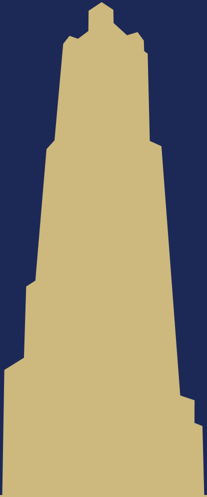
University of Pittsburgh

Document Clustering



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Automatic Bookmark Organizing

Originally wanted to clean up my bookmarks bar..
100s, maybe 1000s of bookmarks...

- Disorganized
- Some (failed) attempts at using folders
- Hard to find things

Automatic Bookmark Organizing

How should they be organized?

- Folders
  - Subfolders!
    - More subfolders?
- Folders also need to be properly **labeled**

Automatic Bookmark Organizing

Idea: Make a Chrome extension that takes list of bookmarks (URLs), automatically clusters them into folders, and rearranges your bookmarks bar!

Requirements:

- Making extension
- Hierarchical Clustering
- Accurate labeling

Simplifications

Focusing on the clustering and labeling for now. Also adopted a fake “bookmarks list” → a dump of Wikipedia.

Wikipedia Corpus

Chose GNU GPLv3 for my repository

- Downloaded 2GB compressed XML files, resulted in 12GB unzipped dataset.
- Used Wikiextractor library to convert to JSON with `title, id, text, url`
- Additional custom formatting

Clustering

How does clustering work?

- Hierarchical
  - Ward’s Method
  - More detailed and useful structure
- K-means
  - Faster
  - Single layer of clustering

K-means Clustering

- Unsupervised learning algorithm
- Produce *k* clusters by finding *k* centroids and a label for each data point, where each observation belongs to the cluster with the nearest centroid(mean).
- First, initialize centroids. Then,
  1. For each point, calculate Euclidean distance to each centroid, assigning it to the closest one.
  2. Centroids are then recalculated to be the averages of all the points in each cluster.

  Repeat 1 and 2 until no change in centroids.

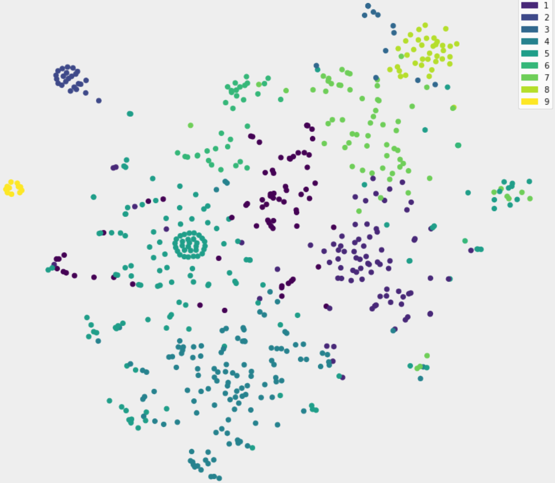
K-means for Wikipedia Corpus

Millions of articles

- First run on a sample and inspect results
  - tf-idf vectors of document text
  - K-means clustering
  - Sparse → dense vectors using TSVD
  - Visualize with t-SNE
    - Maps high-dimensional data to 2D space where similar data is grouped closer together.

K-means for Wikipedia Corpus

Some articles beginning with A



K-means labeling

How can we generate labels automatically?

- Using `spacy`, extract noun phrases and remove stopwords
- Within clusters, take the most frequent occurring topics
- Topic extraction with `gensim` did not work very well
  - Slow and complex
  - Good for extracting topics describing a document
  - For cluster labeling, looking for overlap between many documents
  - Simple noun phrase approach turned out to be good

K-means for Wikipedia Corpus

Some articles beginning with A

Cluster 0: Antigua and Barbuda, Apollo program, NYSE MKT, Australian Labor Party, Ainu people, Aga Khan I, Aga Khan III, Alexander Agassiz, American Chinese cuisine, List of Governors of Alabama, Antarctic Treaty System, Alfred Lawson, Americans with Disabilities Act of 1990, Army, AOL, Anarchism, Alabama, Abraham Lincoln, Academy Awards, Algeria, Austin (disambiguation), Andorra, American Football Conference, Anarcho-capitalism, Demographics of Antigua and Barbuda, Politics of Antigua and Barbuda, Afghanistan, Albania, Azerbaijan, American Revolutionary War, ...

