Seeing Cells Without a Lens: Compact 3D Digital Lensless Holographic Microscopy for Wide-field Imaging

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Optical microscopy is an essential tool for biomedical discoveries and cell diagnosis at micro- to nano-scales. However, conventional microscopes rely on lenses to record 2-D images of samples, which limits in-depth inspection of large volumes of cells. This research project implements a novel 3-D lensless microscopic imaging system that achieves a wide field of view, high resolution, and an extremely compact, cost-effective design: the Digital Lensless Holographic Microscope (DLHM).A lensless holographic microscope is built with only a light source, a sample, and an imaging chip (with other non-essential supporting structures). The entire setup costs $500 to $600. A series of MATLAB-based algorithms were designed to reconstruct phase information of samples simultaneously from the recorded hologram with built-in high-resolution and phase unwrapping functions. This produces 3-D images of cell samples.The 3-D cell reconstruction of biological samples maintained a comparable resolution with conventional optical microscopes while covering a field of view of 36.2mm^2, which is 20-30 times larger. While most microscopes are extremely time-consuming and require professional expertise, the lensless holographic microscope is portable, low-cost, high-stability, and extremely simple. This makes it accessible for point-of-care testing (POCT) to a broader coverage, including developing regions with limited medical facilities.

Awards Won:

Fourth Award of $500