QCIT Meeting - 23rd of Nov. 2022

Organized
by
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Agenda

- **9:00 EDT - Welcome**
- An *Ad Hoc* QCIT Workshop
- Approval of Previous Meeting Minutes
- Next QCIT-ETC Meeting & Informal Workshop: ICC'2023
- Adjourn

Selected Topics in Quantum Communications:
An *Ad Hoc* QCIT Workshop - 23rd of Nov. 2022

I. 9:00 EDT - Balint Koczor: Will quantum error mitigation achieve practical advantage?

Quantum computers are becoming a reality and current generations of machines are already well beyond the 50-qubit frontier. However, hardware imperfections still overwhelm these devices and it is generally believed the fault-tolerant, error corrected systems will not be within reach in the near term: a single logical qubit needs to be encoded into potentially thousands of physical qubits which is prohibitive. It is thus a very exciting challenge in the near term to achieve practical value with noisy intermediate-scale quantum (NISQ) devices. Due to limited resources, in the near term we need to resort to quantum error mitigation techniques. I will explain the basic concepts of error mitigation and will compare these techniques with error correction. I will then discuss recent breakthrough results on exponentially effective error mitigation, including an architecture of multiple quantum processors that perform the same quantum computation in parallel; using their outputs to verify each other results in an exponential suppression of errors. This talk will be based on the papers [PRX 11 (3), 031057, arXiv:2011.05942], [PRApplied, Phys. Rev. Applied 18, 044064, arXiv:2201.08861].

Bio: Dr Blint Koczor is an early career independent research fellow at the Department of Materials of the University of Oxford. Blint obtained his PhD degree from the Technical University of Munich where he held several competitive scholarships and his research focused on fundamental aspects of quantum theory. He later joined the group of Prof. Simon Benjamin in Oxford to work on the theory of early quantum computers and he currently holds a Glasstone Research Fellowship. Blint is internationally recognised for his works on quantum error mitigation and near-term quantum computing. He also works part time for the company Quantum Motion as a senior quantum theorist.

II. Yifeng Xiong - Quantum Error Mitigation Relying on Permutation Filtering

Quantum error mitigation (QEM) is a class of promising techniques capable of reducing the computational error of variational quantum algorithms tailored for current noisy intermediate-scale quantum computers. The recently proposed permutation-based methods are practically attractive, since they do not rely on any *a priori* information concerning the quantum channels. In this treatise, we propose a general framework termed as permutation filters, which includes the existing permutation-based methods as special cases. In particular, we show that the proposed filter design algorithm always converge to the global optimum, and that the optimal filters can provide substantial improvements over the existing permutation-based methods in the presence of narrowband quantum noise, corresponding to large-depth, high-error-rate quantum circuits.

Bio: Yifeng Xiong received his Ph.D. degree in Electronic and Electrical Engineering from University of Southampton, UK, in 2022, and received his B.S. degree in Information Engineering as well as the M.S. degree (with highest honor) in Information and Communication Engineering from Beijing Institute of Technology (BIT), Beijing, China, in 2015 and 2018, respectively.

Since April 2022, he has been a visiting researcher at Southern University of Science and Technology (SUSTech), Shenzhen, China. He is currently an Associate Professor at Beijing University of Posts and Telecommunications (BUPT). His research interests include integrated sensing and communications, quantum computation, quantum information theory, and statistical inference over networks.

III. **Osvaldo Simeone - Quantum machine learning: An introduction**

In the current noisy intermediate-scale quantum (NISQ) era, quantum machine learning is emerging as a dominant paradigm to program gate-based quantum computers. In quantum machine learning, the gates of a quantum circuit are parametrized, and the parameters are tuned via classical optimization based on data and on measurements of the outputs of the circuit. Parametrized quantum circuits (PQCs) can efficiently address combinatorial optimization problems, implement probabilistic generative models, and carry out inference (classification and regression). They can be instantiated within actual quantum computers via cloud-based interfaces accessible through several software libraries – such as IBM's Qiskit, Google's Cirq, and Xanadu's PennyLane. This talk will provide a short introduction to quantum machine learning by describing the general methodology, PQCs, as well as applications to unsupervised and supervised learning. Current research on hybrid quantum-classical models and quantum error mitigation will also be summarized.

Bio: Osvaldo Simeone is a Professor of Information Engineering with the Centre for Telecommunications Research at the Department of Engineering of King's College London, where he directs the King's Communications, Learning and Information Processing lab. He received an M.Sc. degree (with honors) and a Ph.D. degree in information engineering from Politecnico di Milano, Milan, Italy, in 2001 a nd 2005, respectively. From 2006 to 2017, he was a faculty member of the Electrical and Computer Engineering (ECE) Department at New Jersey Institute of Technology (NJIT), where he was affiliated with the Center for Wireless Information Processing (CWiP). His research interests include information theory, machine learning, wireless communications, neuromorphic computing, and quantum machine learning. Dr Simeone is a co-recipient of the 2022 IEEE Communications Society Outstanding Paper Award, the 2021 IEEE Vehicular Technology Society Jack Neubauer Memorial Award, the 2019 IEEE Communication Society Best Tutorial Paper Award, the 2018 IEEE Signal Processing Best Paper Award, the 2017 JCN Best Paper Award, the 2015 IEEE Communication Society Best Tutorial Paper Award and of the Best Paper Awards of IEEE SPAWC 2007 and IEEE WRECOM 2007. He was awarded an Open Fellowship by the EPSRC in 2022 and a Consolidator grant by the European Research Council (ERC) in 2016. His research has been also supported by the U.S. National Science Foundation, the European Commission, the European Research Council, the Vienna Science and Technology Fund, the European Space Agency, as well as by a number of industrial collaborations including with Intel Labs and InterDigital. He is the Chair of the Signal Processing for Communications and Networking Technical Committee of the IEEE Signal Processing Society and of the UK & Ireland Chapter of the IEEE Information Theory Society. He is currently a Distinguished Lecturer of the IEEE Communications Society, and he was a Distinguished Lecturer of the IEEE Information Theory Society in 2017 and 2018. Dr Simeone is the author of the textbook "Machine Learning for Engineers" published by Cambridge University Press, four monographs, two edited books, and more than 180 research journal and magazine papers. He is a Fellow of the IET, EPSRC, and IEEE.