K-means for Wikipedia Corpus

Some articles beginning with A

Cluster 0: Antigua and Barbuda, Apollo program, NYSE MKT, Australian Labor Party, Ainu people, Aga Khan I, Aga Khan III, Alexander Agassiz, American Chinese cuisine, List of Governors of Alabama, Antarctic Treaty System, Alfred Lawson, Americans with Disabilities Act of 1990, Army, AOL, Anarchism, Alabama, Abraham Lincoln, Academy Awards, Algeria, Austin (disambiguation), Andorra, American Football Conference, Anarcho-capitalism, Demographics of Antigua and Barbuda, Politics of Antigua and Barbuda, Afghanistan, Albania, Azerbaijan, American Revolutionary War, ...

My Label: Geography
Top 5 computed labels: Lincoln, Azerbaijan, Jackson, the United States, the country

K-means for Wikipedia Corpus

Some articles beginning with A

Cluster 1: Agnosticism, Author, Andrey Markov, A. A. Milne, Alvin Toffler, Albert Speer, Abdul Alhazred, Ada Lovelace, August Derleth, Albert Camus, Agatha Christie, The Plague, Hercule Poirot, Miss Marple, Allen Ginsberg, Anatoly Karpov, Alan Kay, Alain de Lille, Alfred Russel Wallace, Aimoin, Albertus Magnus, Alfred Nobel, Alexander Graham Bell, Andy Warhol, ...

K-means for Wikipedia Corpus

Some articles beginning with A

Cluster 1: Agnosticism, Author, Andrey Markov, A. A. Milne, Alvin Toffler, Albert Speer, Abdul Alhazred, Ada Lovelace, August Derleth, Albert Camus, Agatha Christie, The Plague, Hercule Poirot, Miss Marple, Allen Ginsberg, Anatoly Karpov, Alan Kay, Alain de Lille, Alfred Russel Wallace, Aimoin, Albertus Magnus, Alfred Nobel, Alexander Graham Bell, Andy Warhol, ...

My Label: People

Top 5 computed labels: Crowley, Aristotle, Speer, Einstein, Wallace

K-means for Wikipedia Corpus

Some articles beginning with A

Cluster 2: August, August 22, August 27, August 6, August 23, August 24, August 31, August 9, August 13, August 2, August 7, August 8, August 14, August 15, August 16, August 17, August 12, August 18, August 19, August 21, August 25, August 1, August 3

K-means for Wikipedia Corpus

Some articles beginning with A

Cluster 2: August, August 22, August 27, August 6, August 23, August 24, August 31, August 9, August 13, August 2, August 7, August 8, August 14, August 15, August 16, August 17, August 12, August 18, August 19, August 21, August 25, August 1, August 3

My Label: August

Top 5 computed labels: August, place, July, the peak, the year

K-means for Wikipedia Corpus

Some articles beginning with A

Cluster 9: April, April 6, April 12, April 15, April 30, April 28, April 22, April 1, April 16, April 29, April 13, April 26

