Research Description

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In Spring 2016, I worked with Professor Henry Wolkowicz as an Undergraduate Research Assistant (URA) in the Department of Combinatorics and Optimization, during which time I received many support and patient guidance from my supervisor. It was an extremely exciting journey both because of the interesting problem we worked on, and the enthusiasm of Professor Wolkowicz.

Our research was on a low-rank matrix completion (LRMC) problem. Specifically, we aim to recover a partially observed matrix such that the recovery has low rank. In our work, we assumed that the "low rank" is pre-defined or pre-estimated, which we called the target rank. We considered two cases separately: when data is clean (noiseless case) and when data is contaminated with additive noise (noisy case).

The important ideas in this paper are the employment of Facial Reduction (FR) and the Nuclear Norm as well as the Semedefinite embedding. To recover any partially observed real matrix, we form the problem as a Semidefinite Programming problem. That is, we transform the rank minimization problem into a nuclear norm minimization problem with the original variable being formed into a positive semidefinite variable. The problem becomes much nicer, since the nuclear norm of a positive semidefinite matrix is equal to its trace. More importantly, we found that since the optimal solution is not strictly feasible but rather on a low rank subspace — a face of the original postive semidefinite cone, we can take advantage of the FR step to largely reduce the size of the problem.

In the noiseless case, we found that there are many redundant constraints that we can safely remove such that a simple semidefinite constrained least squares solution may be enough. In the noisy case, since we cannot remove the constraints, we further adopt the idea of sketch matrix – using a random projection to reduce the size of the constrains and speed up the computation while maintaining high accuracy.

In the end, we revised and optimized our algorithm and code such that we can achieve very efficient computation and promising results.