

2023 IEEE International Conference on Quantum Computing and Engineering (QCE 2023)

**Bellevue, Washington, USA
17-22 September 2023**

**Volume 1, Part A
Pages 1-714**



**IEEE Catalog Number: CFP23W18-POD
ISBN: 979-8-3503-4324-3**

**Copyright © 2023 by the Institute of Electrical and Electronics Engineers, Inc.
All Rights Reserved**

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

***** *This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP23W18-POD
ISBN (Print-On-Demand):	978-1-6654-4324-3
ISBN (Online):	978-1-6654-4323-6

Additional Copies of This Publication Are Available From:

Curran Associates, Inc
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: (845) 758-0400
Fax: (845) 758-2633
E-mail: curran@proceedings.com
Web: www.proceedings.com

2023 IEEE International Conference on Quantum Computing and Engineering (QCE)

QCE 2023

Table of Contents

Message from the QCE 2023 Chairs	xxiv
<i>Hausi Muller (University of Victoria, Canada), Yuri Alexev (Argonne National Laboratory, USA), Andrea Delgado (Oak Ridge National Laboratory, USA), and Greg Byrd (NC State University, USA)</i>	
QCE 2023 Committees	xxvii
Sponsors and Exhibitors	xxxiv
Technical Papers Program	xxxvi

Technical Papers

Quantum Algorithms (QALG)

Divide and Conquer for Combinatorial Optimization and Distributed Quantum Computation	1
<i>Teague Tomesh (Inflection; Princeton University, USA), Zain H. Saleem (Argonne National Laboratory, USA), Michael A. Perlin (Inflection, USA), Pranav Gokhale (Inflection, USA), Martin Suchara (Amazon Web Services, USA), and Margaret Martonosi (Princeton University, USA)</i>	
Quantum Distance Calculation for ϵ -Graph Construction	13
<i>Naomi Mona Chmielewski (Université Paris-Saclay, France), Nina Amini (Université Paris-Saclay, France), Paulin Jacquot (EDF Lab, France), and Joseph Mikael (EDF Lab, France)</i>	
Optimizing Variational Circuits for Higher-Order Binary Optimization	19
<i>Zoé Verchère (Institut Polytechnique de Paris; Conservatoire National des Arts et Métiers, France), Sourour Elloumi (Institut Polytechnique de Paris; Conservatoire National des Arts et Métiers, France), and Andrea Simonetto (Institut Polytechnique de Paris, France)</i>	

Online Detection of Golden Circuit Cutting Points	26
<i>Daniel T. Chen (Case Western Reserve University, USA), Ethan H. Hansen (Case Western Reserve University, USA), Xinpeng Li (Case Western Reserve University, USA), Aaron Orenstein (Case Western Reserve University, USA), Vinooth Kulkarni (Case Western Reserve University, USA), Vipin Chaudhary (Case Western Reserve University, USA), Qiang Guan (Kent State University, USA), Ji Liu (Argonne National Laboratory, USA), Yang Zhang (University of Illinois Urbana-Champaign, USA), and Shuai Xu (Case Western Reserve University, USA)</i>	
Qubit Recycling in Entanglement Distillation	32
<i>Stuart Pelletier (North Carolina State University, USA), Ruozhou Yu (North Carolina State University, USA), George Rouskas (North Carolina State University, USA), and Jianqing Liu (North Carolina State University, USA)</i>	
Crosstalk-Based Parameterized Quantum Circuit Approximation	39
<i>Mohannad Ibrahim (NC State University; IBM Quantum, IBM T.J. Watson Research Center, USA), Nicholas T. Bronn (IBM Quantum, IBM T.J. Watson Research Center, USA), and Gregory T. Byrd (NC State University, USA)</i>	
QuantumSEA: In-Time Sparse Exploration for Noise Adaptive Quantum Circuits	51
<i>Tianlong Chen (University of Texas at Austin, USA), Zhenyu Zhang (University of Texas at Austin, USA), Hanrui Wang (Massachusetts Institute of Technology, USA), Jiaqi Gu (University of Texas at Austin; Arizona State University, USA), Zirui Li (Rutgers University, USA), David Z. Pan (University of Texas at Austin, USA), Frederic T. Chong (University of Chicago, USA), Song Han (Massachusetts Institute of Technology, USA), and Zhangyang Wang (University of Texas at Austin, USA)</i>	
Low-Depth Flag-Style Syndrome Extraction for Small Quantum Error-Correction Codes	63
<i>Dhruv Bhatnagar (Delft University of Technology, The Netherlands), Matthew Steinberg (Delft University of Technology, The Netherlands), David Elkouss (OIST Graduate University, Japan), Carmen G. Almudever (Technical University of Valencia, Spain), and Sebastian Feld (Delft University of Technology, The Netherlands)</i>	
Quantum Error Correction For Dummies	70
<i>Avimita Chatterjee (Pennsylvania State University, USA), Koustubh Phalak (Pennsylvania State University, USA), and Swaroop Ghosh (Pennsylvania State University, USA)</i>	
Noise-Aware Token Swapping for Qubit Routing	82
<i>Asim Sharma (Missouri S&T) and Avah Banerjee (Missouri S&T)</i>	
Towards Fidelity-Optimal Qubit Mapping on NISQ Computers	89
<i>Sri Khandavilli (Kennesaw State University, USA), Indu Palanisamy (Kennesaw State University, USA), Manh V. Nguyen (Kennesaw State University, USA), Thinh V. Le (Kennesaw State University, USA), Tu N. Nguyen (Kennesaw State University, USA), and Thang N. Dinh (Virginia Commonwealth University, USA)</i>	

Adaptive Mitigation of Time-Varying Quantum Noise	99
<i>Samudra Dasgupta (Oak Ridge National Laboratory; University of Tennessee, USA), Arshag Damagezian (Louisiana State University, USA), and Travis S. Humble (Oak Ridge National Laboratory; University of Tennessee, USA)</i>	
Single Qubit State Estimation on NISQ Devices with Limited Resources and SIC-POVMs	111
<i>Cristian A. Galvis-Florez (Aalto University, Finland), Daniel Reitzner (VTT Technical Research Centre of Finland, Finland), and Simo Särkkä (Aalto University, Finland)</i>	
Constant Depth Code Deformations in the Parity Architecture	120
<i>Anette Messinger (Parity Quantum Computing GmbH, Austria), Michael Fellner (Parity Quantum Computing GmbH; University of Innsbruck, Austria), and Wolfgang Lechner (Parity Quantum Computing GmbH; University of Innsbruck, Austria)</i>	
Unbreakable Security in a Quantum Age: A Systematic Literature Review on Post-Quantum Lattice-Based Standards	131
<i>Roisan Wahlang (National Institute of Technology Karnataka, India) and Chandrasekaran K. (National Institute of Technology Karnataka, India)</i>	
Quantum Algorithms for Shapley Value Calculation	142
<i>Iain Burge (Carleton University, Canada), Michel Barbeau (Carleton University, Canada), and Joaquin Garcia-Alfaro (Institut Polytechnique de Paris, France)</i>	
Approximative Lookup-Tables and Arbitrary Function Rotations for Facilitating NISQ-Implementations of the HHL and Beyond	151
<i>Petros Stougiannidis (LMU Munich, Germany), Jonas Stein (LMU Munich, Germany), David Bucher (Aqarios GmbH, Germany), Sebastian Zielinski (LMU Munich, Germany), Claudia Linnhoff-Popien (LMU Munich, Germany), and Sebastian Feld (Delft University of Technology, The Netherlands)</i>	
Towards Distributed Quantum Computing by Qubit and Gate Graph Partitioning Techniques	161
<i>Marc G. Davis (Massachusetts Institute of Technology, USA), Joaquin Chung (Argonne National Laboratory, USA), Dirk Englund (Massachusetts Institute of Technology; Brookhaven National Laboratory, USA), and Rajkumar Kettimuthu (Argonne National Laboratory, USA)</i>	
Quantum Topology Optimization of Ground Structures for Near-Term Devices	168
<i>Yuki Sato (Toyota Central R&D Labs., Inc., Japan), Ruho Kondo (Toyota Central R&D Labs., Inc., Japan), Satoshi Koide (Toyota Central R&D Labs., Inc., Japan), and Seiji Kajita (Toyota Central R&D Labs., Inc., Japan)</i>	
Exploring the Potential of Qutrits for Quantum Optimization of Graph Coloring	177
<i>Gabriel Bottrill (Electrical and Computer Engineering at the University of British Columbia, Canada), Mudit Pandey (Electrical and Computer Engineering at the University of British Columbia, Canada), and Olivia Di Matteo (Electrical and Computer Engineering at the University of British Columbia, Canada)</i>	
Mixed-Integer Programming using a Bosonic Quantum Computer	184
<i>Farhad Khosravi (1QBit, Canada), Artur Scherer (1QBit, Canada), and Pooya Ronagh (1QBit; University of Waterloo; Perimeter Institute, Canada)</i>	

Quantum Eigenfaces: Linear Feature Mapping and Nearest Neighbor Classification with Outlier Detection	196
<i>Armando Bellante (Politecnico di Milano, Italy), William Bonvini (Independent Researcher, Italy), Stefano Vanerio (Politecnico di Milano, Italy), and Stefano Zanero (Politecnico di Milano, Italy)</i>	
MORE: Measurement and Correlation Based Variational Quantum Circuit for Multi-classification	208
<i>Jindi Wu (William & Mary, USA), Tianjie Hu (William & Mary, USA), and Qun Li (William & Mary, USA)</i>	
Quantum Kernel Estimation With Neutral Atoms for Supervised Classification: A Gate-Based Approach	219
<i>Marco Russo (Politecnico di Torino, Italy), Edoardo Giusto (Politecnico di Torino, Italy), and Bartolomeo Montruccchio (Politecnico di Torino, Italy)</i>	
Approximately Equivariant Quantum Neural Network for p4m Group Symmetries in Images	229
<i>Su Yeon Chang (European Organization for Nuclear Research (CERN); École Polytechnique Fédérale de Lausanne, Switzerland), Michele Grossi (European Organization for Nuclear Research (CERN), Switzerland), Bertrand Le Saux (Φ-lab European Space Agency, Italy), and Sofia Vallecorsa (European Organization for Nuclear Research (CERN), Switzerland)</i>	
SnCQA: An Hardware-Efficient Equivariant Quantum Convolutional Circuit Architecture	236
<i>Han Zheng (The University of Chicago, USA), Christopher Kang (The University of Chicago, USA), Gokul Subramanian Ravi (The University of Chicago, USA), Hanrui Wang (MIT, USA), Kanav Setia (qBraid Co., USA), Frederic T. Chong (The University of Chicago, USA), and Junyu Liu (The University of Chicago, USA)</i>	
QNet: A Quantum-Native Sequence Encoder Architecture	246
<i>Wei Day (National Central University, Taiwan), Hao-Sheng Chen (National Central University, Taiwan), and Min-Te Sun (National Central University, Taiwan)</i>	
Quantum Kernel Alignment with Stochastic Gradient Descent	256
<i>Gian Gentinetta (Institute of Physics, EPFL), David Sutter (IBM Quantum, IBM Research Europe Zurich), Christa Zoufal (IBM Quantum, IBM Research Europe Zurich), Bryce Fuller (IBM Quantum, IBM T.J. Watson Research Center), and Stefan Woerner (IBM Quantum, IBM Research Europe Zurich)</i>	
Learning to Optimize Quantum Neural Networks Without Gradients	263
<i>Ankit Kulshrestha (University of Delaware, USA), Xiaoyuan Liu (Fujitsu Research of America, USA), Hayato Ushijima-Mesigwa (Fujitsu Research of America, USA), and Ilya Safro (University of Delaware, USA)</i>	
A Novel Spatial-Temporal Variational Quantum Circuit to Enable Deep Learning on NISQ Devices	272
<i>Jinyang Li (George Mason University, USA), Zhepeng Wang (George Mason University, USA), Zhirui Hu (George Mason University, USA), Prasanna Date (Oak Ridge National Laboratory, USA), Ang Li (Pacific Northwest National Laboratory, USA), and Weiwen Jiang (George Mason University, USA)</i>	

Towards Hamiltonian Simulation with Decision Diagrams	283
Aaron Sander (Technical University of Munich, Germany), Lukas Burgholzer (Technical University of Munich, Germany), and Robert Wille (Technical University of Munich, Germany; Software Competence Center Hagenberg (SCCH) GmbH, Austria)	
Arbitrary Ground State Observables from Quantum Computed Moments	295
Harish J. Vallury (The University of Melbourne, Australia) and Lloyd C. L. Hollenberg (The University of Melbourne, Australia)	
Experimental Demonstration of Fermionic QAOA with One-Dimensional Cyclic Driver Hamiltonian	300
Takuya Yoshioka (TIS Inc., Japan), Keita Sasada (TIS Inc., Japan), Yuichiro Nakano (Osaka University, Japan), and Keisuke Fujii (Osaka University; RIKEN, Japan)	
The Quantum Alternating Operator Ansatz for Satisfiability Problems	307
John Golden (Los Alamos National Laboratory, USA), Andreas Bäertschi (Los Alamos National Laboratory, USA), Daniel O'Malley (Los Alamos National Laboratory, USA), and Stephan Eidenbenz (Los Alamos National Laboratory, USA)	
Grover's Implementation of Quantum Binary Neural Networks	313
Brody Wrighter (Rochester Institute of Technology, USA) and Sonia Lopez Alarcon (Rochester Institute of Technology, USA)	
Mitigating CNOT Errors via Noise-Aware Token Swapping	324
Asim Sharma (Missouri S&T) and Avah Banerjee (Missouri S&T)	

Quantum Applications (QAPP)

Quantum Generative Adversarial Networks For Anomaly Detection In High Energy Physics	331
Elie Bermot (IBM Quantum, IBM Research Europe - Zurich, Switzerland), Christa Zoufal (IBM Quantum, IBM Research Europe - Zurich, Switzerland), Michele Grossi (European Organization for Nuclear Research (CERN), Switzerland), Julian Schuhmacher (IBM Quantum, IBM Research Europe - Zurich, Switzerland), Francesco Tacchino (IBM Quantum, IBM Research Europe - Zurich, Switzerland), Sofia Vallecorsa (European Organization for Nuclear Research (CERN), Switzerland), and Ivano Tavernelli (IBM Quantum, IBM Research Europe - Zurich, Switzerland)	
Application of Quantum-Inspired Generative Models to Small Molecular Datasets	342
Charles Moussa (LIACS, Leiden University, Netherlands), Hao Wang (LIACS, Leiden University, Netherlands), Mauricio Araya-Polo (EP Research & Technology, TotalEnergies, USA), Thomas Bäck (LIACS, Leiden University, Netherlands), and Vedran Dunjko (LIACS, Leiden University, Netherlands)	
Offline Quantum Circuit Pruning for Quantum Chemical Calculations	349
Satoshi Imamura (Fujitsu Limited, Japan), Akihiko Kasagi (Fujitsu Limited, Japan), and Eiji Yoshida (Fujitsu Limited, Japan)	

