

# Mixed-Projection Conic Optimization: A New Paradigm for Modeling Rank Constraints



**Abstract:** We propose a framework for modeling and solving low-rank problems to certifiable optimality. To model rank constraints, we introduce symmetric projection matrices that satisfy  $Y^2 = Y$  and model the row space of a matrix, the matrix analog of binary variables that satisfy  $z^2 = z$ , and model the sparsity of a vector.

In the first part of the talk, we demonstrate that this modeling paradigm yields tractable convex problems over the non-convex set of projection matrices. Further, we design outer-approximation algorithms to solve low-rank problems to certifiable optimality and demonstrate their efficacy on matrix completion problems. All in all, our framework, which we name Mixed-Projection Conic Optimization, solves low-rank problems to certifiable optimality in a tractable and unified fashion.

In the second part of the talk, we study the convex relaxations of low-rank problems. We propose a new preprocessing technique for obtaining strong yet computationally affordable relaxations. The technique parallels and generalizes the perspective reformulation technique—a popular preprocessing technique for obtaining tight relaxations of mixed-integer problems, and leads to new and “embarrassingly tight” convex relaxations of several widely-used low-rank models, including matrix completion problems.

Finally, we briefly discuss an ongoing collaboration with OCP—a large Moroccan fertilizer manufacturer—to optimally decarbonize their production process by investing in an appropriate mixture of batteries, solar panels, and transmission lines.

All papers mentioned in the talk are available at [ryancorywright.github.io](https://ryancorywright.github.io).

**Bio:** Ryan Cory-Wright is a fifth-year Ph.D. candidate at MIT’s Operations Research Center, advised by Dimitris Bertsimas. His research interests lie at the intersection of optimization, machine learning and statistics, and their applications in energy systems. His current research follows two different threads. First, developing a suite of algorithms that efficiently address interpretable (e.g., sparse or low-rank) optimization problems in a certifiably optimal manner. Second, integrating renewables within energy markets to combat climate change. He is a recipient of the INFORMS Nicholson Prize (2020), the INFORMS Pierskalla Award (2020), the INFORMS Computing Society Student Paper Award (2019), the INFORMS Data Mining Section Student Paper Award (2021), and the Operations Research Society of New Zealand Student Paper Award (2016). Before attending MIT, Ryan received a B.E. (1st class Honors) degree in Engineering Science from the University of Auckland, New Zealand.

**USC Viterbi**  
School of Engineering  
*Daniel J. Epstein Department of  
Industrial and Systems Engineering*

**TUESDAY, January 25, 2022**  
**3:30pm – 4:30pm**  
**Zoom/Online**