Interferometric stabilisation of a fibre-based optical computer

Experimental study

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Outline

Introduction

- The development of next generation technological computation paradigm is investigated
- Optical computers use light as information carrier $\longrightarrow$ *fast*
- Optical computers do not need to rely on boolean logic as classical computers do, new computation paradigms based on specific physical properties of light can be implemented
- *Photonic reservoir computing* is one of such implementation

Outline

Reservoir computing

- Special kind of artificial neural network
- State of the art performances for:
  - Real-time data processing
  - Chaotic time series prediction
  - Speech-recognition
  - Nonlinear communication channel equalisation
  - Financial forecasting
- Machine learning computationally lighter than the majority of artificial neural networks
- Scheme imposes very few constraints
  $\Longrightarrow$ implementation in physical systems possible !

Mathematical model

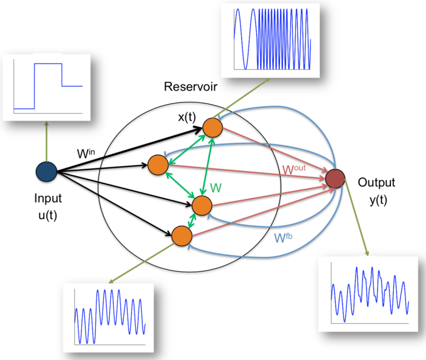
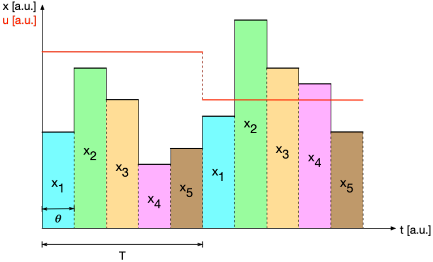


Figure: [BFP12]

- $\mathbf{x}$: state vector (activation levels of the neurons)
- u : input signal
- y : output signal
- $\mathbf{W}^{\text{in}}$: input matrix
- $\mathbf{W}$: connection matrix
- $\mathbf{W}^{\text{out}}$: output matrix

$$\mathbf{x}(n+1) = \mathbf{f}\left(\mathbf{W}^{\text{in}} u(n+1) + \mathbf{W}\mathbf{x}(n)\right)$$
$$y(n+1) = f^{\text{out}}\left(\mathbf{W}^{\text{out}}\mathbf{x}(n+1)\right)$$

Photonic reservoir computing



- So far in optical systems, only **Time Division Multiplexing** of the neurons
- Two main families of optical encoding of the neurons:
  - In the intensity of the light : $x_i = |E_i|^2$
  - In the phaser of the electric field : $x_i = E_i$

Numerical simulations - NARMA10

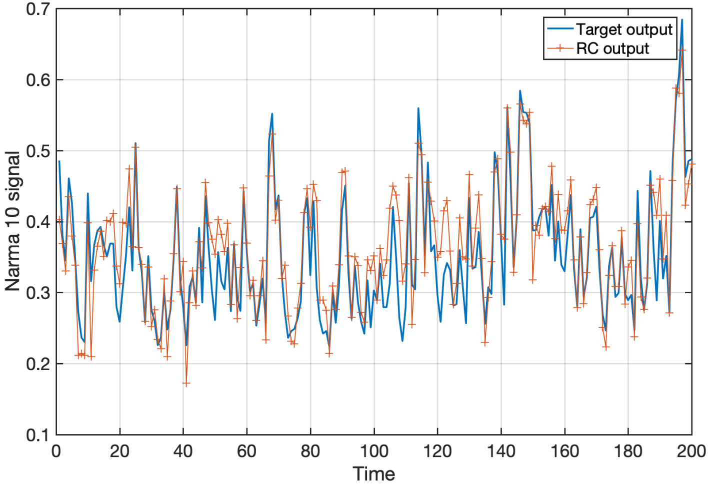


Figure: Simulation with 50 neurons. Normalised Mean Square Error of 0.1541.

