Closed Loop Multi Conjugated Adaptive Optics in Microscopy Using Deformable Lenses

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It is often the case in microscopy that the image contrast is degraded by aberrations usually arising from sample inhomogeneities or a refractive index mismatch in the focusing path.
Adaptive Optics tries to eliminate or reduce these aberrations by placing a deformable optical element in a conjugated plane of the pupil of the microscope.
One of the major limitations in integrating AO systems in a microscope lies in the complexity of the setup that the use of a deformable mirror or a spatial light modulator imposes. In addition to correct for field-dependent aberrations more deformable elements conjugated to different planes are needed, but the system complexity increases exponentially.
For the same reason, the use of a wavefront sensor it is often avoided, and sensorless methods are used instead with the downside of not being able to measure the aberrations.
We want to present a new method capable of measuring aberrations in every point of the sample with a spatial resolution theoretically limited by the camera resolution. This gave us the possibility to avoid the use of a Shack Hartmann wavefront sensor and still be able to correct for the field dependent aberrations in a closed loop multi conjugated adaptive optics (MCAO) system using two deformable lenses. The use of deformable lenses is keystone in this setup because permits to place all the deformable elements we need without any significant change in the microscope setup.

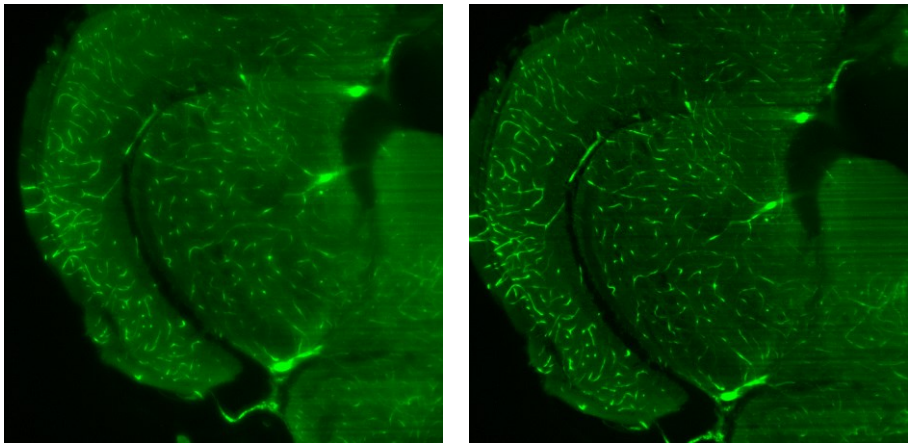

Figure 1 - Example of an uncorrected (left) and corrected in the whole Field of View (right) Cleared zebrafish brain sample