Optimal transport and Wasserstein distances for causal models

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04 December 2024, 17:15–18:15* Berlin time
IRTG 2544: "Stochastic Analysis in Interaction"
— Berlin Probability Colloquium —

Rudower Chaussee 25
12489 Berlin
Room 1.115

Abstract

We introduce a variant of optimal transport adapted to the causal structure given by an underlying directed graph G. Different graph structures lead to different specifications of the optimal transport problem. For instance, a fully connected graph yields standard optimal transport, a linear graph structure corresponds to causal optimal transport between the distributions of two discrete-time stochastic processes, and an empty graph leads to a notion of optimal transport related to CO-OT, Gromov–Wasserstein distances and factored OT.

We derive different characterizations of G-causal transport plans and introduce Wasserstein distances between causal models that respect the underlying graph structure. We show that average treatment effects are continuous with respect to G-causal Wasserstein distances and small perturbations of structural causal models lead to small deviations in G-causal Wasserstein distance. We also introduce an interpolation between causal models based on G-causal Wasserstein distance and compare it to standard Wasserstein interpolation.

*Punctual, i.e. sine tempore!