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FAKULTÄT
FÜR MATHEMATIK, INFORMATIK
UND NATURWISSENSCHAFTEN
Fachbereich Mathematik

Kolloquium über Mathematische Statistik und Stochastische Prozesse

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21.10.2025, 16:15 Uhr, Geom Hörsaal H5

Optimal Cox regression under federated differential privacy: coefficients and cumulative hazards

Abstract: We study two foundational problems in distributed survival analysis: estimating Cox regression coefficients and cumulative hazard functions, under federated differential privacy constraints, allowing for heterogeneous per-sever sample sizes and privacy budgets. To quantify the fundamental cost of privacy, we derive minimax lower bounds along with matching (up to poly-logarithmic factors) upper bounds. In particular, to estimate the cumulative hazard function, we design a private tree-based algorithm for nonparametric integral estimation. Our results reveal server-level phase transitions between the private and non-private rates, as well as the reduced estimation accuracy from imposing privacy constraints on distributed subsets of data.

To address scenarios with partially public information, we also consider a relaxed differential privacy framework and provide a corresponding minimax analysis. To our knowledge, this is the first treatment of partially public data in survival analysis, and it establishes a no-gain in accuracy phenomenon. Finally, we conduct extensive numerical experiments, with an accompanying R package FDPCox, validating our theoretical findings. These experiments also include a fully-interactive algorithm with tighter privacy composition, which demonstrates improved estimation accuracy.

https://arxiv.org/abs/2508.19640

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