Ruslan Shaydulin

E-mail: rshaydu@g.clemson.edu GitHub: https://github.com/rsln-s
Web: shaydul.in Google Scholar: https://scholar.google.com/citations?user=PxOuGGcAAAAJ

Profile

PhD researcher in computer science. My research focuses around the intersection between (hyper)graph problems, optimization, machine learning, quantum and high-performance computing. I have extensive experience designing and implementing hybrid quantum-classical algorithms, with particular interest in variational and decomposition-based approaches (including multilevel) for optimization.

Work Experience

Maria Goeppert Mayer fellow – Argonne Scholar, Argonne National Laboratory   **Fall 2020 - Present**
• Working on quantum optimization and quantum machine learning with focus on DOE applications

Research Intern, IBM Research – Quantum   **Summer 2020**
• Working on Clifford circuit optimization with Dmitri Maslov and Sergey Braviy (paper in submission)

Intern, Quantum Artificial Intelligence Lab (QuAIL)   **Spring 2020**
NASA Ames Research Center (KBR)
• Developed novel analysis connecting the symmetries in problem instance structure to the performance of Quantum Approximate Optimization Algorithm in collaboration with Salvatore Mandra, Stuart Hadfield and Tad Hogg (paper in preparation)
• Performed extensive numerical simulations using HPC resources

Research Aide, Argonne National Laboratory   **Summer 2018, 2019**
• Developed quantum-accelerated frameworks for network community detection and graph partitioning under the supervision of Yuri Alexeev
• Co-authored 6 papers on quantum optimization and machine learning (5 first author)
• Contributed to multiple proposals

Education

Clemson University, SC   **Summer 2020**
PhD in Computer Science, advisor: Ilya Safro
Master of Science in Computer Science en route to PhD   **Fall 2019**
Research in algorithms, high performance computing, big data analysis and quantum computing
Relevant coursework: Design & Analysis of Algorithms, Data Mining, Distributed & Cluster Computing, Parallel Architecture, Network Science

Moscow Institute of Physics and Technology   **Summer 2016**
Department of Control and Applied Math,
Bachelor of Science in Applied Mathematics and Physics
Minor: Computer Science and Data Analysis

Peer-reviewed Publications

Hayato Ushijima-Mwesigwa, **Ruslan Shaydulin**, Christian F. A. Negre, Susan Mniszewski, Yuri Alexeev, Ilya Safro. Multilevel Combinatorial Optimization Across Quantum Architectures. *ACM Transactions on Quantum Computing (to appear)*. Preprint: arXiv:1910.09985

Justin Sybrandt, **Ruslan Shaydulin**, Ilya Safro. Hypergraph Partitioning With Embeddings. *In IEEE Transactions on Knowledge and Data Engineering,* 2020. DOI: 10.1109/TKDE.2020.3017120

Zain Saleem, Kaiwen Gui, **Ruslan Shaydulin**, Martin Suchara. Comparing Constrained and Unconstrained Quantum Approximate Optimization Algorithms. In *Proceedings of the 2nd International Workshop on Quantum Resource Estimation ([QRE 2020](QRE 2020)) (co-located with International Symposium on Computer Architecture (ISCA) 2020).* DOI: [10.1145/3387940.3391471](10.1145/3387940.3391471)

Ruslan Shaydulin, Caleb Thomas, Paige Rodeghero. Making Quantum Computing Open: Lessons from Open-Source Projects. In *Proceedings of First International Workshop on Quantum Software Engineering ([Q-SE 2020](Q-SE 2020)) (co-located with ICSEW 2020) (to appear).* DOI: [10.1145/3387940.3391471](10.1145/3387940.3391471)

Sami Khairy, **Ruslan Shaydulin**, Lukasz Cincio, Yuri Alexeev, Prasanna Balaprakash. Learning to Optimize Variational Quantum Circuits to Solve Combinatorial Problems. In *Proceedings of Thirty-Fourth AAAI Conference on Artificial Intelligence (AAAI-20),* 2020. **Acceptance rate: 20.6%**
DOI: 10.1609/aaai.v34i03.5616

Sami Khairy, **Ruslan Shaydulin**, Lukasz Cincio, Yuri Alexeev, Prasanna Balaprakash. Reinforcement-Learning-Based Variational Quantum Circuits Optimization for Combinatorial Problems. In *Proceedings of the Machine Learning and the Physical Sciences workshop at Conference on Neural Information Processing Systems (NeurIPS 2019),* 2019. (link)
Preprint: arXiv:1911.04574

Ruslan Shaydulin, Yuri Alexeev. Evaluating Quantum Approximate Optimization Algorithm: A Case Study.
In *Proceedings of the 2nd International Workshop on Quantum Computing for Sustainable Computing (QCSC 2019) (in conjunction with 10th International Green and Sustainable Computing Conference (IGSC 2019)),* 2019
DOI: 10.1109/IGSC48788.2019.8957201

