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Running the Dual-PQC GAN on noisy simulators and real quantum hardware

In an earlier work [1], we introduced dual-Parameterized Quantum Circuit (PQC) Generative Adversarial Networks (GAN), an advanced prototype of quantum GAN, which consists of a classical discriminator and two quantum generators that take the form of PQCs. We have shown the model can imitate calorimeter outputs in High-Energy Physics (HEP), interpreted as reduced size pixelated images. But the simulation was only limited to the theoretical statevector simulator in the absence of noise, while noise due to interaction with the environment is the major obstacle to overcome for the existing quantum devices.
In this talk, our study extends the dual-PQC GAN to more practical usage by testing its performance in the presence of different types of quantum noises, including statistical fluctuations. We start by simulating noise models only with two-qubit gate errors, which are the most significant for our dual-PQC GAN architecture. We investigate the impact of the number of measurements and the training hyperparameters on the performance of the model within a range of errors, covering more than that of the real hardware that we will use. The results prove that we consistently get hyperparameters which allow reproducing the result close to the target, while more improvements are required in some areas. We then add to the noisy simulation a read-out error, tuned to probe its level that can be tolerated. Finally, we present the results obtained both on *superconducting* and *trapped-ion* quantum hardware with the hyperparameters that are found to be optimal in noisy simulations. Different ansatz designs are developed as well to be efficient on various hardware architecture. Our work ultimately aims to provide a global overview of the effect of different types of noise in the training of dual-PQC GAN and suggest realistic solutions to lead the model to convergence.

[1] S. Y. Chang, S. Herbert, S. Vallecorsa, E. F. Combarro, R. Duncan, Dual-Parameterized Quantum Circuit GAN Model in High Energy Physics, arXiv:2103.15470

Significance

References

Speaker time zone

Compatible with Europe

Primary author: CHANG, Su Yeon (CERN / EPFL - Ecole Polytechnique Federale Lausanne (CH))

Co-authors: Dr HERBERT, Steven (Cambridge Quantum Computing Ltd / Department of Computer Science and Technology, University of Cambridge); VALLECORSA, Sofia (CERN); Prof. COMBARRO, Elías F. (Department of Computer Science, University of Oviedo); GROSSI, Michele (CERN); AGNEW, Edwin (Cambridge Quantum Computing Ltd); Dr DUNCAN, Ross (Cambridge Quantum Computing Ltd / Department of Computer and Information Sciences, University of Strathclyde / Department of Physics, University College London)

Presenter: CHANG, Su Yeon (CERN / EPFL - Ecole Polytechnique Federale Lausanne (CH))

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