Supplementary Information

OpenLM: An Open-Source Pixel Super-Resolution Platform for Lens-Free Microscopy with Applications in Bacterial Growth Monitoring and Deep Learning-based Bacterial Detection

Weiming Xu[1,2], Samiha Ahmed[1,2], Majed Althumayri[1,2,4], Azra Yaprak Tarman[1,2], Mert Kerem Ulku[1,2], Karston Yong[1], Muhammed Veli[3,], and Hatice Ceylan Koydemir[1,2,*]*

Table S1. Cost of components in OpenLM.

Component	Quantity	Price
Raspberry Pi Camera Module 2	1 unit	$14.99
Thorlab 532 nm Filter	1 unit	$164.67
Adafruit DotStar 8x8 LED array	1 unit	$24.95
Small Neodymium Magnets	4 units	$0.08
Raspberry Pi 4B	1 unit	$75
PLA for 3D Printed Casing	187 g	$4.68
	Total	$284.37

Table S2. Comparison of image-based bacterial detection techniques for portable devices

Technique	Resolution (µm)	FOV without moving sensor (mm²)	Light Source	Supporting Components	Limitation	Reference
Foldable microscope	0.77 – 1.9	0.013 – 0.84	LED	Lens	Limited FOV	37
Subpixel perspective-sweeping microscopy	0.66	24	LED	None	Intensity only, absorption-dependent	39
Ptychography	0.488	30	Laser	Diffuser	Requires an additional diffuser	40
Optofluidic microscopy	0.49	0.018	Halogen lamp	Aperture array layer, microfluidic system	Requires additional hardware and flow control	43
Digital holography	***0.87***	***10.16***	***LED***	***None***	***Twin-image artifact***	***This study***

