Supporting Information

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SI Text

Supplementary Note 1. In this note, we briefly describe the general pixel superresolution model and solution. Detailed description can be found in ref. S1–S4.

We denote the N measured low-resolution images by $Y_k(k = 1,2\cdots N)$. These images are used to reconstruct a single improved high resolution image, denoted as X. The images are all represented by lexicographically ordered column vectors. The low-resolution image can be modeled by the following equation

$$Y_k = DHF_kX + V_k \qquad (k = 1,2\cdots N).$$

The matrix F_k stands for the subpixel shift operation for the image X. The matrix H is the pixel transfer function of the image sensor. The matrix D stands for the decimation operation, representing the reduction of the number of observed pixels in the measured images. V_k represents Gaussian additive measurement noise with zeros mean and auto-correlation matrix $W_k = E\{V_kV_k^T\}$.

The maximum-likelihood estimation of X can be described as following expression

$$\hat{X} = \mathrm{ArgMin}\left\{\sum_{k=1}^{N}(Y_k - DHF_kX)^T W_k^{-1}(Y_k - DHF_kX)\right\}.$$

And the closed-from solution for $\hat{X}$ is shown to be

$$\hat{X} = H^{-1}R^{-1}P$$

where, $R = \sum_{k=1}^{N} F_k^T D^T DF_k$, $P = \sum_{k=1}^{N} F_k^T D^T Y_k$.

It can be proved that R is a diagonal matrix and the computation complexity of this approach is $\mathrm{O}(n * \log(n))$, where n is the number of pixels.

For readers interested in building their own ePetri, a free Matlab-based superresolution software package can be downloaded at ref. S5. For a similar ePetri platform like ours, the default setup of ref. S5 can be used to get a reasonably good result.

1. Hardie R, et al. (1997) Joint MAP registration and high-resolution image estimation using asequence of undersampled images. *IEEE Trans Image Process* 6:1621–1633.
2. Elad M, Hel-Or Y (2001) A fast super-resolution reconstruction algorithm for pure-translational motion and common space-invariant blur. *IEEE Trans Image Process* 10:1187–1193.
3. Farsiu S, et al. (2004) Fast and robust multiframe super resolution. *IEEE Trans Image Process* 13:1327–1344.
4. Farsiu S, et al. (2006) Multiframe demosaicing and super-resolution of color images. *IEEE Trans Image Process* 15:141–159.
5. Farsiu, et al. (2004) MDSP Resolution Enhancement Software, http://users.soe.ucsc.edu/~milanfar/software/superresolution.html.

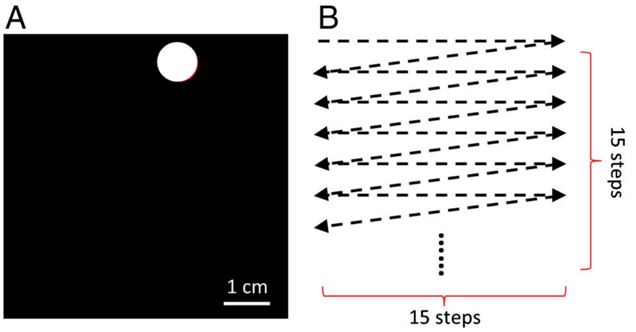


Fig. S1. (*A*) The scanning pattern on the smartphone screen, with 640 × 640 pixel size. (*B*) We use 15 × 15 steps for illumination. When the bright spot moves away from the center of smartphone screen, the readout from the image sensor chip will decease because of the large incident angle; therefore, in our setup, the bright spot size linearly increases when it moves away from the center of the screen.