Hybrid Quantum Machine Learning Assisted Classification of COVID-19 from Computed Tomography Scans	356
<i>Leo Sünkel (LMU Munich, Germany), Darya Martyniuk (Fraunhofer FOKUS, Germany), Julia Reichwald (Smart Reporting GmbH, Germany), Andrei Morariu (Smart Reporting GmbH, Germany), Raja Havish Seggoju (Fraunhofer FOKUS, Germany), Philipp Altmann (LMU Munich, Germany), Christoph Roch (LMU Munich, Germany), and Adrian Paschke (Freie Universität Berlin, Germany and Fraunhofer FOKUS, Germany)</i>	
Advances in Quantum Medical Image Analysis Using Machine Learning: Current Status and Future Directions	367
<i>Nadine Matondo-Mvula (University of Bridgeport, USA) and Khaled Elleithy (University of Bridgeport, USA)</i>	
Efficient Quantum Counting and Quantum Content-Addressable Memory for DNA Similarity	378
<i>Jan Balewski (National Energy Research Scientific Computing Center, Lawrence Berkeley National Laboratory, USA), Daan Camps (National Energy Research Scientific Computing Center, Lawrence Berkeley National Laboratory, USA), Katherine Klymko (National Energy Research Scientific Computing Center, Lawrence Berkeley National Laboratory, USA), and Andrew Tritt (Applied Mathematics and Computational Research Division, Lawrence Berkeley National Laboratory, USA)</i>	
Asymptotic Analysis of Problem Formulations for Quantum Annealers	385
<i>Julio Auto (Bloomberg, USA) and Fred Shi (Princeton University, USA)</i>	
Benchmarking Chain Strength: An Optimal Approach for Quantum Annealing	397
<i>Thinh V. Le (Kennesaw State University, USA), Manh V. Nguyen (Kennesaw State University, USA), Tu N. Nguyen (Kennesaw State University, USA), Thang N. Dinh (Virginia Commonwealth University, USA), Ivan Djordjevic (University of Arizona, USA), and Zhi-Li Zhang (University of Minnesota, USA)</i>	
Benchmarking Adaptative Variational Quantum Algorithms on QUBO Instances	407
<i>Gloria Turati (Politecnico di Milano, Italy), Maurizio Ferrari Dacrema (Politecnico di Milano, Italy), and Paolo Cremonesi (Politecnico di Milano, Italy)</i>	
Computational Results for a Quantum Computing Application in Real-Life Finance	414
<i>W. Bernard Lee (HedgeSPA Pte. Ltd., Singapore) and Anthony G. Constantinides (Imperial College London, UK)</i>	
Hiperwalk: Simulation of Quantum Walks with Heterogeneous High-Performance Computing	424
<i>Paulo Motta (National Laboratory of Scientific Computing, Brazil), Gustavo Bezerra (National Laboratory of Scientific Computing, Brazil), Anderson F. P. Santos (Military Institute of Engineering, Brazil), and Renato Portugal (National Laboratory of Scientific Computing, Brazil)</i>	
Decomposition Algorithm of an Arbitrary Pauli Exponential Through a Quantum Circuit	434
<i>Maximilian Balthasar Mansky (LMU Munich, Germany), Victor Ramos Puigvert (LMU Munich, Germany), Santiago Londoño Castillo (LMU Munich, Germany), and Claudia Linnhoff-Popien (LMU Munich, Germany)</i>	
Quantum Circuit Optimization Through Iteratively Pre-Conditioned Gradient Descent	443
<i>Dhruv Srinivasan (University of Maryland, USA), Kushal Chakrabarti (Tata Consultancy Services Research, India), Nikhil Chopra (University of Maryland, USA), and Avik Dutt (University of Maryland, USA)</i>	

An Empirical Comparison of Optimizers for Quantum Machine Learning with SPSA-Based Gradients	450
<i>Marco Wiedmann (Fraunhofer-IIS, Fraunhofer Institute for Integrated Circuits IIS, Germany), Marc Hölle (Fraunhofer-IIS, Fraunhofer Institute for Integrated Circuits IIS, Germany), Maniraman Periyasamy (Fraunhofer-IIS, Fraunhofer Institute for Integrated Circuits IIS, Germany), Nico Meyer (Fraunhofer-IIS, Fraunhofer Institute for Integrated Circuits IIS, Germany), Christian Utrecht (Fraunhofer-IIS, Fraunhofer Institute for Integrated Circuits IIS, Germany), Daniel D. Scherer (Fraunhofer-IIS, Fraunhofer Institute for Integrated Circuits IIS, Germany), Axel Plinge (Fraunhofer-IIS, Fraunhofer Institute for Integrated Circuits IIS, Germany), and Christopher Mutschler (Fraunhofer-IIS, Fraunhofer Institute for Integrated Circuits IIS, Germany)</i>	
Distributed Coordinate Descent Algorithm for Variational Quantum Classification	457
<i>Izuho Koyasu (The Univ. of Tokyo, Japan), Rudy Raymond (IBM Quantum, IBM Japan, The Univ. of Tokyo, Keio University, Japan), and Hiroshi Imai (The Univ. of Tokyo, Japan)</i>	
Towards Redefining the Reproducibility in Quantum Computing: A Data Analysis Approach on NISQ Devices	468
<i>Priyabrata Senapati (Kent State University), Zhepeng Wang (George Mason University), Weiwen Jiang (George Mason University), Travis S Humble (Oak Ridge National Laboratory), Bo Fang (Pacific Northwest National Laboratory), Shuai Xu (Case Western Reserve University), and Qiang Guan (Kent State University)</i>	
Application-Oriented Benchmarking of Quantum Generative Learning using QUARK	475
<i>Florian J. Kiwit (BMW Group, Ludwig Maximilian University Munich, Germany), Marwa Marso (BMW Group, Technical University Munich, Germany), Philipp Ross (BMW Group, Germany), Carlos A. Riofrío (BMW Group, Germany), Johannes Klepsch (BMW Group, Germany), and Andre Luckow (BMW Group, Ludwig Maximilian University Munich, Germany)</i>	
Sampling Problems on a Quantum Computer	485
<i>Maximilian Balthasar Mansky (LMU Munich, Germany), Jonas Nüßlein (LMU Munich, Germany), David Bucher (Aqarios GmbH, Germany), Daniëlle Schuman (LMU Munich, Germany), Sebastian Zielinski (LMU Munich, Germany), and Claudia Linnhoff-Popien (LMU Munich, Germany)</i>	
Numerical Evidence for Exponential Speed-up of QAOA over Unstructured Search for Approximate Constrained Optimization	496
<i>John Golden (Los Alamos National Laboratory, USA), Andreas Bärtschi (Los Alamos National Laboratory, USA), Daniel O'Malley (Los Alamos National Laboratory, USA), and Stephan Eidenbenz (Los Alamos National Laboratory, USA)</i>	
High-Round QAOA for MAX k-SAT on Trapped Ion NISQ Devices	506
<i>Elijah Pelofske (Los Alamos National Laboratory, USA), Andreas Bärtschi (Los Alamos National Laboratory, USA), John Golden (Los Alamos National Laboratory, USA), and Stephan Eidenbenz (Los Alamos National Laboratory, USA)</i>	

Benchmarking the Variational Quantum Eigensolver using Different Quantum Hardware	518
<i>Amine Bentellis (Technical University of Munich; Fraunhofer Institute for Cognitive Systems IKS, Germany), Andrea Matic-Flierl (Fraunhofer Institute for Cognitive Systems IKS, Germany), Christian B. Mendl (Technical University of Munich, Germany), and Jeanette Miriam Lorenz (Fraunhofer Institute for Cognitive Systems IKS, Germany)</i>	
Efficient MILP Decomposition in Quantum Computing for ReLU Network Robustness	524
<i>Nicola Franco (Fraunhofer Institute for Cognitive Systems IKS, Germany), Tom Wollschlänger (Technical Univ. of Munich, Germany), Benedikt Poggel (Fraunhofer Institute for Cognitive Systems, Germany), Stephan Günnemann (Technical Univ. of Munich, Germany), and Jeanette Miriam Lorenz (Fraunhofer Institute for Cognitive Systems, Germany)</i>	
Improving Performance in Combinatorial Optimization Problems with Inequality Constraints: An Evaluation of the Unbalanced Penalization Method on D-Wave Advantage	535
<i>J. A. Montañez-Barrera (Forschungszentrum Jülich, Germany), Pim van den Heuvel (Forschungszentrum Jülich, Germany), Dennis Willsch (Forschungszentrum Jülich, Germany), and Kristel Michielsen (Forschungszentrum Jülich; AIDAS; RWTH Aachen University, Germany)</i>	
The Role of Entanglement in Quantum-Relaxation Based Optimization Algorithms	543
<i>Kosei Teramoto (The Univ. of Tokyo, Japan), Rudy Raymond (IBM Quantum, IBM Japan, The Univ. of Tokyo, Keio University, Japan), and Hiroshi Imai (The Univ. of Tokyo, Japan)</i>	
The Maximum-Likelihood Quantum Amplitude Estimation Algorithm Provides the Best Tradeoff Between Accuracy and Circuit Depth Among Quantum Solutions for Integral Estimation	554
<i>Marco Maronese (Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche; Università degli Studi di Bologna, Italy), Massimiliano Incudini (Data Reply S.r.l; University of Verona, Italy), Luca Asproni (Data Reply, Italy), and Enrico Prati (Istituto di Fotonica e Nanotecnologie, CNR; Consorzio Nazionale Interuniversitario delle Telecomunicazioni; Università degli Studi di Milano, Italy)</i>	
Quantum Architecture Search for Quantum Monte Carlo Integration via Conditional Parameterized Circuits with Application to Finance	560
<i>Mark-Oliver Wolf (Fraunhofer ITWM, Germany), Tom Ewen (Fraunhofer ITWM, Germany), and Ivica Turkalj (Fraunhofer ITWM, Germany)</i>	
Quantum Fourier Iterative Amplitude Estimation	571
<i>Jorge J. Martínez de Lejarza (University of Valéncia- Consejo Superior de Investigaciones Científicas, Spain), Michele Grossi (European Organization for Nuclear Research (CERN), Switzerland), Leandro Cieri (University of Valéncia- Consejo Superior de Investigaciones Científicas, Spain), and Germán Rodrigo (University of Valéncia- Consejo Superior de Investigaciones Científicas, Spain)</i>	
Bounded Quantum Regular Language Generator	580
<i>YoungMin Kwon (The State University of New York, Korea) and Gul Agha (University of Illinois at Urbana-Champaign, USA)</i>	
Adapting the DisCoCat-Model for Question Answering in the Chinese Language	591
<i>Maximilian Balthasar Mansky (LMU Munich, Germany), Franziska Wörle (LMU Munich, Germany), Jonas Korbinian Stein (LMU Munich, Germany), Robert Müller (LMU Munich, Germany), and Claudia Linnhoff-Popien (LMU Munich, Germany)</i>	

Pooling Techniques in Hybrid Quantum-Classical Convolutional Neural Networks	601
<i>Maureen Monnet (Fraunhofer Institute for Cognitive Systems IKS, Germany), Hanady Gebran (Fraunhofer Institute for Cognitive Systems IKS, Germany), Andrea Matic-Flierl (Fraunhofer Institute for Cognitive Systems IKS, Germany), Florian Kiwit (Fraunhofer Institute for Cognitive Systems IKS, Germany), Balthasar Schachtner (LMU University Hopsital, Germany), Amine Bentellis (Fraunhofer Institute for Cognitive Systems IKS, Germany), and Jeanette Miriam Lorenz (Fraunhofer Institute for Cognitive Systems IKS, Germany)</i>	
Semisupervised Anomaly Detection using Support Vector Regression with Quantum Kernel	611
<i>Kilian Tscharke (Fraunhofer Institute for Applied and Integrated Security, Germany), Sebastian Issel (Fraunhofer Institute for Applied and Integrated Security, Germany), and Pascal Debus (Fraunhofer Institute for Applied and Integrated Security, Germany)</i>	
Higher-Order Topological Kernels via Quantum Computation	621
<i>Massimiliano Incudini (University of Verona, Italy), Francesco Martini (University of Verona, Italy), and Alessandra Di Pierro (University of Verona, Italy)</i>	
Fast Training of Fully-Connected Boltzmann Machines on an Adiabatic Quantum Computer	630
<i>Lorenzo Rocutto (Università di Bologna; Istituto di Fotonica e Nanotecnologia, Consiglio Nazionale delle Ricerche, Italy), Davide Noè (Istituto di Fotonica e Nanotecnologia, Consiglio Nazionale delle Ricerche, Italy), Lorenzo Moro (Politecnico di Milano; Istituto di Fotonica e Nanotecnologia, Consiglio Nazionale delle Ricerche, Italy), and Enrico Prati (Università degli Studi di Milano; Istituto di Fotonica e Nanotecnologia, Consiglio Nazionale delle Ricerche, Italy)</i>	
A Hybrid Quantum-Classical Approach to the Electric Mobility Problem	636
<i>Margarita Veshchezerova (Terra Quantum AG, Switzerland), Mikhail Somov (Terra Quantum AG, Switzerland), David Bertsche (Terra Quantum AG, Switzerland), Steffen Limmer (Honda Research Institute Europe, Germany), Sebastian Schmitt (Honda Research Institute Europe, Germany), Michael Perelshtein (Terra Quantum AG, Switzerland), and Ayush Joshi Tripathi (Terra Quantum AG, Switzerland)</i>	
A Hybrid Classical Quantum Computing Approach to the Satellite Mission Planning Problem	642
<i>Nils Quetschlich (Technical University of Munich, Germany), Vincent Koch (Technical University of Munich, Germany), Lukas Burgholzer (Technical University of Munich, Germany), and Robert Wille (Technical University of Munich, Germany; Software Competence Center Hagenberg GmbH (SCCH), Austria)</i>	
Quantum-Assisted Solution Paths for the Capacitated Vehicle Routing Problem	648
<i>Lilly Palackal (Infineon Technologies AG; Technical University of Munich, Germany), Benedikt Poggel (Fraunhofer Institute for Cognitive Systems IKS), Matthias Wulff (Infineon Technologies AG, Germany), Hans Ehm (Infineon Technologies AG, Germany), Jeanette Miriam Lorenz (Fraunhofer Institute for Cognitive Systems IKS), and Christian B. Mendl (Technical University of Munich, Germany)</i>	
Quantum Sensor Network Algorithms for Transmitter Localization	659
<i>Caitao Zhan (Stony Brook University, USA) and Himanshu Gupta (Stony Brook University, USA)</i>	

Tactile Network Resource Allocation Enabled by Quantum Annealing Based on ILP Modeling	670
<i>Arthur Witt (University of Stuttgart, Germany), Christopher Körber (Ruhr-University Bochum; Fraunhofer Research Institution for Energy Infrastructures and Geothermal Systems IEG, Germany), Andreas Kirstädter (University of Stuttgart, Germany), and Thomas Luu (Forschungszentrum Jülich, Germany)</i>	

Application of the Variational Quantum Eigensolver to the Ultimate pit Problem	681
<i>Yousef Hindy (Stanford University, USA), Jessica Pointing (Stanford University, USA; University of Oxford, United Kingdom), Meltem Tolunay (Stanford University; IBM Quantum, IBM Research Almaden, USA), Sreeram Venkataraao (Stanford University, USA), Mario Motta (IBM Quantum, IBM Research Almaden, USA), and Joseph A. Latone (IBM Quantum, IBM Research Almaden, USA)</i>	

Quantum Systems Software (QSYS)

