

# 报告题目与摘要

## 1. 包承龙, 清华大学

**题目:** Recent Computational Approaches in Cryogenic Electron Microscopy: Towards Formalizing a Data-Driven Cycle

**摘要:** Cryogenic Electron Microscopy (cryo-EM) is a powerful imaging technique for determining the high-resolution structures of biological macromolecules. However, it still faces several challenges, including an extremely low signal-to-noise ratio, heterogeneity, and preferred orientation. In this talk, we will present our computational approaches to addressing these challenges, covering the entire cryo-EM data processing pipeline. Specifically, we will discuss methods for data evaluation, processing, post-processing, and model building, combining mathematical models and unsupervised deep learning approaches. We will also present experimental results from biological laboratories to demonstrate the effectiveness of the proposed algorithms.

## 2. 陈林, 浙江大学

**题目:** Multidimensional Dense Subset Sum and Integer Programming

**摘要:** We study the additive structure of dense subset sum in multi-dimension, and use the structure to develop efficient algorithms for the dense subset sum problem. More precisely, given a set  $A$  of  $n$  vectors in the  $d$ -dimensional hyperrectangular  $[N_1] \times [N_2] \times \cdots \times [N_d]$ , we study the structure of  $\mathcal{S}(A)$ , which is the set of all subset sums of  $A$ , and then utilize the structure to develop efficient algorithms for determining whether  $\vec{t} \in \mathcal{S}(A)$  for a given  $\vec{t}$ . We focus on the dense regime of the problem where  $n$  is not too small when compared to  $\Phi$ , where  $\Phi = \prod_{i=1}^d N_i$  is the volume of the hyperrectangular containing  $A$ .

The problem is much well-understood in the 1-dimensional case. It is known that if  $n \gg \sqrt{\Phi}$ , then  $\mathcal{S}(A)$  contains an arithmetic progression of length  $\Phi$  [Sárközy '94, Szemerédi & Vu '06]. If we further have that no prime can divide the majority of  $A$ , then  $\mathcal{S}(A)$  contains all integers in the the range  $[o(1)\sigma(A), (1 - o(1))\sigma(A)]$ , where  $\sigma(A) = \sum_{a \in A} a$  [Lev '03]. Using this combinatorics result, it has been shown that with the sole condition that  $n \gg \sqrt{\Phi}$ , then one can determine whether  $\vec{t} \in \mathcal{S}(A)$  in  $\tilde{O}(n)$  time for any  $t \in [o(1)\sigma(A), (1 - o(1))\sigma(A)]$  [Galil & Margalit '91, Bringmann & Wellnitz '21].

For multi-dimension, the problem is far from clear. It is only known that if no non-

trivial lattice (lattice other than  $\mathbb{Z}^d$ ) can contain the majority of  $A$ , then  $\mathcal{S}(A)$  contains all integer points within some ellipsoid provided that  $n \gg \Phi^{2/3}$  for  $d = 2$  [Freiman '96, Plagne '99], and  $n \gg \Phi^{\frac{d-1}{d}}$  for  $d \geq 3$  [Chaimovich '91].

We improve upon these combinatorics results by showing that for any constant  $d \geq 1$ , if  $n \gg \sqrt{\Phi}$ , then  $\mathcal{S}(A)$  contains a sufficiently long generalized progression in multi-dimension. If we further have that no non-trivial lattice can contain the majority of  $A$ , then  $\mathcal{S}(A)$  contains all the integers points in the zonotope  $\{x_1\vec{a}_1 + \dots + x_n\vec{a}_n : o(1) \leq x_j \leq 1 - o(1), x_j \in \mathbb{R}\}$ . Compared to the previous results, our result significantly reduces the requirement on  $n$ , and enlarges the region inside which all the integer points belong to  $\mathcal{S}(A)$ .

Using our combinatorics result, we improve the running time of 0-1 integer programming from  $\Delta^{d^2+d}d^{O(d^2)}poly(|I|)$  to  $\Delta^{d^2/2+d}(d \log \Delta)^{O(d^2)}poly(|I|)$ , where  $\Delta$  denotes the largest absolute value among coefficients in constraint matrix.