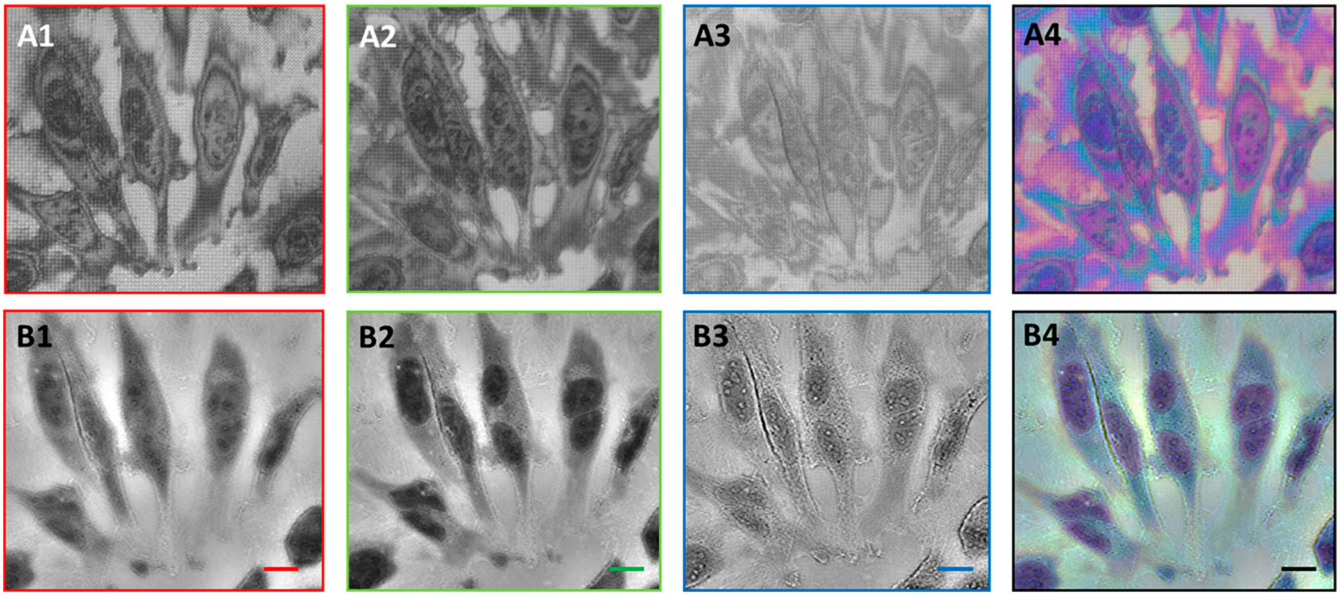


Fig. S2. The comparison between the conventional microscopy image (in reflection mode) and the image acquired by the ePetri platform. The HeLa cells were cultured on a CMOS sensor chip, fixed and stained with Giemsa. (*A1–A3*) The conventional microscopy images with red, green, and blue LED illuminations (Olympus BX41 with a 20× objective, 0.5 N.A.). *A4* is the color image based on *A1–A3*. Note that the sensor chip is not transparent, and thus these microscopy images are taken in the reflection mode. The color we saw in *A4* is due to the light interference between the sensor surface and sample. The grid pattern in *A1* to *A4* is the pixel array of the image sensor (2.2 μm pixel size). (*B1–B3*) The reconstructed high resolution images of ePetri platform under the red, green, and blue light source scanning. *B4* is the reconstructed color image based on *B1–B3*. Scale bar, 20 μm.

