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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] x [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(loglog_B U + k/B), and O(1 + k/B) I/Os when the universe is R^2, a U x 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 \le e \le 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