PROJECT 2019

CLUSTERING DOCUMENTS TO COMPRESS INVERTED INDEX

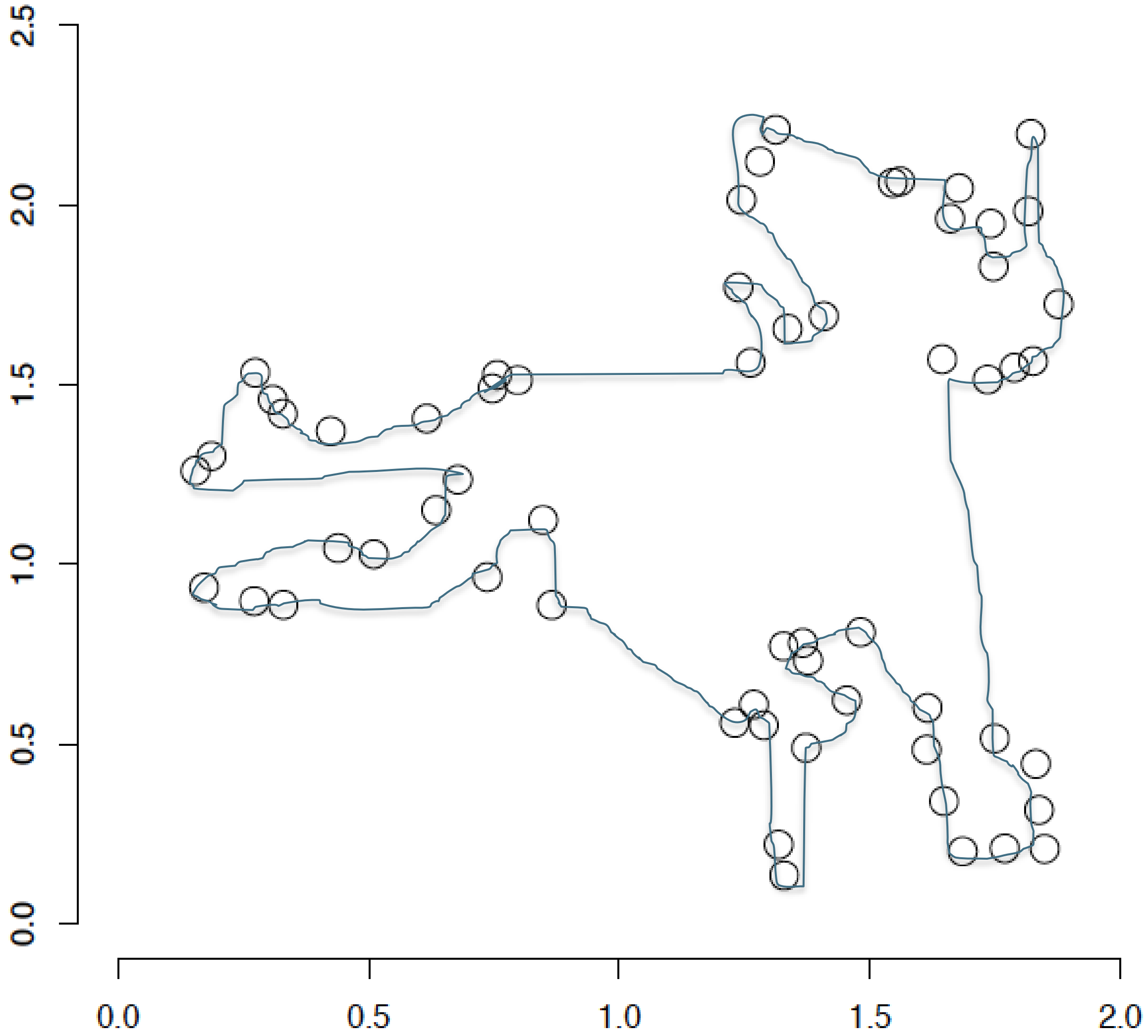
DocID reasssignment

- Small **d-gaps** are much more frequent (high probability) than large ones within postings lists
  - this feature of posting lists is called **Clustering property**, and is passively exploited by compression algorithms
  - variable-length encoding schemes allow indexes to be compressed very well by using **shorter codes** for **small d-gaps**
- Research Question: May we permute the DocID assignment to increase the frequency of small d-gaps?
  - If yes, we may increase the compression of the index

DocID reassignment - TSP

- A technique proposed in the literature is based on the travelling salesman problem (TSP)
- The heuristic computes a *pairwise distance* between every pairs of documents
  - proportional to the number of shared terms,
  - e.g., **Jaccard distance** = *1 – JaccardSim*
- Then use TSP to find the **shorted cycle** traversing all documents in the graph.
  - The cycle is finally broken at some point
  - the DocIDs are reassigned to the documents according to the ordering established by the cycle
  - Close documents in the cycle share many terms

