23rd Workshop on

Stochastic Geometry, Stereology and Image Analysis

8-12 June 2026
Split, Croatia

Programme and Abstracts

https://events.pmfst.unist.hr/sgsia23/

Contents

General information

Conference Venue

The conference will be held at MedILS.

MedILS, Meštrovićevo šetalište 45, University of Split

MedILS is about a 30-minute pleasant walk from the city center.
You can also reach the venue by city bus number 12 (the ticket costs 1 euro) or using Uber (cheaper option than a city taxi).
For the schedule of bus number 12, visit the Promet Split website. You can also download the Promet Split application to see bus routes and their current locations.

Meals and Conference Dinner

Complimentary banquet lunches for all registered participants will be provided daily from Monday, 8 June 2026, to Thursday, 11 June 2026, between 12:20 and 14:00.

The Conference Dinner will be held on Thursday, 11 June 2026, at 20:00 at Maestro Grill Club.

Wireless Internet Access

To be announced...

Session Format

The invited lecture lasts 50 minutes, including 5 minutes for questions, while a contributed talk lasts 30 minutes, including 5 minutes for questions.

Poster Session

Posters must be in A0 format. Before the poster session, there will be short 3-minute poster presentations, during which the presenters will briefly present their research. Slides may be used if needed.

Schedule

Invited talks: 50 minutes, Talks: 30 minutes

Time	Monday	Tuesday	Wednesday	Thursday	Friday
08:50–09:00	**Welcome**				
09:00–09:50	Last	Yukich	Reitzner	Thäle	Šebek
09:50–10:20	Penrose	Trauthwein	Petráková	Spanos	Panzo
10:20–10:50	**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**	**Coffee break**
10:50–11:20	Ghosh	Hafer	Frommer	van Haastert	Pegoraro
11:20–11:50	Jhawar	Kramer-Bang	Lotz	Kiderlen	Vígh
11:50–12:20	Nagy	Roostaei	Mastrilli	Marín Sola	**Farewell**
12:20–14:00	**Lunch & Discussion**	**Lunch & Discussion**	**Lunch & Discussion**	**Lunch & Discussion**	
14:00–14:30	Cuevas-Pacheco	Svane	**Free time / city tour**	van Lieshout	
14:00–14:50	d'Alayer				
14:50–15:00		Flimmel		Beck	
15:00–15:20	Rodríguez-Cortés				
15:20–15:30		**Coffee break**		**Coffee break**	
15:30–16:00	**Coffee break**				
16:00–16:30	Molchanov	Ambrus		Grünfelder	
16:30–17:00	Stoica	Papvári		Jin	
17:00–17:30	**Posters presentations**				
17:30–19:30	**Posters & wine**				
19:30–00:00				**Conference dinner**	

Talk Contributions

Invited speakers

- Günter Last (Karlsruhe)
- Marie-Colette van Lieshout (Amsterdam)
- Matthias Reitzner (Osnabrück)
- Anne Marie Svane (Aalborg)
- Stjepan Šebek (Zagreb)
- Christoph Thäle (Bochum)
- Joseph Yukich (Lehigh)

Other talk contributions

- Gergely Ambrus
- Dominik Beck
- Francisco Cuevas-Pacheco
- Francois d'Alayer
- Daniela Flimmel
- Fabio Frommer
- Partha Pratim Ghosh
- Balász Grünfelder
- Bernhard Hafer
- David Kramer Bang
- Sanjoy Kumar Jhawar
- Bochen Jin
- Markus Kiderlen
- Luca Lotz
- Francisco Marin Sola
- Gabriel Mastrilli
- Ilya Molchanov
- Kinga Nagy
- Hugo Panzo
- Dániel István Papvári
- Matteo Pegoraro
- Mathew Penrose
- Martina Petrakova
- Francisco Javier Rodriguez Cortes
- Arash Roostaei
- Panagiotis Spanos
- Radu S. Stoica
- Tara Trauthwein
- Jeroen van Haastert
- Viktor Vigh

Percolation properties of the random connection model

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Abstract

We consider a random connection model (RCM) driven by a Poisson process on a general state space and a symmetric connection function. This is a spatial random graph resulting by connecting pairs of Poisson points independently with a probability that is determined by a symmetric connection function. Percolation refers to the existence of an infinite component in this random graph. The infinite clusters are deletion stable, if the removal of a Poisson point cannot split a cluster in two or more infinite clusters. We prove that this stability together with a natural irreducibility assumption implies uniqueness of the infinite cluster. We also derive uniform exponential moment bounds for the number of clusters points, provided that the intensity is below a certain critical intensity defined in terms of a uniform first moment condition on cluster sizes,

In the second part of the talk we will focus on the important special case of a stationary marked RCM. We will show that then the infinite clusters are indeed deletion stable. We also present assumptions implying the coincidence of the uniform with the standard percolation threshold. Under these assumptions cluster sizes are exponentially small in the subcritical regime. The results are illustrated with some examples, as the Boolean model and the weighted random connection model.

References

[1] Chebunin, M., Last, G. (2025): On the uniqueness of the infinite cluster and the cluster density in the Poisson driven random connection model. *Electronic Journal of Probability* **3**0, Article no. 175.

[2] Chebunin, M., Last, G. (2025): On strong sharp phase transition in the random connection model. Preprint. https://arxiv.org/abs/2512.00213

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Poisson-Voronoi and Poisson-Delaunay Approximation

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Abstract

For a stationary Poisson point process of uniform intensity we construct the Poisson-Voronoi and the Poisson-Delaunay tessellation generated by the point process.

For a Borel set A the Poisson-Voronoi approximation of A is the union of all Voronoi cells generated by the points of the point process in A. Analogously, the Poisson-Delaunay approximation of A is the union of all Delaunay cells generated by the points of the point process with center in A.

