DRIVING MEMS MIRRORS FAR BEYOND THEIR SPECIFICATIONS
FOR FAST, PRECISE, SYNCHRONIZED LASER SCANNING

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ABSTRACT: Confocal, two-photon, and light-sheet microscopy require fast, accurate laser scanning. Microelectromechanical system (MEMS) mirrors enable high speed scanning [1], but scanning a mirror near or above its resonance frequency is typically limited to sinusoidal motion. Using a novel deconvolution-based feedback system, we demonstrate flexible, user-specified motion at or above the device’s resonant frequency. We also demonstrate precise synchronization of multiple MEMS devices, important for applications like rescan confocal microscopy [2].

Our devices are 1200 µm diameter mirrors with +/- 4º angular range and ~4 kHz resonant frequency. We measure each mirror’s response to input voltages via strobed illumination. Using measured impulse responses, we calculate inputs to produce our (arbitrary) desired output, via iterative deconvolution [3]. Due to nonlinearity, the output deviates from the response predicted by linear convolution. We use the same algorithm and impulse response to calculate an input that will produce this error, and subtract it from the previous input voltage to produce the next input voltage. This process converges rapidly to an input which produces the desired waveform with <0.04 degree accuracy after <10 iterations. We also demonstrate synchronization of independent mirrors to <0.04 degree accuracy.