Defining Best Practices for Quantum Benchmarks	692
<i>Mirko Amico (IBM Quantum, USA), Helena Zhang (IBM Quantum, USA), Petar Jurcevic (IBM Quantum, USA), Lev S. Bishop (IBM Quantum, USA), Paul Nation (IBM Quantum, USA), Andrew Wack (IBM Quantum, USA), and David C. McKay (IBM Quantum, USA)</i>	
Evaluating Robust Entanglement on a Trapped ion Platform	703
<i>Kathleen Hamilton (Oak Ridge National Laboratory, USA), Titus Morris (Oak Ridge National Laboratory, USA), Raphael Pooser (Oak Ridge National Laboratory, USA), Kübra Yeter-Aydeniz (The MITRE Corporation, USA), Luning Zhao (IonQ Inc, USA), Nouamane Laanait (Carelon Digital Platforms, USA), Harrison Cooley (Georgetown University, USA), Mu-hun Kang (Cornell University, USA), George Barron (Department of Physics Virginia Tech, USA), Sophia Economou (Department of Physics Virginia Tech, USA), Akhil Francis (Department of Physics North Carolina State University, USA), and Alexander F. Kemper (Department of Physics North Carolina State University, USA)</i>	
Predictive Models from Quantum Computer Benchmarks	709
<i>Daniel Hothem (Sandia National Laboratories, USA), Jordan Hines (Sandia National Laboratories; University of California, USA), Karthik Nataraj (Stanford University, USA), Robin Blume-Kohout (Sandia National Laboratories, USA), and Timothy Proctor (Sandia National Laboratories, USA)</i>	
PCOAST: A Pauli-Based Quantum Circuit Optimization Framework	715
<i>Jennifer Paykin (Intel Corporation, USA), Albert T. Schmitz (Intel Corporation, USA), Mohannad Ibrahim (Intel Corporation, USA), Xin-Chuan Wu (Intel Corporation, USA), and A. Y. Matsuura (Intel Corporation, USA)</i>	

Optimization at the Interface of Unitary and Non-Unitary Quantum Operations in PCOAST	727
<i>Albert T. Schmitz (Intel Labs, Intel Corporation, USA), Mohannad Ibrahim (Intel Labs, Intel Corporation, USA), Nicolas P. D. Sawaya (Intel Labs, Intel Corporation, USA), Gian Giacomo Guerreschi (Intel Labs, Intel Corporation, USA), Jennifer Paykin (Intel Labs, Intel Corporation, USA), Xin-Chuan Wu (Intel Labs, Intel Corporation, USA), and A. Y. Matsuura (Intel Labs, USA)</i>	
GTQCP: Greedy Topology-Aware Quantum Circuit Partitioning	739
<i>Joseph Clark (University of Tennessee, USA), Travis S. Humble (Oak Ridge National Laboratory, USA), and Himanshu Thapliyal (University of Tennessee, USA)</i>	
Tackling the Qubit Mapping Problem with Permutation-Aware Synthesis	745
<i>Ji Liu (Argonne National Laboratory), Ed Younis (Lawrence Berkeley National Laboratory), Mathias Weiden (University of California), Paul Hovland (Argonne National Laboratory), John Kubiatowicz (University of California), and Costin Iancu (Lawrence Berkeley National Laboratory)</i>	
Reducing the Compilation Time of Quantum Circuits using Pre-Compilation on the Gate Level	757
<i>Nils Quetschlich (Technical University of Munich, Germany), Lukas Burgholzer (Technical University of Munich, Germany), and Robert Wille (Technical University of Munich, Germany; Software Competence Center Hagenberg GmbH (SCCH), Austria)</i>	
Numerical Circuit Synthesis and Compilation for Multi-state Preparation	768
<i>Aaron Szasz (Lawrence Berkeley National Laboratory, USA), Ed Younis (Lawrence Berkeley National Laboratory, USA), and Wibe de Jong (Lawrence Berkeley National Laboratory, USA)</i>	
Improving Quantum Circuit Synthesis with Machine Learning	779
<i>Mathias Weiden (University of California Berkeley, USA), Ed Younis (Lawrence Berkeley National Lab, USA), Justin Kalloor (University of California Berkeley, USA), John Kubiatowicz (University of California Berkeley, USA), and Costin Iancu (Lawrence Berkeley National Lab, USA)</i>	
Mapping Quantum Circuits to Modular Architectures with QUBO	790
<i>Medina Bandic (Delft University of Technology (QuTech), The Netherlands), Luise Prielinger (Delft University of Technology (QuTech), The Netherlands), Jonas Nüßlein (LMU Munich, Germany), Anabel Ovide (Universitat Politècnica de Valencia, Spain), Santiago Rodrigo (Universitat Politècnica de Catalunya, Spain), Sergi Abadal (Universitat Politècnica de Catalunya, Spain), Hans van Someren (Delft University of Technology (QuTech), The Netherlands), Gayane Vardoyan (Delft University of Technology (QuTech), The Netherlands), Eduard Alarcon (Universitat Politècnica de Catalunya, Spain), Carmen G. Almudever (Universitat Politècnica de Valencia, Spain), and Sebastian Feld (Delft University of Technology (QuTech), The Netherlands)</i>	
Depth-Optimal Synthesis of Clifford Circuits with SAT Solvers	802
<i>Tom Peham (Technical University of Munich, Germany), Nina Brandl (Johannes Kepler University Linz, Germany), Richard Kueng (Johannes Kepler University Linz, Germany), Robert Wille (Technical University of Munich, Germany; Software Competence Center Hagenberg GmbH, Austria), and Lukas Burgholzer (Johannes Kepler University Linz, Austria)</i>	

QFactor: A Domain-Specific Optimizer for Quantum Circuit Instantiation	814
Alon Kukliansky (<i>Naval Postgraduate School, USA</i>), Ed Younis (<i>Lawrence Berkeley National Laboratory, USA</i>), Lukasz Cincio (<i>Los Alamos National Laboratory, USA</i>), and Costin Iancu (<i>Lawrence Berkeley National Laboratory, USA</i>)	
QisDAX: An Open Source Bridge from Qiskit to Trapped-Ion Quantum Devices	825
Kaustubh Badrike (<i>North Carolina State University</i>), Aniket S. Dalvi (<i>Duke University</i>), Filip Mazurek (<i>Duke University</i>), Marissa D'Onofrio (<i>Duke University</i>), Jacob Whitlow (<i>Duke University</i>), Tianyi Chen (<i>Duke University</i>), Samuel Phiri (<i>Duke University</i>), Leon Riesenbos (<i>Duke University</i>), Kenneth R. Brown (<i>Duke University</i>), and Frank Mueller (<i>North Carolina State University</i>)	
A Recursively Partitioned Approach to Architecture-Aware ZX Polynomial Synthesis and Optimization	837
David Winderl (<i>Technical University of Munich, Germany</i>), Qunsheng Huang (<i>Technical University of Munich, Germany</i>), and Christian B. Mendl (<i>Technical University of Munich, Germany</i>)	
Toward Consistent High-fidelity Quantum Learning on Unstable Devices via Efficient In-situ Calibration	848
Zhirui Hu (<i>George Mason University, USA</i>), Robert Wolle (<i>George Mason University, USA</i>), Mingzhen Tian (<i>George Mason University, USA</i>), Qiang Guan (<i>Kent State University, USA</i>), Travis Humble (<i>Oak Ridge National Laboratory, USA</i>), and Weiwen Jiang (<i>George Mason University, USA</i>)	
Optimal Qubit Reuse for Near-Term Quantum Computers	859
Sebastian Brandhofer (<i>Institute of Computer Architecture and Computer Engineering and Center for Integrated Quantum Science and Technology, University of Stuttgart, Germany</i>), IBM Quantum, IBM TJ Watson Research Center, USA), Ilia Polian (<i>Institute of Computer Architecture and Computer Engineering and Center for Integrated Quantum Science and Technology, University of Stuttgart, Germany</i>), and Kevin Krsulich (<i>IBM Quantum, IBM TJ Watson Research Center, USA</i>)	
A Substrate Scheduler for Compiling Arbitrary Fault-Tolerant Graph States	870
Sitong Liu (<i>Keio University Shonan Fujisawa Campus; Keio University, Japan</i>), Naphan Benchasattabuse (<i>Keio University Shonan Fujisawa Campus; Keio University, Japan</i>), Darcy Q.C. Morgan (<i>University of Technology Sydney, Australia</i>), Michal Hajdušek (<i>Keio University Shonan Fujisawa Campus; Keio University, Japan</i>), Simon J. Devitt (<i>University of Technology Sydney, Australia</i>), and Rodney Van Meter (<i>Keio University Shonan Fujisawa Campus; Keio University, Japan</i>)	
Best Practices for Quantum Error Mitigation with Digital Zero-Noise Extrapolation	881
Ritajit Majumdar (<i>IBM Quantum, IBM India Research Lab, India</i>), Pedro Rivero (<i>IBM Quantum, IBM T. J. Watson Research Center, USA</i>), Friederike Metz (<i>IBM Quantum, IBM T. J. Watson Research Center, USA; École Polytechnique Fédérale de Lausanne, France</i>), Areeq Hasan (<i>IBM Quantum, IBM T. J. Watson Research Center, USA; Princeton University, USA</i>), and Derek S. Wang (<i>IBM Quantum, IBM T. J. Watson Research Center, USA</i>)	

Zero Noise Extrapolation on Logical Qubits by Scaling the Error Correction Code Distance	888
Misty A. Wahl (<i>Unitary Fund, USA</i>), Andrea Mari (<i>Unitary Fund, USA</i> ; <i>Università di Camerino, Italy</i>), Nathan Shammah (<i>Unitary Fund, USA</i>), William J. Zeng (<i>Unitary Fund, USA; Quantonation, France</i>), and Gokul Subramanian Ravi (<i>University of Chicago; University of Michigan, USA</i>)	
Folding-Free ZNE: A Comprehensive Quantum Zero-Noise Extrapolation Approach for Mitigating Depolarizing and Decoherence Noise	898
Hrushikesh Pramod Patil (<i>NC State University, USA</i>), Peiyi Li (<i>NC State University, USA</i>), Ji Liu (<i>Argonne National Laboratory, USA</i>), and Huiyang Zhou (<i>NC State University, USA</i>)	
Transversal Injection: Using the Surface Code to Prepare Non-Pauli Eigenstates	910
Jason Gavriel (<i>University of Technology Sydney, Australia</i>), Daniel Herr (<i>d-fine GmbH, Germany</i>), Alexis Shaw (<i>Centre for Quantum Computation and Communication Technology; University of Technology Sydney, Australia</i>), Michael J. Bremner (<i>Centre for Quantum Computation and Communication Technology; University of Technology Sydney, Australia</i>), Alexandru Paler (<i>Aalto University, Finland</i>), and Simon J. Devitt (<i>University of Technology Sydney, Australia</i>)	
Scalable Quantum Error Correction for Surface Codes using FPGA	916
Namitha Liyanage (<i>Yale University</i>), Yue Wu (<i>Yale University</i>), Alexander Deters (<i>Yale University</i>), and Lin Zhong (<i>Yale University</i>)	
Fusion Blossom: Fast MWPM Decoders for QEC	928
Yue Wu (<i>Yale University</i>) and Lin Zhong (<i>Yale University</i>)	
Investigating the Characteristics of Ising Machines	939
Kazuhiko Komatsu (<i>Tohoku University, Japan</i>), Makoto Onoda (<i>Tohoku University, Japan</i>), Masahito Kumagai (<i>Tohoku University, Japan</i>), and Hiroaki Kobayashi (<i>Tohoku University, Japan</i>)	
Exact and Approximate Simulation of Large Quantum Circuits on a Single GPU	949
Daniel Strano (<i>Unitary Fund</i>), Benn Bollay (<i>Independent researcher</i>), Aryan Blaauw (<i>Independent researcher</i>), Nathan Shammah (<i>Unitary Fund</i>), William J. Zeng (<i>Unitary Fund; Goldman, Sachs & Co</i>), and Andrea Mari (<i>Università di Camerino, Italy; Unitary Fund</i>)	
mpiQulacs: A Scalable Distributed Quantum Computer Simulator for ARM-Based Clusters	959
Akihiro Tabuchi (<i>Fujitsu Limited, Japan</i>), Satoshi Imamura (<i>Fujitsu Limited, Japan</i>), Masafumi Yamazaki (<i>Fujitsu Limited, Japan</i>), Takumi Honda (<i>Fujitsu Limited, Japan</i>), Akihiko Kasagi (<i>Fujitsu Limited, Japan</i>), Hiroshi Nakao (<i>Fujitsu Limited, Japan</i>), Naoto Fukumoto (<i>Fujitsu Limited, Japan</i>), and Kohta Nakashima (<i>Fujitsu Limited, Japan</i>)	
Decision Diagrams for Symbolic Verification of Quantum Circuits	970
Xin Hong (<i>University of Technology Sydney, Australia</i>), Wei-Jia Huang (<i>Hon Hai Quantum Computing Research Center, Taiwan</i>), Wei-Chen Chien (<i>MediaTek, Inc., Taiwan</i>), Yuan Feng (<i>University of Technology Sydney, Australia</i>), Min-Hsiu Hsieh (<i>Hon Hai Quantum Computing Research Center, Taiwan</i>), Sanjiang Li (<i>University of Technology Sydney, Australia</i>), Chia-Shun Yeh (<i>MediaTek, Inc., Taiwan</i>), and Mingsheng Ying (<i>Chinese Academy of Sciences, China</i>)	