### 3. 陈翌佳, 上海交通大学

题目: Algorithms and Complexity through the lens of Homomorphism Counts

摘要: In 1967, Lovász proved that two graphs  $G$  and  $H$  are isomorphic if and only if for every (pattern) graph  $F$ , the number  $\text{hom}(F, G)$  of homomorphisms from  $F$  to  $G$  equals  $\text{hom}(F, H)$ . Thus every graph  $G$  is characterized by its homomorphism vector  $(\text{hom}(F, G))_F$  up to isomorphism. By restricting the pattern graphs  $F$  to a given graph class  $K$ , e.g., trees, planar graphs, or bounded-degree graphs, the restricted homomorphism vector  $(\text{hom}(F, G))_{F \in K}$  provides a meaningful way to measure similarity between graphs. For instance, equality of homomorphism vectors for all trees holds if and only if  $G$  and  $H$  cannot be distinguished by the color-refinement algorithm, a well-known heuristic for the graph isomorphism problem. Such homomorphism vectors have found numerous applications in algorithms, complexity, logic, and machine learning. In this talk I will explain some recent results and report on our findings.

### 4. 杜东雷, University of New Brunswick

题目: Liftability and Separation for Property Preservation in Parametric Optimization

摘要: We develop a certificate-based framework for property preservation in parametric optimization. Its central object is an exact liftability set combining upstairs certificates, and feasible lifts of the positive and negative parts of a downstairs certificate. Membership implies preservation; separation yields a violating witness. This gives a unified treatment of convexity, submodularity, and related preservation phenomena for value functions.

## 5. 雷震东, 华为技术有限公司

**题目:** 工业场景下的求解器挑战与实践

**摘要:** 当前约束规划问题可以细分成几大类, 包括 SAT, MIP, SMT, CP 等。这些问题之间最主要区别在于约束的形式和表达能力不同。正因此, 每类问题也发展出了一些独特的求解框架和技术。像 MIP 中的 BNB, SAT 中的 CDCL。本报告旨在从求解器角度思考这些技术是否可以统一。同时也从实际应用角度出发, 探索问题模型与约束表达能力对求解效果的影响。

## 6. 郦旭东, 复旦大学

**题目:** A New Dual Semismooth Newton Method for Polyhedral Projections

**摘要:** We study dual semismooth Newton methods for polyhedral projection problems with linear equality constraints. In degenerate settings, singular generalized Hessians of the dual objective destroy the classical local superlinear convergence theory. We show that this singularity is not intrinsic to the primal projection, but is caused by the choice of the dual representation. Using a primal-dual lifted projection-equivalent set, we characterize dual representations with nonsingular Han–Sun generalized Jacobians through extreme points, and relate this property to a full-column-rank condition and the weak strict Robinson constraint qualification. Based on this analysis, we develop an inexact SSN method with local superlinear convergence without a priori regularity assumptions, and a globalized SSN-CG method that avoids cycling, ensures global convergence, and eventually recovers the local superlinear rate.

## 7. 罗川, 北京航空航天大学

**题目:** 约束采样方法研究及其应用实践

**摘要:** 约束采样是计算机科学中的一个基本问题。给定一组约束条件, 约束采样的目标是在生成多个满足所有约束的赋值的同时, 确保这些赋值具备高度的多样性。与仅需寻找一个可行解的经典约束求解问题相比, 约束采样在理论上更具挑战性。同时, 该问题在保障关键系统软件可靠性方面具有广泛的实际应用价值。由于约束采样问题的高度复杂性, 现有方法普遍面临严峻的可扩展性瓶颈, 难以高效处理大规模实例。本次报告将介绍一种高效的约束采样算法。在大量实例上的实验结果表明, 该算法的性能显著优于当前最先进的方法。值得关注的是, 该算法已被成功应用于软件测试领域, 为基础编译器检测出了多个此前未知的缺陷。

## 8. 孙德锋, 香港理工大学

**题目:** The Aubin Property for Generalized Equations over  $C^2$ -cone Reducible Sets

**摘要:** In this talk, we address a fundamental and long-standing question in variational analysis by proving the equivalence between the Aubin property and strong regularity for generalized equations over  $C^2$ -cone reducible sets. We also construct a counterexample showing that the  $C^2$ -cone reducibility assumption cannot be dropped.

## 9. 唐志皓, 上海财经大学

**题目:** Online Matching in General Graphs

**摘要:** In this talk, I will discuss several extensions of the classic online bipartite matching problem to general graphs, with a particular focus on the fully online model and the general vertex-arrival model.

I will present the current state of the art, highlighting algorithmic ideas that go beyond the classical Ranking and Water-filling paradigms, as well as hardness constructions beyond the standard upper-triangular instances. I will conclude with a discussion of open questions and future directions.