Sami Khairy, **Ruslan Shaydulin**, Lukasz Cincio, Yuri Alexeev, Prasanna Balaprakash. Reinforcement Learning for Quantum Approximate Optimization. *Research Poster, Supercomputing '19,* 2019 (available in Proceedings)

Ruslan Shaydulin, Ilya Safro, and Jeffrey Larson. Multistart Methods for Quantum Approximate Optimization. In *Proceedings of 2019 IEEE High Performance Extreme Computing Conference (HPEC),* 2019
Best Student Paper (of ~50 student papers). DOI: 10.1109/HPEC.2019.8916288

Ruslan Shaydulin, Hayato Ushijima-Mwesigwa, Christian F.A. Negre, Ilya Safro, Susan M Mniszewski, and Yuri Alexeev. A Hybrid Approach for Solving Optimization Problems on Small Quantum Computers. *Computer*, 52(6):18–26, 2019. **Cover Feature.** DOI: [10.1109/MC.2019.2908942](10.1109/MC.2019.2908942)

Ruslan Shaydulin, Hayato Ushijima-Mwesigwa, Ilya Safro, Susan Mniszewski, and Yuri Alexeev. Network Community Detection on Small Quantum Computers. *Advanced Quantum Technologies*, 2(9):1900029, 2019.
DOI: 10.1002/qute.201900029

Ruslan Shaydulin, Hayato Ushijima-Mwesigwa, Ilya Safro, Susan Mniszewski, and Yuri Alexeev. Community Detection Across Emerging Quantum Architectures. In *Proceedings of the 3rd International Workshop on Post Moore's Era Supercomputing (in conjunction with Supercomputing '18),* 12-14, 2018. Preprint arXiv:1810.07765

Ruslan Shaydulin and Ilya Safro. Aggregative Coarsening for Multilevel Hypergraph Partitioning. *In Proceedings of 17th International Symposium on Experimental Algorithms (SEA 2018)*, 103:2:1–2:15, 2018.
DOI: 10.4230/LIPIcs.SEA.2018.2

Ruslan Shaydulin, Jie Chen, and Ilya Safro. Relaxation-Based Coarsening for Multilevel Hypergraph Partitioning. *Multiscale Modeling & Simulation*, 17(1):482–506, 2019. DOI: [10.1137/17M1152735](10.1137/17M1152735)

Invited Articles

Yuri Alexeev, Jeffrey Larson, Sven Leyffer, and **Ruslan Shaydulin**. Solving Combinatorial Optimization Problems on Quantum Computers. *In SIAM News Vol. 53 #6 July/August 2020*

Online Preprints and In-Submission Works

Ruslan Shaydulin, Stefan M. Wild. Exploiting Symmetry Reduces the Cost of Training QAOA. *In submission.*
Preprint: arXiv:2101.10296

Ruslan Shaydulin, Stuart Hadfield, Tad Hogg, Ilya Safro. Classical symmetries and QAOA. *In submission.*
Preprint: arXiv:2012.04713

Zirou Qiu, **Ruslan Shaydulin**, Xiaoyuan Liu, Yuri Alexeev, Christopher S. Henry, Ilya Safro. ELRUNA: Elimination Rule-based Network Alignment. *In submission.* Preprint: arXiv:1911.05486

Ruslan Shaydulin, Justin Sybrandt. To Agile, or not to Agile: A Comparison of Software Development Methodologies. Preprint: arXiv:1704.07469

Contributed Talks and Posters

INFORMS Annual Meeting   **Nov 13, 2020**
Gave talk "Classical Symmetries And The Quantum Approximate Optimization Algorithm"

Quantum Computing Seminar *IBM Research*   **Sep 24, 2020**
Gave talk "Practical Optimization on Near-term Quantum Computers"

Quantum Computing Tutorial *Argonne National Laboratory*   **Jun 15, 2020**
Led a tutorial on Quantum Approximate Optimization Algorithm.