Mixed-Dimensional Quantum Circuit Simulation with Decision Diagrams	978
<i>Kevin Mato (Technical University of Munich, Germany), Stefan Hillmich (Software Competence Center Hagenberg (SCCH) GmbH; Johannes Kepler University Linz, Austria), and Robert Wille (Technical University of Munich; Software Competence Center Hagenberg (SCCH) GmbH, Germany)</i>	
Parallelizing Quantum-Classical Workloads: Profiling the Impact of Splitting Techniques	990
<i>Tuhin Khare (Indian Institute of Science (IISc), India), Ritajit Majumdar (IBM Quantum, IBM India Research Lab, India), Rajiv Sangle (Indian Institute of Science (IISc), India), Anupama Ray (IBM Quantum, IBM India Research Lab, India), Padmanabha Venkatagiri Seshadri (IBM India Research Lab, India), and Yogesh Simmhan (Indian Institute of Science (IISc), India)</i>	
quAPL: Modeling Quantum Computation in an Array Programming Language	1001
<i>Santiago Núñez-Corrales (NCSA/IQUIST, UIUC, United States), Marcos Frenkel (NCSA, UIUC, United States), and Bruno Abreu (NCSA/IQUIST, UIUC, United States)</i>	
A Uniform Representation of Classical and Quantum Source Code for Static Code Analysis	1013
<i>Maximilian Kaul (Fraunhofer AISEC, Germany), Alexander Küchler (Fraunhofer AISEC, Germany), and Christian Banse (Fraunhofer AISEC, Germany)</i>	
Superstaq: Deep Optimization of Quantum Programs	1020
<i>Colin Campbell (Infleqtion), Frederic T. Chong (Infleqtion), Denny Dahl (Infleqtion), Paige Frederick (Infleqtion), Palash Goiporia (Infleqtion), Pranav Gokhale (Infleqtion), Benjamin Hall (Infleqtion), Salahedeen Issa (Infleqtion), Eric Jones (Infleqtion), Stephanie Lee (Infleqtion), Andrew Litteken (Infleqtion), Victory Omole (Infleqtion), David Owusu-Antwi (Infleqtion), Michael A. Perlin (Infleqtion), Rich Rines (Infleqtion), Kaitlin N. Smith (Infleqtion), Noah Goss (University of California at Berkeley), Akel Hashim (University of California at Berkeley), Ravi Naik (University of California at Berkeley), Ed Younis (Lawrence Berkeley National Laboratory), Daniel Lobser (Sandia National Laboratories), Christopher G. Yale (Sandia National Laboratories), Benchen Huang (University of Chicago), and Ji Liu (Argonne National Laboratory)</i>	
VanQiRA: A Vanishing-State-Based Framework for Quantum Circuit Runtime Assertion	1033
<i>Tian-Fu Chen (National Taiwan University; National Center for Theoretical Sciences, Taiwan), Chun-Yu Wei (National Taiwan University, Taiwan), and Jie-Hong R. Jiang (National Taiwan University; National Center for Theoretical Sciences, Taiwan)</i>	
QPLEX: Realizing the Integration of Quantum Computing into Combinatorial Optimization Software	1044
<i>Juan Giraldo (University of Victoria, Canada), José Ossorio (University of Victoria, Canada), Norha M. Villegas (Universidad Icesi, Colombia), Gabriel Tamura (Universidad Icesi, Colombia), and Ulrike Stege (University of Victoria, Canada)</i>	

cuQuantum SDK: A High-Performance Library for Accelerating Quantum Science	1050
<i>Harun Bayraktar (NVIDIA Corp, USA), Ali Charara (NVIDIA Corp, USA), David Clark (NVIDIA Corp, USA), Saul Cohen (NVIDIA Corp, USA), Timothy Costa (NVIDIA Corp, USA), Yao-Lung L. Fang (NVIDIA Corp, USA), Yang Gao (NVIDIA Corp, USA), Jack Guan (NVIDIA Corp, USA), John Gunnels (NVIDIA Corp, USA), Azzam Haidar (NVIDIA Corp, USA), Andreas Hehn (NVIDIA Corp, USA), Markus Hohnerbach (NVIDIA Corp, USA), Matthew Jones (NVIDIA Corp, USA), Tom Lubowe (NVIDIA Corp, USA), Dmitry Lyakh (NVIDIA Corp, USA), Shinya Morino (NVIDIA Corp, USA), Paul Springer (NVIDIA Corp, USA), Sam Stanwyck (NVIDIA Corp, USA), Igor Terentyev (NVIDIA Corp, USA), Satya Varadhan (NVIDIA Corp, USA), Jonathan Wong (NVIDIA Corp, USA), and Takuma Yamaguchi (NVIDIA Corp, USA)</i>	
DISQ: Dynamic Iteration Skipping for Variational Quantum Algorithms	1062
<i>Junyao Zhang (Duke University), Hanrui Wang (MIT), Gokul Subramanian Ravi (University of Chicago; University of Michigan), Frederic T. Chong (University of Chicago), Song Han (MIT), Frank Mueller (North Carolina State University), and Yiran Chen (Duke University)</i>	
QAOA with $N \cdot p \geq 200$	1074
<i>Ruslan Shaydulin (JPMorgan Chase, USA) and Marco Pistoia (JPMorgan Chase, USA)</i>	
Scalable Quantum Circuits for n-Qubit Unitary Matrices	1078
<i>Rohit Sarma Sarkar (IIT Kharagpur, India) and Bibhas Adhikari (IIT Kharagpur, India)</i>	
QuMoS: A Framework for Preserving Security of Quantum Machine Learning Model	1089
<i>Zhepeng Wang (George Mason University, USA), Jinyang Li (George Mason University, USA), Zhirui Hu (George Mason University, USA), Blake Gage (Leidos, USA), Elizabeth Iwasawa (Leidos, USA), and Weiwen Jiang (George Mason University, USA)</i>	
QDoor: Exploiting Approximate Synthesis for Backdoor Attacks in Quantum Neural Networks ..	1098
<i>Cheng Chu (Indiana University Bloomington, USA), Fan Chen (Indiana University Bloomington, USA), Philip Richerme (Indiana University Bloomington, USA), and Lei Jiang (Indiana University Bloomington, USA)</i>	
Improving phishing detection in Ethereum transaction network using Quantum Machine Learning	1107
<i>Anupama Ray (Staff Research Scientist), Sai Sakunthala (Student, IIT Madras), and Anil Prabhakar (Professor, IIT Madras)</i>	

Quantum Networks & Communications (QNET)

Entanglement Distribution in the Quantum Internet: an Optimal Decision Problem Formulation..	1114
<i>Michele Viscardi (University of Naples Federico II, Italy), Jessica Illiano (University of Naples Federico II, Italy), Angela Sara Cacciapuoti (University of Naples Federico II, Italy), and Marcello Caleffi (University of Naples Federico II, Italy)</i>	
Generation and Distribution of GHZ States in Quantum Networks	1120
<i>Mohammad Ghaderibaneh (Stony Brook University, USA), Himanshu Gupta (Stony Brook University, USA), and C.R. Ramakrishnan (Stony Brook University, USA)</i>	

A Routing Framework for Quantum Entanglements with Heterogeneous Duration	1132
<i>Yuhang Gan (University of California, USA), Xiaoxue Zhang (University of California, USA), Ruilin Zhou (University of California, USA), Yi Liu (University of California, USA), and Chen Qian (University of California, USA)</i>	
Optimistic Entanglement Purification in Quantum Networks	1143
<i>Mohammad Mobayenjarihani (University of Massachusetts), Gayane Vardoyan (Delft University of Technology), and Don Towsley (University of Massachusetts)</i>	
Distribution of Entanglement in Two-Dimensional Square Grid Network	1154
<i>Eneet Kaur (The University of Arizona, USA) and Saikat Guha (The University of Arizona, USA)</i>	
Trapped Ion Quantum Repeaters with Entanglement Distillation Based on Quantum LDPC Codes	1165
<i>Ann Kang (Carnegie Mellon University, USA), Saikat Guha (University of Arizona, USA), Narayanan Rengaswamy (University of Arizona, USA), and Kaushik P. Seshadreesan (University of Pittsburgh, USA)</i>	
The Impact of Quantum Memory Quality on Entanglement Assisted Communication	1172
<i>Stephen DiAdamo (Technische Universität München, Germany) and Janis Nötzel (Technische Universität München, Germany)</i>	
Experimental Free-Space Quantum key Distribution over a Turbulent High-Loss Channel	1182
<i>Md Mehdi Hassan (The University of Tennessee, USA), Kazi Reaz (The University of Tennessee, USA), Adrien Green (The University of Tennessee, USA), Noah Crum (The University of Tennessee, USA), and George Siopsis (The University of Tennessee, USA)</i>	
Maximizing Key Distribution Capability: An Application in Quantum Cryptography	1187
<i>Tu N. Nguyen (Kennesaw State University, USA), Dung H. P. Nguyen (National Kaohsiung University of Science and Technology, Taiwan), Manh V. Nguyen (Kennesaw State University, USA), Thinh V. Le (Kennesaw State University, USA), Bing-Hong Liu (National Kaohsiung University of Science and Technology, Taiwan), and Thang N. Dinh (Virginia Commonwealth University, USA)</i>	
Optimal Entanglement Distillation Policies for Quantum Switches	1198
<i>Vivek Kumar (University of Pittsburgh, USA), Nitish K. Chandra (University of Pittsburgh, USA), Kaushik P. Seshadreesan (University of Pittsburgh, USA), Allan Scheller-Wolf (Carnegie Mellon University, USA), and Sridhar Tayur (Carnegie Mellon University, USA)</i>	
Scaling Limits of Quantum Repeater Networks	1205
<i>Mahdi Chehimi (Virginia Tech, USA), Shahrooz Pouryousef (University of Massachusetts Amherst, USA), Nitish K. Panigrahy (University of Massachusetts Amherst; Yale University, USA), Don Towsley (University of Massachusetts Amherst, USA), and Walid Saad (Virginia Tech, USA)</i>	
Semi-Quantum Random Number Generation	1211
<i>Julia Guskind (University of Connecticut, USA) and Walter O. Krawec (University of Connecticut, USA)</i>	
Entropic Uncertainty for Biased Measurements	1220
<i>Walter O. Krawec (University of Connecticut, USA)</i>	

CryptoQFL: Quantum Federated Learning on Encrypted Data	1231
<i>Cheng Chu (Indiana University Bloomington, USA), Lei Jiang (Indiana University Bloomington, USA), and Fan Chen (Indiana University Bloomington, USA)</i>	
Quantum Network Utility Maximization	1238
<i>Gayane Vardoyan (Delft University of Technology) and Stephanie Wehner (Delft University of Technology)</i>	
Quantum Distributed Algorithms for Approximate Steiner Trees and Directed Minimum Spanning Trees	1249
<i>Phillip A. Kerger (Johns Hopkins University; USRA; NASA Ames Research Center, USA), David E. Bernal Neira (USRA; NASA Ames Research Center, USA), Eleanor G. Rieffel (NASA Ames Research Center, USA), and Zoe Gonzalez Izquierdo (USRA; NASA Ames Research Center, USA)</i>	
On the Characterization of Quantum Flip Stars with Quantum Network Tomography	1260
<i>Matheus Guedes de Andrade (University of Massachusetts Amherst, United States), Jake Navas (Northern Arizona University, United States), Inès Montaño (Northern Arizona University, United States), and Don Towsley (University of Massachusetts Amherst, United States)</i>	
A Simulator of Atom-Atom Entanglement with Atomic Ensembles and Quantum Optics	1271
<i>Ruilin Zhou (University of California, United States), Xuanying Lai (University of Texas at Dallas, United States), Yuhang Gan (University of California, United States), Katia Obraczka (University of California, United States), Shewang Du (University of Texas at Dallas, United States), and Chen Qian (University of California, United States)</i>	

Quantum Technologies and Systems Engineering (QTEM)

Direct Collocation for Quantum Optimal Control	1278
<i>Aaron Trowbridge (Carnegie Mellon University), Aditya Bhardwaj (University of Chicago), Kevin He (University of Chicago), David I. Schuster (Stanford University; University of Chicago), and Zachary Manchester (Carnegie Mellon University)</i>	
Efficient Control Pulses for Continuous Quantum gate Families Through Coordinated re-Optimization	1286
<i>Jason D. Chadwick (University of Chicago, USA) and Frederic T. Chong (University of Chicago, USA)</i>	
Fast Quantum Gate Design with Deep Reinforcement Learning using Real-Time Feedback on Readout Signals	1295
<i>Emily Wright (University of Victoria, Canada) and Rogério de Sousa (University of Victoria, Canada)</i>	
Robust Quantum Control for Set-Membership Hamiltonian Uncertainty	1304
<i>Robert Kosut (SC Solutions; Princeton University) and Herschel Rabitz (Princeton University)</i>	
Feedback-Based Steering for Quantum State Preparation	1308
<i>Daniel Volya (University of Florida, USA), Zhixin Pan (University of Florida, USA), and Prabhat Mishra (University of Florida, USA)</i>	

A Nonlinear Regression for Characterizing Two-qubit Processors	1319
<i>Melinda Andrews (Booz Allen Hamilton), Thomas Halverson (Booz Allen Hamilton), Joshua Heath (Booz Allen Hamilton), I. Michael Mandelberg (Laboratory for Physical Sciences), Martin J. McHugh (Laboratory for Physical Sciences), and Shawn M. Wilder (Booz Allen Hamilton)</i>	
Towards the Quantum Internet: Entanglement Rate Analysis of High-Efficiency Electro-Optic Transducer	1325
<i>Laura d'Avossa (Department of Electrical Engineering and Information Technology (DIETI)), Marcello Caleffi (Department of Electrical Engineering and Information Technology (DIETI)), Changqing Wang (Fermi National Accelerator Laboratory, USA), Jessica Illiano (Department of Electrical Engineering and Information Technology (DIETI)), Silvia Zorzetti (Fermi National Accelerator Laboratory, USA), and Angela Sara Cacciapuoti (Department of Electrical Engineering and Information Technology (DIETI))</i>	
Discovery of Novel Superconducting Materials with Deep Learning	1335
<i>Colin Burdine (Baylor University) and E. P. Blair (Baylor University)</i>	
Exploration of Superconducting Multi-mode Cavity Architectures for Quantum Computing	1342
<i>Alessandro Reineri (Fermi National Acellerator Laboratory, USA), Silvia Zorzetti (Fermi National Accelerator Laboratory, USA), Tanay Roy (Fermi National Acelerator Laboratory, USA), and Xinyuan You (Fermi National Acelerator Laboratory, USA)</i>	
Realistic Neutral Atom Image Simulation	1349
<i>Jonas Winklmann (Technical University of Munich, Germany), Dimitrios Tsevas (Max Planck Institute of Quantum Optics, Germany), and Martin Schulz (Technical University of Munich, Germany)</i>	
Machine Learning-Based Predictive Modeling for Designing Transmon Superconducting Qubits .	1360
<i>Ferris Prima Nugraha (The Hong Kong University of Science and Technology, China) and Qiming Shao (The Hong Kong University of Science and Technology, China)</i>	
Single-Qubit Cross Platform Comparison of Quantum Computing Hardware	1369
<i>Adrien Suau (University of Montpellier, France; LANL, USA), Jon Nelson (Los Alamos National Laboratory, USA), Marc Vuffray (Los Alamos National Laboratory, USA), Andrey Y. Lokhov (Los Alamos National Laboratory, USA), Lukasz Cincio (Los Alamos National Laboratory), and Carleton Coffrin (Los Alamos National Laboratory, USA)</i>	
Fight or Flight: Cosmic Ray-Induced Phonons and the Quantum Surface Code	1378
<i>Bernard Ousmane Sane (Keio University, Japan), Rodney Van Meter (Keio University, Japan), and Michal Hajdušek (Keio University, Japan)</i>	
Mitigation of Cosmic Rays-Induced Errors in Superconducting Quantum Processors	1389
<i>Ambra Mariani (INFN - Sezione di Roma, Italy), Laura Cardani (INFN - Sezione di Roma, Italy), Nicola Casali (INFN - Sezione di Roma, Italy), Angelo Cruciani (INFN - Sezione di Roma, Italy), Anna Grassellino (Fermi National Accelerator Laboratory, USA), Valerio Pettinacci (INFN - Sezione di Roma, Italy), David Van Zanten (Fermi National Accelerator Laboratory, USA), and Marco Vignati (Sapienza Università di Roma and INFN - Sezione di Roma, Italy)</i>	

Quantum Steering of Surface Error Correcting Codes	1394
<i>Daniel Volya (University of Florida, USA) and Prabhat Mishra (University of Florida, USA)</i>	
Streaming Quantum Gate Set Tomography using the Extended Kalman Filter	1401
<i>J. P. Marceaux (University of California, USA) and Kevin Young (Quantum Performance Laboratory, Sandia National Laboratories, USA)</i>	
A Reconfigurable Quantum State Tomography Solver in FPGA	1412
<i>Nathan Eli Miller (Georgia Institute of Technology, USA), Biswadeep Chakraborty (Georgia Institute of Technology, USA), and Saibal Mukhopadhyay (Georgia Institute of Technology, USA)</i>	
Near-Minimal Gate Set Tomography Experiment Designs	1422
<i>Corey Ostrove (Sandia National Laboratories, USA), Kenneth Rudinger (Sandia National Laboratories, USA), Stefan Seritan (Sandia National Laboratories, USA), Kevin Young (Sandia National Laboratories, USA), and Robin Blume-Kohout (Sandia National Laboratories, USA)</i>	