K-means for Wikipedia Corpus

Some articles beginning with A

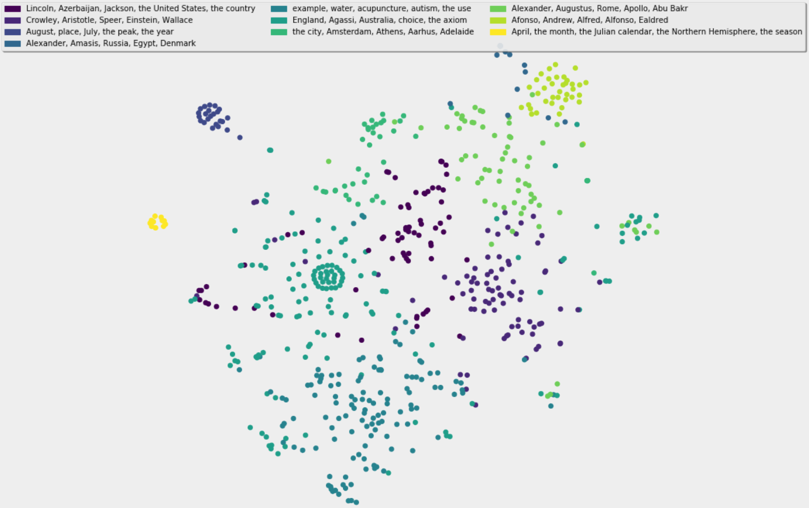
Cluster 9: April, April 6, April 12, April 15, April 30, April 28, April 22, April 1, April 16, April 29, April 13, April 26

My Label: April

Top 5 computed labels: April, the month, the Julian calendar, the Northern Hemisphere, the season

K-means for Wikipedia Corpus

t-SNE with generated labels



K-means Conclusions

K-means is pretty good.

- Number of clusters (k) is a bit arbitrary
- Some clusters turned out well, but others cover a wide range of topics

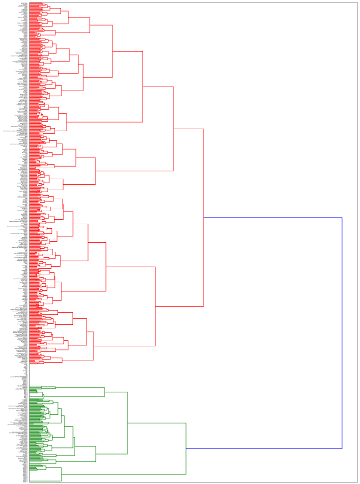
Hierarchical Clustering

Agglomerative clustering builds a binary tree

- Where K-means requires a parameter *k* and initial centroids, agglomerative clustering just requires some distance metric
  - Used cosine similarity
- Algorithm:
  1. Place each data point in its own group
  2. Repeatedly merge two closest groups until everything is in a single cluster

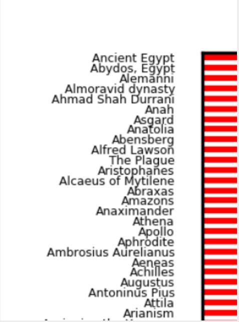
Hierarchical labeling

Hierarchical Clustering Results

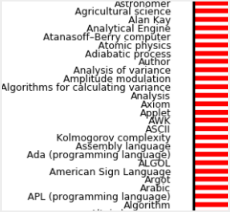


Hierarchical Clustering Results

Egypt, Greek Mythology

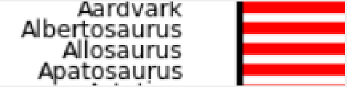


Some technical subjects

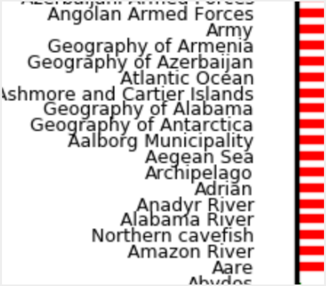


Hierarchical Clustering Results

Dinosaurs!

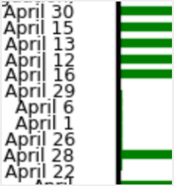


Geography

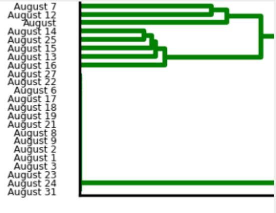


Hierarchical Clustering Results

April



August



Future work

Can't measure how good Wikipedia clusters are.

- Figure out Scipy dendogram construction
    - Define hierarchical labels
- Define my own metric (web scraping?)
- Run on more data
- Maybe try different corpus (20 newsgroups?)