The volume of the Poisson-Voronoi approximation and the volume of the Poisson-Delaunay approximation are unbiased estimators for the volume of A. Variance bounds and quantitative central limit theorems using Steins method are given. The asymptotic behaviour of the volume of the symmetric difference between A and the Poisson-Voronoi approximation, resp. Poisson-Delaunay approximation are investigated. Also functional versions of these approximations are introduced.

Acknowledgment: This is joint work with Anna Strotmann.

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Seeing Through Hyperbolic Space

Christoph Thäle

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Abstract

This talk explores recent advances in hyperbolic stochastic geometry. We start by looking at Boolean models and the natural visibility problems associated with them. In particular, we are interested in the mean visible volume around a fixed noncovered point. We then shift our focus to hyperbolic Poisson hyperplane tessellations to take a closer look at the geometry of the zero cell. We discuss its boundedness properties and then determine its first and second volume moment using tools from harmonic analysis. If time permits, we present findings for λ-geodesic processes, which serve as a natural bridge between standard hyperplane processes and the Boolean model.

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Optimal local interventions in the two-dimensional Abelian sandpile model

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Abstract

The Abelian sandpile model serves as a canonical example of self-organized criticality. This critical behavior manifests itself through large cascading events triggered by small perturbations. Such large-scale events, known as avalanches, are often regarded as stylized representations of catastrophic phenomena, such as earthquakes or forest fires. Motivated by this perspective, we study strategies to reduce avalanche sizes. We provide a rigorous analysis of the impact of interventions in the Abelian sandpile model, considering a setting in which an external controller can perturb a configuration by removing sand grains at selected locations. We first develop and formalize an extended method to compute the expected size of an avalanche originating from a connected component of critical vertices, i.e., vertices at maximum height. Using this method, we characterize the structure of avalanches starting from square components and explicitly analyze the effect of interventions in such components. Our results show that the optimal intervention locations strike an interesting balance between reduction of largest avalanche sizes and increasing the number of mitigated avalanches.

References

[1] De Jongh, M.C., Boucherie, R.J., Van Lieshout, M.N.M. (2026): Optimal local interventions in the two-dimensional Abelian sandpile model. *ArXiv* **2603.24459**.

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Expected perimeter of the convex hull of planar Brownian motion run up to the exit time from the unit disk

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Coauthor: Hugo Panzo (Department of Mathematics and Statistics, Saint Louis University, St. Louis, USA)

Abstract

We study the convex hull of planar Brownian motion stopped upon exiting the unit disk. Our primary objective is to compute the expected perimeter of this convex hull, thereby complementing recent results on the convex hull of reflecting Brownian motion in confined geometries. We reduce the problem to computing the expected maximum of the horizontal coordinate up to the exit time, and then recast this maximum in terms of harmonic measure in a domain we call the *truncated disk*. In particular, we obtain an exact expression for the expected perimeter. We also obtain nontrivial bounds on the expected area of the convex hull and comment on why computing the exact expected area is a much harder problem.

Acknowledgment: Financial support through the Croatian Science Foundation under project IP-2022-10-2277 is gratefully acknowledged.

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Normal Approximation in Stochastic Geometry

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Abstract

Given a mean zero functional F of a Poisson measure on a metric space, we apply the Malliavin-Stein method to establish sharpened second-order Poincaré inequalities for F, when rescaled by its standard deviation. The rates of normal approximation are expressed in the Kolmogorov and Wasserstein distances and require fewer error terms than corresponding previous results. When F is expressible as a sum of score functions which are distributionally close to scores having short-range structure, then we deduce that F satisfies Berry-Esseen bounds. The normal approximation criteria of the scores, here called bounded Lipschitz localization, are more general than stabilization criteria and allow for unbounded interactions of scores. The approach yields Berry-Esseen bounds for local U-statistics on metric measures spaces, localizing functionals on hyperbolic space, as well as for Poisson functionals in a space-time setting, with infinite time horizon, including statistics of spatial birth-growth models and Laguerre tessellations. The talk is based on joint work with Tara Trauthwein.

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Normal (and Poisson) approximation for Gibbs point processes with a pair potential

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Coauthor(s): Christian Pascal Hirsch (Department of Mathematics, Aarhus University, Denmark), Moritz Otto (Mathematical Institute, Leiden University, Netherlands)

Abstract

The talk will focus on normal approximation for geometric functionals of Gibbs point processes with a pair potential possibly having unbounded interaction range. We present a qualitative CLT for weakly stabilizing functionals and a quantitative CLT for exponentially stabilizing functionals. A key ingredient in the proofs is controlling the spatial correlations of the Gibbs point process. Following an idea of Betsch and Last (2023), this is achieved by coupling the point process to a non-percolating random connection model. We provide explicit couplings in finite and infinite-volume domains and use this to control the spatial effects of locally modifying the Gibbs model. This is joint work with C. Hirsch and M. Otto.

References

[1] Betsch, S. and Last, G. (2023): On the uniqueness of Gibbs distributions with a non-negative and subcritical pair potential. *Annales de l'Institut Henri Poincaré, Probabilités et Statistiques* **59** (2).

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Longest k-monotone chains

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Abstract

We study higher order convexity properties of random point sets in the plane, following the work of Eliáš and Matoušek [4]. Given n uniform i.i.d. random points in the unit square, we derive asymptotic estimates for the maximal number of them which are in k-monotone position, subject to mild boundary conditions. Besides determining the order of magnitude of the expectation, we also prove strong concentration estimates. We provide a general framework that includes the previously studied cases of $k = 1$ (longest increasing sequences, see [1,3]) and $k = 2$ (longest convex chains, see [2]), and thus extend previously knonwn asymptotic estimates to point sets that satisfy higher order convexity constraints.

References

[1] D. Aldous and P. Diaconis (1999): Longest increasing subsequences: from patience sorting to the Baik-Deift- Johansson theorem. Bull. Amer. Math. Soc. **36**, 413-–432.

[2] G. Ambrus and I. Bárány (2009): Longest convex chains. Random Structures & Algorithms, **35**(2), 137–162.

