Integrated photonic pillar scatterers for speeding up classification of cell holograms

Alessio Lugnan[1], Joni Dambre[2], Peter Bienstman[1]

[1]Photonics Research Group, UGent – imec, Technologiepark 15, 9052 Gent, Belgium

[2]IDLab, UGent - imec, Technologiepark 15, 9052 Gent, Belgium

Tel: +32 9 264 3450, Fax: +32 9 264 3593, e-mail: alessio.lugnan@ugent.be

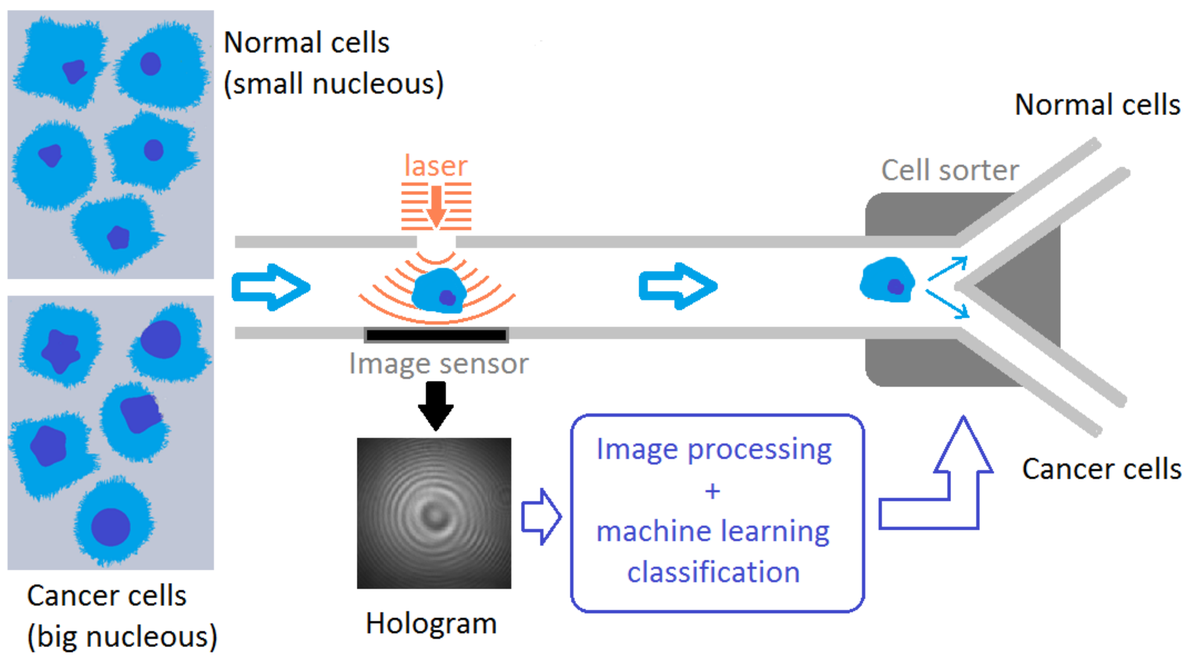
Flow cytometry enables *high-speed sorting* of different kinds of cells flowing in a fluidic channel

