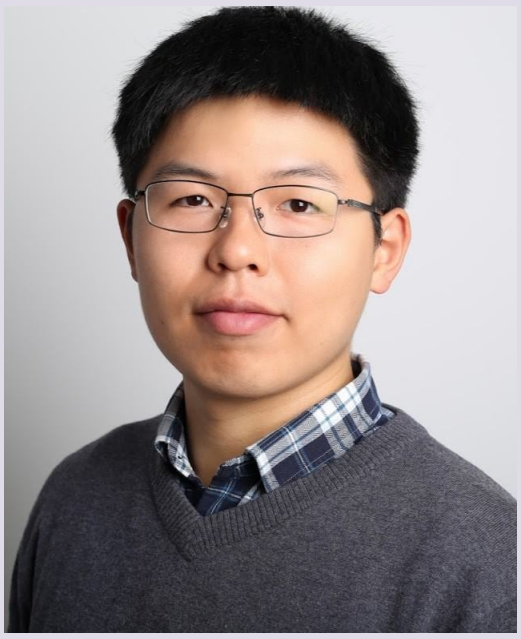
# Contextual Stochastic Bilevel Optimization and Three-Stage Stochastic Programming

## BIOGRAPHY



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## ABSTRACT

We introduce contextual stochastic bilevel optimization (CSBO) -- a stochastic bilevel optimization framework with the lower-level problem minimizing an expectation conditioned on some contextual information and the upper-level decision variable. This framework extends classical stochastic bilevel optimization when the lower-level decision maker responds optimally not only to the decision of the upper-level decision maker but also to some side information and when there are multiple or even infinite many followers. It captures important applications such as meta-learning, personalized federated learning, end-to-end learning, and Wasserstein distributionally robust optimization with side information (WDRO-SI). Due to the presence of contextual information, existing single-loop methods for classical stochastic bilevel optimization are not applicable. To overcome this challenge, we introduce an efficient double-loop gradient method based on the Multilevel Monte-Carlo (MLMC) technique and establish its sample and computational complexities. When specialized to stochastic nonconvex optimization, our method matches existing lower bounds. Extending to three-stage stochastic programming, our results break the long-standing belief that three-stage stochastic programming is harder than classical stochastic optimization, and open up new directions for algorithmic design for three-stage problems. I will further discuss bilevel reinforcement learning that can be used in LLM training.