[3] J. Baik, P. Deift, and K. Johansson (1999): On the distribution of the length of the longest increasing subsequence of random permutations. J. Amer. Math. Soc. **12**, 1119-–1178.

[4] M. Eliáš and J. Matoušek (2013): Higher order Erdős-Szekeres theorems. Adv. Math. **244**, 1-–15.

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Cluster Expansion of Dimer Tilings

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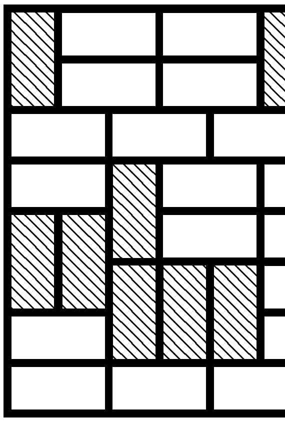
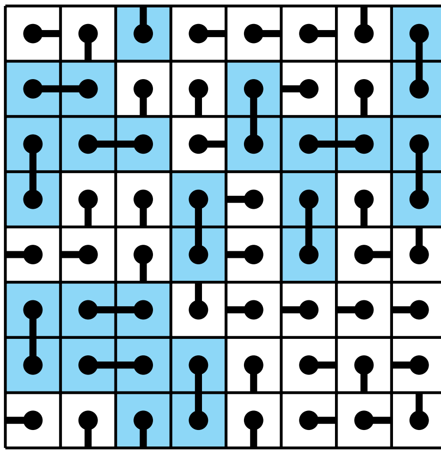
Abstract

Many exact counting problems suffer the feared combinatorial explosion. As a toy model, consider a (non-overlapping) domino tiling of the standard 8×8 chess board. One such tiling is shown below. In total, there are $Z_{8,8} = 12\,988\,816$ of all such tilings. For a general $n \times n$ board, the total number $Z_{n,n}$ of all tilings grows exponentially with the size of the board. More concretely, we have $\ln Z_{n,n} \approx Cn^2$ with $C \approx 0.29156$. Hence, counting the exact number of tilings quickly becomes infeasible. However, by tying dimer tilings with pffafians, Kasteleyn [2] showed that $C = G/\pi$, where $G = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)^2} \approx 0.9159655941$ is the *Catalan's constant*. Unfortunately, Kasteleyn method is only applicable for dimers and for special lattices. An alternative and more general approach (although only numerical) is by generating the tiles randomly (allowing overlaps) and keeping track of their interactions. The resulting structure is amenable by means of the so called Cluster Expansion Technique (CET) [3].



An 8×8 domino

It turns out we can decompose the dimer tiling into random cell-interactions. In the context of the example above, one may treat each cell as being randomly uniformly selected from the set of four cells up, down, right and left. Although it may seem waste-full to through away many placements of those cells (most placements do not generate a valid tiling), it is non-the-less surprising that, according to my simulations, the method provides a mildly converging series for constant C (see picture on the right). In our talk, we introduce the technique and apply it on the problem of counting all domino tilings in $n \times n$ boards, deducing the constant C numerically. We would also like to address the effect of the boundary conditions, which play a non-negligible role as shown in the exact expansion of Allegra [1].



An 8×8 cell tiling

References

[1] Allegra N. (2015): *Exact solution of the 2d dimer model: Corner free energy, correlation functions and combinatorics.* Nuclear Physics B **894**, 685–732. Elsevier

[2] Kasteleyn P.W. (1961): *The statistics of dimers on a lattice: I. The number of dimer arrangements on a quadratic lattice.* Physica **27**(12), 1209–1225.

[3] Kotecký R., Preiss D. (1986): *Cluster expansion for abstract polymer models.* Communications in Mathematical Physics **103**(3), 491–498. Springer

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The K-Function for point patterns on surfaces

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Abstract The K-function is a well-known summary statistic used to determine whether a point pattern exhibits aggregation, repulsion, or complete spatial randomness. Its development has been applied to different surfaces by leveraging the invariance properties of the surface on which the point pattern is defined, such as the unit sphere or the unit sphere cross time. In this work, we present two extensions of the K-function to more general surfaces. The first extension is based on tangent plane approximations of the surface, while the second relies on geodesic distance. We provide computational algorithms and conduct simulation studies to demonstrate the performance of the extended K-function in detecting various point pattern properties.

Acknowledgment: This work was supported by CONICYT/ANID/INICIACION with the grant 11240330.

Designing Efficient Monitoring Systems: A Unified Approach to Sequential Surveillance Using Stochastic Geometry

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Abstract

In this presentation, I introduce a general statistical framework designed to guide spatio-temporal surveillance strategies across a variety of domains, including epidemiological monitoring, crime detection, and species distribution assessment. I begin by illustrating the motivation and key principles of this framework through examples drawn from my research on plant disease surveillance [1,2]. Specifically, I discuss approaches for optimizing the survey parameters, developing efficient surveillance schemes for minimizing a stopping time and producing a spatial map. Building on these case studies, I then formalize the general framework for spatio-temporal surveillance, showing its adaptability to diverse contexts and its potential to enhance the efficiency and precision of surveillance programs.

References

[1] d'Alayer, F., Gabriel, E., Soubeyrand, S., 2025a. A marked sequential point process for disease surveillance: Modeling and optimization. Spatial Statistics 68.

[2] d'Alayer, F., Gabriel, E., Soubeyrand, S., 2025b. Sequential Area Interaction Sampling for Early Plant Disease Detection. Preprint.

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Stabilizing functionals of perturbed lattices

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Abstract

Hyperuniformity describes many-body systems in which large-scale density fluctuations are suppressed, placing them between crystals and typical disordered materials. The concept was formalized in [5], where examples ranging from atomic systems to photonic materials and cosmology were unified under a common framework. Since then, hyperuniformity has become a central concept in condensed matter physics, materials science, and soft matter, with applications to wave control, transport, and biological organization. It has also motivated substantial mathematical developments in the theory of point processes, optimal transport or random matrix theory.

