Electronic Supplementary Material (ESI) for Analyst.

Supplementary Information

A critical evaluation of compressed line-scan Raman imaging

Yajun Yu,*[a] Yichuan Dai,[a] Xianli Wang,[a] Kaiqin Chu,[b] and Zachary J. Smith*[a]

[a]*Key Laboratory of Precision Scientific Instrumentation of Anhui Higher Education Institutes, Department of Precision Machinery and Precision Instrumentation, University of Science and Technology of China, Hefei, Anhui, China.*

[b]*Suzhou Institute for Advanced Research, University of Science and Technology of China, Suzhou, Jiangsu, China.*

**E-mail: yajunyu@ustc.edu.cn; zsmith@ustc.edu.cn*

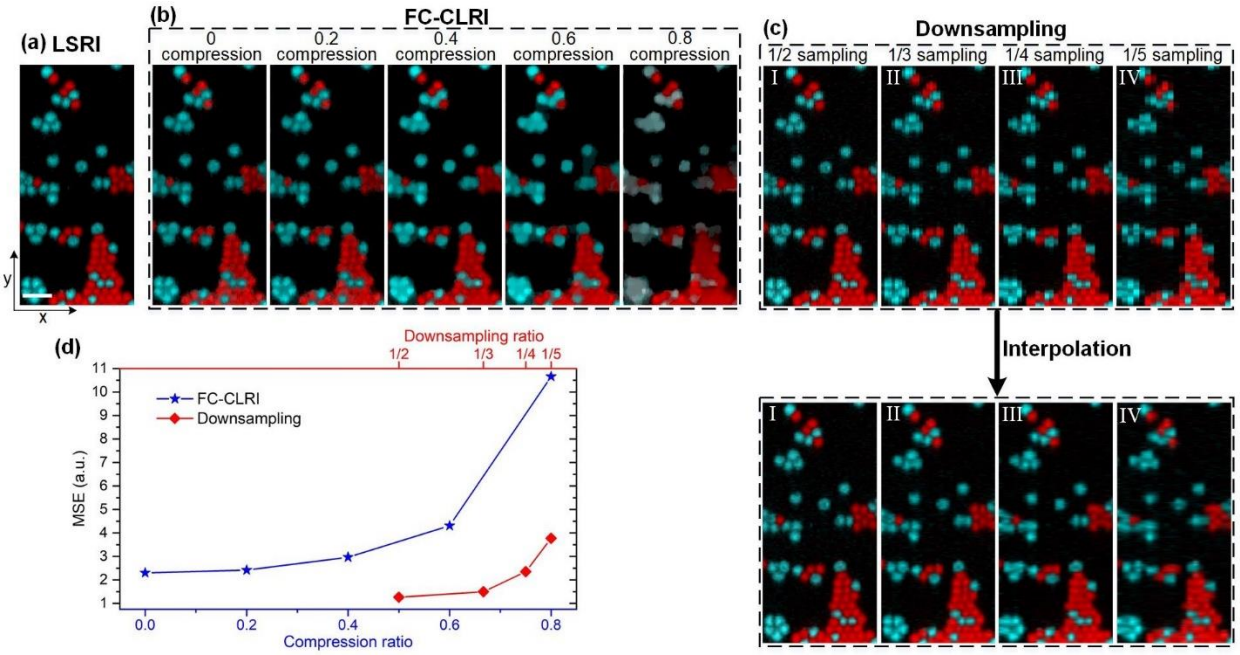

Fig. S1 (**a**) Images of 1 μm PS (red) and 1 μm PMMA (cyan) beads measured by LSRI. Scale bar is 4 μm. The same sample measured by (**b**) FC-CLRI with 0, 0.2, 0.4, 0.6 and 0.8 compressions. (**c**) The same sample downsampled by a factor of 2, 3, 4 and 5, as well as their corresponding interpolated images. (**d**) MSE of FC-CLRI based on the reference beads image of LSRI with respect to 5 compression ratios, while MSE of downsampling-interpolated images with respect to 4 downsampling ratios.

