less than 1ms by using a fast steering mirror. To further minimize the DM control time, open loop control to update the DM using the wavefront measurement and an accurate DM model could be applied after the calibration of the DM. In this case, the correction speeds would be only limited by the wavefront measurement. Applying Field Programmable Gate Arrays (FPGA) in wavefront measurement will be beneficial for time-critical applications. For tissues with small isoplanatic patches [23], the guide-star searching algorithm could find the optimal local guide-star in each patch. The large field of view with correction can be provided by stitching those patches together. Finally, the application of FPCGS also simplifies the design of the hardware and software. Due to sharing a similar concept of wavefront sensing based on a laser guide-star in astronomy and vision science, the knowledge of AO application in those fields will facilitate its application in microscopy. The method we present here can be also applied to other fluorescence microscopes, such as wide-field microscopy, multi-photon microscopy or super-resolution microscopy.

Table 1. Zernike Polynomials used in this paper

Index (j)	$Z_n^m(\rho,\theta)$	Aberration mode
1	1	Bias
2	$2r\cos(\theta)$	Tilt x
3	$2r\sin(\theta)$	Tilt y
4	$\sqrt{3}(2r^2-1)$	Defocus
5	$\sqrt{6}r^2\cos(2\theta)$	Astigmatism x
6	$\sqrt{6}r^2\sin(2\theta)$	Astigmatism y
7	$2\sqrt{2}(3r^3-2r)\cos(\theta)$	Coma x
8	$2\sqrt{2}(3r^3-2r)\sin(\theta)$	Coma y
9	$2\sqrt{2}r^3\cos(3\theta)$	Trefoil x
10	$2\sqrt{2}r^3\sin(3\theta)$	Trefoil y
11	$\sqrt{5}(6r^4-6r^2+1)$	Primary Spherical
12	$\sqrt{10}(4r^4-3r^2)\cos(2\theta)$	Secondary Astigmatism x
13	$\sqrt{10}(4r^4-3r^2)\sin(2\theta)$	Secondary Astigmatism y
14	$\sqrt{10}r^4\cos(3\theta)$	Tetrafoil x
15	$\sqrt{10}r^4\sin(3\theta)$	Tetrafoil y

Acknowledgments

We acknowledge technical support from Ben Abrams in the UCSC Life Sciences Microscopy Center. We would also like to thank T. Megraw for the EGFP-Cnn flies and C. Sunkel for the GFP-Polo flies. This material is based upon work supported by the National Science Foundation (NSF) under Award No. 0852742, the W.M. Keck Center for Adaptive Optical Microscopy at UC Santa Cruz and the California Institute for Regenerative Medicine (CIRM), Grant #RT1-1095-1. The contents of this publication are solely the responsibility of the authors and do not necessarily represent the official views of CIRM or any other agency of the State of California. This work was also supported by a grant to W. S. from the National Institutes of Health (GM44757).