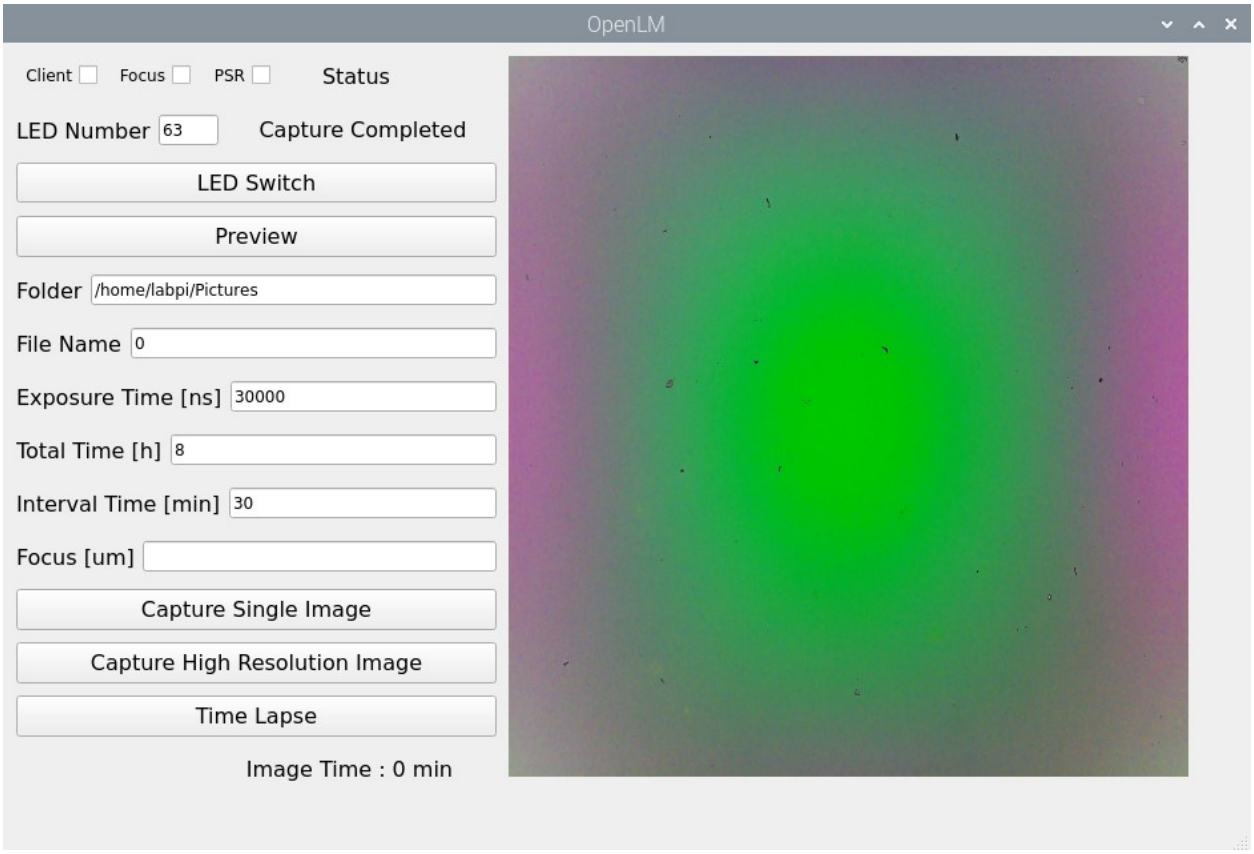

Figure S1. Device control application running on a Raspberry Pi, shown after capturing a single hologram. The file is available https://github.com/xuwimming/OpenLM.

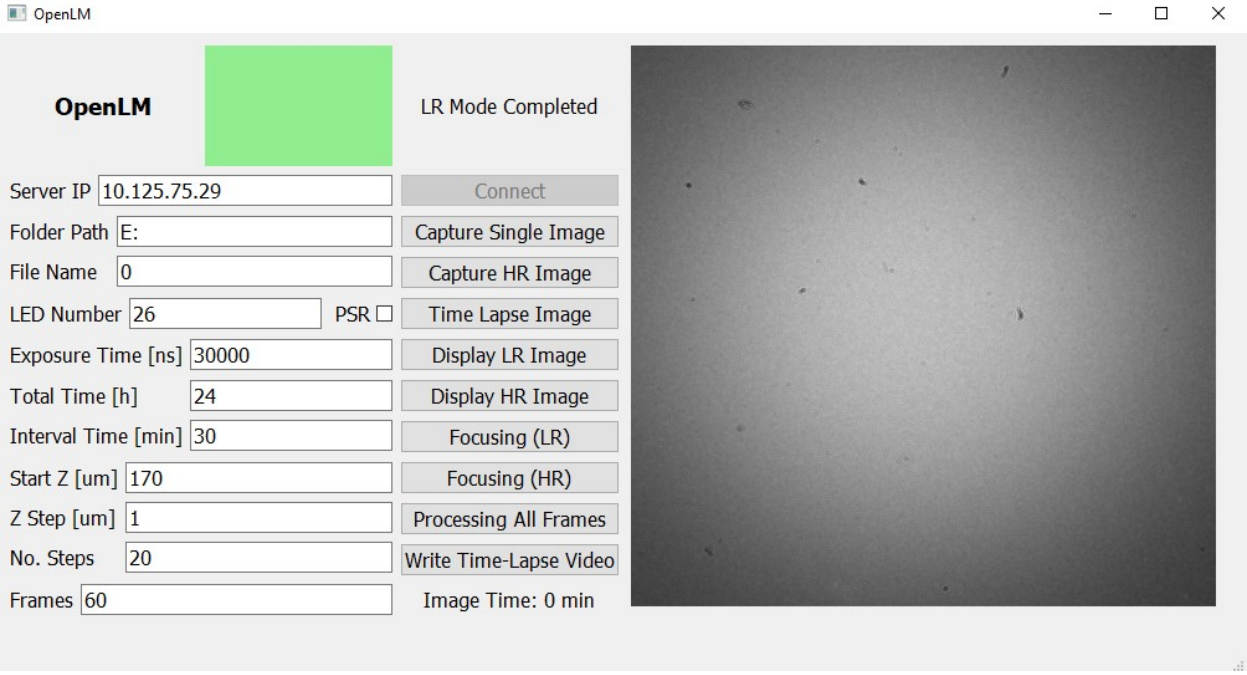

Figure S2. Device control application running on a Windows desktop, shown after capturing and reconstructing a single hologram. The file is available https://github.com/xuwimming/OpenLM.