TSP



DocID reassignment - TSP

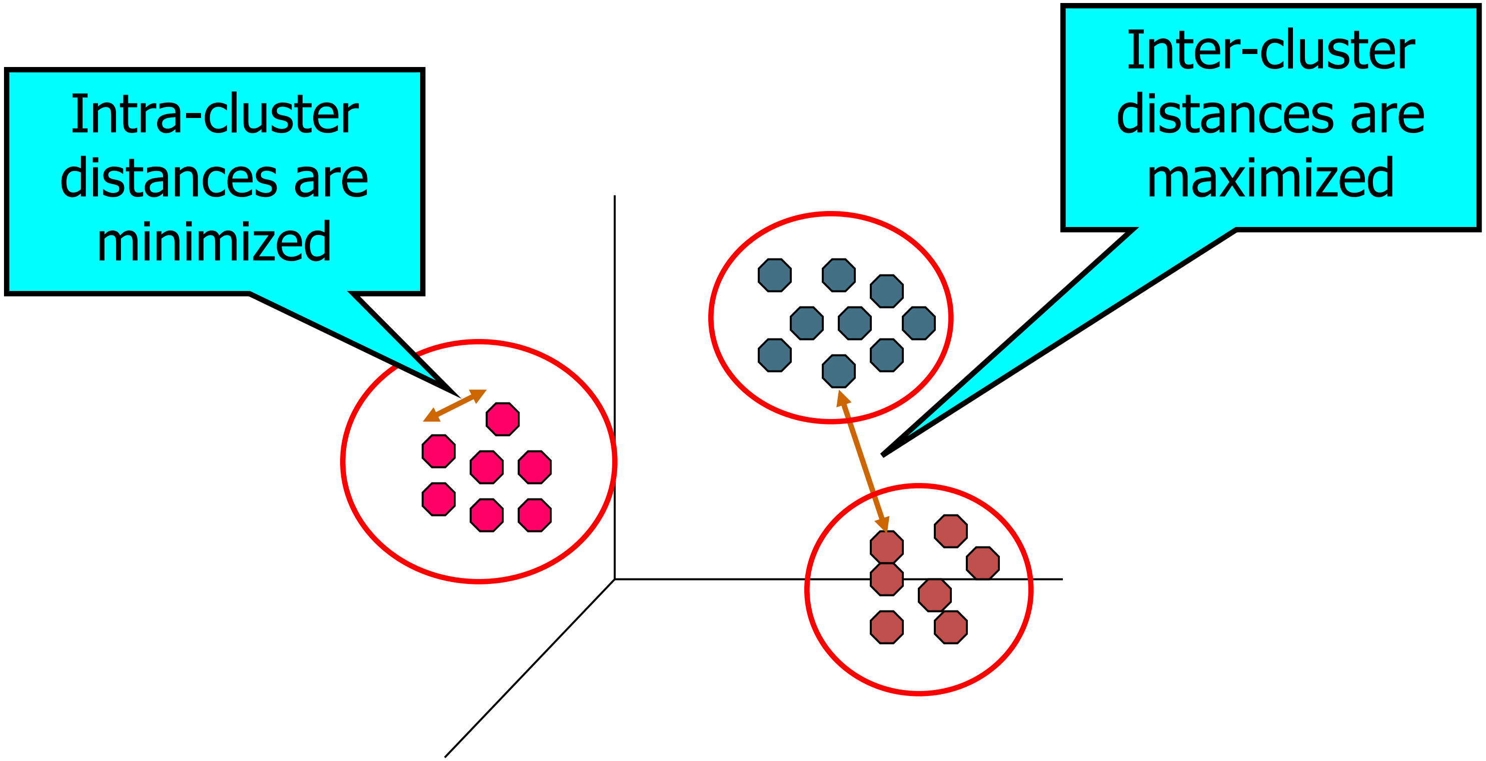
- The rationale of TSP usage
  - the TSP cycle preferably traverses edges connecting documents sharing a lot of terms (characterized by a small Jaccard distance)
  - if we assign close DocIDs to these documents, we expect a reduction in the average value of *d-gaps*, and thus in the size of the compressed inverted index
- However, this TSP approach doesn't scale

What is clustering?

- Clustering: the process of grouping a set of objects into classes of similar objects
    - Documents within a cluster should be similar.
    - Documents from different clusters should be dissimilar.
- The commonest form of *unsupervised learning*
        - Unsupervised learning = learning from raw data, as opposed to supervised data where a classification of examples is given
    - A common and important task that finds many applications in IR and other places

What is Cluster Analysis?

- Finding groups of objects such that the objects in a group will be similar (or related, or less distant of) to one another and different from (or unrelated to, ore more distant of) the objects in other groups



Intra-cluster distances are minimized

Inter-cluster distances are maximized

DocID reassignment: possible scalable solution

- (1) First **cluster documents**, then (2) Exploits TSP to **reorder clusters** (rather than single documents), using the representative document of each cluster
- Possible clustering algorithm
  - **scan linearly** the documents, sorted in reverse order of length
  - Each cluster returned will be identified by a **medoid**, i.e., a document that represents all the others in the cluster
  - The medoid should be the **most centrally located** point in the cluster. *However, the stream clustering algorithm does not guarantee this property of medoids*

DocID reassignment: possible scalable solution

- Transform each document into a set of **termIDs**
- Reorder the collection according to the document length (in reverse order) and scan linearly the collection of document to clustering them using **the Jaccard distance = 1 - JaccardSim**

  ```
      C = Stream_cluster(SortedCollection, Radius)
  ```

  where `C` is the returned set of clusters, each cluster represented by its Medoid.
- Apply TSP to the Medoids of each cluster, using the Jaccard distances between each pair of Medoids
- Assign the DocIds linearly cluster by cluster, using the TSP-induced order. Within each cluster the order is arbitrary.
- For each **postings list**, reassign the docIDs, compute the d-gaps, and determine the total size of all postings lists.

  It is not needed to materialize the compressed posting lists, but it suffices to determine the average bits per d-gap.

  - Compute avg bit for posting, e.g., for VB, the bits for a posting *G* are*:* $\left\lceil \frac{\lfloor \log G \rfloor + 1}{7} \right\rceil$**8*

DocID reassignment: possible scalable solution

- The pseudo-code of the stream algorithm that visits each document only once is the following:

```
Stream_cluster(SortedCollection, Radius)
    C = EmptySet
    for each d in SortedCollection
        Dist_c = Min (JaccardDistance(c, d), for each medoid c in C)
        if (Dist_c < radius) then
            add d to cluster c
        else
            make d a new medoid, and add this singleton cluster to C
    return C
```