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Optimization Challenges in Machine Learning

In this talk, we examine model selection problems in machine learning and the optimization challenges that they represent. Great progress has been made in machine learning by cleverly reducing machine learning problems to convex optimization problems with one or more hyper-parameters. For example, in support vector machines, highly non-linear classifiers are constructed by solving a convex quadratic program with at least two hyper-parameters specified by the users.

While cross validation is a commonly employed and widely accepted method for selecting these parameters, its implementation by a grid-search procedure in the parameter space effectively limits the desirable number of hyper-parameters in a model, due to the combinatorial explosion of grid points in high-dimensions. Explicitly tackling model selection by cross validation as a bilevel optimization problem allows for efficient systematic search of large numbers of hyper-parameters. We discuss recent progress in solution of the resulting bilevel problems, and the many interesting optimization challenges that remain. Finally, we investigate the intriguing possibility of novel machine learning models enabled by multilevel programming.