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Dissertation Defense:

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Algebraic and Differential Geometry in Modern Optimization

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Stochastic optimization algorithms have become indispensable in modern machine learning. The developments of theories and algorithms of modern optimization also requires the application of tools from different mathematical branches, such as algebraic and differential geometry. In this dissertation, we answer several problems in stochastic optimization by a wide range of tools. We disprove the noncommutative arithmetic and geometric mean inequality using results from noncommutative polynomial optimization. This is based on joint works with Lek-Heng Lim. We propose new, simpler and efficient models and algorithms for optimization over Grassmannian and flag manifolds. This is based on the join works with Lek-Heng Lim and Ke Ye. We study the problem of statistical inference in gradient-free optimization and contextual bandit optimization, and prove central limit theorems to construct confidence interval. This is based on joint works with He Li, Xi Chen, and Yichen Zhang.