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THE HONG KONG UNIVERSITY OF SCIENCE & TECHNOLOGY

Department of Mathematics

SEMINAR ON PROBABILITY

New Matrix Perturbation Bounds with Relative Strength

By

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Abstract

Let A be a ground-truth data matrix and g a matrix functional associated with a computational task. In practice, A is often observed only through a perturbed matrix $\tilde{A} = A + E$, where E may be deterministic or random. A fundamental problem in matrix perturbation theory is to establish sharp bounds on

$$\|g(\tilde{A}) - g(A)\|_*,$$

for an appropriate norm $\|\cdot\|_*$. Important examples include eigenvalues, eigenvectors, best low-rank approximations, and spectral matrix functionals, whose stability plays a central role in mathematics, statistics, numerical analysis, and machine learning.

Classical results, such as Weyl's inequality for eigenvalues and the Davis–Kahan theorem for eigenspaces, typically quantify perturbations through the spectral norm $\|E\|$. While these bounds are optimal in worst-case settings, they can be overly pessimistic when the perturbation is random, unstructured, or weakly aligned with the relevant spectral directions of A.

In this talk, I will introduce a new framework that goes beyond the global spectral norm $\|E\|$ by exploiting the *relative strength* of the perturbation, which measures its effective action on the relevant eigenvectors or singular vectors of A. Our analysis is based on a new technique, which we call the *method of combinatorial contour expansion*.

To illustrate the main ideas and applications of this framework, I will focus on perturbation bounds for spectral projections onto the leading eigenspace of A and the related applications.

The talk is based on joint work with Prof. Van Vu: https://arxiv.org/abs/2409.20207.

Bio: Phuc Dang Tran is a Postdoctoral Fellow in the Department of Mathematics at the University of Hong Kong. He received his Ph.D. in Mathematics from Yale University in 2026. His research focuses on random matrix theory, matrix perturbation theory, and their applications to data science and machine learning. His recent work develops new theoretical tools for spectral analysis, low-rank matrix approximation, and differential privacy.

Date : 18 November 2026 (Wednesday)
***Time : 2:00p.m.-3:00p.m.**
***Venue : Room 4472 (near Lift 25/26)**

All are Welcome!