Author Index - Vol. 1

2023 IEEE International Conference on Quantum Computing and Engineering (QCE 2023)

**Bellevue, Washington, USA
17-22 September 2023**

**Volume 2
Pages 1-418**



**IEEE Catalog Number: CFP23W18-POD
ISBN: 979-8-3503-4324-3**

2023 IEEE International Conference on Quantum Computing and Engineering (QCE)

QCE 2023

Table of Contents

Message from the QCE 2023 Chairs	xxiii
<i>Hausi Muller (University of Victoria, Canada), Yuri Alexev (Argonne National Laboratory, USA), Andrea Delgado (Oak Ridge National Laboratory, USA), and Greg Byrd (NC State University, USA)</i>	
QCE 2023 Committees	xxvi
Sponsors and Exhibitors	xxxiii
Workshops Program	xxxv
Posters Program	lxviii
Panels Program	lxix
Tutorials Program	lxxxiii

Workshop Papers

WKS06 — Quantum Machine Learning: From Foundations to Applications

Workshop Summary: Quantum Machine Learning	1
<i>Volker Tresp (Ludwig Maximilian University, Siemens AG, Technology, Germany), Steffen Udluft (Siemens AG, Technology, Germany), Daniel Hein (Siemens AG, Technology, Germany), Werner Hauptmann (Siemens AG, Technology, Germany), Martin Leib (IQM, Germany), Christopher Mutschler (Fraunhofer IIS, Germany), Daniel D. Scherer (Fraunhofer IIS, Germany), and Wolfgang Mauerer (Technical University of Applied Sciences Regensburg; Siemens AG, Technology, Germany)</i>	
Towards an End-to-End Approach for Quantum Principal Component Analysis	4
<i>Emanuele Dri (Politecnico di Torino, Italy), Antonello Aita (IBM Italia, Italy), Tommaso Fioravanti (IBM Italia, Italy), Giulia Franco (IBM Italia, Italy), Edoardo Giusto (Politecnico di Torino, Italy), Giacomo Ranieri (Intesa Sanpaolo, Italy), Davide Corbelletto (Intesa Sanpaolo, Italy), and Bartolomeo Montruccchio (Politecnico di Torino, Italy)</i>	
Quantum Machine Learning with Quantum Topological Data Analysis	10
<i>Ankit Khandelwal (Tata Consultancy Services, India) and M Girish Chandra (Tata Consultancy Services, India)</i>	

Differentiable Quantum Architecture Search for Quantum Reinforcement Learning	15
<i>Yize Sun (Ludwig Maximilians University, Siemens AG, Germany), Yunpu Ma (Ludwig Maximilians University, Siemens AG, Germany), and Volker Tresp (Ludwig Maximilians University, Siemens AG, Germany)</i>	
Applying QNLP to Sentiment Analysis in Finance	20
<i>Jonas Stein (LMU Munich, Germany), Ivo Christ (Aqarios GmbH, Germany), Nicolas Kraus (Aqarios GmbH, Germany), Maximilian Balthasar Mansky (LMU Munich, Germany), Robert Müller (LMU Munich, Germany), and Claudia Linnhoff-Popien (LMU Munich, Germany)</i>	
qgym: A Gym for Training and Benchmarking RL-Based Quantum Compilation	26
<i>Stan van der Linde (The Netherlands Organisation for Applied Scientific Research (TNO), The Netherlands), Willem de Kok (The Netherlands Organisation for Applied Scientific Research (TNO), The Netherlands), Tariq Bontekoe (University of Groningen, The Netherlands), and Sebastian Feld (Delft University of Technology, The Netherlands)</i>	
Quantum Deep Q-Learning with Distributed Prioritized Experience Replay	31
<i>Samuel Yen-Chi Chen (Wells Fargo, USA)</i>	
Quantum Natural Policy Gradients: Towards Sample-Efficient Reinforcement Learning	36
<i>Nico Meyer (Fraunhofer Institute for Integrated Circuits IIS, Friedrich-Alexander University Erlangen-Nürnberg (FAU), Germany), Daniel D. Scherer (Fraunhofer Institute for Integrated Circuits IIS, Germany), Axel Plinge (Fraunhofer Institute for Integrated Circuits IIS, Germany), Christopher Mutschler (Fraunhofer Institute for Integrated Circuits IIS, Germany), and Michael J. Hartmann (Friedrich-Alexander University Erlangen-Nürnberg (FAU), Germany)</i>	
Transfer Learning for Large-Scale Image Classification using Annealing-Based Quantum Boltzmann Machines	42
<i>Daniëlle Schuman (LMU Munich), Leo Süntel (LMU Munich), Philipp Altmann (LMU Munich), Jonas Stein (LMU Munich), Christoph Roch (LMU Munich), Thomas Gabor (LMU Munich), and Claudia Linnhoff-Popien (LMU Munich)</i>	

WKS09 – Quantum Algorithms for Differential Equations

Continuous Variables Quantum Algorithm for Solving Ordinary Differential Equations	48
<i>Alice Barthe (CERN, Switzerland), Michele Grossi (CERN, Switzerland), Jordi Tura (Leiden University, the Netherlands), and Vedran Dunjko (Leiden University, the Netherlands)</i>	
Efficient Computation of Causality in Globally Hyperbolic Spacetimes using Link Invariants and Relevant Applications to Quantum Computing	54
<i>Anthony Kim (Bergen County Academies, United States), Jeremy Pitcock (Bergen County Academies, United States), and Justin Zhang (Bergen County Academies, United States)</i>	

Quantum Algorithm for the Linear Vlasov Equation with Collisions	56
<i>Abtin Ameri (Massachusetts Institute of Technology, USA), Erika Ye (Massachusetts Institute of Technology, USA), Paola Cappellaro (Massachusetts Institute of Technology, USA), Hari Krovi (Riverlane Research, USA), and Nuno F. Loureiro (Massachusetts Institute of Technology, USA)</i>	

Efficient Quantum Algorithms for Nonlinear Stochastic Dynamical Systems	66
<i>Abeynaya Gnanasekaran (Raytheon Technologies Research Center, USA), Amit Surana (Raytheon Technologies Research Center, USA), and Tuhin Sahai (SRI International, USA)</i>	

WKS10 – Chemical Applications of Quantum Computing

Molecular Symmetry in VQE: A Dual Approach for Trapped-Ion Simulations of Benzene	76
<i>Joshua Goings (IonQ, Inc., United States), Luning Zhao (IonQ, Inc., United States), Jacek Jakowski (Oak Ridge National Laboratory, United States), Titus Morris (Oak Ridge National Laboratory, United States), and Raphael Pooser (Oak Ridge National Laboratory, United States)</i>	

Benchmarking Adaptive Quantum Circuit Optimization Algorithms for Quantum Chemistry	83
<i>Waheeda Saib (Universiteit Leiden, Netherlands; IBM Research, South Africa), Xavier Bonet-Monroig (Universiteit Leiden, Netherlands), Vedran Dunjko (Universiteit Leiden, Netherlands), Ivano Tavernelli (IBM Research, Zurich), Thomas Back (Universiteit Leiden, Netherlands), and Hao Wang (Universiteit Leiden, Netherlands)</i>	

Quantum Simulations for Carbon Capture on Metal-Organic Frameworks	89
<i>Gopal Ramesh Dahale (Alumni of Indian Institute of Technology Bhilai, India)</i>	

Symmetry Breaking Slows Convergence of the ADAPT Variational Quantum Eigensolver	94
<i>Luke W. Bertels (Oak Ridge National Lab; Virginia Tech, USA), Harper R. Grimsley (Virginia Tech, USA), Sophia E. Economou (Virginia Tech, USA), Edwin Barnes (Virginia Tech, USA), and Nicholas J. Mayhall (Virginia Tech, USA)</i>	

WKS17 – Third International Workshop on Integrating High-Performance Computing with Quantum Computing (WIHPQC 2023)

Toward a Unified Hybrid HPCQC Toolchain	96
<i>Philipp Seitz (Technical University of Munich, Germany), Amr Elsharkawy (Technical University of Munich, Germany), Xiao-Ting Michelle To (Ludwig-Maximilians-Universität in Munich, Germany), and Martin Schulz (Technical University of Munich, Germany)</i>	

Efficient Parameterised Compilation for Hybrid Quantum Programming	103
<i>Anna M. Krol (Delft University of Technology, The Netherlands), Koen Mesman (Delft University of Technology, The Netherlands), Aritra Sarkar (Delft University of Technology, The Netherlands), and Zaid Al-Ars (Delft University of Technology, The Netherlands)</i>	

One Nine Availability of a Photonic Quantum Computer on the Cloud Toward HPC Integration ..	112
Nicolas Maring (<i>Quandela, France</i>), Andreas Fyrillas (<i>Quandela; Université Paris-Saclay, France</i>), Mathias Pont (<i>Quandela, France</i>), Edouard Ivanov (<i>Quandela, France</i>), Eric Bertasi (<i>Quandela, France</i>), Mario Valdivia (<i>Quandela, France</i>), and Jean Senellart (<i>Quandela, France</i>)	
A Hybrid Classical-Quantum HPC Workload	117
Aniello Esposito (<i>HPC/AI EMEA Research Lab, Hewlett Packard Labs, Switzerland</i>), Jessica R. Jones (<i>HPC/AI EMEA Research Lab, Hewlett Packard Labs, UK</i>), Sébastien Cabaniols (<i>HPC/AI EMEA Research Lab, Hewlett Packard Labs, France</i>), and David Brayford (<i>HPC/AI EMEA Research Lab, Hewlett Packard Labs, Germany</i>)	
Modeling of Errors in Quantum Computers with Generated Structural Circuits	122
Jakob Schneider (<i>Technical University of Denmark, Denmark</i>), Mathias Gammelmark (<i>Technical University of Denmark, Denmark</i>), and Sven Karlsson (<i>Technical University of Denmark, Denmark</i>)	
Exploring Hybrid Classical-Quantum Compute Systems Through Simulation	127
Muhammad Nufail Farooqi (<i>Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities, Germany</i>) and Martin Ruefenacht (<i>Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities, Germany</i>)	
Experimenting with Hybrid Quantum Optimization in HPC Software Stack for CPU Register Allocation	134
Brice Chichereau (<i>CEA, DAM, DIF, Université Paris-Saclay, France</i>), Stéphane Vialle (<i>CentraleSupélec, Université Paris-Saclay, France</i>), and Patrick Carribault (<i>CEA, DAM, DIF, Université Paris-Saclay, France</i>)	
BBQ-mIS: a Parallel Quantum Algorithm for Graph Coloring Problems	141
Chiara Vercellino (<i>LINKS Foundation; Politecnico di Torino, Italy</i>), Giacomo Vitali (<i>LINKS Foundation; Politecnico di Torino, Italy</i>), Paolo Viviani (<i>LINKS Foundation, Italy</i>), Edoardo Giusto (<i>Politecnico di Torino, Italy</i>), Alberto Scionti (<i>LINKS Foundation, Italy</i>), Andrea Scarabosio (<i>LINKS Foundation, Italy</i>), Olivier Terzo (<i>LINKS Foundation, Italy</i>), and Bartolomeo Montruccio (<i>Politecnico di Torino, Italy</i>)	
Towards a Dutch Hybrid Quantum/HPC Infrastructure	148
Olaf Schüsler (<i>QuTech, The Netherlands</i>), Ariana Torres-Knoop (<i>SURF B.V., The Netherlands</i>), Jaap Dijkshoorn (<i>SURF B.V., The Netherlands</i>), Christiaan Hollemans (<i>QuTech, The Netherlands</i>), Bas van der Vlies (<i>SURF B.V., The Netherlands</i>), and Richard Verluis (<i>QuTech, The Netherlands</i>)	

Quantum Computer Metrics and HPC Center Environmental Sensor Data Analysis Towards Fidelity Prediction	154
--	-----

Hossam Ahmed (Leibniz Supercomputing Centre, Germany), Xiaolong Deng (Leibniz Supercomputing Centre, Germany), Helmut Heller (Leibniz Supercomputing Centre, Germany), Carla Guillen (Leibniz Supercomputing Centre, Germany), Asim Zulfiqar (Leibniz Supercomputing Centre, Germany), Martin Ruefnacht (Leibniz Supercomputing Centre, Germany), Amit Jamadagni (Leibniz Supercomputing Centre, Germany), Matthew Tovey (Leibniz Supercomputing Centre, Germany), Martin Schulz (Leibniz Supercomputing Centre; Technical University of Munich, Germany), and Laura Schulz (Leibniz Supercomputing Centre, Germany)

WKS21 — 3rd International Workshop on Quantum Software Engineering and Technology

Towards Quantum Software Requirements Engineering	161
<i>Tao Yue (Simula Research Laboratory, Norway), Shaukat Ali (Simula Research Laboratory and Oslo Metropolitan University, Norway), and Paolo Arcaini (National Institute of Informatics, Japan)</i>	
Generation of Classical-Quantum Code from UML Models	165
<i>Ricardo Pérez-Castillo (University of Castilla-La Mancha, Spain), Luis Jiménez-Navajas (University of Castilla-La Mancha, Spain), Iván Cantalejo (University of Castilla-La Mancha, Spain), and Mario Piattini (University of Castilla-La Mancha, Spain)</i>	
On Refactoring Quantum Programs in Q#	169
<i>Jianjun Zhao (Kyushu University, Japan)</i>	
Quantum Software Engineering Challenges from Developers' Perspective: Mapping Research Challenges to the Proposed Workflow Model	173
<i>Majid Haghparast (University of Jyväskylä, Finland), Tommi Mikkonen (University of Jyväskylä, Finland), Jukka K. Nurminen (University of Helsinki, Finland), and Vlad Stirbu (University of Jyväskylä, Finland)</i>	
Full-Stack Quantum Software in Practice: Ecosystem, Stakeholders and Challenges	177
<i>Vlad Stirbu (University of Jyväskylä, Finland), Majid Haghparast (University of Jyväskylä, Finland), Muhammad Waseem (University of Jyväskylä, Finland), Niraj Dayama (University of Jyväskylä, Finland), and Tommi Mikkonen (University of Jyväskylä, Finland)</i>	
Comparing Quantum Service Offerings	181
<i>Julian Obst (University of Stuttgart, Germany), Johanna Barzen (University of Stuttgart, Germany), Martin Beisel (University of Stuttgart, Germany), Frank Leymann (University of Stuttgart, Germany), Marie Salm (University of Stuttgart, Germany), and Felix Truger (University of Stuttgart, Germany)</i>	
Towards Efficient Automatic Oracle Synthesis and Resource Estimation using QDK and QIR	185
<i>I-Tung Chen (University of Washington, USA) and Chaman Gupta (University of Washington, USA)</i>	