A natural and tractable class of hyperuniform point processes is provided by *perturbed lattices*. We review the conditions ensuring their hyperuniformity that have been recently clarified in [1,2,3]. Then we investigate limit theorems for stabilizing functionals in the sense of [4] defined on perturbed lattices, with particular emphasis on estimators of cell characteristics of Voronoi tessellations and on the effect of suppressed number fluctuations on these estimators.

References

[1] Dereudre, D., Flimmel, D. Huesmann, M. and Leblé, T. (2024+): (Non)-hyperuniformity of perturbed lattices. Preprint.

[2] Flimmel, D. (2025+): Fitting regular point patterns with a hyperuniform perturbed lattice. Preprint.

[3] Klatt, M. A., Last, G., Lotz, L. and Yogeshwaran, D. (2025+): Invariant transports of stationary random measures: asymptotic variance, hyperuniformity, and examples. Preprint.

[4] Lachièze-Rey, R., Schulte, M. and Yukich, J. E. (2019): Normal approximation for stabilizing functionals. *Annals of Applied Probability* **29** (2), 931–993.

[5] Torquato, S. and Stillinger, F. H. (2003): Local density fluctuations, hyperuniformity, and order metrics, *Physical Review E* 68, 041113.

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(Non-)Hyperuniformity properties for second-order statistics of stationary point processes

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Abstract For stationary point processes on $\mathbb{R}^d$ it is well-known that the expected value of the number of points N_R in the ball $B_R(0)$ scales with the volume of $B_R(0)$. However, this is not necessarily true for the variance of N_R, a point process is called *hyperuniform* if $\mathsf{Var}(N_R) = o(R^d)$ this is e.g. the case for determinantal point processes with projection kernels or a simple perturbed lattice while for fast decaying Gibbs point processes it is known that $\mathsf{Var}(N_R)/R^d \to c > 0$, cf. [1].

We investigate the variance of second order statistics, i.e. random variables of the type $F_R(\eta) = \sum_{x \neq y \in \eta \cap B_R(0)} f(x-y)$. We do so for pair interaction Gibbs point processes and determinantal point processes. We show instances where $\mathsf{Var}(F_R)/R^d \to c = c(f) > 0$.

References

[1] D. DEREUDRE AND D. FLIMMEL (2024): Non-hyperuniformity of Gibbs point processes with short-range interactions. J. Appl. Prob. **61**, pp. 1380–1406.

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Large and moderate deviations in Poisson navigations

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Coauthor(s): Benedikt Jahnel (TU Braunschweig & WIAS Berlin),
Sanjoy Kumar Jhawar (INRIA Paris & Telecom Paris)

Abstract

We derive large- and moderate-deviation results in random networks given as planar directed navigations on homogeneous Poisson point processes. In this non-Markovian routing scheme, starting from the origin, at each consecutive step a Poisson point is joined by an edge to its nearest Poisson point to the right within a cone. We establish precise exponential rates of decay for the probability that the vertical displacement of the random path is unexpectedly large. The proofs rest on controlling the dependencies of the individual steps and the randomness in the horizonal displacement as well as renewal-process arguments.

References

1. Baccelli, F. and Bordenave, C. (2007). The radial spanning tree of a Poisson point process. *Annals of Applied Probability*, **17**(1):305–359.

2. Bordenave, C. (2008). Navigation on a Poisson point process. *Annals of Applied Probability*, **18**(2):708–746.

3. Coupier, D., Saha, K., Sarkar, A. and Tran, V. C. (2021). The 2d-directed spanning forest converges to the Brownian web. *Annals of Probability*, **49**(1):435–484.

4. **Ghosh, Partha Pratim**, Jahnel, B., and Jhawar, S. K. (2026). Large and moderate deviations in Poisson navigations. *Advances in Applied Probability*.

5. Roy, R., Saha, K. and Sarkar, A. (2016). Random directed forest and the Brownian web. *Annales de l'Institut Henri Poincaré Probabilité et Statistiques*, **52**(3):1106–1143.

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Variance bounds and central limit theorems for random beta-polytopes

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Abstract

We prove upper and lower bounds of the same order of magnitude on the variances of the intrinsic volumes of random beta-polytopes in the d-dimensional unit ball. Based on the lower bound, using Stein's method we also prove central limit theorems. The variance upper bound of the intrinsic volumes implies a strong law of large numbers. The talk briefly covers non-Euclidean results as well.

Acknowledgment: This research was supported by the University Research Scholarship Programme (EKÖP) no. EKÖP-452-SZTE, which has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary and the National Research, Development and Innovation Fund. This research was also supported by NKFIH project no. 150151, which has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the ADVANCED_24 funding scheme.

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Multivariate Poisson process approximation

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Abstract

This talk presents a multivariate version of a Poisson process approximation theorem for certain point processes. We consider several special cases of the main theorem. This result can, for example, be used to derive multivariate compound Poisson limit theorems in total variation distance for vectors whose components are all U-statistics of the same Poisson point process. In general, the components have to be asymptotically independent, but we will also discuss how to handle situations where this is not the case. The theory is illustrated with examples based on random graph models.

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Dynamical Poisson-Voronoi Tessellations

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Abstract

Consider a dynamical network model featuring mobile stations on the Euclidean plane. The initial locations of the stations are given by a homogeneous Poisson point process. The stations are all moving at a constant speed and in a random direction. Consider fixed users located in the Euclidean plane, which are served by the mobile stations. Each user stays connected to the nearest station at any given point of time. Since the stations are moving, a user disconnects and connects with different stations over time, by always selecting which ever station is the closest. This gives rise to a dynamical version of the Poisson-Voronoi tessellation. The focus of this paper is on the sequence of "handover" events of a typical user, which are the epochs when its association changes. This defines a point process on the time-axis, the "handover point process". We show that this point process is stationary and we determine its main properties, in particular its intensity and the joint distribution of its inter-event times. We also analyze the handover Palm distributions of several variables of practical interest. This includes the distance to the closest mobile stations and the point process of all other mobile stations at handover epochs. The analysis is conducted both in the single-speed and in the multi-speed scenarios. The analysis is based on a specific system of non-compact particles. The motivations are in the modeling of low or medium orbit satellite wireless communication networks. The model studied here is a planar "caricature" of this problem, which is initially defined on the sphere. This is a joint work with François Baccelli (INRIA and Télécom Paris)

Acknowledgment: ERC-NEMO grant (788851) and France 2030 BPI "5G NTN mmWave" project.

