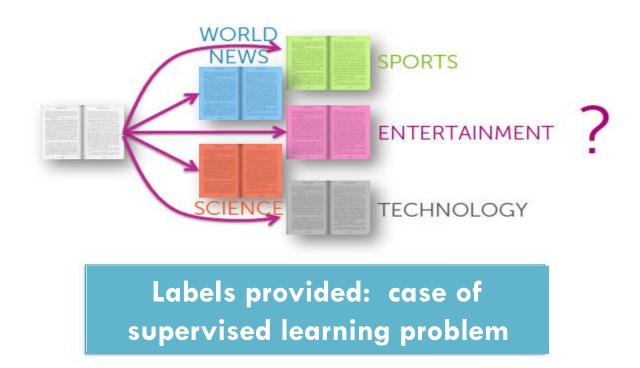
#### What if some of the labels are known?

• Training set of labeled docs



## Structure documents by topics

#### Multiclass classification problem



# Clustering

- No labels provided
- Want to uncover cluster structure
- Input: docs as vectors
- Output: cluster labels

fluster

No labels provided unsupervised learning

12/01/2022

word

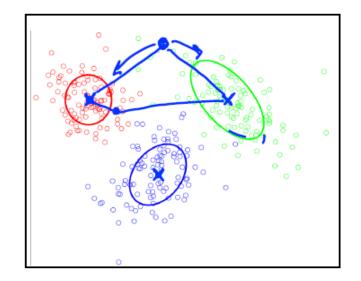
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# Clustering

#### What defines a cluster?

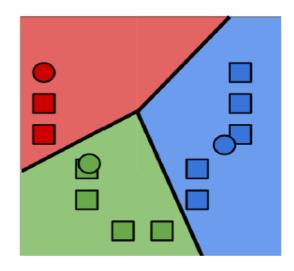
- Cluster defined by center & shape/spread
- Assign observation (doc) to cluster (topic label)
  - Score under cluster is higher than others
  - Often, just more similar to assigned cluster center than other cluster centers



# Clustering

#### 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



#### **Clustering images**

- For search, group as:
  - Ocean
  - Pink flower
  - Dog

- ...

- Sunset
- Clouds





#### **Products on Amazon**

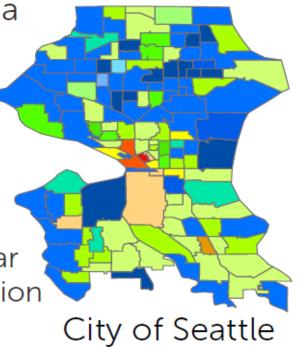
 Discover product categories from purchase histories



Or discovering groups of users

#### 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



#### Discovering similar neighborhoods

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

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Washington, DC

## We discussed how to ...

- 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