ID de Contribution: **227** Type: **Invited talk**

A Functional Model Method for Nonconvex Nonsmooth Conditional Stochastic Optimization

mardi 29 juillet 2025 11:15 (30 minutes)

We consider stochastic optimization problems involving an expected value of a nonlinear function of a base random vector and a conditional expectation of another function depending on the base random vector, a dependent random vector, and the decision variables. We call such problems conditional stochastic optimization problems. They arise in many applications, such as uplift modeling, reinforcement learning, and contextual optimization.

We propose a specialized single time-scale stochastic method for nonconvex constrained conditional stochastic optimization problems with a Lipschitz smooth outer function and a generalized differentiable inner function. In the method, we approximate the inner conditional expectation with a rich parametric model whose mean squared error satisfies a stochastic version of a Lojasiewicz condition. The model is used by an inner learning algorithm. The main feature of our approach is that unbiased stochastic estimates of the directions used by the method can be generated with one observation from the joint distribution per iteration, which makes it applicable to real-time learning. The directions, however, are not gradients or subgradients of any overall objective function. We prove the convergence of the method with probability one, using the method of differential inclusions and a specially designed Lyapunov function, involving a stochastic generalization of the Bregman distance. Finally, a numerical illustration demonstrates the viability of our approach.

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Classification de Session: ML

Classification de thématique: Machine learning