Coherent Fiber-Ring Reservoir Computer with Distributed Nonlinearity

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Introduction

We exploit the transient dynamics of a nonlinear photonic system within the framework of reservoir computing, allowing to perform useful computation. State of the art photonic implementations [1] target simple reservoir architectures. Even a linear photonic cavity can be a potent reservoir, provided some nonlinearity is present in either the input mapping or readout layer. When transitioning from opto-electronic towards all-optical reservoir computers, commonly present non-linearities in opto-electronic conversion equipment (e.g. modulators and photodiodes) can no longer be relied on, and thus optical nonlinearities must be considered. We investigate a simple delay-based reservoir architecture which exploits the optical Kerr nonlinearity throughout the reservoir's extent.

Setup & Results

In this paper we study an optical fiber ring cavity, Fig. 1, and exploit the inherent nonlinear response of the waveguiding material to build a state-of-the-art photonic reservoir. We have considered different scenarios with linear and nonlinear input and readout schemes. This allowed us to quantify the effects of different nonlinearities in the reservoir computer on its performance. We also investigated the effect of the distributed Kerr nonlinearity on both the linear memory and nonlinear computational capacity of our reservoir, as shown in Fig. 2.

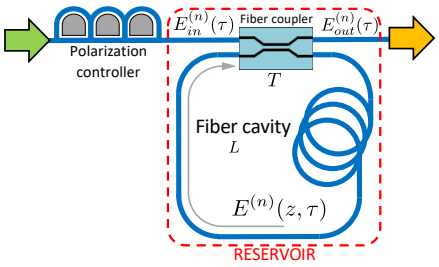

Figure 1. Photonic delay-based reservoir setup (input and readout layer not shown), based on a fiber ring setup.

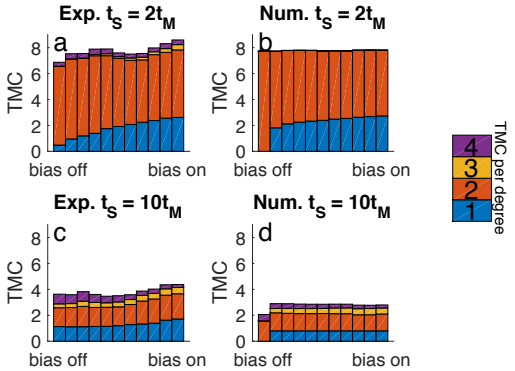

Figure 1. Comparison of experimental and numerical total memory capacities (TMC) for varying sample durations t_S w.r.t. the input mask length t_M (approximately the roundtrip delay).

Conclusion

We have found a broad range of power levels where this distributed nonlinear effect improves the reservoir's performance. With this approach, the reservoir computer can deliver state-of-the-art performance even without any opto-electronic nonlinearities in its input and readout layer.

References

[1] Van der Sande G, Brunner D, Soriano MC. Advances in photonic reservoir computing. *Nanophotonics* 6 (2017) 561–576.