SYSTEM DESIGN ASPECTS OF A STRUCTURED ILLUMINATION MICROSCOPE

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1. INTRODUCTION
Structured illumination microscopes (SIM) use a combination of image processing and non-linear response in amplitude from a fluorescent sample to generate optical images whose frequency cut-off is beyond what would be possible to achieve with a wide field optical microscope having an identical effective numerical aperture. Although technically misleading some researchers prefer to call this effect “breaking the diffraction limit”. In this work we look at system design aspects of SIMs including the effect of aberrations on fringe- and in turn on reconstructed image quality, the possibility to use a fluorescent “sea” to recover the modulation transfer function of the microscope, and give details of an algorithm implemented on a GPU that permits close to real-time reconstruction of SIM images.

2. DISCUSSION
Modern microscopy methods are often based on some modification of conventional off the shelf optical microscopes, which, more often than not, are treated by researchers as black boxes due to the extreme secrecy of microscope manufacturers. In SIM the microscope objective lens is used quite different than what it was designed for (Fig. 1) potentially leading to aberrations in the illumination pattern. Since most SIM implementations produce a set of straight fringes to illuminate the sample, the presence of certain lens aberrations will make the fringe pattern distorted. In order to demonstrate this we present simulations shown in Fig. 2. The original object (top left) is illuminated by a perfect fringe pattern (top right) and a distorted fringe pattern (bottom right). Note that the distorted fringe pattern does not correspond to any specific aberration term. The one illuminated with perfect fringe pattern is faithfully reconstructed (not shown) while the one having the distorted fringe pattern is reconstructed with significant artifacts (bottom left). This talk will look at the effect of most common lens aberrations on the fringe pattern and thus the quality of reconstruction. It will also discuss if it is possible to establish a fringe generation strategy that permits more robust reconstruction. The talk will also describe in detail an implementation of a reconstruction algorithm on a graphical processing unit (GPU), which permits close to video rate SIM image reconstruction.