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MADALGO seminar by Casper Kejlberg-Rasmussen, Aarhus University

I/O-Efficient Planar Range Skyline and Attrition Priority Queues

Abstract:

In the planar range skyline reporting problem, we store a set P of n 2D points in a structure such that, given a query rectangle $Q = [a_1, a_2] \times [b_1, b_2]$, the maxima (a.k.a. skyline) of $P \cap Q$ can be reported efficiently. The query is 3-sided if an edge of Q is grounded, giving rise to two variants: top-open ($b_2 = -\infty$) and left-open ($a_1 = -\infty$) queries.

All our results are in external memory under the $O(n/B)$ space budget, for both the static and dynamic settings:

* For static P , we give structures that answer top-open queries in $O(\log_B n + k/B)$, $O(\log \log_B U + k/B)$, and $O(1 + k/B)$ I/Os when the universe is \mathbb{R}^2 , a $U \times U$ grid, and a rank space grid $[O(n)]^2$, respectively (where k is the number of reported points). The query complexity is optimal in all cases.

* We show that the left-open case is harder, such that any linear-size structure must incur $\Omega((n/B)^e + k/B)$ I/Os for a query. We show that this case is as difficult as the general 4-sided queries, for which we give a static structure with the optimal query cost $O((n/B)^e + k/B)$.

* We give a dynamic structure that supports top-open queries in $O(\log_{2B}^e (n/B) + k/B^{1-e})$ I/Os, and updates in $O(\log_{2B}^e (n/B))$ I/Os, for any e satisfying $0 \leq e \leq 1$. This leads to a dynamic structure for 4-sided queries with optimal query cost $O((n/B)^e + k/B)$, and amortized update cost $O(\log(n/B))$.

As a contribution of independent interest, we propose an I/O-efficient version of the fundamental structure priority queue with attrition (PQA). Our PQA supports FindMin, DeleteMin, and InsertAndAttrite all in $O(1)$ worst case I/Os, and $O(1/B)$ amortized I/Os per operation.

We also add the new CatenateAndAttrite operation that catenates two PQAs in $O(1)$ worst case and $O(1/B)$ amortized I/Os. This operation is a non-trivial extension to the classic PQA of Sundar, even in internal memory.

Joint work with: Yufei Tao, Konstantinos Tsakalidis, Kostas Tsichlas, Jeonghun Yoon