The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

Non-Convex Algorithms for Spectrally Sparse Signal Reconstruction

By

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ABSTRACT

Spectrally sparse signals arise in various applications, including autoregressive modeling and nuclear magnetic resonance spectroscopy. Reconstructing such signals from uniformly spaced sub-samples in the time domain can be reformulated as a low-rank Hankel matrix completion problem. This thesis makes three key contributions to this field. First, we introduce the novel generator framework that unifies factorization-based and low-rank matrix-based approaches, enabling efficient computation in factorization space and streamlined analysis in matrix space for complex structured problems. Second, by analyzing the singular pairs of the Jacobi operator associated with the generator framework, we propose Jacobi-preconditioned symmetric Hankel gradient descent (JHGD), a provably linear convergent algorithm with superior efficiency. Third, we develop preconditioned non-symmetric fast iterative hard thresholding (PFIHT), which leverages data-adaptive preconditioning to achieve faster computational performance. Comparative analyses demonstrate that the proposed algorithms significantly improve both the convergence speed and the success rate of signal recovery. These advancements contribute to both the theoretical understanding and practical methods for spectrally sparse signal reconstruction, with broader implications for structured matrix completion tasks.

Date : **25 Jul 2025, Friday**

Time : **3:00 pm**

Venue : **Room 4472 (Lifts 25/26)**

Thesis Examination Committee:

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The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).