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Cluster Analysis
Winter 2018/19

Problem Set 2

Please hand in your solutions for this problem set via email (roesner@cs.uni-bonn.de) or personally at Room 2.060 until *Tuesday, 23th of October*.

Problem 1

Recall that Gonzalez' algorithm computes a sequence of centers $c_1, c_2, \ldots$, which adds one additional center in each iteration. This way the algorithm not only computes a solution with k clusters, but also implicitly computes for each $1 \leq k' \leq k$ an additional clustering with k' clusters. If we set $k = |P|$ this yields an incremental clustering.

- Show with an example that these incremental clusterings computed with Gonzalez' algorithms are not necessarily hierarchical.

Problem 2

Incremental/hierarchical clusterings compute a k-clustering for every $k \in [|P|]$. If we want to compare two incremental/hierarchical clusterings, one of them might have the better clustering for some $k \in [|P|]$ while the other might have the better clustering for a different $k' \in [|P|]$.

- Give an example of a k-center problem, where no incremental clustering has an optimal solution for all $k' \in [|P|]$.
- Give an example of a k-center problem, where no hierarchical clustering has an optimal solution for all $k' \in [|P|]$.
- Show that for every incremental/hierarchical clustering, in some instances of the k-center problem, there exists another incremental/hierarchical clustering that has a truly better clustering for some $k' \in [|P|]$.

Problem 3

Given a set of elements $U = \{1, 2, \ldots, n\}$ and a collection of m subsets $U_i \subseteq U$ $(1 \leq i \leq m)$ together with $k \in \{1, \ldots, m\}$, the Set Cover problem asks for some the question if there exists a sub collection of at most k of these subsets, whose union contains every element of U. Formally, the Set Cover problem asks to decide if there exists a set $I \subseteq \{1, \ldots, m\}$ with $|I| \leq k$ such that $\bigcup_{i \in I} U_i = U$. The Set Cover problem is known to be an NP-hard problem.

- Use the Set Cover problem to show that the k-supplier problem is NP-hard.
- Furthermore show that it is NP-hard to compute an α-approximation for the k-supplier problem for any $\alpha \leq 3$.