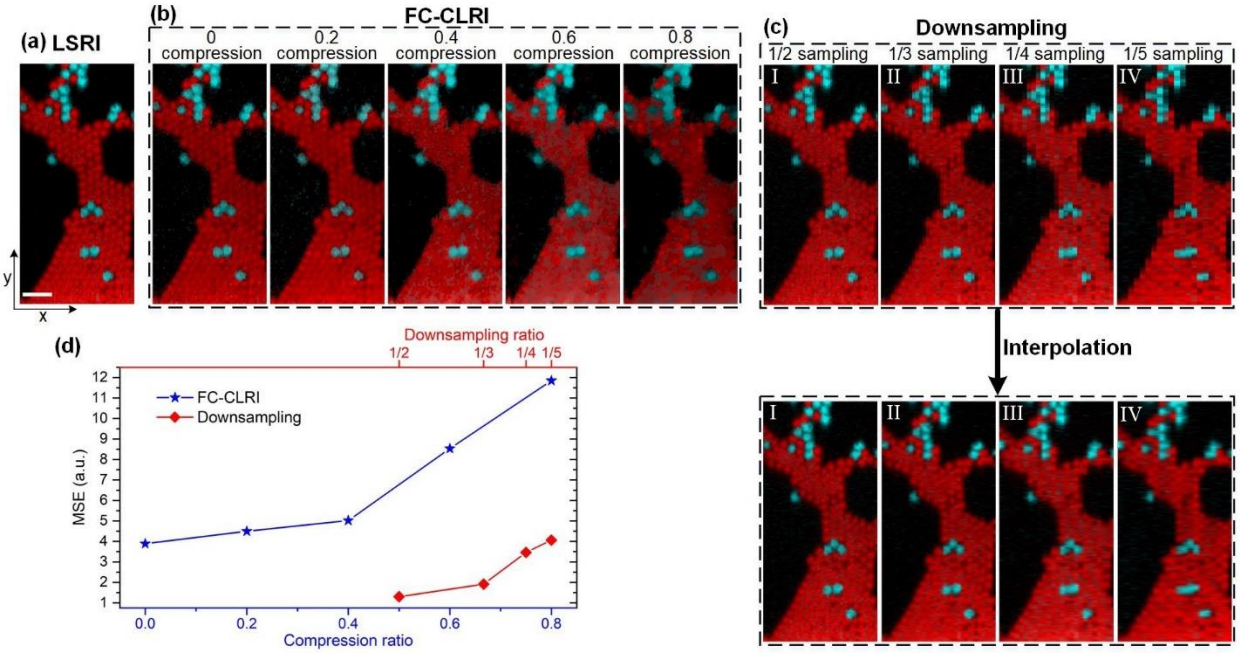

Fig. S2 Same caption as in **Fig. S1** for a different sample.

