Integrated photonic pillar scatterers for speeding up classification of cell holograms

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Flow cytometry enables high-speed sorting of different kinds of cells flowing in a fluidic channel

- Obtains information about the cell optical structure by lighting it with coherent light and acquiring its interference pattern (hologram)
- Allows for label-free classification without altering the cells, but image reconstruction is computationally expensive (major limit to sorting speed)

We designed a passive integrated photonic stage to speed up machine learning classification of cell holograms.

A cell hologram is determined by

- Small refractive index contrast: 
  n(cell)=1.37 
  n(water)=1.34
- Negligible absorption

The information is encoded in the optical phase of the light scattered by a cell

The transfer function between the optical phase and the optical intensity, which is measured by a detector, is of a sinusoidal nature

Power-independent nonlinearity available for computation

We employed a spatial analog of reservoir computing, in which the reservoir is a collection of silica scatterers that mixes the phase-encoded optical signal before applying a linear classifier.

Simulations show that the application of scatterers increases the performances of a logistic regression in the classification of cells with two different average nucleus sizes ("normal" and "cancer" cells).

In order to increase the phase-to-intensity nonlinearity with respect to different nucleus sizes, and thus the performances, the light wavelength can be decreased (UV laser) or the cell can be placed in an optical cavity (e.g. integrated Fabry-Perot cavity using Bragg reflectors).

Classification error rate on 2000 samples with 5% readout noise

Classification error rate on 1600 samples with 5% readout noise

Classification error rate on 1600 samples with 5% readout noise
Laboratoire d'Information Quantique

Dynamical Systems and Brain Inspired Computing - Program

Dynamical Systems and Brain Inspired Computing

Dates: 31 May – 2 June 2017

Location:
ULB (Université Libre de Bruxelles) - Campus Plaine - Bld de la Plaine - 1050 Brussels
(Building N.O. – 5th Level – Salle Solvay)

Program

31 May 2017

9:20-9:30  S. Massar: Welcome address
9:30-10:10  H. Jaeger (Invited Speaker): A high-speed tutorial on reservoir computing and even more

Coffee break
11:30-12:00  A. Baumbach (Invited Speakers): Training a Deep Spiking Network on the BrainScaleS Wafer-Scale System

Lunch
14:00-14:40  M. Riou (Invited Speaker): Nanodevices and Brain Inspired Computing
14:40-15:20  Raul Vicente (Invited Speaker): Comparing visual processing in biological and artificial networks: what can deep learning tell us about human perception?

Coffee break
15:50-16:30  Damien Querlioz (Invited Speaker): Exploiting the Intrinsic Timescales of Nanoelectronic Devices for Unconventional Computing

Break
17:00-18:30  Poster session

1 June 2017

9:30-10:10  Wolf Singer (Invited Speaker): Does the brain exploit the high dimensional dynamic space provided by recurrent networks for computation?
10:10-10:50  J. Sylvestre (Invited Speaker): Mechanical Computation

Coffee break
11:20-12:00  David Wolpert (Invited Speaker): TBA
12:00-12:30  Piotr Antonik (Contributed Talk): Photonic reservoir computer with output feedback for periodic pattern generation and chaotic system emulation

Lunch