References

[1] Baccelli F., Jhawar S. K. (2025): On a class of dynamical Poisson-Voronoi tessellations. *arXiv:2511.15893*.

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Pareto points in growing dimensions

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Abstract

We study Pareto points among n i.i.d. random points uniformly distributed in the unit cube $[0,1]^{d_n}$, where the dimension d_n increases with the sample size n. While the classical fixed-dimensional regime is well understood in [1], allowing the dimension to grow reveals new phenomena.

We identify a sharp phase transition in the number of non-Pareto points. Specifically, if

$$d_n = \frac{2}{\log 2} \log n + c + o(1), \quad c \in \mathbb{R},$$

then this number converges in distribution to a Poisson random variable with mean 2^{-c}. Below this critical regime, the number of non-Pareto points diverges in probability, whereas above it, it converges to zero in probability. Moreover, in the critical regime, asymptotically all non-Pareto points dominate exactly one other point.

We further establish convergence of non-Pareto points at the level of point processes. We prove that the projection of non-Pareto points onto each fixed m-dimensional coordinate subspace converges in distribution (with respect to the vague topology) to an inhomogeneous Poisson point process on $[0,1]^m$ with intensity $2^{m-c}|x|\mathrm{d}x$, where $|x|$ denotes the product of coordinates of $x \in \mathbb{R}^m$.

Finally, we investigate the asymptotic behavior of the moments of the number of points that dominate exactly $r \geq 2$ other points.

Acknowledgment: The authors are grateful to Ilya Molchanov and Chinmoy Bhattacharjee for useful discussions.

References

[1] Zhi-Dong Bai, Luc Devroye, Hsien-Kuei Hwang, and Tsung-Hsi Tsai. (2005): Maxima in hypercubes. *Random Structures Algorithms* **27**(3), 290–309.

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Stability for opaque sets of n-dimensional convex bodies with surface area close to Jones' bound

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Abstract

Let K be a convex body (a non-empty compact convex subset of $\mathbb{R}^n$). A set $B \subset \mathbb{R}^n$ is *an opaque set for* K if every line that intersects K also intersects B. Despite the fact that opaque sets have been introduced by Mazurkiewicz already in 1916, they are still poorly understood. Since there are opaque sets for K with finite surface area (i.e. $(n-1)$-dimensional Hausdorff measure; think of the boundary of K), one may ask for the minimal opaque set in terms of surface area. This problem is open and surprisingly difficult to solve. However, there are lower bounds for the surface area of any opaque set for a given K. The classical lower bound by Jones, based on Crofton's formula, states that the surface area of a sufficiently regular opaque set is at least half the surface area of the boundary of K. Recent results for simple convex bodies in $\mathbb{R}^2$ have shown that this lower bound can be improved by constructing a contradiction when a hypothetical opaque sets with surface area very close to Jones' bound is assumed. In this context, Steinerberger showed last year a quantitative stability result in $\mathbb{R}^2$ stating that an opaque set with surface area very close to Jones' bound must have an orientation distribution very close to the one of the boundary of K. For instance, if K is the unit cube, such opaque sets consist of curves that are 'almost' horizontal or vertical.

We show that this stability result also holds in higher dimensions. The arguments are interesting, as they employ the concept of convexification to relate the opaque set problem to a convex geometric setting. We also show how such a stability result can be used explicitly for the unit square in the plane to improve the best known lower bound. The application of the theory to the unit square is joint work with Florian Pausinger, Lisbon University, Portugal.

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Quantitative Bounds for High-Dimensional Random Vectors on Gaussian Spaces

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Abstract

As an ongoing extension of [1], we derive explicit dimension-dependent bounds for multivariate Gaussian approximations of random vectors admitting Wiener–Itô chaos expansions, with a particular focus on high-dimensional regimes. Our estimates control hyper-rectangular, convex and 1-Wasserstein distances via Malliavin–Stein approach and require only a natural contraction condition on the kernels governing the Wiener–Itô expansion. The developed methodology is applied to obtain a quantitative Breuer–Major theorem for vector-valued functions of multivariate stationary Gaussian sequences, and finite-sample Gaussian approximation bounds for parameter estimation for a stable VAR(p) process.

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Persistence of asymptotic variance under transport: from hyperfluctuation to stealthy hyperuniformity

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Abstract

We introduce p-uniformity to characterize the scaling of density fluctuations in spatial random systems in $\mathbb{R}^d$, ranging from hyperfluctuation to stealthy hyperuniformity. Our central theorem establishes sufficient conditions to preserve p-uniformity under transport. First, a finite $d+p$-th moment of the transport distance allows for a Taylor expansion of the transport. The second condition controls the corresponding terms. We thus answer a previously stated open problem; indeed we extend it, since our result applies to a general p-uniform source in any dimension, and the source and transport may be dependent. As an application, we construct new classes of point processes that are isotropic and p-uniform with arbitrarily high p, and that can be simulated in linear time. We conclude with an outlook on a possible converse statement.

Acknowledgment: The author thanks Günter Last for his guidance and helpful discussions. This work was supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) through the SPP 2265, under grant number KL 3391/2-2, as well as by the Initiative and Networking Fund of the Helmholtz Association through the Project "DataMat".

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Stochastic forms of functional isoperimetric inequalities

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Abstract

In this talk, we will present probabilistic interpretations of functional isoperimetric inequalities within the class of log-concave functions, building on random models for such functions introduced by P. Pivovarov and J. Rebollo-Bueno. First, we will show a stochastic isoperimetric inequality for a functional extension of the classical quermassintegrals, which yields a Sobolev-type inequality in this random setting as a particular case. Second, we will establish that Zhang's affine Sobolev inequality holds in expectation when dealing with these random models of log-concave functions. Finally, if time permits, we will discuss how our results recover their deterministic counterparts.