Leveraging API Specifications for Scaffolding Quantum Applications	187
<i>Javier Romero-Álvarez (Universidad de Extremadura, Spain), Jaime Alvarado-Valiente (Universidad de Extremadura, Spain), Enrique Moguel (Computing and Advanced Technologies Foundation of Extremadura, Spain), Carlos Canal (Universidad de Málaga, Spain), Jose García-Alonso (Universidad de Extremadura, Spain), and Juan M. Murillo (Computing and Advanced Technologies Foundation of Extremadura, Spain)</i>	
Minimizing Deployment Cost of Hybrid Applications	191
<i>Álvaro M. Aparicio-Morales (Universidad de Extremadura, Spain), Juan Luis Herrera (Universidad de Extremadura, Spain), Enrique Moguel (Computing and Advanced Technologies Foundation of Extremadura, Spain), Javier Berrocal (Universidad de Extremadura, Spain), Jose García-Alonso (Universidad de Extremadura, Spain), and Juan M. Murillo (Computing and Advanced Technologies Foundation of Extremadura, Spain)</i>	
Dispatching Shots Among Multiple Quantum Computers: an Architectural Proposal	195
<i>Giuseppe Bisicchia (University of Pisa, Italy), José García-Alonso (University of Extremadura, Spain), Juan M. Murillo (University of Extremadura, Spain), and Antonio Brogi (University of Pisa, Italy)</i>	
Resource Estimation of Quantum Multiplication Algorithms	199
<i>Ethan Hansen (University of Washington, USA), Sanskriti Joshi (University of Washington, USA), and Hannah Rarick (University of Washington, USA)</i>	

WKS26 – Workshop on Software Architecture Concerns for Quantum (WOSAQ)

Software Architecture Challenges in Integrating Hybrid Classical-Quantum Systems	203
<i>Vlad Stirbu (University of Jyväskylä, Finland) and Tommi Mikkonen (University of Jyväskylä, Finland)</i>	
A QIR Toolchain with XACC	205
<i>Elaine Wong (Oak Ridge National Laboratory, USA), Sharmin Afrose (Oak Ridge National Laboratory, USA), Meenambika Gowrishankar (University of Tennessee Knoxville, USA), Daniel Claudino (Oak Ridge National Laboratory, USA), Vicente Leyton-Ortega (Oak Ridge National Laboratory, USA), Seth Johnson (Oak Ridge National Laboratory, USA), and Travis S. Humble (Oak Ridge National Laboratory, USA)</i>	

WKS30 – Quantum System Stability and Reproducibility Workshop

Short-Depth Circuits and Error Mitigation for Large-Scale GHZ-State Preparation, and Benchmarking on IBM's 127-Qubit System	207
<i>Kuan-Cheng Chen (Imperial College London, UK)</i>	
QVis: A Visual Analytics Tool for Exploring Noise and Errors in Quantum Computing Systems	211
<i>Chad A. Steed (Oak Ridge National Laboratory, USA), Junghoon Chae (Oak Ridge National Laboratory, USA), Samudra Dasgupta (Oak Ridge National Laboratory, USA), and Travis S. Humble (Oak Ridge National Laboratory, USA)</i>	

Reinforcement Learning for Gate Synthesis in Noisy Quantum Systems	215
<i>Amara Katabarwa (Zapata Computing, USA), Collin Farquhar (Zapata computing, USA), Hyeongrak Choi (Massachusetts Institute of Technology, USA), Marc Davis (Massachusetts Institute of Technology, India), Dirk Englund (Massachusetts Institute of Technology, USA), Yudong Cao (Zapata Computing, USA), and Mekena Metcalf (HSBC Holdings Plc., USA)</i>	
Noise Modeling of the IBM Quantum Platform	219
<i>Yasuo Oda (Johns Hopkins University, USA), Omar Shehab (IBM Quantum, USA), and Gregory Quiroz (Johns Hopkins University Applied Physics Laboratory, USA)</i>	
Reliable Devices Yield Stable Quantum Computations	223
<i>Samudra Dasgupta (Oak Ridge National Laboratory; University of Tennessee, USA) and Travis S. Humble (Oak Ridge National Laboratory; University of Tennessee, USA)</i>	
Extremum Seeking Control of Quantum Gates	227
<i>Erfan Abbasgholinejad (University of Washington, United States), Haoqin Deng (University of Washington, United States), John Gamble (IonQ, United States), J. Nathan Kutz (University of Washington, United States), Erik Nielsen (IonQ, United States), Neal Pisenti (IonQ, United States), and Ningzhi Xie (University of Washington, United States)</i>	
Understanding the Effect of Transpilation in the Reliability of Quantum Circuits	232
<i>Nicola Dilillo (Politecnico di Torino, Italy), Edoardo Giusto (Politecnico di Torino, Italy), Emanuele Dri (Politecnico di Torino, Italy), Betis Baheri (Kent State University, US), Qiang Guan (Kent State University, US), Bartolomeo Montruccchio (Politecnico di Torino, Italy), and Paolo Rech (University of Trento, Italy)</i>	

Poster Papers

Hybrid Variational Quantum Circuit with Transformer for Classifying Medical Conditions	236
<i>Waseem Ahmad (HCL Technologies Ltd., India), Kalpesh Prajapati (HCL Technologies Ltd., India), and Kameshwar Rao JV (HCL Technologies Ltd., India)</i>	
Evaluating Quantum Machine Learning Approaches for Histopathological Cancer Detection: Classical, Hybrid Simulation, and IBM Quantum Computing	238
<i>Biswaraj Baral (Quantum Computing Group Qausal AI, USA), Reek Majumdar (Clemson University, USA), Bhavika Bhalgamiya (Mississippi State University, USA), and Taposh Dutta Roy (Kaiser Permanente, USA)</i>	
Analysis of Superconducting Qubit Layouts using InductEx	240
<i>Sean Crowe (CERF Laboratory, NIWC-PAC, United States), Benjamin Taylor (CERF Laboratory, NIWC-PAC, United States), Nicholas Ferrante (CERF Laboratory, NIWC-PAC, United States), Brad Liu (CERF Laboratory, NIWC-PAC, United States), and Susan Berggren (CERF Laboratory, NIWC-PAC, United States)</i>	

Achieving Scalable Quantum Error Correction with Union-Find on Systolic Arrays by using Multi-Context Processing Elements	242
<i>Maximilian Jakob Heer (RIKEN Center for Computational Science, Japan), Jan-Erik R. Wichmann (RIKEN Center for Computational Science, Japan), and Kentaro Sano (RIKEN Center for Computational Science, Japan)</i>	
Scalable Quantum Simulation for Topological Phases on NISQ Devices	244
<i>Rong-Yang Sun (RIKEN Center for Computational Science (R-CCS), Japan), Tomonori Shirakawa (RIKEN Center for Computational Science (R-CCS), Japan), and Seiji Yunoki (RIKEN Center for Computational Science (R-CCS), Japan)</i>	
Reinforcement Learning Quantum Local Search	246
<i>Chen-Yu Liu (National Taiwan University, Taiwan) and Hsi-Sheng Goan (National Taiwan University, Taiwan)</i>	
QubiC 2.0: A Flexible Advanced Full Stack Quantum Bit Control System	248
<i>Gang Huang (Lawrence Berkeley National Laboratory, USA), Yilun Xu (Lawrence Berkeley National Laboratory, USA), Neelay Fruitwala (Lawrence Berkeley National Laboratory, USA), Abhi D. Rajagopala (Lawrence Berkeley National Laboratory, USA), Kasra Nowrouzi (Lawrence Berkeley National Laboratory, USA), Ravi K. Naik (Lawrence Berkeley National Laboratory, USA), David Santiago (Lawrence Berkeley National Laboratory, USA), and Irfan Siddiqi (University of California at Berkeley, USA; Lawrence Berkeley National Laboratory, USA)</i>	
Oraqle: Quantum Matter Services for the Masses	250
<i>Anjul Loiacono (Quantum Matter Platforms Inflection, USA), Alex Tingle (Quantum Matter Platforms Inflection, USA), Victor Colussi (Quantum Software Division Inflection, USA), and Noah Fitch (Quantum Matter Platforms Inflection, USA)</i>	
Multipartite Entanglement in Quantum Networks using Subgraph Complementations	252
<i>Aniruddha Sen (University of Massachusetts Amherst), Kenneth Goodenough (University of Massachusetts Amherst), and Don Towsley (University of Massachusetts Amherst)</i>	
Harnessing the Power of Long-Range Entanglement for Clifford Circuit Synthesis	254
<i>Willers Yang (University of Chicago) and Patrick Rall (IBM Quantum)</i>	
Implementing a Hybrid Quantum-Classical Neural Network by Utilizing a Variational Quantum Circuit for Detection of Dementia	256
<i>Ryan Kim (Thomas Jefferson High School for Science and Technology, USA)</i>	
Narrow Linewidth Semiconductor Laser for Ba+ Quantum Applications	258
<i>Kostiantyn Nechay (Modulight Corporation, Finland), Soile Talmila (Modulight Corporation, Finland), Kalle Palomäki (Modulight Corporation, Finland), Luukas Kuusela (Modulight Corporation, Finland), Pekko Sipilä (Modulight Corporation, Finland), Petteri Uusimaa (Modulight Corporation, Finland), and Andreas Schramm (Modulight Corporation, Finland)</i>	

Multidimensional Quantum Convolution with Arbitrary Filtering and Unity Stride	260
<i>Mingyoung Jeng (University of Kansas, United States of America), Md. Alvir Islam Nobel (University of Kansas, United States of America), Vinayak Jha (University of Kansas, United States of America), David Levy (University of Kansas, United States of America), Dylan Kneidel (University of Kansas, United States of America), Manu Chaudhary (University of Kansas, United States of America), SM Ishraq Ull Islam (University of Kansas, United States of America), and Esam El-Araby (University of Kansas, United States of America)</i>	
Quantum Kernels for Difficult Visual Discrimination	262
<i>Takao Tomono (Toppan Inc., Japan), Kazuya Tsujimura (Toppan Inc., Japan), and Takumi Godo (Toppan Inc., Japan)</i>	
Hybrid Classical-Quantum Computing: are we Forgetting the Classical Part in the Binomial?	264
<i>Esther Villar-Rodriguez (TECNALIA, Basque Research and Technology Alliance (BRTA), Spain), Aitor Gomez-Tejedor (TECNALIA, Basque Research and Technology Alliance (BRTA), Spain), and Eneko Osaba (TECNALIA, Basque Research and Technology Alliance (BRTA), Spain)</i>	
A Novel Approach to face Early Pandemics using QUBO Models	266
<i>Stefano Speziali (Idea-re S.r.l., Italy), Andrea Marini (Idea-re S.r.l., Italy), Alessandro Vispa (Idea-re S.r.l., Italy), Federico Bianchi (Idea-re S.r.l., Italy), Massimiliano Proietti (Idea-re S.r.l., Italy), Alberto Garinei (Idea-re S.r.l.; Guglielmo Marconi University, Italy), Lorenzo Mattioli (Idea-re S.r.l., Italy), Lorenzo Sani (Idea-re S.r.l., Italy), Emanuele Piccioni (Idea-re S.r.l., Italy), and Marcello Marconi (Idea-re S.r.l.; Guglielmo Marconi University, Italy)</i>	
Hypergraphic Partitioning of Quantum Circuits for Distributed Quantum Computing	268
<i>Waldemir Cambiucci (Escola Politécnica, University of São Paulo, Brazil), Regina Melo Silveira (Escola Politécnica, University of São Paulo, Brazil), and Wilson Vicente (Escola Politécnica, University of São Paulo, Brazil)</i>	
Embedding All Feasible Solutions of Traveling Salesman Problem by Divide-and-Conquer Quantum Search	270
<i>Rei Sato (KDDI Research, Inc.; Tokyo University of Science, Japan), Kazuhiro Saito (KDDI Research, Inc., Japan), Tetsuro Nikuni (Tokyo University of Scicence, Japan), and Shohei Watabe (Shibaura Institute of Technology, Japan)</i>	
Solving Graph Problems with Single-Photons and Linear Optics	274
<i>Rawad Mezher (Quandela SAS, France), Ana Filipa Carvalho (Quandela SAS, France), and Shane Mansfield (Quandela SAS, France)</i>	
Random Quantum Neural Networks for Noisy Image Recognition	276
<i>Debanjan Konar (Purdue University, USA), Erol Gelenbe (Polish Academy of Sciences, Poland), Soham Bhandary (Jadavpur University, India), Aditya Das Sarma (Jadavpur University, India), and Attila Cangi (Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany)</i>	
Effect of Repetitions and Entanglement on Performance of Pauli Feature Map	278
<i>Annika Daspal (Bill Hogarth Secondary School, Canada)</i>	

Quantum Negative Sampling Strategy for Knowledge Graph Embedding with Variational Circuit	280
<i>Pulak Ranjan Giri (KDDI Research, Inc., Japan), Mori Kurokawa (KDDI Research, Inc., Japan), and Kazuhiro Saito (KDDI Research, Inc., Japan)</i>	
Quantum Relaxation Based Branch-and-Bound Algorithm	282
<i>Wei-hao Huang (Jij Inc., Japan), Hiromichi Matsuyama (Jij Inc., Japan), Kohji Nishimura (Jij Inc., Japan), and Yu Yamashiro (Jij Inc., Japan)</i>	
A Max K-Cut Implementation for QAOA in the Measurement Based Quantum Computing Formalism	284
<i>Sebastiano Corli (Politecnico di Milano; Istituto di Fotonica e NanotecnologiaCNR, Italy), Daniele Dragoni (Leonardo s.p.a, Italy), Massimiliano Proietti (Leonardo s.p.a, Italy), Massimiliano Dispenza (Leonardo s.p.a, Italy), Carlo Cavazzoni (Leonardo s.p.a, Italy), and Enrico Prati (Università degli Studi di Milano; Istituto di Fotonica e Nanotecnologia, CNR, Italy)</i>	
Efficient and Flexible Annealer-Gate Hybrid Model for Solving Large-Scale Portfolio Optimization	286
<i>Naman Jain (Tata Consultancy Services, India), Ankit Khandelwal (Tata Consultancy Services, India), and M Girish Chandra (Tata Consultancy Services, India)</i>	
Extended Approach for Efficient Coupling Strength Determination for Superconducting Qubit	288
<i>Zhen Luo (Technical University of Munich, Germany), Ivan Tsitsilin (Walther-Meißner-Institut, Technical University of Munich, Germany), Christian Schneider (Walther-Meißner-Institut, Technical University of Munich, Germany), Marco Dietz (Fraunhofer Institute for Electronic Microsystems and Solid State Technologies EMFT, Germany), and Amelie Hagelauer (Fraunhofer Institute for Electronic Microsystems and Solid State Technologies EMFT and Technical University of Munich, Germany)</i>	
Compiling a Simple Chemistry Application to Quantum Error Correction Primitives	290
<i>Nick S. Blunt (Riverlane, United Kingdom), György P. Gehér (Riverlane, United Kingdom), and Alexandra E. Moylett (Riverlane, United Kingdom)</i>	
A Reference Implementation for a Quantum Message Passing Interface	292
<i>Tommy Nguyen (University of Washington, USA), Yue Shi (University of Washington, USA), Samuel Stein (Pacific Northwest National Labs, USA), Tim Stavenger (Pacific Northwest National Labs, USA), Marvin Warner (Pacific Northwest National Labs, USA), Martin Roetteler (Microsoft, USA), Torsten Hoefer (Microsoft, USA), and Ang Li (Pacific Northwest National Labs, USA)</i>	

