MAE Praxair Seminar

Designing a Wide Field Microscope: An Optomechatronics Approach using Adaptive Optics

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Adaptive optical elements such as deformable mirrors have long been used in astronomical science to correct for atmospheric aberrations. The high cost of piezoelectric actuated mirrors had prevented the broader adoption of this technology until the recent emergence of the MEMS based deformable mirrors. These MEMS mirrors are much less costly and are now enabling many new applications in bio-imaging, including retina imaging, optical coherence tomography, and wide field microscopy.

Our work in this area is motivated by the limitation of traditional microscopes in terms of the trade-off between the field of view and resolution. This limitation particularly hampers the imaging of moving biological specimens and microorganisms. The traditional solution of using a moving stage cannot address highly dynamic or multi-organism observations and also disturbs the sample under observation. We introduce a low inertia high speed scanning mirror as the moving element to achieve a wide field of observation.

Imaging at the off-axis, however, introduces significant aberrations. We show that by synergistically designing the scan lens together with a MEMS deformable mirror, it is possible to correct for the off-axis aberrations despite the displacement constraint and membrane dynamics of the deformable mirror. The high speed scanning motion also introduces vibration in the scanning mirror. We apply the iterative refinement based vibration suppression technique that we developed for semiconductor manufacturing to significantly improve the response of a commercial scanning mirror.

Previous work on imaging motile organisms has primarily focused on tracking only one organism at a time within a single field of view. We have demonstrated that the ASOM can simultaneously track multiple moving organisms at both the full animal and single cell level, achieving true multi-scale observation. In studies requiring targeted probing, manipulation, external stimulation, or sensing, the ability of the microscope to automatically monitor several regions of the specimen without agitating the workspace is particularly advantageous. A scanning illumination system that can be rapidly turned on and off minimizes unnecessary light exposure to the specimen.

The basic ASOM technology has now been licensed to and commercialized by Thorlabs, Inc. The current ASOM design can simultaneously achieve a large field of view (40mm diameter) and high optical resolution (about 1um). We are now extending the capability of ASOM to include fluorescence imaging and laser injection for manipulation and actuation.

Bio

John Ting-Yung Wen received his B.Eng. from McGill University in 1979, M.S. from University of Illinois in 1981, and Ph.D. from Rensselaer Polytechnic Institute in 1985, all in Electrical Engineering. From 1985-1988, he was a member of technical staff at the Jet Propulsion Laboratory. Since 1988, he has been with Rensselaer Polytechnic Institute where he is currently a professor in the Department of Electrical, Computer, and Systems Engineering with a joint appointment n the Department of Mechanical, Aerospace, and Nuclear Engineering. He was appointed in 2005 as the Director of a New York State sponsored interdisciplinary research center, Center for Automation Technologies and Systems (CATS). Dr. Wen's research interest lies in the general area of dynamical systems modeling, control, and planning with applications to optomechatronics systems, material processing, and distributed control. Dr. Wen is a Fellow of IEEE.

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