## 10. 虞文武, 东南大学

**题目:** 博弈智能理论与场景应用

**摘要:** 博弈智能是人工智能认知决策领域备受关注的热点前沿问题, 是人类活动特别是人类智能的重要体现。随着社会的发展, 智能通信及智能物流等领域的博弈场景不可避免的会面临博弈要素及其关系复杂、博弈目标及约束多样、博弈空间动态随机等因素造成的博弈建模与求解困难。本次报告围绕博弈智能理论与场景应用展开, 介绍本人及团队基于大数据相关理论技术、网络群体智能理论及多智能体强化学习理论在上述博弈智能领域瓶颈问题解决上做的探索工作。进而介绍基于上述理论创新搭建的可解释、可迁移、可人机协同求解的智能算子平台及相关理论在智能通信及智能物流等实际领域中的应用成效。

## 11. 张羊晶, 中国科学院数学与系统科学研究院

**题目:** Low Rank Convex Clustering for Matrix-valued Observations

**摘要:** Common clustering methods, such as k-means and convex clustering, group similar vector-valued observations into clusters. However, with the increasing prevalence of matrixvalued observations, which often exhibit low rank characteristics, there is a growing need for specialized clustering techniques for these data types. In this paper, we propose a low rank convex clustering model tailored for matrix-valued observations. Our approach extends the convex clustering model originally designed for vector-valued data to classify matrix-valued observations. Additionally, it serves as a convex relax-

ation of the low rank k-means method proposed by Z. Lyu, and D. Xia (J. R. Stat. Soc. B, to appear). Theoretically, we establish exact cluster recovery for finite samples and asymptotic cluster recovery as the sample size approaches infinity. We also give a finite sample bound on prediction error in terms of centroid estimation, and further establish the prediction consistency. To make the model practically useful, we develop an efficient double-loop algorithm for solving it. Extensive numerical experiments are conducted to show the effectiveness of our proposed model.

## 12. 张宇昊, 上海交通大学

**题目:** The Price of Anarchy for Selfish Load Balancing

**摘要:** We revisit the canonical Koutsoupias–Papadimitriou model, also known as the selfish load balancing problem, providing a fairly complete picture of the **Price of Anarchy (PoA)** under several standard equilibrium concepts.

For **Bayesian Nash equilibria** (including both pure and mixed equilibria), we obtain the first non-trivial upper bounds on the PoA:  $O\left(\frac{\log m}{\log \log m}\right)$  for identical links and  $O\left(\frac{\log m}{\log \log \log m}\right)$  for related links. These bounds match the previously known lower bounds of (Gairing, Monien, and Tiemann, SPAA’05 & TOCS’08), and thus fully characterize the inefficiency of both equilibrium concepts.

For **Correlated Equilibria**, we obtain the first non-trivial upper bounds as well, namely  $\sqrt{m} \pm \Theta(1)$  for identical links and  $\tilde{\Theta}(\sqrt{m})$  for related links, thereby closing the gaps left by prior work of (Blum, Hajiaghayi, Ligett, and Roth, STOC’08).

Finally, for **Coarse Correlated Equilibria**, we prove the first non-trivial upper bounds:  $\sqrt{m} \pm \Theta(1)$  for identical links, and  $O(\sqrt{m \cdot s_1/s_m})$  for related links together with a matching lower bound, where  $s_1/s_m \geq 1$  is the aspect ratio of the fastest and slowest link speeds. This again resolves an open question of (Blum, Hajiaghayi, Ligett, and Roth, STOC’08).

## 13. 赵欣苑, 北京工业大学

**题目:** A GPU Based Halpern Peaceman-Rachford (HPR) Method for Solving Convex Programming

**摘要:** We study the acceleration of a preconditioned alternating direction method of multipliers (pADMM), where the proximal terms are convex quadratic functions, for solving linearly constrained convex optimization problems. Our approach begins by reformulating pADMM as a proximal point method (PPM) with a positive semidefinite preconditioner, which may be degenerate due to the lack of strong convexity in the original proximal terms. We then accelerate pADMM by accelerating the resulting degener-

ate PPM (dPPM). In particular, we first develop an accelerated dPPM by incorporating Halpern iteration, achieving non-asymptotic convergence guarantees. Building upon this result, we further design an accelerated pADMM that enjoys non-asymptotic and nonergodic convergence rates under practical stopping criteria, including the Karush–Kuhn–Tucker (KKT) residual and the primal objective gap. Extensive GPU-based experiments on large-scale linear programming and convex composite quadratic programming benchmarks demonstrate the substantial advantages of our Halpern Peaceman–Rachford (HPR) method—a special case of the Halpern-accelerated pADMM applied to the dual formulation—over state-of-the-art solvers, including the award-winning PDLP, as well as PDQP, SCS, CuClabrel, and Gurobi, in delivering high-accuracy solutions.