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Asymptotic Fluctuations of Smooth Linear Statistics of Independently Perturbed Lattices

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Abstract

We study the large-scale fluctuations of smooth linear statistics of independently perturbed lattices $\Phi = \{x + \xi_x \mid x \in \mathbb{Z}^d\}$, where $(\xi_x)_{x \in \mathbb{Z}^d}$ are i.i.d. random variables: $T_r(f) = \sum_{x \in \Phi} f(x/r)$, $r \to \infty$. This model is a canonical example of a hyperuniform point process [1], i.e. a random point configuration where the variance of the number of points in a ball of radius r grows slower than r^d, unlike a Poisson process. For $d \geq 2$, a Central Limit Theorem holds under mild assumptions. However, in dimension $d = 1$, three behaviors emerge depending on the tail of the perturbations. The limiting distribution is either Gaussian, a Poisson integral limit, or an α-stable limit, depending on the asymptotic behavior of $\mathrm{Var}[T_r]$.

References

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RANDOM VALUATIONS

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Abstract

Random valuation is a stochastic process Φ indexed by convex bodies in $\mathbb{R}^d$, which is also an additive function, meaning that

$$\Phi(K \cup L) + \Phi(K \cap L) = \Phi(K) + \Phi(L)$$

for all convex bodies K and L such that their union is also convex. If the sample paths of Φ are invariant under rigid motions and continuous, then Hadwiger's theorem immediately yields that Φ is a linear combination of intrinsic volumes with random coefficients. We aim to replace the motion invariance of the paths by distributional invariance properties of Φ, most importantly, stationarity.

In order to handle valuations without imposing motion invariance on their realisations, we first discuss what is possible to say about deterministic valuations which are not translation invariant, replacing the invariance property by other conditions, e.g., assuming that the valuations are integer-valued. On this way, a complete description of integer-valued σ-continuous monotone valuations on the plane is obtained.

Then we pass to the random setting and show that meaningful results on random valuations are possible, assuming their infinite divisibility under addition and a kind of independence of the increments together with a suitable continuity property. Under these assumptions and assuming stationarity and non-negativity, Φ is the sum of indicator random valuations $t_i \mathbf{1}_{K \cap F_i}$, where $\{(F_i, t_i), i \geq 1\}$ is a Poisson process on the product of the family of convex closed sets and the positive half-line. We describe all such processes and provide a variant of McMullen's decomposition theorem for random valuations.

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Number of crossings, and the planarity of the soft random geometric graph

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Abstract

Consider a random graph that is geometrically defined in d-dimensional space, such that the vertices are given by a random point configuration, and the existence of each edge (represented by the line segment between the points) is decided by independent marks on the edge and its endpoints. We can generate a drawing of the graph by projecting the construction onto a plane. In this talk, we consider the number of crossings in such a projection, focusing on the case when the underlying graph is a soft random geometric graph: each edge exists independently with Pareto-type probability depending on the distance of the points. We study the overall behaviour of the model depending on the tail index of the edge probabilities. In addition, we consider the graph-theoretical planarity of the original graph, and how this relates to the number of crossings in the projection.

Acknowledgment: Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 531562368.

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On the star hull of planar Brownian motion and bridge

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Abstract

We study the *star hull* of planar Brownian motion and bridge, and relate this random compact set to the more familiar convex and topological hulls. Roughly speaking, the star hull is the smallest starshaped set (with respect to the starting point) that contains the trace of the path. In particular, we prove that the expected areas of the star hulls are $\frac{3\pi}{8}$ and $\frac{\pi}{4}$ for planar Brownian motion and bridge, respectively. Several open questions are raised.

References

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Series expansions for generalized random polygons

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This is joint work with Ferenc Fodor (University of Szeged).

Abstract

We prove power series expansions for the expectations of the number of vertices and missed area of random L-convex polygons in planar convex bodies with sufficiently smooth boundaries. Random L-convex polygons arise as the intersection of all translates of a fixed convex set L that contain i.i.d. uniform random points from a suitable plane convex body K. Our results extend the asymptotic formulas proved in Fodor, Papvári and Vígh [2] and Fodor and Montenegro [3], and have consequences about L-convex floating bodies and relative affine surface area that have recently been investigated by Schütt, Werner and Yalikun [1].

Acknowledgment: This research was supported by the National Research, Development and Innovation Fund of the Ministry of Culture and Innovation of Hungary, under NKFIH project no. 150151 (ADVANCED_24 funding scheme) and project EKÖP-24-3-SZTE-558 (EKÖP-24-3 funding scheme).

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Persistence spheres: bi-continuous linear representation of measures for partial optimal transport

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Abstract

Topological data analysis and point process methods interact in a natural way: persistence diagrams can be viewed as point patterns, while topological summaries are especially appealing for homogeneous spatial data because of their invariance under isometries. A key challenge is that persistence diagrams are naturally compared through partial optimal transport, and this geometry is not linear. For statistical purposes, one would therefore like representations that linearize measures, including persistence diagrams viewed as counting measuresm, while still remaining well aligned with their underlying geometry. In this talk, I will present persistence spheres, a functional representation designed precisely for this purpose. The construction is rooted in the geometry of lift zonoids and maps measures on the upper half-plane to functions on the sphere. It yields a representation that is stable with respect to partial optimal transport and also admits continuous reconstruction on its image, so that it is not only robust under perturbations but also retains significant geometric information. I will conclude with case studies and comparisons with other standard topological summaries.

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Components of dense random geometric graphs

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Abstract

The random geometric graph (RGG) is obtained by placing n vertices uniformly at random in a bounded region of $\mathbf{R}^d$ and connecting any two vertices distant at most r apart. We discuss large-n asymptotics with $r = r_n$ a specified sequence.

