LABORATORY OF NANOSCALE BIOLOGY

EPFL STI LBEN
Bâtiment BM 5.134
Station 17
CH-1015 Lausanne

Telephone
Fax
e-Mail
Site web http://lben.epfl.ch/

3D parameter free resolution estimation

The laboratory of nanoscale biology (LBEN) at EPFL is offering a semester (master) project related to the resolution estimation of 3D imaging datasets.

As he was studying the ultimate limit of optical microscope in terms of resolution (i.e. the smallest resolvable distance between two ideal point sources), Ernst Abbe understood in 1983 that the fundamental limit was related to the wave nature of light and that it was impossible to resolve any structure smaller than half the wavelength of the light used to illuminate the sample (λ/2). However, Ernst Abbe could not foresee the astonishing improvement of optical sensor, light sources and most importantly fluorescent labels. About 20 years ago, it was realized that that by being able to switch molecules on or off (stochastically or via stimulated emission), it was possible to localize molecules with a resolution far beyond the Abbe limit.

At that moment a new research field, called super-resolution microscopy, emerged, with new methods such as STimulated Emission Depletion (STED), STochastic Optical Reconstruction Microscopy (STORM) and many more. One aspect of super-resolution microscopy is that the final resolution is now not only a related to the wavelength but is also a function of the photo-physical properties of the fluorescent label and laser illumination power. Therefore, there is a need for a universal tool that would be able to estimate the resolution of any image, super-resolution or not.

Recently we published a new method for image resolution estimation. The method is parameter free and exploits the phase information contained in the Fourier space of the image. Through the calculation of many partial phase correlation of the image with a filtered version, we are able to reliably extract the frequency support of any image, that is the highest frequency with significant contrast with respect to noise.

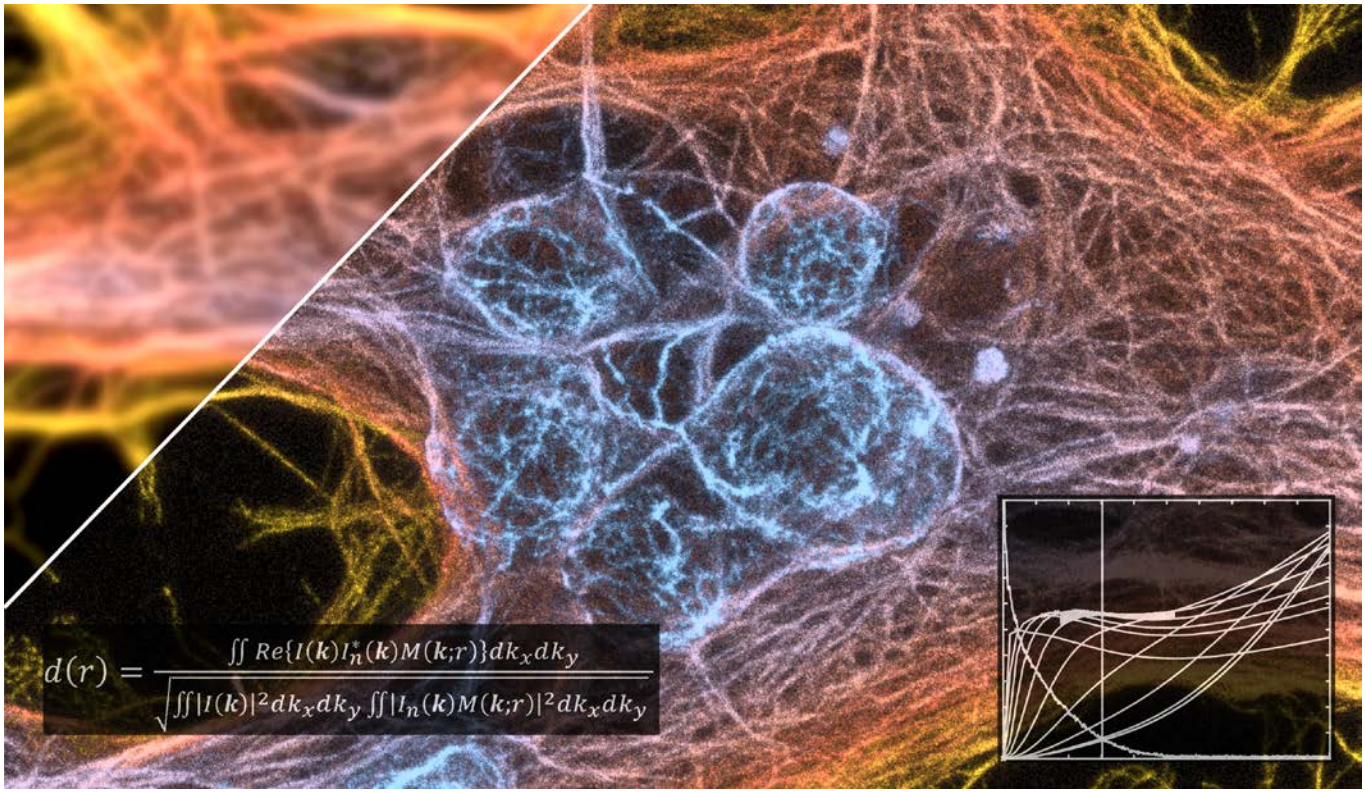

Figure 1. Illustration of the method where the formula for d(r) is used to compute several decorrelation curves which allows then to estimate the image resolution.

So far we demonstrated the ability of the method to estimate the global, local and sectorial resolution of various cell samples and we would like to extend the method in the third dimension. This extension presents several problems that the student will have to understand and overcome, such as limited axial sampling, plane to plane coregistration, increased computational complexity, etc…

The task of the student will be to implement the 3D version of the algorithm based on the current implementation (first in Matlab and then Java). The student will also have to investigate several options for processing optimization (code refactoring, GPU implementation, minimizing the number of correlations to be computed) due to the large amount of data to be processed inherent to volumetric imaging.

Skills: Knowledge in signal and image processing, Matlab, Java and basics of optical imaging,

Recommended courses: Image Processing, Signals and Systems I & II, linear algebra, analysis
Assistant: A. Descloux (adrien.descloux@epfl.ch)
Superviser : Prof. Aleksandra Radenovic (aleksandra.radenovic@epfl.ch)