Design of quantum optical experiments with logic artificial intelligence

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Logic artificial intelligence (AI) is a subfield of AI where variables can take two defined arguments, True or False, and are arranged in clauses that follow the rules of formal logic. Several problems that span from physical systems to mathematical conjectures can be encoded into these clauses and be solved by checking their satisfiability (SAT). Recently, SAT solvers have become a sophisticated and powerful computational tool capable, among other things, of solving long-standing mathematical conjectures. In this work, we propose the use of logic AI for the design of optical quantum experiments. We show how to map into a SAT problem the experimental preparation of an arbitrary quantum state and propose a logic-based algorithm, called Klaus, to find an interpretable representation of the photonic setup that generates it. We compare the performance of Klaus with the state-of-the-art algorithm for this purpose based on continuous optimization. We also combine both logic and numeric strategies to find that the use of logic AI improves significantly the resolution of this problem, paving the path to develop more formal-based approaches in the context of quantum physics experiments.

References

[1] A. Cervera-Lierta, M. Krenn, A. Aspuru-Guzik, arXiv:2109.13273 [quant-ph] (2021).
[2] Code: https://github.com/albacl/klaus
[3] M. Krenn, J. S. Kottmann, N. Tischler, and A. Aspuru-Guzik, Phys. Rev. X 11 (2021), 031044.

Figures

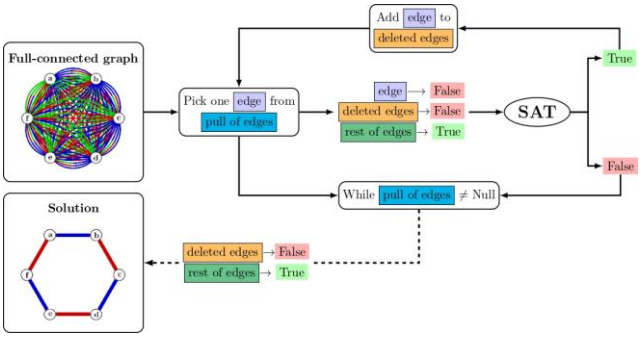

Figure 1: Diagram of Klaus algorithm.

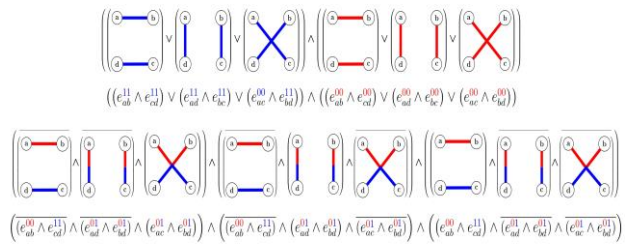

Figure 2: Example on how to encode photonic state preparation experiments into logic clauses.