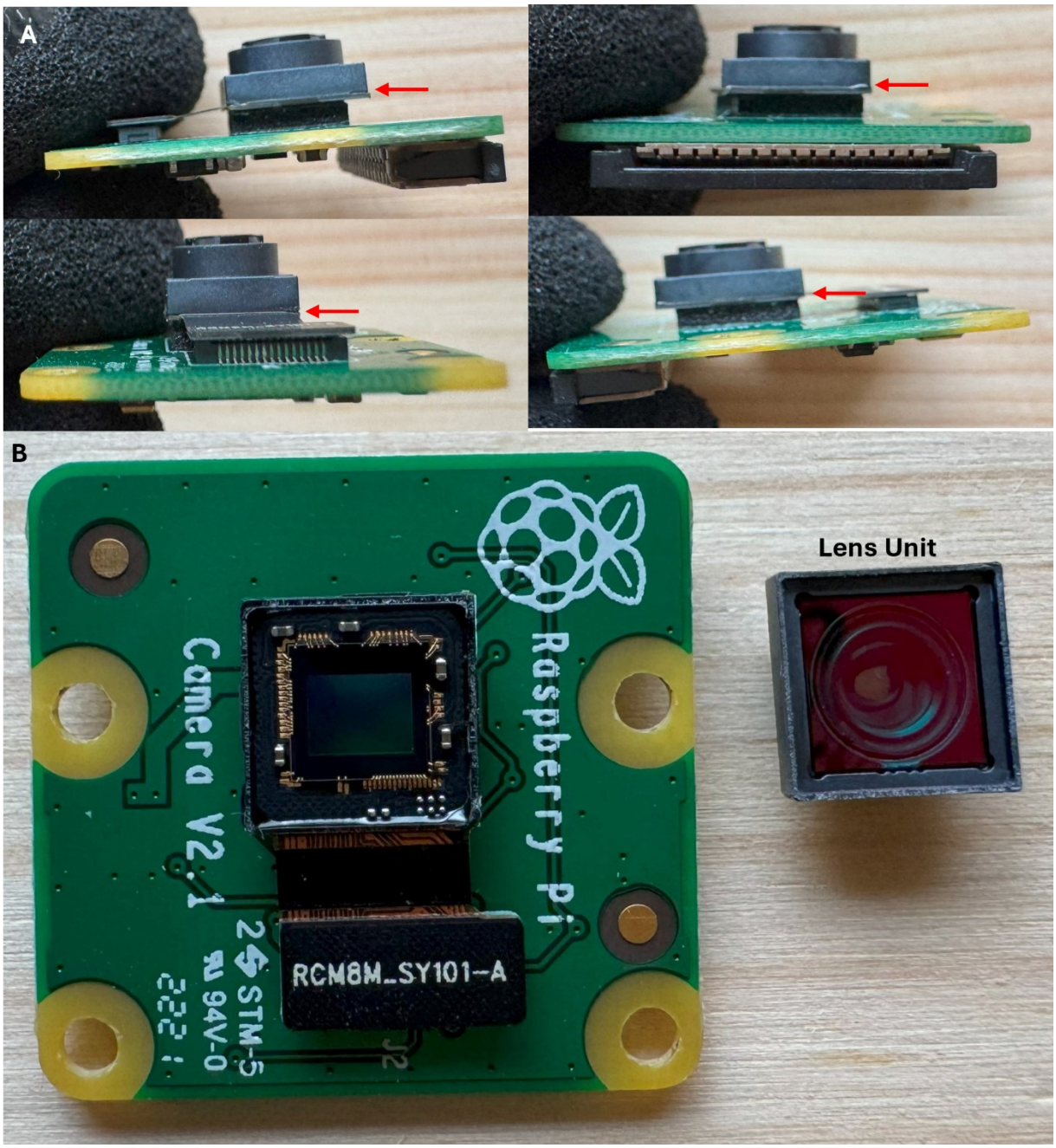

Figure S3. A) Four side views of a Raspberry Pi Camera Module 2. Red arrows indicate the glue line between the lens unit and the CMOS sensor. By carefully sliding a blade or knife along this glue line, the plastic shell can be cut, allowing the lens unit to be removed from the top of the CMOS. B) Photo of the Raspberry Pi Camera Module 2 after lens removal, showing both the exposed sensor and the detached lens unit.

