Jinguo Liu (刘金国)

Postdoc fellow in Harvard university

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"朝正确的方向努力，而不是去摘下垂的果实。"

Education

Nanjing Institute of Technology — *Nanjing*

B.S. in Software Engineering — *2008–2012*

When I was a college student, I read a book "Quantum Computation and Quantum Information" by Michael A. Nielsen. I was deeply impressed by the beautiful computation framework in the book, and eagered to learn more about quantum computing in a department of physics.

Nanjing University — *Nanjing*

Ph.D. Theoretical Physics — *2012–2017*

Adviced under Prof. Qianghua Wang, I built up my interest in condensed matter numeric methodology. I mastered tensor networks algorithms and renormalizationing group theories, and became a geek in simulating quantum many body systems. Most of my works are about designing numeric algorithms to solve problems in physics, like multi-channel Kondo problem and fractional topological excitation. In the last year as a doctor candidate, I won the first prize in ZTE fantastic algorithm challenge, which is a good proof of my solid algorithmic background of matrix computation and combinatorial optimization.

Skills

Programming Julia, Python, Fortran

Language Chinese, English

Knowledge Tensor Networks, Differentiable Programming, Quantum computing, Condensed matter physics, Combinatorial optimization

Experience

Institute of Physics (IOP), Chinese Academy of Sciences — *Beijing*

Postdoc — *2017–2019*

I became a postdoc of Lei-Wang, one of the smartest people I knew, in Institute of Physics (IOP), Chinese Academy of Sciences (CAS). Besides providing valuable advices about research, Lei also creates a lot of opportunities for me, like encouraging me to give lectures and talks in international conferences and summer schools. That time my research interest is automatic differentiation and quantum algorithms.

QuEra computing — *Waterloo*

Consultant — *2020.01-2020.07*

Trapped in Waterloo, I worked on projects stachastic optimizers and classical benchmarking quantum approximation optimization algorithm (QAOA) for QuEra as a consultant. Waterloo is a nice place, and I can see wild animals on the steets.

Harvard university — *Boston*

Postdoc fellow — *2020.08-*

QuEra Computing Inc. sponsored my postdoc in Mikhail Lukin's group. It is the first time for me to work abroad, while my skills help experimentalists and theorists, I learnt more from them.

- I managed to map a general maximum independent set (MIS) problem to one with restricted geometry of diagonal coupled grid graph, which is patented now. I learn how to reduce many other hard problems to maximum independent set problem in turn.
- I developed generic tensor networks (tensor networks with generic element type being a commutative semiring) to understand solution space properties of some computational hard problems, I learnt their approach to analyse hardness from the solution space geometry: the overlap gap property and adiabatic gap analysis.
- I improved fourier transformation for generating arbitrary optical traps (will probably be patented). I learnt how Rydberg atom experiment works in turn.

Honors & Awards

2007	**First prize**, Physics Olympiad	*JiangSu, China*
2017	**First prize (out of 8000 teams, 100,000 RMB award)**, ZTE Fantastic Algorithm Challenge	*Xi An, China*
2016	**Academic Excellence Scholarship**, Nanjing University	*NanJing*

Open Source Contributions

Yao.jl

ONE OF THE MAIN DEVELOPERS

`Yao.jl` is the most popular quantum circuit simulation framework in Julia community. The Yao repository has 650+ Github stars and the paper has 50+ citations. It is fast, generic, GPU accelerated and differentiable.

OMEinsum.jl and OMEinsumContractionOrders.jl

MENTOR OF OMEINSUM.JL, MAIN DEVELOPER OF OMEINSUMCONTRACTIONORDERS.JL

`OMEinsum.jl` is a generic, differentiable einsum library with GPU support. It was developed by Andreas Peter (mentor under me) on the Google Summer of Code (GSoC) project about differential programming tensor networks. This project is a successful one and now its Github repo has 100+ stars. `OMEinsumContractionOrders.jl` is its extension for contraction order optimization, which includes many state of the art algorithms.

GraphTensorNetworks.jl

MAIN DEVELOPER

`GraphTensorNetworks.jl` is the a package using generic tensor network contraction for solving graph properties. It comes together with the paper: *"Computing solution space properties by generic programming tensor networks"* (see section "Selected Publications").

Selected Presentations

The FOR 1807 Winter School on Numerical Methods for Strongly Correlated Quantum Systems — *Marburg*

LECTURER — *2018*

Lecture: "Deep learning and quantum many body systems".

March Meeting — *Boston*

SPEAKER — *2019*

Talk: "Differentiale Quantum Circuits and Generative Modeling"

Juliacon — *Baltimore*

SPEAKER — *2019*

Talk: "Differential Programming Tensor Networks"

Deep Learning and Quantum Programming: A Spring School — *Dongguan*

LECTURER — *2019*

Lectures on the quantum computing part, one of the main organizers of "happy fatty night" (coding party for resolving student's issues).

Selected Publications

Maximum independent sets: from unit disk graphs to arbitrary connectivity — *Unpublished*

JINGUO LIU, MIN-THI NGUYEN, SHENGTAO WANG ET AL AND HANNES PICHLER — *2022*

Recent progresses of variational quantum algorithms show great potential of using Rydberg atom arrays to solve the maximum independent set (MIS) problem defined on diagonal coupled unit disk grid graphs. We propose a scheme to reduce the problem of finding an MIS of a general graph G to these graphs with highly restricted geometry to boost the power of these quantum algorithms. The mapped graph has an overhead bounded by $4\mathrm{pw}(G)$, where $\mathrm{pw}(G)$ is the path width of graph G. We show this mapping scheme is optimal up to a constant if there is no sub-exponential algorithms for finding an MIS of a general graph. Understanding its value to quantum algorithms, we are now patenting it.

Computing solution space properties by generic programming tensor networks — *Unpublished*

JINGUO LIU, XUN GAO, SHENGTAO WANG, MIDELYN CAIN AND MIKHAIL LUKIN — *2022*

We introduce a tensor network algorithm to compute various solution space properties of a class of combinatorial optimization problems on graphs that can be rephrased as satisfiability problems of constraints over local sets of vertices, including the independent set problem, the maximum cut problem, the vertex coloring problem, the maximal clique problem, the dominating set problem, and the satisfiability problem, among others. We look at the independent set problem as an example, and show how to compute the size of the maximum independent set, count the number of independent sets of a given size, and enumerate/sample the independent sets of a given size. By using generic programming techniques, the same simple-to-implement framework can be used to compute all of these properties. Our algorithm utilizes recent advances in tensor network contraction techniques to achieve high performance, including methods to quickly find a near-optimal contraction order and slicing. To demonstrate how our versatile tool helps to understand these hard problems, we apply it to a few examples, including computing the entropy constant for several hardcore gases on disordered lattices, studying the Overlap Gap Property on unit disk graphs and regular graphs, and analyzing the performance of quantum and classical optimization algorithms for the independent set problem.

Tropical tensor network for ground states of spin glasses — *Phys. Rev. Lett. 126, 090506*

JINGUO LIU, LEI WANG AND PAN ZHANG — *2021*

Yao.jl: Extensible, Efficient Framework for Quantum Algorithm Design — *Quantum*

XIUZHE LUO, JINGUO LIU, PAN ZHANG AND LEI WANG — *2020*