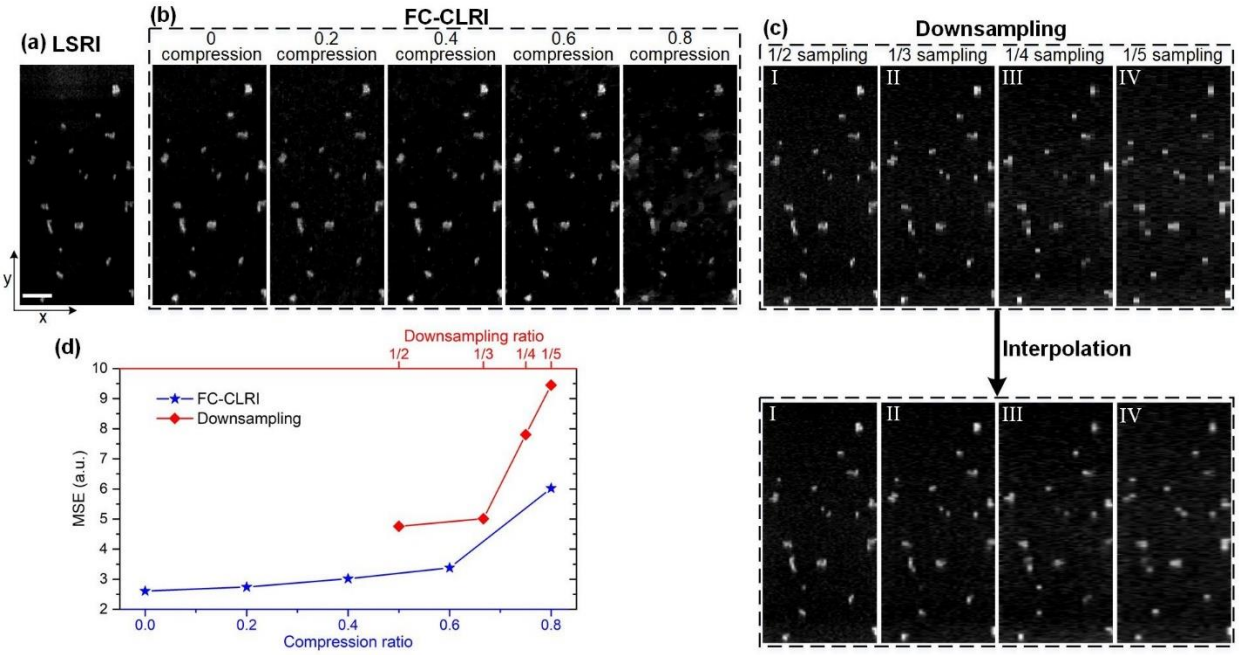

Fig. S3 (**a**) Images of 300 nm PS beads measured by LSRI. Scale bar is 4 μm. The same sample measured by (**b**) The same sample measured by FC-CLRI with 0, 0.2, 0.4, 0.6 and 0.8 compressions. (**c**) The same sample downsampled by a factor of 2, 3, 4 and 5, as well as their corresponding interpolated images. (**d**) MSE of FC-CLRI based on the reference beads image of LSRI with respect to 5 compression ratios, while MSE of downsampling-interpolated images with respect to 4 downsampling ratios.

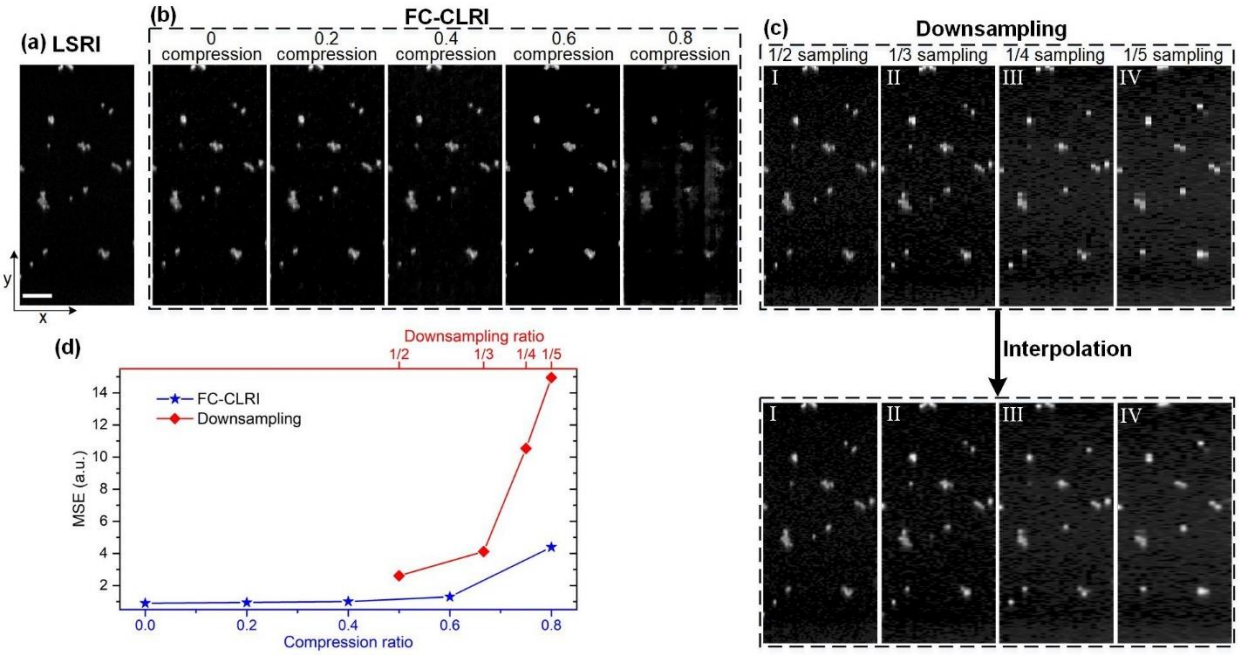

Fig. S4 Same caption as in **Fig. S3** for a different sample.

