Time series prediction with photonic quantum memristor

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Time series prediction is a crucial task for many human activities e.g. weather forecasts or predicting stock prices. One solution to this problem is to use the Reservoir Computing paradigm [1]. The purpose of the reservoir is to map the input data into a computational space using fixed and non-linear dynamical systems (Fig. 1). In recent years, various quantum dynamical systems have been proposed to serve as reservoirs which can potentially improve the prediction capability over the classical reservoirs [2].

In our work we utilize the photonic quantum memristor [3] to build a quantum reservoir. We show that the photonic quantum memristor is the source of a temporal memory and non-linearity in the reservoir. We evaluate the performance of the reservoir using the standard task of NARMA prediction [4], which contains a quadratic temporal dependance. Our findings indicate that a single memristor is sufficient for the network to effectively learn the NARMA task, maintaining an average relative error of less than 5% (Fig. 2).

References

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[2] Fujii, K. & Nakajima, K., Phys. Rev. Applied 8, 2, (2017) 024030
[3] Spagnolo, M. et al. Nat Photon 16, 4, (2022) 318–323
[4] Appeltant, L. et al. Nat Commun 2, 1, (2011) 468.

Figures

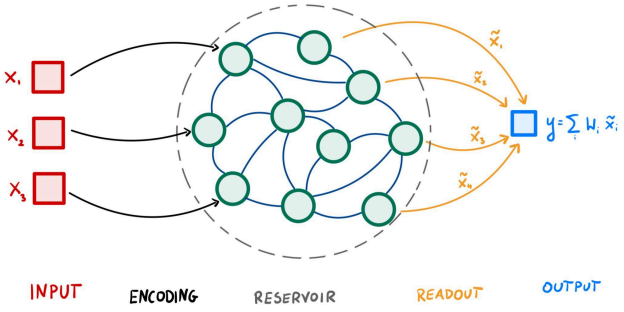

Figure 1: Visualization of the reservoir computing

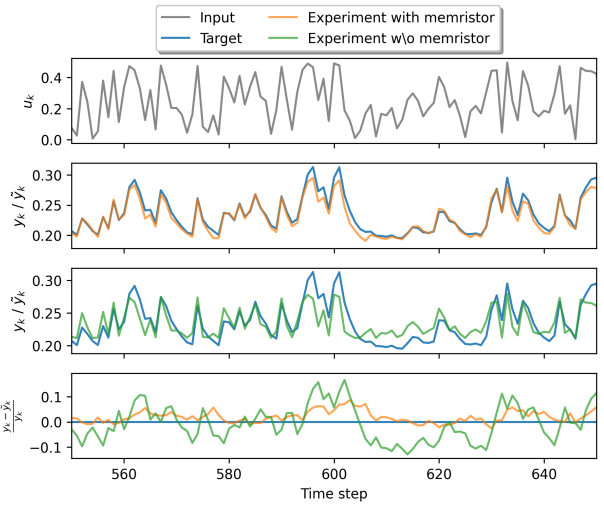

Figure 2: Results of the NARMA prediction. Top row is the input fed to the quantum circuit (gray). Second and third row shows the target sequence (blue) and the prediction of the reservoir with (orange) and without (green) memristor. Bottom row presents the relative errors of corresponding predictions.