Given a positive integer k, let $S_{n,k}$ be the number of components of order k in this graph, and let $S_n := \sum_k S_{n,k}$, the total number of components. Let $L_n = \max\{k : S_{n,k} > 0\}$, the order of the largest component.

In the 'thermodynamic limit' where $nr_n^d \to c \in (0, \infty)$, a law of large numbers and central limit theorem were already known for $S_{n,k}$, and for S_n, and for L_n. We discuss newer results of this type in the 'dense limit' where $nr_n^d \to \infty$ slowly.

In a related result, we determine the large-λ asymptotics for the probability that the origin lies in a cluster of order k in a Poisson Boolean model with intensity λ.

Acknowledgment: Supported by EPSRC grant EP/T028653/1

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Point Process Convergence of Large Inradii of Poisson–Laguerre Tessellation

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Abstract

Random tessellations form a popular family of models used in a variety of fields. The object of our research is the Poisson–Laguerre tessellation, i. e. a random Laguerre tessellation whose generator is a stationary Poisson marked point process η in $\mathbb{R}^d \times [0,\infty)$. We are interested in the behavior of the large cells of the tessellation, which we study through the behavior of their inradii. The inradius of a Laguerre cell $L((x,m),\eta)$ generated by the point (x,m) is defined as the largest radius r such that the ball $B(x,r)$ lies inside the cell $L((x,m),\eta)$.

We discuss the convergence of the process of large inradii and their generating points to a suitable Poisson process first in a setting with uniformly bounded marks, where we observe a different behavior depending on the dimension d, and also in a setting with heavy-tailed marks. As a corollary, we get a convergence in distribution for the correctly rescaled maximal inradius.

Acknowledgment: This work was supported by the Charles University Grant Agency, project no. 70524.

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Fractal-dimension-based analysis of spatial correlation in point processes on linear networks

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Abstract

In the literature, point process theory is typically developed within the broader framework of random measure theory. This approach leverages the properties of stationarity and isotropy to construct distance-based summary functions that capture the trend and correlation structure of spatial point processes in metric spaces such as the plane, linear networks, or the sphere. Particularly, characterizing spatial dependence through statistical measures for point processes on linear networks constitutes a vibrant and challenging research area. The complexity stems from the inherent difficulties posed by the geometrical domain and the stringent conditions as second-order pseudostationarity required to build reliable analytical tools.

In this work, we assess complete spatial randomness within the geometric framework of point processes on linear networks. Specifically, we connect random fractal theory and the associated notion of fractal dimension to the analysis of spatial dependence in point processes defined on linear networks, demonstrating the advantages of working with these tools in the metric space of linear networks. As an alternative approach, we propose a novel statistical test of complete spatial randomness based on the fractal dimension, estimated via the box-counting method. This provides a robust inferential perspective, representing a meaningful departure from the more common descriptive applications of this method. Moreover, it enables discrimination between clustered and inhibitory behaviors of point patterns. We evaluate the performance of our methodology through a simulation study and analysis of a real dataset. The results support the efficacy of our approach, establishing it as a viable and computationally lighter alternative to the classical distance-based strategies.

Acknowledgment: The research work of Francisco J. Rodríguez-Cortés has been partially supported by Universidad Nacional de Colombia, HERMES projects, Grant/Award Number: 66404.

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Discretized normal approximation in total variation distance for Poisson functionals

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Abstract

In this work, we use the Malliavin-Stein method to establish a general upper bound for the total variation distance of an integer-valued functional of a Poisson process and a discretized version of an appropriate normal distribution. This general upper bound can be applied to a large class of functionals whose difference operators are determined locally. With the help of our general results, we investigate the asymptotic behavior of two specific applications in Euclidean space, namely that of the Euler characteristic of Boolean models and stabilizing functionals.

Acknowledgment: This work is supported by the DFG priority programme "Random Geometric Systems".

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Laguerre tessellations in hyperbolic space

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Abstract

Voronoi tessellations partition space according to proximity to a given set of points and play a central role in stochastic geometry when the points are generated by a point process. In Euclidean space, Laguerre tessellations arise as a natural generalisation, and it is known that the intersection of a Poisson–Voronoi tessellation with a subspace yields a Poisson–Laguerre tessellation.
In this talk, we study an analogous construction in hyperbolic space. We introduce a natural definition of Laguerre tessellations in this setting, supported by geometric intuition, and show that intersections of Poisson–Voronoi tessellations with subspaces again produce Laguerre tessellations. Recent work on the low-intensity limit of Poisson–Voronoi tessellations in hyperbolic space has shown the emergence of a limiting tessellation. We extend the previous results on sectional tessellations by showing that sections of the limiting tessellation give rise to Laguerre tessellations.

Acknowledgment: This work has been supported by the German Research Foundation (DFG) via SPP 2265 Random Geometric Systems.

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Lévy-Driven Branching Cox Processes as Random Sets

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Abstract

This talk presents a class of spatial point processes, called Lévy-driven branching Cox processes, obtained by combining a Lévy-based random intensity with a spatial branching mechanism. In this framework, an initial configuration of points is generated by a Lévy basis, while successive generations of points evolve according to a branching kernel, leading to hierarchical point patterns.

Expressions for fundamental characteristics of the process are derived, including the intensity, higher-order product densities and the pair correlation function, highlighting the complex dependence structure induced by the interaction between the Lévy component and the branching dynamics. As these quantities become analytically involved, we propose an alternative description of the model in terms of capacity functionals. Using tools from potential theory and the theory of random sets, we construct a Choquet capacity associated with the branching dynamics and show that it characterizes the process. This representation provides a natural stochastic geometry framework for the analysis of spatial branching point processes and suggests new directions for the study of their geometric and probabilistic properties.