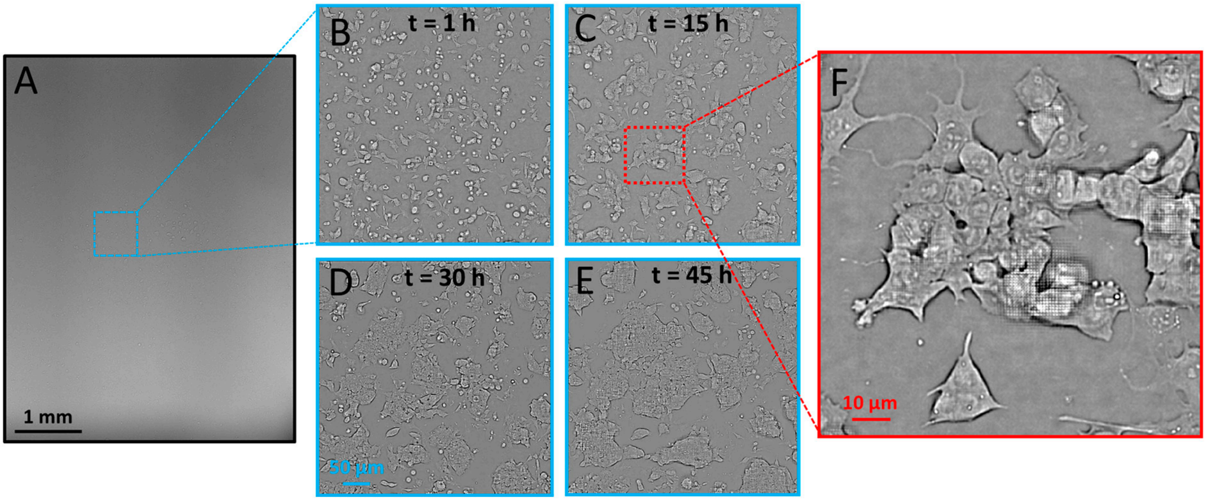
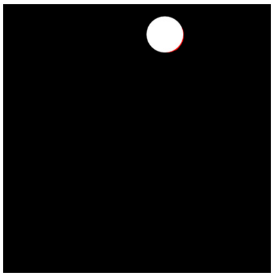
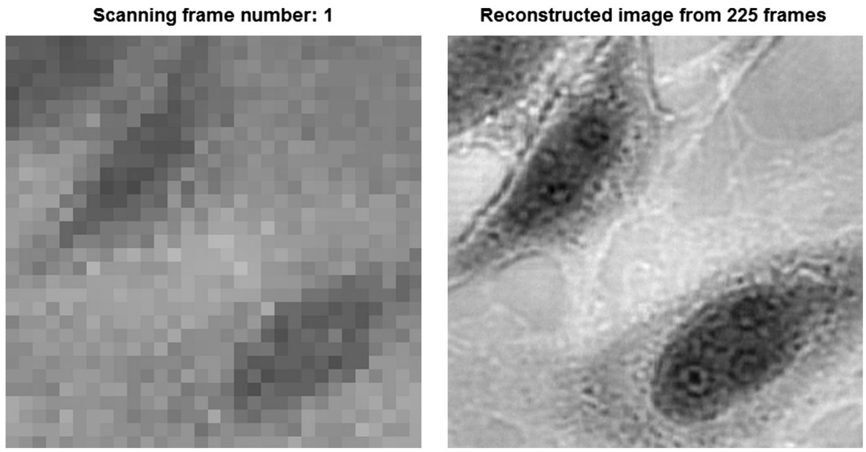


Fig. S3. Time-lapse imaging of first-stage embryonic stem cell culture on the ePetri platform. For this stage, cells were maintained in a standard stem cell medium (high glucose DMEM, supplemented with 15% FBS, L-glutamine/Pen/Strep, NEAA, sodium pyruvate, and 0.1 mM 2-mercaptoethanol) enriched with LIF (1,000 U/mL, Millipore) in order to sustain pluripotency. The media were replaced daily to resupply nutrients and maintain a proper pH level.

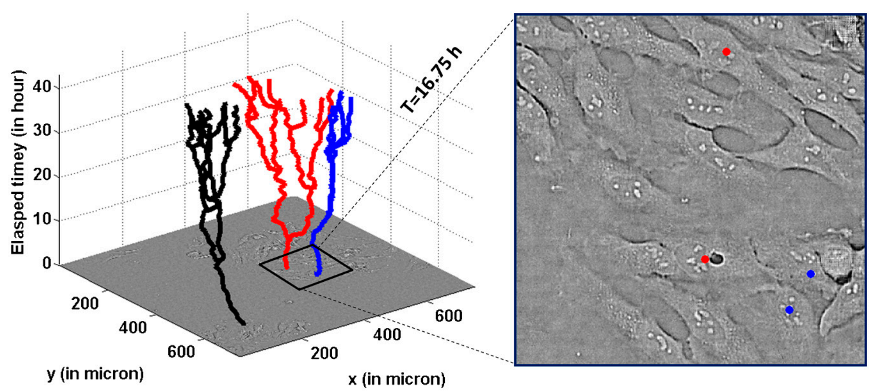


Movie S1. Scanning light pattern for the smartphone. Data corresponds to Fig. S1.
Movie S1 (MOV)



Movie S2. Acquired low-resolution image (2.2-µm pixel size) sequence for HeLa cell sample and the reconstructed high resolution image. Data corresponds to Fig. 6*B*.

Movie S2 (MOV)



Movie S3. Time-lapse cell culture imaging and cell tracking. The defocus effect in some of the images in the video is due to the cell detaching from the sensor surface when cell division occurs. The quality of images may be degraded in video due to the compression.

Movie S3 (MOV)