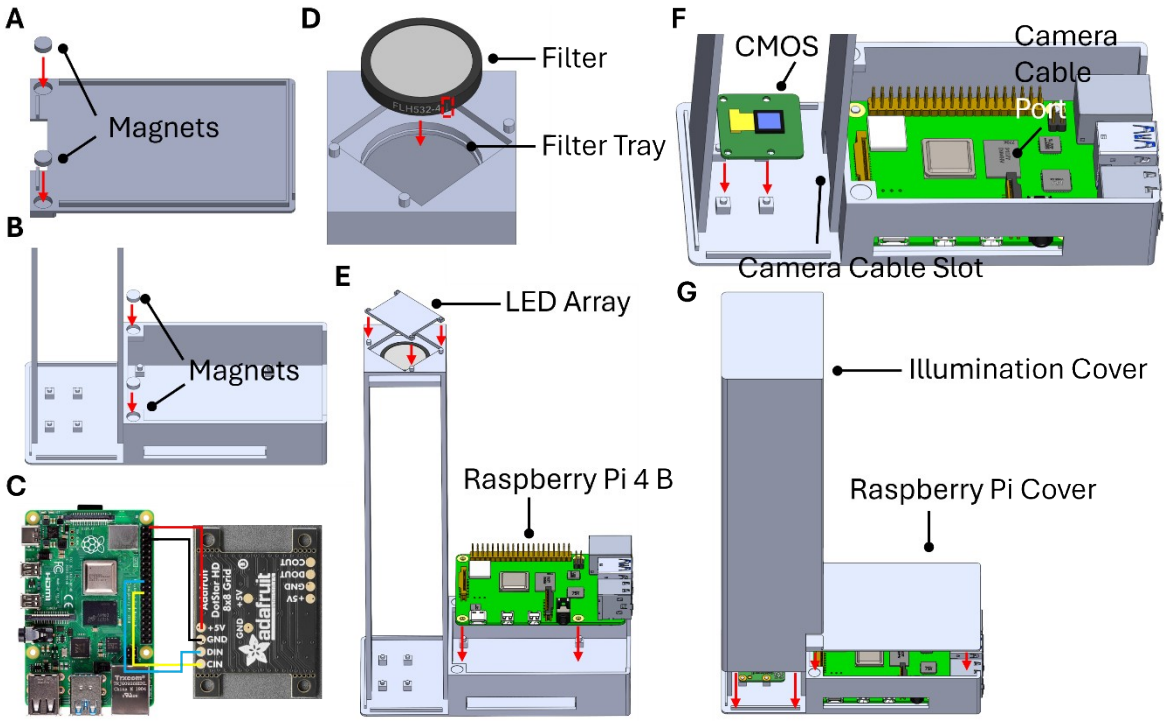

Figure S4. OpenLM Assembly Workflow. A–B) Insert four neodymium magnets into the Raspberry Pi cover and the platform holder—two in each part. C) Connect the LED array to the Raspberry Pi. D) Place the optical filter into the filter tray on the platform. E) Assemble the LED array and Raspberry Pi onto the platform. The small alignment pegs on the platform fit into corresponding holes on the LED array and Raspberry Pi 4B, securing their positions. F) Mount the camera module onto the platform. Alignment pegs will hold the module in place. The camera cable should pass through the designated cable slot and connect to the camera port on the Raspberry Pi. G) Attach the illumination cover and the Raspberry Pi cover to enclose and protect the illumination system.

