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Information-Theoretic Thresholds for Bipartite Latent-Space Graphs Under Noisy Observations

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Abstract

We study information-theoretic phase transitions for the detectability of latent geometry in bipartite random geometric graphs RGGs with Gaussian d-dimensional latent vectors while only a subset of edges carries latent information determined by a random mask with i.i.d. $\mathsf{Bern}(q)$ entries. For any fixed edge density $p \in (0, 1)$ we determine essentially tight thresholds for this problem as a function of d and q. Our results show that the detection problem is substantially easier if the mask is known up-front, compared to the case where the mask is hidden.

Our analysis is built upon a novel Fourier-analytic framework for bounding signed subgraph counts in Gaussian random geometric graphs that exploits cancellations which arise after approximating characteristic functions by an appropriate power series. The resulting bounds are applicable to much larger subgraphs than considered in previous work which enables tight information-theoretic bounds, while the bounds considered in previous works only lead to lower bounds from the lens of low-degree polynomials. As a consequence we identify the optimal information-theoretic thresholds and rule out the presence of computational-statistical gaps. Our bounds further improve upon the bounds on Fourier coefficients of random geometric graphs recently given by Bangachev and Bresler (2024) in the dense, bipartite case. The techniques also extend to sparser and non-bipartite settings, at least if the considered subgraphs are sufficiently small. We further believe that they might help resolve open questions for related detection problems[1].

Keywords: testing thresholds, latent geometry, random geometric graphs, information theory

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1. Extended abstract. Full version appears as `https://arxiv.org/abs/2602.11129`, v6; see also (Göbel et al., 2026)