The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

Plating Privacy onto Structured Data: Estimation Examples in Regression and an Open Challenge in PCA

By

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ABSTRACT

While the traditional goal of statistics is to learn about population parameters, modern practices have raised concerns about individuals and their privacy. One approach to addressing these concerns involves upgrading statistical methods into privacy-preserving algorithms. However, this upgrade is non-trivial when the data to be protected exhibits specific structures. We illustrate this problem by studying differentially private (DP) Huber regression and trace regression. We propose DP Huber estimators that are robust to heavy-tailed regression noise in both low- and high-dimensional settings, achieving near-optimal convergence rates. By quantitatively exploring the interplay among bias, privacy, and robustness, we extend and complement classical perspectives on robustness and privacy. Our proposed algorithm for DP trace regression leverages low-rankness and also attains near-optimal convergence rates. We then explore DP principal component analysis (PCA) under the spiked covariance model. Quantifying the minimum sufficient noise required for privacy protection in this problem is challenging because the sensitivity depends non-linearly on the input data. Moreover, sensitivity analysis requires exact knowledge of the leading eigenvectors, which makes truncations impossible. This leads us to an interesting open problem: how should we define "good" datasets that are safe for discussing privacy when the definition itself requires information about the true parameters we aim to estimate? Another contribution of this work on DP trace regression and DP PCA is a slightly improved version of DP Fano's Lemma.

Date :		**7 May 2025, Wednesday**
Time :		**10:00 am**
Venue :		**Room 4475 (Lifts 25/26)**

Thesis Examination Committee:

Chairman	:	**Prof. Jun ZHANG, ECE/HKUST**
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The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).