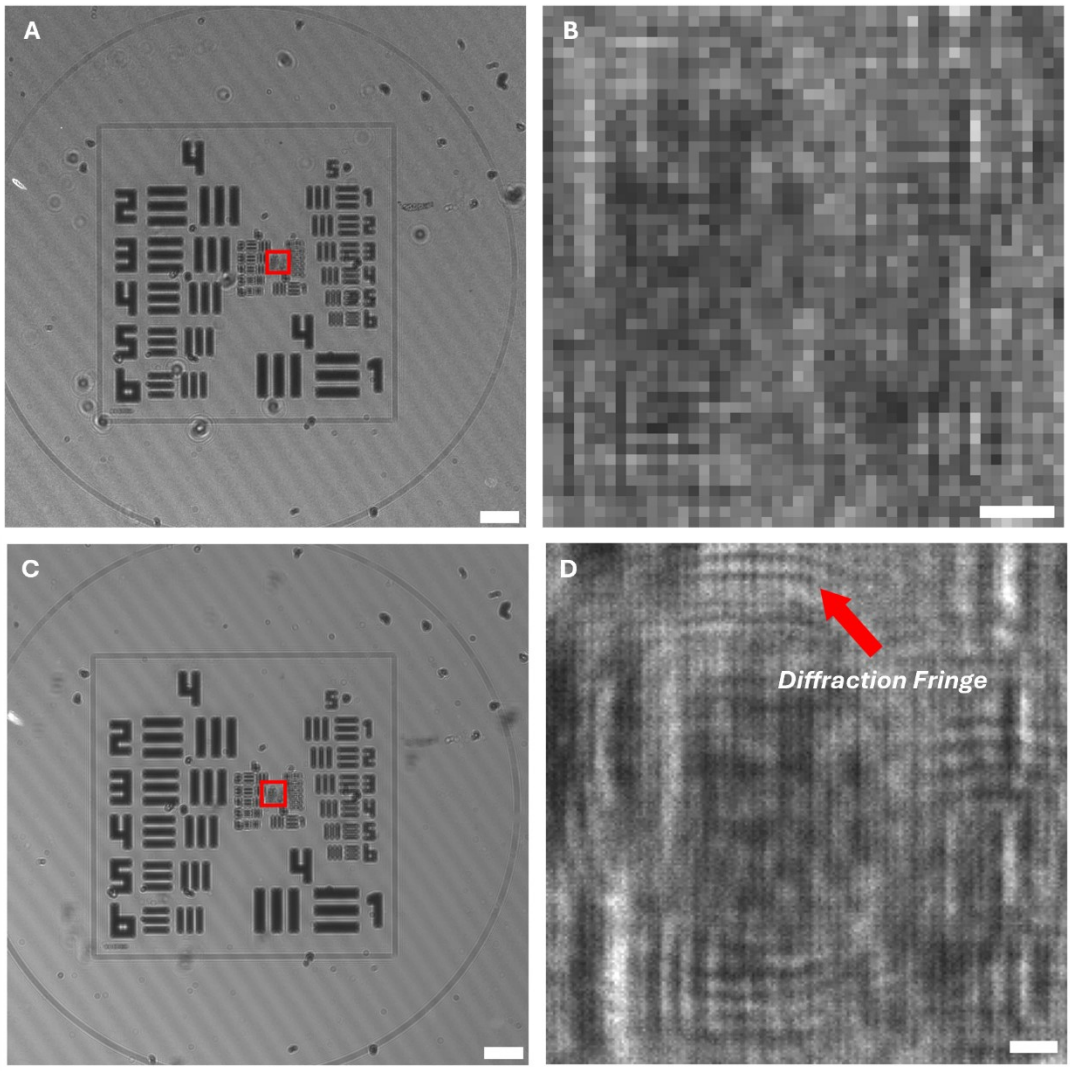

Figure S5. Comparison of resolution between a LR hologram (A, B) and a HR hologram (C, D). These four holograms correspond to the reconstructed images shown in Figure 2C. Scale bars: 100 μm (left), 10 μm (right).