

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 eager to learn more about quantum computing.

Nanjing University

Nanjing

PH.D. THEORETICAL PHYSICS

2012–2017

Advised under Prof. Qianghua Wang, doing numeric simulation of condensed matters. I mastered tensor networks algorithms and renormalization 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

Then I became a postdoc of a young and charming guy [Lei-Wang](#) in Institute of Physics (IOP), Chinese Academy of Sciences (CAS). Besides providing valuable suggestions in my 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

Working on projects stochastic optimizers and classical benchmarking quantum approximation optimization algorithm (QAOA). Waterloo is a nice place, I like the animals on the street.

Harvard university

Boston

POSTDOC FELLOW

2020.08–

QuEra Computing Inc. sponsored my postdoc in Mikhail Lukin's group. I am working on several projects I am proud of. One is using generic tensor network for understanding solution space properties of some computational hard problems, mainly motivated to understand quantum systems better, I am my collaborators proposed the generic tensor network approach to solve solution space properties in a unified framework. Another is mapping a general maximum independent set (MIS) problem to one with restricted geometry of diagonal coupled grid graph. For a n vertex graph, our algorithm introduces an overhead of $O(n^2)$ which is probably optimal, which is a leap comparing to the previous algorithm having an $O(n^8)$ overhead. Since our algorithm makes solving MIS problem with physical devices practical, with the understanding of its value, it is now being patented. Other projects including speeding up SLM hologram computation for generating arbitrary geometry by 4 orders with an improved fourier transformation, a time evolution algorithm on random tensor networks et al.

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, and is designed for research and education,

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 implemented.

GraphTensorNetworks.jl

MAIN DEVELOPER

GraphTensorNetworks.jl is the a package using random tensor network contraction for solving graph properties, .

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

PRESENTER

2019

Talk: "Differential Quantum Circuits and Generative Modeling"

Juliacon

Baltimore

PRESENTER

2019

Talk: "Differential Programming Tensor Networks"

Deep Learning and Quantum Programming: A Spring School

Dongguan

LECTURER

2019

Lectures on the quantum computing part.

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 $4\text{pw}(G)$, where $\text{pw}(G)$ 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