Photonic Delay-based Reservoir Computing Integrated on InP Chip

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Integrated Photonics Reservoir computing

Delay-based reservoir computing (RC) offers a simple technological route to implement photonic neuromorphic computation. Its operation boils down to a time-multiplexing with the delay limiting the processing speed. As most optical setups end up to be bulky employing long fiber loops or free-space optics, the processing speeds are limited in the range of kSa/s to tens of MSa/s [1]. In this work, we focus on external cavities which are far shorter than what has been realized before in experiment. We present the results of an experimental validation of reservoir computing based on a semiconductor laser with a 10.8 cm delay line, both integrated on an active/passive InP photonic chip built on the Jeppix platform [3]. The single mode laser operates around 1550nm with a side mode suppression of larger than 20dB.

Results

The performance is tested by one-step-ahead prediction of a laser generated timeseries from the Santa-Fe timeseries competition. A three level mask with 23 nodes separated by 50ps is employed, which corresponds to a speed of 0.87 GSa/s. The performances are indicated by the Normalized Mean Square Error(NMSE) in Fig. 1. The NMSE is calculated by a 80-20% split of the data set for training and testing, and the best performance out of 5-fold cross validation is chosen as the performance of a particular set.

The left plot in figure 1, illustrates how the performance relates to the pump current of the reservoir laser (Threshold current I_{th}=15mA). At higher pump strength the performance improves significantly. In the middle plot we put the injection wavelength along the abscissa. The lowest NMSE or the best performance is observed at 1549.96nm, which is also the lasing wavelength, hence at the point where injection locking is achieved. The last plot has the total current applied to the two feedback SOA's placed along the abscissa, i.e. the feedback strength increases along the y-axis. We see that the performance generally improves as feedback increases, with some outliers that can be attributed to changes of feedback phase.

The best experimental NMSEs reached here, is an NMSE of 0.13. Which is in the same range as the value of 0.12 reached by Larger et. al. [5] with an optoelectronic setup with 400 virtual nodes at a processing speed of 48 kSa/s. Brunner et al. [3] achieved a prediction error as low as 10.6%, at a speed of 13 MSa/s with a fiberloop. We have achieved a significant speed up, with computation speed of 0.87 GSa/s, while also drastically decreasing the footprint of the setup.

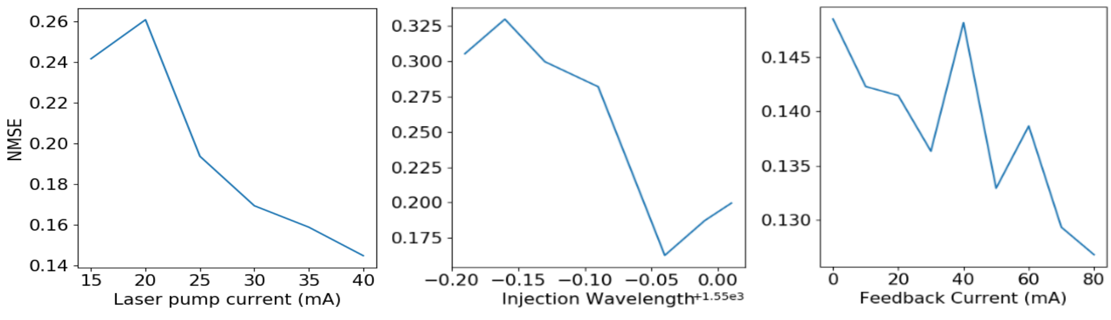

Fig. 1 The performance indicated by the NMSE as a function of the pump current (left), Injection wavelength (middle) and combined current applied to the two SOA's in the delay line (right)

References

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35 words abstract:

We present an experimental validation of delay-based reservoir computing using a semiconductor laser integrated on an InP chip, reaching computation speeds of up to 0.87 GSa/s. The scheme is benchmarked using timeseries prediction tasks.