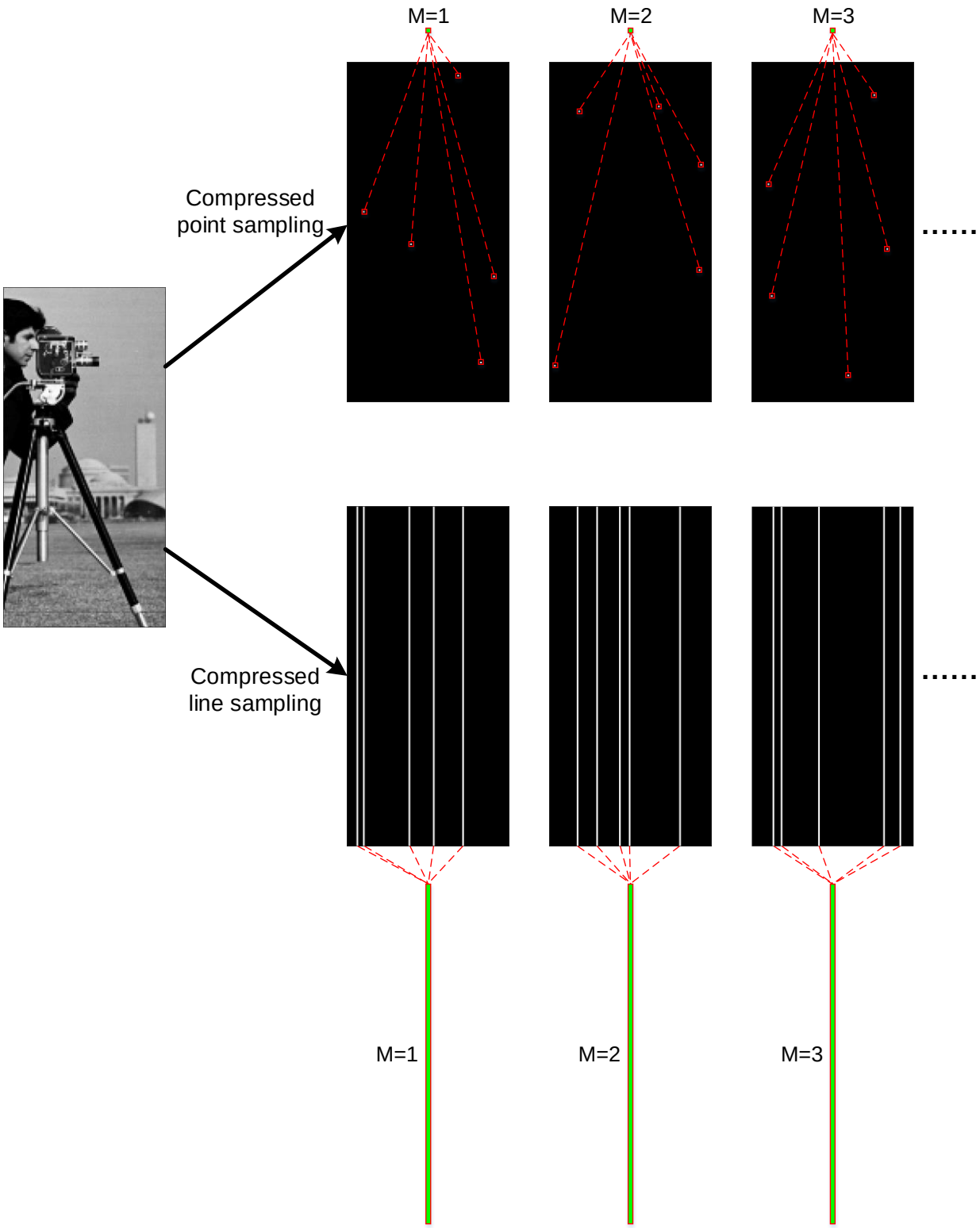

Fig. S5 Schematic of compressed point sampling (CPS) and compressed line sampling (CLS) for a two-dimensional grayscale image (*Cameraman* with a size of 210*100 pixels). For each sampling, CPS integrates multiple stochastic points (5 points in the illustration), while CLS randomly selects multiple lines (5 lines in the illustration).