SIAM Conference on Parallel Processing for Scientific Computing (PP20) *Seattle, WA*   **Feb 13, 2020**
Gave talk "Multilevel Hybrid Quantum-Classical Algorithms on Graphs"

Information Science and Technology Institute Seminar *Los Alamos National Laboratory*   **Nov 26, 2019**
Gave talk "Practical Optimization on Near-term Quantum Computers"

Supercomputing '19 *Denver, CO*   **Nov 17-22, 2019**
Gave talk "Hybrid Quantum-Classical Algorithms for Graph Problems: Forging a Path to Near-Term Applications" at
 the Clemson booth and at the SC Theater

Mathematics and Computer Science Seminar *Argonne National Laboratory* Nov 15, 2019
Gave talk "Practical Optimization on Near-term Quantum Computers"

Quantum Computing Seminar *Oak Ridge National Laboratory* Nov 4, 2019
Gave talk "Practical Optimization on Near-term Quantum Computers"

International Green and Sustainable Computing Conference (IGSC 2019) *Alexandria, VA* Oct 22, 2019
Presented poster "Reinforcement Learning for Quantum Approximate Optimization"

Chicago Quantum Exchange Meeting *University of Chicago* June 12, 2019
Presented poster "Practical Quantum Approximate Optimization"

SIAM Conference on Computational Science and Engineering (CSE19) *Spokane, WA* Feb 25-28, 2019
Presented poster ["Quantum Local Search for Graph Community Detection"](#)

Quantum Computing Tutorial *Argonne National Laboratory* Dec 10-11, 2018
Gave talk ["QAOA Algorithm Introduction"](#)

Supercomputing '18 *Dallas, TX* Nov 11-16, 2018
Gave talk "Community Detection Across Emerging Quantum Architectures" at Clemson booth

Quantum Computing Workshop *Argonne National Laboratory* Jul 25-27, 2018
Presented preliminary results on ["Machine Learning on Near-Term Quantum Computers"](#)

32nd Clemson Mini-Conference on Discrete Mathematics and Algorithms *Clemson University* Nov 4, 2017
Presented poster "Relaxation-Based Coarsening for Multilevel Hypergraph Partitioning"

58th Scientific Conference *Moscow Institute of Physics and Technology* Nov 23–28, 2015
Gave talk "IPC (Inter-Process Communication) in OS X"

Leadership and Service

Requested Reviewer (peer review)
- [Quantum](#) journal
- npj Quantum Information
- IEEE Transactions on Computers
- IEEE Transactions on Quantum Engineering

IEEE Quantum Week Oct 15, 2020
Led and co-organized a minitutorial ["Combinatorial Optimization on Quantum Computers"](#)

SIAM Conference on Parallel Processing for Scientific Computing (PP20) *Seattle, WA* Feb 12-15, 2020
Led and co-organized a minitutorial ["Combinatorial Optimization on Quantum Computers"](#)

SIAM Conference on Parallel Processing for Scientific Computing (PP20) *Seattle, WA* Feb 12-15, 2020
Co-organized a minisymposium "Recent Advances and Trends in Hybrid Quantum-Classical Algorithms"

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shaydul.in

Supercomputing '19 *Denver, CO*   **Nov 17-22, 2019**
Student volunteer, run tutorials, technical program session and Birds-of-Feather

Quantum Computing Tutorial *Argonne National Laboratory*   **May 14, 2019**
Led and co-organized a [hands-on tutorial for Qiskit, a framework for quantum computing](#)

Mathematics Teacher, Summer School *Kostroma, Russia*   **Summer 2014**
School administrator, organized extracurricular activities.

Teaching

Network Science CPSC 8480 *Clemson University*   **Fall 2018, 2019**
Teaching Assistant responsible for grading and answering students' questions during office hours

Design and Analysis of Algorithms CPSC 8400 *Clemson University*   **Spring 2019**
Teaching Assistant responsible for grading and answering students' questions during office hours

Algorithms and Data Structures CPSC 2120 *Clemson University*   **Spring 2019**
Teaching Assistant responsible for running the lab section, grading and answering students' questions during office hours

Mathematics Teacher, Summer School *Kostroma, Russia*   **Summer 2014**
Created and taught a course on basics of graph theory, combinatorics and number theory to middle and high school students.

Languages and Technologies

C , Python
Prior experience: C++, MATLAB, Objective-C, Swift, Bash, IBM QISKit
Limited prior experience: R, SQL, yacc, bison, AWS, Google Cloud Engine, Rigetti PyQuil
Technologies and tools: UNIX/Linux, MPI, OpenMP

Honors and Awards

- International Green and Sustainable Computing Conference (IGSC 2019) student travel award, *recipient*
- Best Student Paper at IEEE HPEC 2019 (of ~50 student papers), *recipient*
- IBM Teach-the-Qiskit-Teacher training program, *selected to represent Argonne National Laboratory*
- Upsilon Pi Epsilon CS Honor Society, *member*
- Supercomputing '19 Student Volunteer Travel award, *recipient*
- SIAM CSE '19 Broader Engagement Travel award, *recipient*
- Clemson CCIT Supercomputing '17, '18 and '19 travel award, *recipient*
- Clemson Graduate Travel Grant, Spring '19, *recipient*
- Moscow Institute of Physics and technology Abramov scholarship – Top 300 students in the university, based on high academic achievement, *recipient*