Sinara and ARTIQ: open-Source ion-Trapping Control System	294
Tomasz Przywózki (<i>Warsaw University of Technology, Poland</i>), Paweł Kulik (<i>Warsaw University of Technology, Poland</i>), Mikołaj Sowiński (<i>Warsaw University of Technology, Poland</i>), Grzegorz Kasprowicz (<i>Warsaw University of Technology, Poland</i>), David T. C. Allcock (<i>University of Oregon, United States</i>), Christopher Ballance (<i>Oxford Ionics, United Kingdom</i>), Sébastien Bourdeauducq (<i>M-Labs Ltd., China</i>), J. W. Britton (<i>Army Research Laboratory, United States</i>), Thomas Harty (<i>Oxford Ionics, United Kingdom</i>), Robert Jördens (<i>QUARTIQ GmbH, Germany</i>), Marcin Kiepiela (<i>Technosystem Sp. z o.o., Poland</i>), Norman Krackow (<i>QUARTIQ GmbH, Germany</i>), David Nadlinger (<i>University of Oxford, United Kingdom</i>), Daniel Slichter (<i>National Institute of Standards and Technology, United States</i>), Filip Świtakowski (<i>Warsaw University of Technology, Poland</i>), and Marius Weber (<i>University of Oxford, United Kingdom</i>)	
Adiabatic Quantum Support Vector Machines	296
Dong Jun Woun (<i>University of Tennessee</i>) and Prasanna Date (<i>Oak Ridge National Laboratory</i>)	
Classification with Integrated Quantum and Spiking Neural Networks	298
Dominic Pasquali (<i>University California Santa Cruz, USA; CERN, Switzerland</i>), Michele Grossi (<i>CERN, Switzerland</i>), and Sofia Vallecorsa (<i>CERN, Switzerland</i>)	
Parameter Transferability in QAOA Under Noisy Conditions	300
Quinn Langfitt (<i>Argonne National Laboratory</i>), Jose Falla (<i>University of Delaware</i>), Ilya Safro (<i>University of Delaware</i>), and Yuri Alexeev (<i>Argonne National Laboratory</i>)	
Estimating Eigenenergies from Quantum Dynamics: A Unified Noise-Resilient Measurement-Driven Approach	302
Yizhi Shen (<i>Lawrence Berkeley National Laboratory, USA</i>), Daan Camps (<i>Lawrence Berkeley National Laboratory, USA</i>), Aaron Szasz (<i>Lawrence Berkeley National Laboratory, USA</i>), Siva Darbha (<i>Lawrence Berkeley National Laboratory, USA</i>), Katherine Klymko (<i>Lawrence Berkeley National Laboratory, USA</i>), David B. Williams-Young (<i>Lawrence Berkeley National Laboratory, USA</i>), Norm M. Tubman (<i>NASA Ames Research Center, USA</i>), and Roel Van Beeumen (<i>Lawrence Berkeley National Laboratory, USA</i>)	
QUBO Formulation for a Nurse Scheduling Problem: an Application for Sales Force Scheduling....	304
Bernardo Palma (<i>Universidad de Montevideo, Uruguay</i>), Laura Gatti (<i>Universidad de Montevideo, Uruguay</i>), and Rafael Sotelo (<i>Universidad de Montevideo, Uruguay</i>)	
Synthesis of Approximate Parametric Circuits for Variational Quantum Algorithms	306
Blake Burgstahler (<i>North Carolina State University, USA</i>), Frank Mueller (<i>North Carolina State University, USA</i>), and Scott Pakin (<i>Los Alamos National Laboratory, USA</i>)	
Approximate State Preparation using Tensor Network Optimization Techniques	308
Tomonori Shirakawa (<i>RIKEN Center for Computational Science, Japan</i>) and Seiji Yunoki (<i>RIKEN Cluster for Pioneering Research, Japan</i>)	

Optimization of Silicon MOS Architecture for Self-Referenced Quantum Current Standard	310
<i>Ajit Dash (University of New South Wales, Australia), Steve Yianni (University of New South Wales; Diraq, Australia), Jonathan Yue Huang (University of New South Wales, Australia), MengKe Feng (University of New South Wales, Australia), Fay Hudson (University of New South Wales; Diraq, Australia), Andre Saraiva (University of New South Wales; Diraq, Australia), Andrew Dzurak (University of New South Wales; Diraq, Australia), and Tuomo Tanttu (University of New South Wales; Diraq, Australia)</i>	
Molecular Geometry Generation Processes Through Hybrid Quantum-Classical Generative Adversarial Networks and Python-Based Self-Consistent Field Molecular Calculations	312
<i>Max Cui (Sir Winston Churchill Secondary School, Canada), Adelina Chau (Archbishop Mitty High School, USA), Michelle Pan (The Quarry Lane School, USA), Vaibhav Vaiyakarnam (The Quarry Lane School, USA), and Larry McMahan (Aspiring Scholars Directed Research Program, USA)</i>	
Protocols for all-Photonic Quantum Repeaters	314
<i>Naphan Benchasattabuse (Keio University Shonan Fujisawa Campus; Keio University, Japan), Michal Hajdušek (Keio University Shonan Fujisawa Campus; Keio University, Japan), and Rodney Van Meter (Keio University Shonan Fujisawa Campus; Keio University, Japan)</i>	
Modifying Crystal Symmetries via Shear Distortion	316
<i>Sarah Edwards (University of Washington, United States), Qixuan Lin (University of Washington, United States), Morgan Sherer (University of Washington, United States), Elliott Rosenberg (University of Washington, United States), Jiun-Haw Chu (University of Washington, United States), and Arthur Barnard (University of Washington, United States)</i>	
Minimum-Length Chain Embedding for the Phase Unwrapping Problem on D-Wave's Pegasus Graph	318
<i>Mohammad Kashfi Haghghi (University of Victoria) and Nikitas Dimopoulos (University of Victoria)</i>	
Leveraging Quantum Dynamics for Physical Computing Applications	320
<i>Frederik Lohof (University of Bremen, Germany), Niclas Götting (University of Bremen, Germany), and Christopher Gies (University of Bremen, Germany)</i>	
A Fully Pipelined Architecture of Quantum-Classical Interface for Realizing Fault-Tolerant Quantum Computer	322
<i>Takefumi Miyoshi (e-trees.Japan, Inc., QIQB Osaka Univ., QuEL, Inc., Japan), Keisuke Koike (e-trees.Japan, Inc., Japan), Shinichi Morisaka (QIQB Osaka Univ., QuEL, Inc., Japan), Hidehisa Shiomi (QIQB Osaka Univ., Japan), Ryo Matsuda (Osaka Univ., Japan), Kazuhisa Ogawa (QIQB Osaka Univ., Japan), Yutaka Tabuchi (RIKEN RQC, Japan), and Makoto Negoro (QIQB Osaka Univ., QuEL, Inc., Japan)</i>	

QuantumPro: An Integrated Workflow for the Design of Superconducting Qubits using PathWave Advanced Design System (ADS)	324
<i>Jungu Choi (Keysight Technologies), Mohamed I. Abdelrahman (Keysight Technologies; Cornell University), Derek Slater (Keysight Technologies), Tom Parker (Keysight Technologies), Philip Krantz (Keysight Technologies), Phil Sohn (Keysight Technologies), Mohamed Awida Hassan (Keysight Technologies), and Chris Mueth (Keysight Technologies)</i>	
A Study on Concentric Feature Embeddings in Variational Multiclass Classification for Small-Scale Quantum Computers	326
<i>Seokhun Jeon (Korea Electronics Technology Institute, Korea), Yunpyo Hong (Korea Electronics Technology Institute, Korea), and Byung-Soo Kim (Korea Electronics Technology Institute, Korea)</i>	
Parallel Quantum Annealing: A Novel Approach to Solving Multiple NP-Hard Problems Concurrently	328
<i>Jargalsaikhan Artag (Tokyo University of Agriculture and Technology, Japan), Moe Shimada (Tokyo University of Agriculture and Technology, Japan), and Jun-ichi Shirakashi (Tokyo University of Agriculture and Technology, Japan)</i>	
Modeling Neuronal Activity with Quantum Generative Adversarial Networks	330
<i>Vinicius Hernandes (Delft University of Technology, the Netherlands) and Eliska Greplova (Delft University of Technology, the Netherlands)</i>	
Gaussian Boson Sampling for Binary Optimization	332
<i>Jean Cazalis (Q.ant GmbH, Germany), Yahui Chai (CQTA, DESY, Germany), Karl Jansen (CQTA, DESY, Germany), Stefan Kühn (CQTA, DESY, Germany), and Tirth Shah (Q.ant GmbH, Germany)</i>	
Robustness of Quantum Algorithms Against Approximate Data Representations	334
<i>Vladyslav Los (Haiqu Inc.), Mykola Maksymenko (Haiqu Inc.), Maciej Koch-Janusz (Haiqu Inc.), Yuriy Pryyma (Haiqu Inc.), and Richard Givhan (Haiqu Inc.)</i>	
An Evaluation of Training Strategies in QuGAN	336
<i>Tuan A. Ngo (The University of Aizu, Japan), Nhan T. Luu (The University of Aizu, Japan), and Truong Cong Thang (The University of Aizu, Japan)</i>	
The Hitchhiker's Guide to FPGA-Accelerated Quantum Error Correction	338
<i>Beatrice Branchini (Politecnico di Milano, Italy), Davide Conficconi (Politecnico di Milano, Italy), Donatella Sciuto (Politecnico di Milano, Italy), and Marco D. Santambrogio (Politecnico di Milano, Italy)</i>	
A Quantum-Inspired Approach to Emergency Patient Allocation using Digital Annealing	340
<i>Chia-Ho Ou (National Pingtung University, Taiwan), Bo-Yuan Zhu (National Pingtung University, Taiwan), Zong-Wei Huang (National Pingtung University, Taiwan), Chih-Yu Chen (Chung Yuan Christian University, Taiwan), Ching-Ray Chang (Chung Yuan Christian University, Taiwan), Wen-Hsi Huang (National Pingtung University, Taiwan), and Wei-Cheng Chen (National Pingtung University, Taiwan)</i>	

Tangling Schedules Eases Hardware Connectivity Requirements for Quantum Error Correction	342
<i>Gyorgy P. Geher (Riverlane, St. Andrew's House, United Kingdom), Ophelia Crawford (Riverlane, St. Andrew's House, United Kingdom), and Earl T. Campbell (Riverlane, St. Andrew's House, United Kingdom; University of Sheffield, United Kingdom)</i>	
Reduced Gate Count for Quantum State Preparation of 2D Data	344
<i>John Burke (Trinity College Dublin, Ireland), Biswajit Basu (Trinity College Dublin, Ireland), and Ciaran McGoldrick (Trinity College Dublin, Ireland)</i>	
A Categorization of Bugs in Quantum Programs	346
<i>Sara Ayman Metwalli (Keio University, Japan) and Rodney Van Meter (Keio University, Japan)</i>	
Quantum-Inspired Optimization for Task Scheduling in Software Development Projects	348
<i>Chia-Ho Ou (National Pingtung University, Taiwan), Yu-Hong Li (National Pingtung University, Taiwan), Chih-Yu Chen (Chung Yuan Christian University, Taiwan), Chi-Hsuan Wu (National Pingtung University, Taiwan), Yu-Chen Tsai (National Pingtung University, Taiwan), Zhi-You Yan (National Pingtung University, Taiwan), and Ching-Ray Chang (Chung Yuan Christian University, Taiwan)</i>	
Complement Grover's Search Algorithm: An Amplitude Suppression Implementation	350
<i>Andrew Vlasic (Deloitte Consulting, LLP, United States), Salvatore Certo (Deloitte Consulting, LLP, United States), and Anh Pham (Deloitte Consulting, LLP, United States)</i>	
Electromagnetic Modeling and Scripted Quantum Parameter Extraction of 3D Superconducting Qubits using PathWave EMPro	352
<i>Mohamed I. Abdelrahman (Keysight Technologies; Cornell University), Jungu Choi (Keysight Technologies), Derek Slater (Keysight Technologies), Tom Parker (Keysight Technologies), Philip Krantz (Keysight Technologies), Phil Sohn (Keysight Technologies), Mohamed Awida Hassan (Keysight Technologies), and Chris Mueth (Keysight Technologies)</i>	
Quantum Radar with Genuine Tripartite Entanglement	354
<i>Michael Würth (Technical University of Munich, Germany), Florian Bischeltsrieder (Microwaves and Radar Institute, German Aerospace Center, Germany), and Wolfgang Utschick (Technical University of Munich, Germany)</i>	
Control Infrastructure for Near-Term Long-Chain QCCD	357
<i>Andrew Van Horn (Duke University, USA), Hezekiah Gabaldon (Duke University, USA), Kenneth Brown (Duke University, USA), and Jungsang Kim (Duke University, USA)</i>	
A Design of Software Architecture for Validate and Verification of Linear-Optical Quantum Computing Platform	359
<i>Duwon Lee (Pukyong National University, South Korea), Yong Kwon (Pukyong National University, South Korea), Kanghyeon Kim (Pukyong National University, South Korea), Jaehyeok Lee (Pukyong National University, South Korea), and Byung-Soo Choi (Pukyong National University, South Korea)</i>	

Developing Workforce in Quantum Industry: The Wond'ry Quantum Studio	361
<i>Serat Mahmud Saad (Vanderbilt University), Anish Giri (Vanderbilt University), Mubarak Ganiyu (Vanderbilt University), David Nizovsky (Vanderbilt University), David Owens (Vanderbilt University), and Mandy Lalrindiki (Vanderbilt University)</i>	
Demonstration of a Micro-Fabricated Penning trap for Quantum Computing	363
<i>Sägesser Tobias (ETH Zürich, Switzerland), Jain Shreyans (ETH Zürich, Switzerland), Hrmo Pavel (ETH Zürich, Switzerland), Kienzler Daniel (ETH Zürich, Switzerland), and Home Jonathan (ETH Zürich, Switzerland)</i>	
Sum-of-Squares Bounds for Quantum Optimal Control	365
<i>Flemming Holtorf (Massachusetts Institute of Technology, USA), Frank Schäfer (Massachusetts Institute of Technology, USA), Julian Arnold (University of Basel, Switzerland), Christopher Rackauckas (Massachusetts Institute of Technology, USA), and Alan Edelman (Massachusetts Institute of Technology, USA)</i>	
Laser Frequency Stabilization using a Prescaler and a High-Resolution Frequency to Voltage Converter	367
<i>Yu Liu (ETH Zurich, Switzerland), Alexander C. Frank (ETH Zurich, Switzerland), Tilman Esslinger (ETH Zurich, Switzerland), Tobias Donner (ETH Zurich, Switzerland), and Abdulkadir Akin (ETH Zurich, Switzerland)</i>	
Characterizing Quantum Classifier Utility in Natural Language Processing Workflows	369
<i>Kathleen Hamilton (Oak Ridge National Laboratory, USA), Mayanka Chandra Shekar (Oak Ridge National Laboratory, USA), John Gounley (Oak Ridge National Laboratory, USA), Dhanvi Bharadwaj (University of Wisconsin-Madison, USA), Prasanna Date (Oak Ridge National Laboratory, USA), Eduardo Antonio Coello Pérez (Oak Ridge National Laboratory, USA), In-Saeng Suh (Oak Ridge National Laboratory, USA), and Georgia Tourassi (Oak Ridge National Laboratory, USA)</i>	
Estimating Fidelity Lower Bounds of Quantum Subroutines	371
<i>Karl Mayer (Quantinuum, USA) and Charlie Baldwin (Quantinuum, USA)</i>	
QNotation: An Interactive Visual Tool to Lower Learning Barriers in Quantum Computing	373
<i>Samantha Norrie (University of Victoria) and Anthony Estey (University of Victoria)</i>	
A Highly Efficient QEC Decoder Implemented on FPGA and ASIC	375
<i>Kenton M. Barnes (Riverlane, UK), Tomasz Bialas (Riverlane, UK), Okan Buğdayci (Riverlane, UK), Earl T. Campbell (Riverlane, UK), Neil I. Gillespie (Riverlane, UK), Kauser Johar (Riverlane, UK), Ram Rajan (Riverlane, UK), Adam W. Richardson (Riverlane, UK), Luka Skoric (Riverlane, UK), Canberk Topal (Riverlane, UK), Mark L. Turner (Riverlane, UK), and Abbas B. Ziad (Riverlane, UK)</i>	
Quantum Resource Estimation of Arithmetic Primitives	377
<i>Ethan Hansen (University of Washington, USA), Sanskriti Joshi (University of Washington, USA), and Hannah Rarick (University of Washington, USA)</i>	

