Invited Talk Abstract

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RiNNAL+: A Riemannian ALM Solver for SDP-RLT Relaxations of Mixed-Binary Quadratic Programs

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Date	July 28, 2026
Time	15:30–16:00
Session	Session 5
Venue	S102, Lecture Hall, Gong-Guan Campus, NTNU

Abstract

Doubly nonnegative (DNN) relaxation usually provides a tight lower bound for a mixed-binary quadratic program (MBQP). However, solving DNN problems is challenging because: (1) the problem size is $\Omega((n+l)^2)$ for an MBQP with n variables and l inequality constraints, and (2) the rank of optimal solutions cannot be estimated a priori due to the absence of theoretical bounds. In this work, we propose RiNNAL+, a Riemannian augmented Lagrangian method (ALM) for solving DNN problems. We prove that the DNN relaxation of an MBQP, with matrix dimension $n+l+1$, is equivalent to the SDP-RLT relaxation (based on the reformulation-linearization technique) with a smaller matrix dimension $n+1$. In addition, we develop a hybrid method that alternates between two phases to solve the ALM subproblems. In phase one, we apply low-rank matrix factorization and random perturbation to transform the feasible region into a lower-dimensional manifold so that we can use the Riemannian gradient descent method. In phase two, we apply a single projected gradient step to update the rank of the underlying variable and escape from spurious local minima arising in the first phase if necessary. To reduce the computation cost of the projected gradient step, we develop pre-processing and warm-start techniques for acceleration. Unlike traditional rank-adaptive methods that require extensive parameter tuning, our hybrid method requires minimal tuning. Extensive experiments confirm the efficiency and robustness of RiNNAL+ in solving various classes of large-scale DNN problems.

This talk is based mainly on joint work with Di Hou and Tianyun Tang.