hausdorff
CENTER FOR MATHEMATICS

UNIVERSITÄT BONN

Workshop

“Massive Data Models and Computational Geometry II”

September 22 – 26, 2025

organized by

Anne Driemel, Morteza Monemizadeh, André Nusser, Jeff Phillips

Location: Institut für Informatik, Friedrich-Hirzebruch-Allee 8, 53115 Bonn
Registration and all plenary sessions: room 0.016 (lecture hall on the ground floor)
Coffee breaks: room 2.111 (foyer on the second floor)

- **Monday, September 22**

08:45 - 09:00	*Self Registration*
09:00 - 09:10	**Opening**
09:10 - 9:30	**Round of introduction**
9:30 - 10:30	**Open problems session**
10:30 - 11:00	*Coffee & Tea Break*
11:00 - 12:30	**Open problems session and voting**
12:30 - 14:00	*Lunch on your own*
14:00 - 15:30	**Work in groups**
15:30 - 16:00	*Coffee & Tea Break*
16:00 - 17:00	**Work in groups**

- **Tuesday, September 23**

09:00 - 09:45	**Invited Talk by Sandeep Silwal:** Algorithms for Kernel Matrices
09:45 - 10:15	*Coffee & Tea Break*
10:15 - 12:00	**Work in groups**
12:00 - 13:30	*Lunch on your own*
13:30 - 14:15	**Invited Talk by Sharath Raghvendra:** Sub-Quadratic Exact Algorithms for the Geometric k-Disjoint Path Cover Problem via Euclidean Bipartite Matching
14:15 - 15:30	**Work in groups**
15:30 - 16:00	*Coffee & Tea Break*
16:00 - 17:15	**Work in groups**
17:15 - 18:00	**Group progress reports**

- **Wednesday, September 24**

09:00 - 09:45	**Invited Talk by Eunjin Oh:** MPC algorithms for geometric proximity problems
09:45 - 10:15	*Coffee & Tea Break*
10:15 - 12:00	**Work in groups**
12:00 - 13:30	*Lunch on your own*
13:30	**Excursion**
19:00 - 21:00	**Workshop Dinner**

- **Thursday, September 25**

09:00 - 09:45	**Invited Talk by Christian Sohler:** Algorithmic Earth System Science
09:45 - 10:15	*Coffee & Tea Break*
10:15 - 12:00	**Work in groups**
12:00 - 13:30	*Lunch on your own*
13:30 - 14:15	**Invited Talk by Sariel Har-Peled:** No-dimensional Tverberg Partitions Revisited

14:15 - 15:30	**Work in groups**
15:30 - 16:00	*Coffee & Tea Break*
16:00 - 17:15	**Work in groups**
17:15 - 18:00	**Group progress reports**

- **Friday, September 26**

09:00 - 09:30	**tba**
09:30 - 10:00	*Coffee & Tea Break*
10:00 - 12:00	**Work in groups**
12:00 - 12:30	**Final group reports and formal closing of workshop**
12:30 - 13:30	*Departure*

Abstracts

Sandeep Silwal: Faster Algorithms for Kernel Matrices

Given n points $x_1, \ldots, x_n \in \mathbb{R}^d$, we are interested in the $n \times n$ matrix K where every entry is a *geometric* function of the underlying points, defined by $K_{i,j} = f(\|x - y\|_2)$ for some suitable function f. We focus on the case where f is a kernel function, such as $f(\|x - y\|_2) = e^{-\|x-y\|_2^2}$. These are called kernel matrices in literature and are common in many machine learning applications. However, explicitly initializing them incurs a prohibitive $\Omega(n^2)$ computational bottleneck.
In this talk, I will describe some new algorithms for computing fundamental quantities about K in sub-quadratic time. Our main result is an algorithm for outputing a unit vector v satisfying $v^T K v \geq (1 - \epsilon) \cdot \lambda_1(K)$ in time $\tilde{O}(n^{1.173}/\epsilon^{3.346})$, without any assumptions on the point sets, where $\lambda_1(K)$ is the top eigenvalue of K. This improves upon a prior work of Backurs, Indyk, Musco, and Wagner by poly$(1/\epsilon)$ factors. Interestingly, we also provide some evidence suggesting that our runtime maybe the limit of a broad class of "natural" algorithms.
For the top eigenpair application, I will also discuss some non-intuitive dynamics that occur when we try to use the classic power method for computing the top eigenvector, where it will be shown that the "standard" way to analyze the power method is perhaps not the "right way" when using approximate matrix vector products.
This is joint work with Rikhav Shah and Haike Xu.

Sharath Raghvendra: Sub-Quadratic Exact Algorithms for the Geometric k-Disjoint Path Cover Problem via Euclidean Bipartite Matching

We study a variant of the k-disjoint path cover problem where a sequence of requests arrives over time, and the goal is to construct k vertex-disjoint paths that serve all requests in order of arrival while minimizing total cost.
In this talk, I will present a new sub-quadratic time exact algorithm for this problem, based on a reduction to Euclidean bipartite matching. While no sub-quadratic algorithms are known for solving exact Euclidean bipartite matching in general, we show that the structured instances arising from the k-disjoint path cover problem can indeed be solved within sub-quadratic time.
Furthermore, our approach extends to a stochastic variant of Euclidean bipartite matching, where the bipartite graph is formed from two sets of n points independently drawn from the same unknown distribution, and we again obtain a sub-quadratic time exact solution.

Eunjin Oh: MPC algorithms for geometric proximity problems

In this talk, I will talk about my recent work on MPC algorithms for constructing a $(1/\varepsilon)$-*well-separated pair decomposition* (WSPD). In particular, we focus on the *fully scalable regime* where each machine has local memory of size $O(n^\delta)$ for an arbitrary constant $\delta \in (0, 1)$. The WSPD is a fundamental tool in computational geometry with numerous applications. However, to the best of our knowledge, even in Euclidean space, no MPC algorithm is known to compute a WSPD in $o(\log n)$ rounds. The only known approach simulates the classic PRAM algorithm of Callahan and Kosaraju, which requires $O(\log n)$ rounds in the MPC model. In this talk, I will present $O(1)$-round MPC algorithm for constructing a $(1/\varepsilon)$-WSPD of size $(1/\varepsilon)^{O(d)}n$ for point sets in a doubling metric space. Moreover, we demonstrate several applications of our WSPD construction: computing a $(1+\varepsilon)$-spanner, a $(1-\varepsilon)$-approximation diameter, the closest pair, and the k-nearest neighbors (k-NN). While our k-NN algorithm is specific to Euclidean space, the other three problems can be solved in both Euclidean and doubling metric spaces.

Christian Sohler: Algorithmic Earth System Science

Predicting extreme weather events and climate development requires to analyze very large data sets such as satellite observation data. In my talk I will outline a vision of establishing a new field of algorithmic earth system science that connects algorithm theory and earth system science to lead to new algorithmic questions and new applications of algorithmic techniques.

Sariel Har-Peled: No-dimensional Tverberg Partitions Revisited

Given a set $P \subset \mathbb{R}^d$ of n points, with diameter Δ, and a parameter $\delta \in (0, 1)$, it is known that there is a partition of P into sets $P_1, \ldots, P_t$, each of size $O(1/\delta^2)$, such that their convex-hulls all intersect a common ball of radius $\delta\Delta$. We prove that a random partition, with a simple alteration step, yields the desired partition, resulting in a linear time algorithm. Previous proofs were either existential (i.e., at least exponential time), or required much bigger sets. In addition, the algorithm and its proof of correctness are significantly simpler than previous work, and the constants are slightly better.