Electro-Optical Control and Readout of Superconducting Devices	379
<i>Calum Rose (University of Glasgow, United Kingdom), Natale Pruiti (University of Glasgow, United Kingdom), Daniel Kelly (University of Glasgow, United Kingdom), Marc Sorel (University of Glasgow, United Kingdom), Alessandro Casaburi (University of Glasgow, United Kingdom), and Martin Weides (University of Glasgow, United Kingdom)</i>	
Algebraic Compression of Free Fermionic Quantum Circuits: Particle Creation, Arbitrary Lattices and Controlled Evolution	381
<i>Efekan Kökcü (North Carolina State University, USA), Daan Camps (Lawrence Berkeley National Laboratory, USA), Lindsay Bassman Oftelie (Lawrence Berkeley National Laboratory, Consiglio Nazionale delle Ricerche, USA), Wibe A. de Jong (Lawrence Berkeley National Laboratory, USA), Roel Van Beeumen (Lawrence Berkeley National Laboratory, USA), and Alexander F. Kemper (North Carolina State University, USA)</i>	
A PEPS Plugin for TNQVM	383
<i>Srikan Chundury (North Carolina State University; Oak Ridge National Laboratory, USA), Justin Lietz (Oak Ridge National Laboratory, USA), Eduardo Antonio Coello Pérez (Oak Ridge National Laboratory, USA), Amir Shehata (Oak Ridge National Laboratory, USA), In-Saeng Suh (Oak Ridge National Laboratory, USA), and Frank Mueller (North Carolina State University, USA)</i>	
Tensor Network-Based Continuous Variable Quantum Circuit Optimization for Preparation of GKP State	385
<i>Ryutaro Nagai (blueqat inc., Japan) and Takao Tomono (Digital Innovation Div., Toppan Inc., Japan)</i>	
Quantum Task Mapping for Distributed Heterogeneous Computing Systems	387
<i>Kenzie Ellenberger (Mississippi State University), Dylan Couch (Mississippi State University), Jeffrey Greer (Mississippi State University), Noah Gregory (Mississippi State University), Luis Sanchez (Mississippi State University), Kaleb Love (Mississippi State University), Yaroslav Koshka (Mississippi State University), and Samee U. Khan (Mississippi State University)</i>	
HamLib: A Library of Hamiltonians for Benchmarking Quantum Algorithms and Hardware	389
<i>Nicolas P.D. Sawaya (Intel Labs, USA), Daniel Marti-Dafcik (University of Oxford, UK), Yang Ho (Sandia National Laboratories, USA), Daniel P. Tabor (Texas A&M University, USA), David E. Bernal (NASA Ames Research Center, USA), Alicia B. Magann (Sandia National Laboratories, USA), Shavindra Premaratne (Intel Labs, USA), Pradeep Dubey (Intel Labs, USA), Anne Matsuura (Intel Labs, USA), Nathan Bishop (Intel Corporation, USA), Wibe A. de Jong (LBL), Simon Benjamin (University of Oxford, UK), Ojas D. Parekh (Sandia National Laboratories, USA), Norm M. Tubman (NASA Ames Research Center, USA), Katherine Klymko (NERSC, LBL, USA), and Daan Camps (NERSC, LBL, USA)</i>	
Scalable Multipartite Entanglement Distribution in Quantum Networks	391
<i>Nitish K. Panigrahy (University of Massachusetts Amherst, USA), Matheus Guedes de Andrade (University of Massachusetts Amherst, USA), Shahrooz Pouryousef (University of Massachusetts Amherst, USA), Don Towsley (University of Massachusetts Amherst, USA), and Leandros Tassiulas (Yale University, USA)</i>	

Resource Management in Quantum Virtual Private Networks	393
<i>Shahrooz Pouryousef (University of Massachusetts Amherst), Nitish K. Panigrahy (University of Massachusetts Amherst & Yale University), Monimoy Deb Purkayastha (Juniper Networks), Sabyasachi Mukhopadhyay (Juniper Networks), Gert Grammel (Juniper Networks), Domenico Di Mola (Juniper Networks), and Don Towsley (University of Massachusetts Amherst)</i>	
Noise Robustness of Data Re-Uploading Quantum Classifiers	395
<i>Daniel E. Molina (University of Southern California, USA) and Kathleen Hamilton (Oak Ridge National Laboratory, USA)</i>	
Prepare Ground States of Highly Frustrated Magnetic Clusters on Quantum Computers	397
<i>Yan Wang (Oak Ridge National Laboratory, USA)</i>	
Towards the Munich Quantum Software Stack: Enabling Efficient Access and Tool Support for Quantum Computers	399
<i>Martin Schulz (Technical University of Munich, Germany), Laura Schulz (Leibniz Supercomputing Centre, Germany), Martin Ruefenacht (Leibniz Supercomputing Centre, Germany), and Robert Wille (Technical University of Munich, Germany)</i>	
Predicting Expressibility of Parameterized Quantum Circuits using Graph Neural Network	401
<i>Shaminiuj Aktar (New Mexico State University, USA), Andreas Bärtschi (Los Alamos National Laboratory, USA), Abdel-Hameed Badawy (New Mexico State University, USA), Diane Oyen (Los Alamos National Laboratory, USA), and Stephan Eidenbenz (Los Alamos National Laboratory, USA)</i>	
Improving Signal-to-Noise Ratio (SNR) for Readout Signals using Adaptive Filters on Reconfigurable Controls Hardware	403
<i>Hans Johnson (Illinois Institute of Technology, USA; Superconducting Quantum Materials and Systems Center (SQMS) at Fermi National Accelerator Laboratory, USA), Silvia Zorzetti (Superconducting Quantum Materials and Systems Center (SQMS) at Fermi National Accelerator Laboratory, USA), and Jafar Saniie (Illinois Institute of Technology, USA)</i>	
Challenges in HPCQC Integration	405
<i>Amr Elsharkawy (Technical University of Munich, Germany), Xiao-Ting Michelle To (Ludwig-Maximilians-Universität in Munich, Germany), Philipp Seitz (Technical University of Munich, Germany), Yanbin Chen (Technical University of Munich, Germany), Yannick Stade (Technical University of Munich, Germany), Manuel Geiger (Technical University of Munich, Germany), Qunsheng Huang (Technical University of Munich, Germany), Xiaorang Guo (Technical University of Munich, Germany), Muhammad Arslan Ansari (Technical University of Munich, Germany), Martin Ruefenacht (Leibniz Supercomputing Centre, Germany), Laura Schulz (Leibniz Supercomputing Centre, Germany), Sven Karlsson (Technical University of Denmark, Denmark), Christian B. Mendl (Technical University of Munich, Germany), Dieter Kranzlmüller (Ludwig-Maximilians-Universität in Munich, Germany), and Martin Schulz (Technical University of Munich, Germany)</i>	

General Algorithms for SPAM Noise Characterization	407
<i>Abhijith Jayakumar (Los Alamos National Lab, USA), Stefano Chessa (University of Illinois Urbana-Champaign, USA; NEST, Scuola Normale Superiore and Istituto Nanoscienze-CNR, Italy; Los Alamos National Lab, USA), Carleton Coffrin (Los Alamos National Lab, USA), Andrey Lokhov (Los Alamos National Lab, USA), Marc Vuffray (Los Alamos National Lab, USA), and Sidhant Misra (Los Alamos National Lab, USA)</i>	
Space-Efficient Embedding of the Clique Cover Problem for Quantum Optimization	409
<i>Bence Bakó (Wigner Research Centre for Physics; Eötvös Loránd University, Hungary), Dániel T. R. Nagy (Wigner Research Centre for Physics; Eötvös Loránd University, Hungary), Péter Hágá (Ericsson Research, Hungary), Zsófia Kallus (Ericsson Research, Hungary), and Zoltán Zimborás (Wigner Research Centre for Physics; Eötvös Loránd University, Hungary)</i>	
Author Index - Vol. 2	411

2023 IEEE International Conference on Quantum Computing and Engineering (QCE 2023)

**Bellevue, Washington, USA
17-22 September 2023**

**Volume 3
Pages 1-129**



**IEEE Catalog Number: CFP23W18-POD
ISBN: 979-8-3503-4324-3**

2023 IEEE International Conference on Quantum Computing and Engineering (QCE)

QCE 2023

Table of Contents

Message from the QCE 2023 Chairs	viii
<i>Hausi Muller (University of Victoria, Canada), Yuri Alexev (Argonne National Laboratory, USA), Andrea Delgado (Oak Ridge National Laboratory, USA), and Greg Byrd (NC State University, USA)</i>	
Message from the QSEEC 2023 Chairs	xiii
<i>Brian La Cour (University of Texas at Austin, USA), Lia Yeh (University of Oxford, United Kingdom), and Marek Osinski (University of New Mexico, USA)</i>	
QSEEC 2023 Committees	xiv
QSEEC Technical Program	xv
QSEEC Posters Program	xxxi
QSEEC Tutorials Program	xlii

QSEEC 2023 - Quantum Science and Engineering Education

Quantum Computing, Math, and Physics (QCaMP): Introducing Quantum Computing in high Schools	1
<i>Megan Ivory (Sandia National Laboratories, USA), Alisa Bettale (Lawrence Berkeley National Laboratory, USA), Rachel Boren (New Mexico State University, USA), Ashlyn D. Burch (Sandia National Laboratories, USA), Jake Douglass (Sandia National Laboratories, USA), Lisa Hackett (Sandia National Laboratories, USA), Boris Kiefer (New Mexico State University, USA), Alina Kononov (Sandia National Laboratories, USA), Maryanne Long (New Mexico State University, USA), Mekena Metcalf (HSBC Holdings Plc., USA), Tzula B. Propp (University of New Mexico, USA), and Mohan Sarovar (Sandia National Laboratories, USA)</i>	
Leveraging Dual Enrollment Programs to Expand Secondary Education in Quantum Computation .	10
<i>Derrick L. Tucker (The University of Texas at Austin, USA)</i>	
Teaching Quantum Computing using Microsoft Quantum Development Kit and Azure Quantum ..	15
<i>Mariia Mykhailova (Microsoft Quantum, USA)</i>	

Quantum Picturalism: Learning Quantum Theory in High School	21
<i>Selma Dündar-Coecke (Quantinuum; Centre for Educational Neuroscience, UK), Lia Yeh (Quantinuum; University of Oxford, UK), Caterina Puca (Quantinuum, UK), Sieglinde M.-L. Pfaendler (IBM Deutschland Research & Development GmbH, Germany), Muhammad Hamza Waseem (Quantinuum; University of Oxford, UK), Thomas Cervoni (Quantinuum, UK), Aleks Kissinger (University of Oxford, UK), Stefano Gogioso (University of Oxford; Hashberg Ltd, UK), and Bob Coecke (Quantinuum, UK)</i>	
Investigating Students' Strengths and Difficulties in Quantum Computing	33
<i>Tunde Kushimo (Southern Methodist University, USA) and Beth Thacker (Texas Tech University, USA)</i>	
QuCS: A Lecture Series on Quantum Computer Software and System	40
<i>Zhiding Liang (University of Notre Dame, USA) and Hanrui Wang (Massachusetts Institute of Technology, USA)</i>	
Taiwan Student Quantum Computer Society	49
<i>Ran-Yu Chang (National Yang Ming Chiao Tung University, Taiwan), Yu-Chao Hsu (National Cheng Kung University, Taiwan), and Tsung-Wei Huang (Chung Yuan Christian University, Taiwan)</i>	
A Physics lab Inside Your Head: Quantum Thought Experiments as an Educational Tool	58
<i>Maria Violaris (University of Oxford, IBM Quantum, United Kingdom)</i>	
Design of Quantum Machine Learning Course for a Computer Science Program	68
<i>Sathish Kumar (Cleveland State University, USA), Temitope Adeniyi (Cleveland State University, USA), Ahmad Alomari (Cleveland State University, USA), and Santanu Ganguly (Photonic Inc., UK)</i>	
A Brief Overview of Programmed Instructions for Quantum Software Education	78
<i>Richard A. Wolf (University of Galway, Irish Center for High-End Computing, Ireland) and Sho Araiba (University of Hawaii, United States)</i>	
QWalkVis: Quantum Walks Visualization Application	87
<i>Addie Jordon (University of Victoria, Canada), Austin Hawkins-Seagram (University of Victoria, Canada), Samantha Norrie (University of Victoria, Canada), José Ossorio (University of Victoria, Canada), and Ulrike Stege (University of Victoria, Canada)</i>	
Harnessing the VQE to Simulate Quantum Chemistry in an Undergraduate Project: Properties of Hydrogen, Oxygen and Water Molecules	94
<i>Shah Ishmam Mohtashim (University of Dhaka, Bangladesh), Sheikh Mahatabuddin (Bangladesh Atomic Energy Regulatory Authority, Bangladesh), and Md. Abdul Jabbar (University of Dhaka, Bangladesh)</i>	
QPCC: a Quantum Programming Course for Inhomogeneous Cohorts of Professional Learners	101
<i>Emil Dimitrov (University of Galway, Ireland), Conor Dunne (University of Galway, Ireland), Venkatesh Kannan (University of Galway, Ireland), Karthik Krishnakumar (University of Galway, Ireland), Pablo Lauret Martínez de Rituerto (University of Galway, Ireland), Pablo Suárez Vieites (University of Galway, Ireland), Rajarshi Tiwari (University of Galway, Ireland), and Richard A. Wolf (University of Galway, Ireland)</i>	

Exploring Architecture of Qiskit Runtime for Educational Enablement	112
<i>Syed Farhan Ahmad (North Carolina State University, USA), Nate Earnest-Noble (IBM Quantum, USA), and Gregory T. Byrd (North Carolina State University, USA)</i>	
A Holistic Approach to Quantum Ethics Education	119
<i>Joan Étude Arrow (University of Waterloo, Canada), Sara E. Marsh (Ontario Certified Teacher (OCT), Canada), and Josephine C. Meyer (University of Colorado Boulder, USA)</i>	
Author Index - Vol. 3	129