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Multivariate Second-Order p-Poincaré Inequalities (and a Variance)

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Abstract

In this talk, we discuss new bounds for the normal approximation of multivariate Poisson functionals under minimal moment assumptions. Such bounds require one to estimate moments of so-called add-one costs of the functional. Previous works required the estimation of 4th moments, while our result only requires $(2+\varepsilon)$-moments, based on the Malliavin-Stein method and recent improvements introduced by (Trauthwein 2025). In addition, we show a quantitative convergence result for covariance matrices of vectors of functionals exhibiting stabilizing behaviour. Applications include weighted total edge lengths of the random geometric graph and k-Nearest Neighbour graphs. These examples were out of scope for previous methods. The talk is based on an updated version of [1].

References

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Poisson Line Tessellations in the 3-Regular Tree

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Abstract

We consider a Poisson process on the set of lines (bi-infinite geodesics) of the infinite 3-regular tree, as introduced by Blanc [1], and the random forest obtained by deleting these lines from the tree. This model can be viewed as a discrete analogue of the Poisson line tessellations in hyperbolic space.

We study the geometry of the zero cell and the typical cell in the subcritical, critical, and supercritical regimes. Our main result is a central limit theorem for the number of connected components (cells) inside a ball of radius r in the 3-regular tree as $r \to \infty$.

References

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Circumscribed random spherical disc-polygons via duality

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Coauthor: Kinga Nagy (Osnabrück University and University of Szeged)

Abstract

In this talk, we work on S^2 and study random spherical disc-polygons within a spherical convex disc whose boundary is C^2 smooth. This model encompasses the usual spherical convex model and, as a limiting case, planar spindle convexity as well. We establish asymptotic results for the area and perimeter of the inscribed random disc-polygon. Next, we introduce a spherical spindle-convex duality, which allows us to naturally define circumscribed random spherical disc-polygons. Using the area and perimeter formulas of the dual disc, we obtain asymptotic results in the circumscribed model as well.

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Poster Contributions

- Karambir Das
- Emil Dare
- Kateřina Helisová
- Bogdan Radović
- Jakub Stanek
- Benjamin Taylor

Functional CLT for the Coverage Process in Random Geometric Graph

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Abstract

Consider a sequence of Random Geometric Graphs G(P, r(n,t)), with vertex set P being a Poisson point process (PPP) and there is an edge between two vertices if they are within distance r(n,t). We analyze the network's coverage, defined as the total area covered by the union of Euclidean balls of radius r(n,t) centered at each Poisson point. Operating within an extended network, where the observation window size n grows while the PPP intensity remains constant, we establish the conditions on the radius r(n,t) required to achieve a functional Central Limit Theorem (CLT) for the coverage. This is based on ongoing work with Srikanth Iyer.

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100% Confidence Intervals for Spherical Sampling Schemes in Stereology

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Abstract

We study the problem of estimating the integral of a function f over the unit sphere S^{n-1} in n-dimensional Euclidean space. Our approach is based on approximating the integral by a weighted sum of function values at the points of an isotropic point process on the sphere. The motivation for this problem comes from applied stereological estimators, such as the nucleator, which fit into the present framework. We construct the weights using reproducing kernel Hilbert space (RKHS) theory. This makes it possible to bound the worst-case integration error explicitly in terms of the RKHS-representer, and to derive deterministic error bounds for it. We focus on weights that minimize the worst-case error, especially those that integrate constants exactly. For isotropic point processes, these estimators are unbiased and admit almost sure 100% confidence interval. We further derive rates in terms of the geometry of the sampling points.

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Assessing dissimilarity of random sets through the geometry of their components

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Abstract

The poster introduces a statistical approach to evaluating how different two realisations of random sets are. The method emphasizes the geometry of the sets' components, particularly the curvature of their boundaries as well as relationships between their perimeters and areas. It begins with an overview of the theoretical framework, followed by a detailed description of the method. Then, its validation through a simulation study is shown, and finally its application to real datasets involving two types of tissue - mammary cancer and mastopathy - is presented.

Acknowledgment: Supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS26/031/OHK3/1T/13.

References

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Classification of Realisations of Random Sets

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Abstract

This poster presents approaches to the classification of realizations of random sets. The proposed framework combines functional representations with ideas inspired by spatial statistics, leading to characteristics that capture key structural properties. These characteristics are then used within a nonparametric classification setting, considering both supervised and unsupervised approaches. Several standard techniques are examined to illustrate the general approach. The methodology is currently under development and is demonstrated through preliminary experiments, including simulation studies and applications to real-world data, highlighting its potential and indicating directions for further research.

Acknowledgment: Supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS26/031/OHK3/1T/13.

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Multivariate asymptotic test of pairwise independence for orientations with the same symmetry group

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Abstract

This work focuses on testing pairwise independence in r-tuples of orientations of symmetric objects in three-dimensional space, which commonly arise in crystallography and materials science. We introduce a novel definition of covariance between two random orientations and use it to construct multivariate asymptotic tests based on U-statistics.

The finite-sample performance of the proposed tests is evaluated through a simulation study, where their power is assessed under three models of random orientation tuples and compared with a permutation-based approach. The methodology is further illustrated using data from a polycrystalline material with cubic crystal symmetry.

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Modelling the Clustering of Proteins in Cultured Neuronal Tissue

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Abstract

The motivation for this work stems from empirical observation that in cultured neuronal tissue samples, patients with Amyotrophic Lateral Sclerosis (ALS) display greater clustering of certain proteins along neurites compared to a control group. Manual extraction of features from images of the tissue samples is very time consuming and prone to observer bias. Moreover, standard methods of image processing [2,3] rely on simple correlations and do not account for the geometric structure of neurites and clustering orientation. We present a formal methodology for both extraction and quantification of the clustering properties of these proteins based on data consisting of multiple (hetrogeneous) images per individual from each member of the case and control groups [1].

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References

[1] Baddeley, A., Nair, G., Rakshit, S., McSwiggan, G., Davies, T. (2021): Analysing point patterns on networks – A review. *Spatial Statistics* **42**

[2] Image.sc Forum, *https://forum.image.sc*, accessed Sept 2025.

[3] ImageJ Wiki *https://imagej.net/*, accessed Sept 2025.

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