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Yikai Wu

Work Experience

Princeton University — **Princeton, NJ, USA**
Assistant in Instruction — *Aug 2023–May 2024*
Serving as a teaching assistant in 2 courses

Education

Princeton University — **Princeton, NJ, USA**
Ph.D. student in Computer Science — *2022–present*
Advisor: Prof. Sanjeev Arora

Yale University — **New Haven, CT, USA**
Ph.D. student in Computer Science — *2021–2022*
No advisor assigned

Duke University — **Durham, NC, USA**
Bachelor of Science (Summa Cum Laude) — *2017–2021*
Double major in Computer Science and Mathematics

Research Experience

Benchmark of combinatorial optimization algorithms — **Princeton University**
Mentor: Prof. Sanjeev Arora — *Nov 2023-present*

- Combinatorial optimization problems are important problems in theoretical computer science. We aim to build a meaningful benchmark for combinatorial optimization algorithms by creating hard instances for existing algorithms. We specifically focus on several combinatorial optimization problems, namely maximum independent set, graph coloring, and travelling salesman problem.

Implicit bias in optimization algorithms — **Princeton University**
Mentor: Prof. Sanjeev Arora — *Jan 2023-present*

- Using different optimization algorithms sometimes provide vastly different answers for the same problem. The underlying reason is called implicit bias. We aims to build a mathematical theory on implicit bias, so that one can decide which optimization algorithm is best suited for a given problem. To achieve this aim, we analyze the geometry of the optimization landscape to predict the optimizatin path.

Optimization on Unitary Orbits **Yale University**
Mentor: Prof. Nisheeth Vishnoi *Jun 2021–Feb 2022*

- Consider the following optimization problem: Given $n \times n$ matrices A and Λ, maximize $\langle A, U\Lambda U \rangle$ where U varies over the unitary group $\mathrm{U}(\Lambda)$. The optimization can be used in multiple matrix approximation problems such as PCA and rank-k approximation. Our optimization algorithm can be used to create an efficient differentially private algorithm when A is constructed using users' private data. We also provided upper and lower bounds for the utility of the optimization.
- Paper [1] was presented at the Conference on Learning Theory (COLT) 2022.

Hessian in Stochastic Gradient Descent **Duke University**
Mentor: Prof. Rong Ge *May 2020–Aug 2021*

- The Hessian of the loss function captures important properties of optimization algorithms such as Stochastic Gradient Descent (SGD). We observed that the Hessian has several interesting structures which appear commonly when using SGD. We explained these structures using Kronecker factorization. Our new understanding of the Hessian can be used with PAC-Bayes techniques to get better generalization bounds.

Differential Privacy for Multiple Analysts **Duke University**
Mentor: Prof. Ashwin Machanavajjhala *May 2018–May 2021*

- Differential privacy is the gold standard of privacy protection. Existing differentially private algorithms are designed for a single analyst and are problematic for multiple analysts. We formulated three criteria to decide whether an algorithm is good for multiple analysts. We demonstrated how existing algorithms fail to satisfy them. We also designed new differentially private algorithms which satisfy these criteria provably.
- Paper [2] was presented at the International Conference on Very Large Data Bases (VLDB) 2021.
- During this project, we also proposed an algorithm using truncation to answer differentially private summation queries. A short paper [3] was presented at the Theory and Practice of Differential Privacy Workshop (TPDP) 2019.

Publications

[1] Oren Mangoubi, Yikai Wu, Satyen Kale, Abhradeep Thakurta, and Nisheeth K Vishnoi. Private matrix approximation and geometry of unitary orbits. In *Conference on Learning Theory*, pages 3547–3588. PMLR, 2022.
Presented at the Conference on Learning Theory (COLT) 2022.

[2] David Pujol, Yikai Wu, Brandon Fain, and Ashwin Machanavajjhala. Budget sharing for multi-analyst differential privacy. *Proceedings of the VLDB Endowment (PVLDB)*, 14(10): 1805–1817, 2021. doi: 10.14778/3467861.3467870.
Presented at the International Conference on Very Large Data Bases (VLDB) 2021.

[3] Yikai Wu, David Pujol, Ios Kotsogiannis, and Ashwin Machanavajjhala. Answering summation queries for numerical attributes under differential privacy. *arXiv:1908.10268 [cs.DB]*, 2019.
Presented at the Theory and Practice of Differential Privacy Workshop (TPDP) 2019.

Honors and Awards

Computing Research Association (CRA)
Outstanding Undergraduate Researcher Honorable Mention *2020*

Mathematical Contest in Modeling (MCM)
Meritorious Winner *2019*

Duke University Mathematics Student Award
The Karl Menger Award *2018*