
Mathematics of Machine Learning
Les mathématiques de l'apprentissage machine
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Agnostic Model-Assisted Estimation in Finite Population Sampling

The aim of survey sampling is to estimate finite population parameters. In many settings, auxiliary information is available at the population level and can be incorporated through modeling within the model-assisted framework. Establishing the asymptotic properties of such estimators has traditionally been carried out on a method-by-method basis and has remained an active area of research over the past 25 years. Although these estimators often share similar properties, the techniques used to analyze them are typically tailored to the specific prediction method. A general theoretical framework applicable to arbitrary prediction methods is currently lacking.

In this work, we address this gap by introducing a novel form of conditional cross-fitting adapted to the dependence arising in survey sampling. Leveraging this approach, we develop a unified theory for the asymptotic behavior of model-assisted estimators based on general prediction methods. In particular, we establish the asymptotic normality of the proposed estimators and the consistency of a corresponding cross-fitting variance estimator, thereby enabling the construction of asymptotically valid confidence intervals. The proposed approach is shown to be asymptotically optimal in that it reaches the Godambe-Joshi lower bound. Simulation studies further demonstrate the favorable finite-sample performance of the proposed methodology.

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Minimum enclosing ball algorithms in geodesic spaces

Finding the smallest ball enclosing a bounded set of points is a fundamental optimization problem in computational geometry and operations research, where it is sometimes known as the minimax facility location problem. Algorithms for solving this problem in Euclidean space are plentiful, but there are fewer viable options in non-Euclidean spaces like Riemannian manifolds and geodesic metric spaces. In this talk we highlight the role that geodesics have played in the design of minimum enclosing ball algorithms on non-Euclidean spaces, dating back to a finitely-convergent algorithm on tree graphs. We demonstrate that a simple greedy geodesic-following algorithm, known to converge in the Riemannian case, admits a simple complexity analysis in geodesic metric spaces satisfying an upper curvature bound. In the case of nonpositive curvature, we also propose a projection-based algorithm that generates certifiable lower bounds on the minimum enclosing ball radius.

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