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 employing digital holographic microscopy.

- 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-Pérot cavity using Bragg reflectors).