Abstract
論 文 の 内 容 の 要 旨

論文題目　Submodular and Sparse Optimization Methods for Machine Learning and Communication
（機械学習と通信のための劣モジュラ･スパース最適化手法）

氏　　名　相馬　輔

This dissertation considers optimization problems arising from machine learning and communication, and devises efficient algorithms by exploiting submodular and sparse optimization techniques.

The first subject of this dissertation is submodular function maximization over the integer lattice. Maximizing a monotone submodular set function has been extensively studied in machine learning, social science, and related areas, since it encompasses a variety of problems considered in these areas and efficient greedy algorithms are available. However, we often face real scenarios that are beyond these existing models based on submodular set functions. For example, the existing models cannot capture the budget allocation problem in which we have to decide how much budget should be set aside. In this dissertation, we overcome this fundamental limitation of the existing models by exploiting submodularity over the integer lattice. We demonstrate that our new framework can naturally and concisely capture these difficult real scenarios, and provide efficient approximation algorithms for various constraints. In addition to theoretical guarantees, we conduct numerical experiments to establish practical efficiency of our model and algorithms.

Then we move on matrix completion problems. Roughly speaking, matrix completion problems are to determine missing entries in a given partial matrix under some criteria. Our first result is a new algorithm for constructing a multicast code for a wireless network using max-rank matrix completion. In the main ingredient of our algorithm, we employ the theory of mixed matrices, matroids, and submodular optimization. Second, we propose a new problem, the low-rank basis problem for a matrix subspace. Originally this problem comes from combinatorial optimization, but it turns out that this problem has various applications, including image separation and data compression. We present an efficient heuristic algorithm for this problem, using matroid theory and sparse optimization.

The last subject of this dissertation is compressed sensing. The main goal of compressed sensing is to recover a high-dimensional sparse signal from a few linear measurements. While the problem setup is quite simple, compressed sensing has been widely applied to machine learning, statistics, and signal processing. In this dissertation, we consider stable signal recovery in compressed sensing and show that the sum-of-squares method yields a new polynomial time recovery method for Rademacher sensing matrices. Our result sheds light on the power of sum-of-squares method on nonconvex problem arising from compressed sensing literature.

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