Numerical simulations - nonlinear channel equalisation

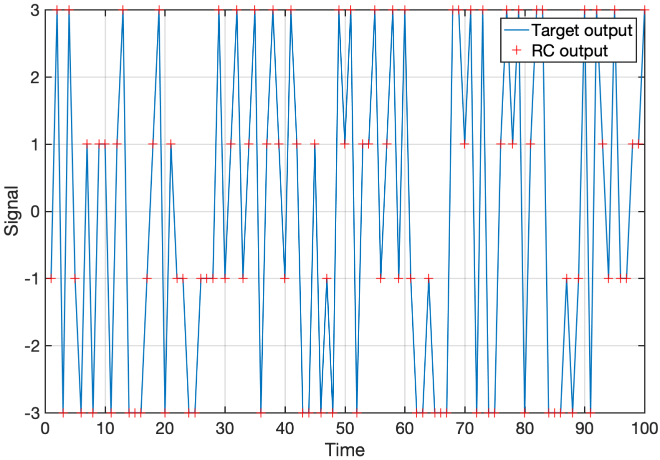
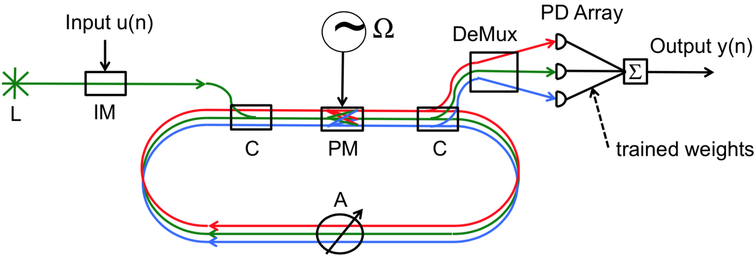


Figure: Simulation with 50 neurons. Signal-to-Noise Ratio of 32 dB. Signal Error Rate of 5×10^{-4}.

Outline



Input u(n)
Ω
DeMux
PD Array
Output y(n)
Σ
L
IM
C
PM
C
trained weights
A

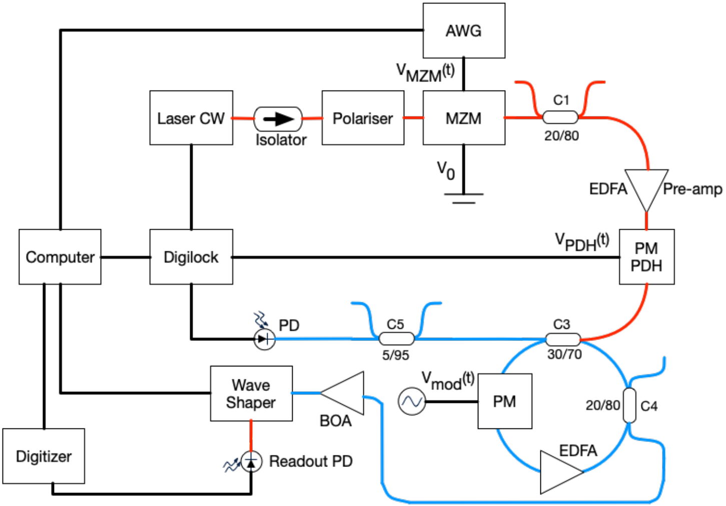
Frequency coupling of the neurons

Mathematical model

Outline

Interferometry

Experimental setup



Transfer function of the cavity

Classical cavity stabilisation

Pound-Drever-Hall technique

Pound-Drever-Hall technique for the reservoir cavity

Cavity stabilisation performances

Results

Outline

Erratum

Conclusion

References

[BFP12] A. Bernal, S. Fok, and R. Pidaparthi. "Financial Market Time Series Prediction with Recurrent Neural Networks". In: (2012). URL: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.278.3606&rep=rep1&type=pdf.