Machine Learning with Quantum Optics

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Classical programming means writing explicit instructions so that a program processes the input data and correctly answers our questions. Machine learning (ML) is a branch of artificial intelligence research that uses implicit programming, where the program does not receive explicit instructions. This method is particularly suitable for problems that are intuitive to humans but difficult to convert to set of machine instructions. Some complex problems resist known ML methods, especially in quantum systems [1, 3]. *E.g.* designing new drug molecules or supervising quantum communication networks, which under certain assumptions should be protected from eavesdropping by the laws of quantum physics. These tasks quickly become unfeasible as the complexity of the problem increases. Solutions to such problems must be sought using quantum computing for ML [1, 2]. This is the original motivation to combine ML and quantum physics [1]. However, there are many other reasons to do so. In particular, ML can be used to motivate theoretical and experimental research in quantum information, quantum state engineering, classification and detection. To illustrate this, we will discuss a few assorted examples of combining ML and optical quantum information processing, including [2, 4, 5]. Finally, we will discuss how a new paradigm for generative ML emerges from quantum state discrimination [6].

References

[1] Biamonte J., Wittek P., Pancotti N., Rebentrost P., Wiebe N., Lloyd S., Nature 549, 195-202 (2017).

[2] Trávníček V., Bartkiewicz K., Černoch A., Lemr K., Phys. Rev. Lett. 123, 260501 (2019).

[3] Carleo G. *et al.*, Rev. Mod. Phys. 91, 045002 (2019).

[4] Bartkiewicz K., Gneiting C., Černoch A., Jiráková K., Lemr K., Nori F., Sci. Rep. 10, 12356 (2020).

[5] Jašek J., Jiráková K., Bartkiewicz K., Černoch A., Fürst T., Lemr K., Opt. Express 27, 32454-32464 (2019).

[6] Bartkiewicz K., Tulewicz P., Roik J., Lemr K., arXiv:2112.13255 arXiv: 2112.13255 (2021).