↓ **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

↓

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

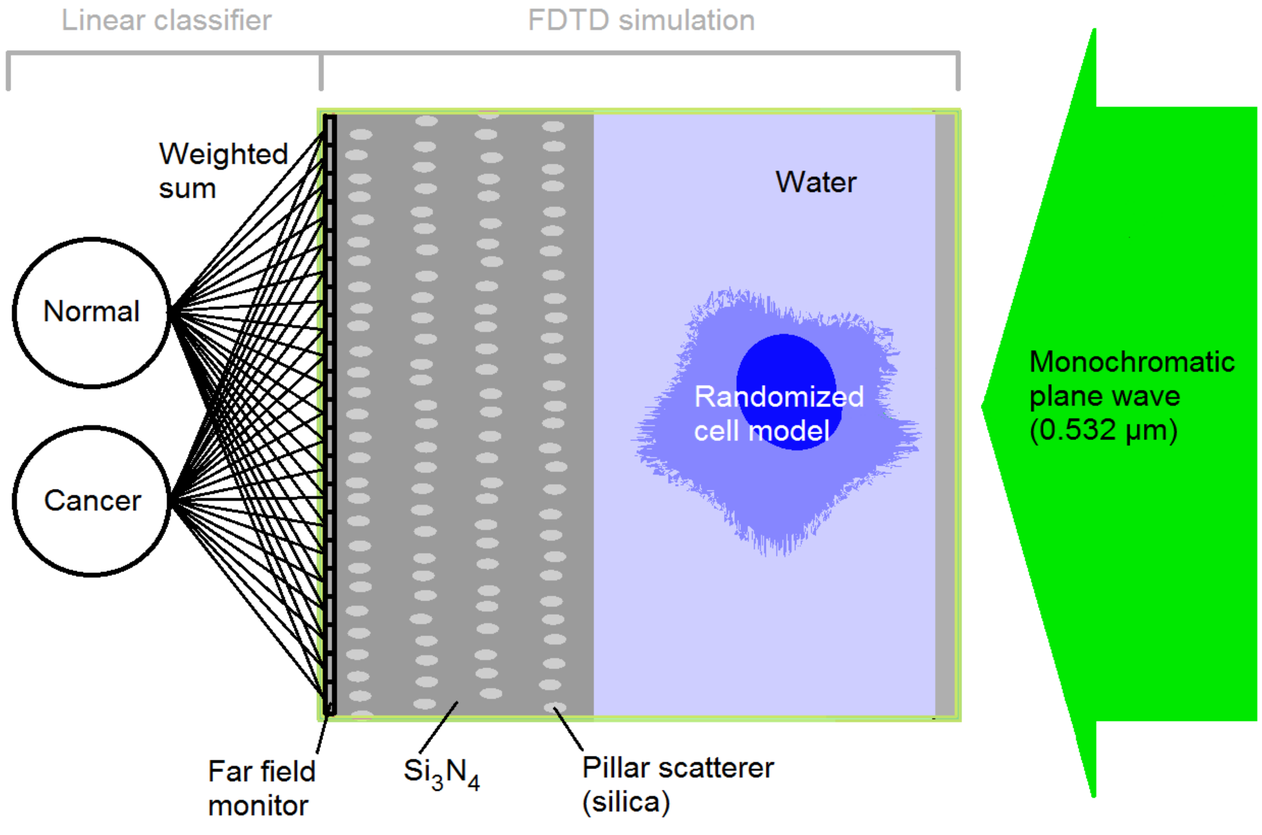
↓

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

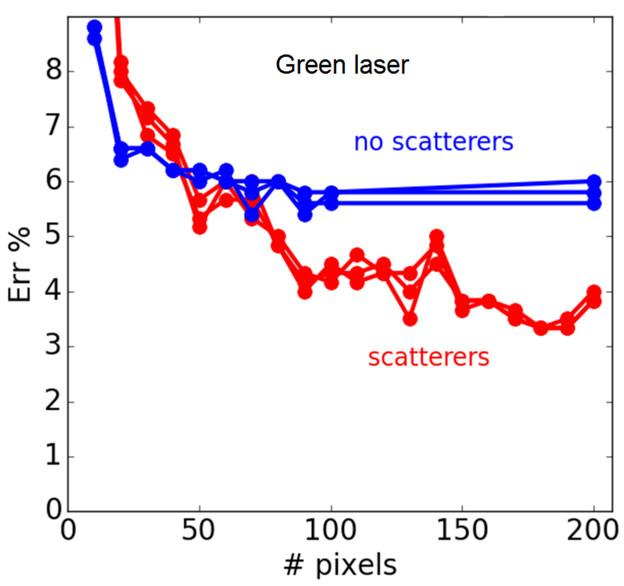
↳ **Power-independent nonlinearity** available for computation

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

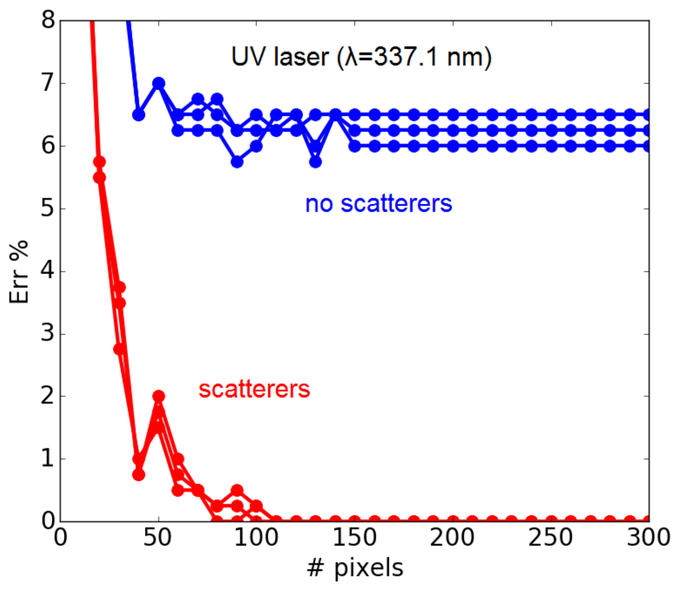
We employed a **spatial analog of reservoir computing**, in which the reservoir is a *collection of silica scatterers* that mixes the phase-encoded optical signal before applying a linear classifier.



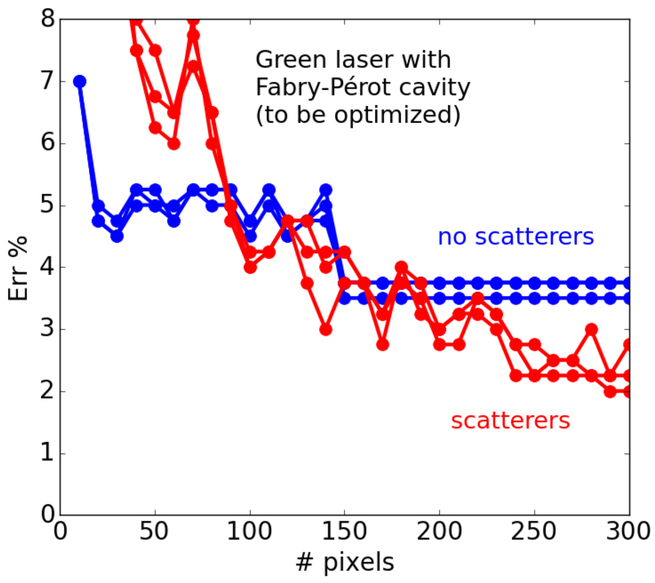
- Simulations show that the application of scatterers increases the performances of a logistic regression in the classification of cells with two different average nucleus sizes (“normal” and “cancer” cells).
- In order to increase the phase-to-intensity nonlinearity with respect to different nucleus 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).



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