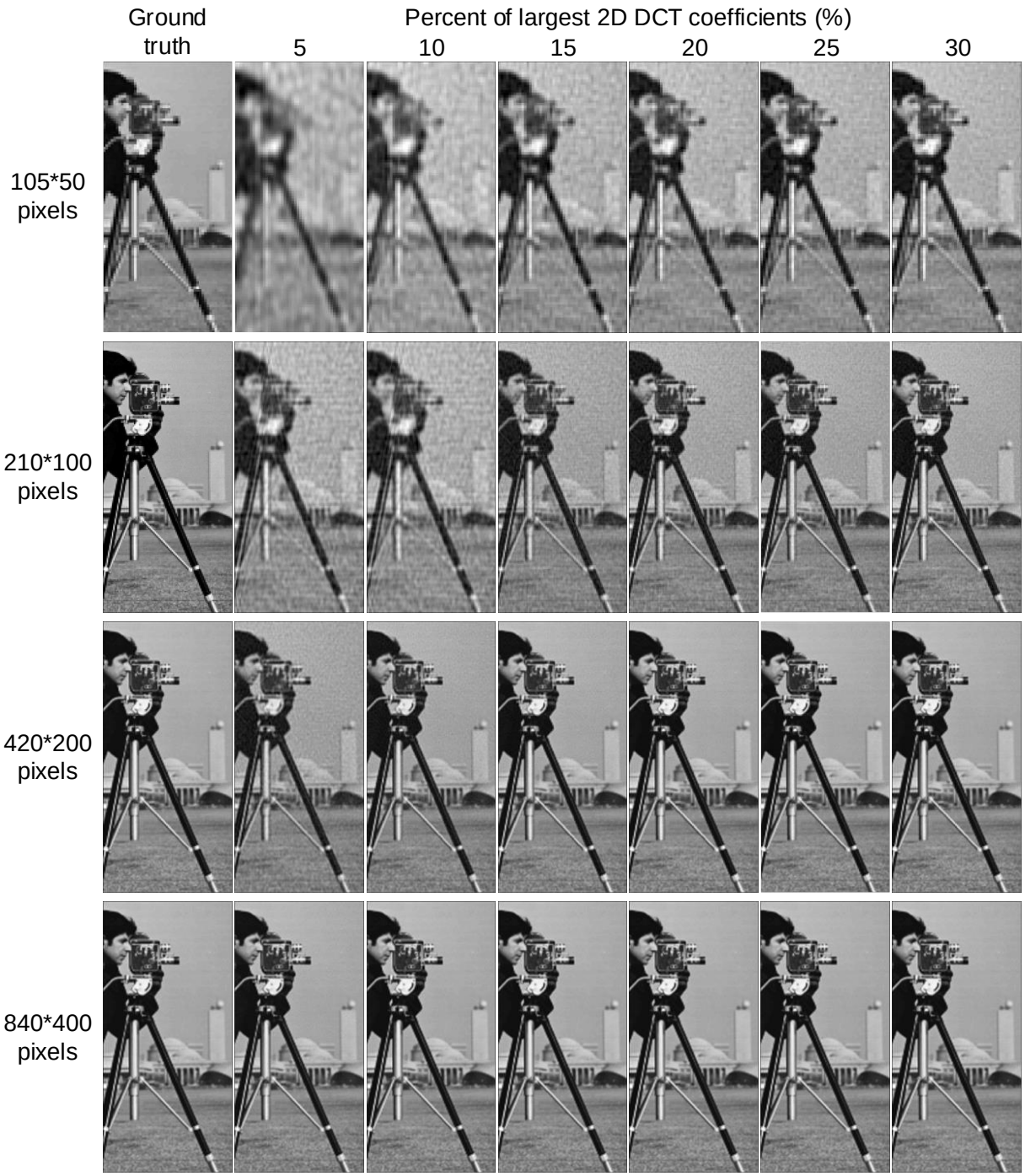

Fig. S6 *Cameraman* images with 4 different sizes are projected into 2D discrete cosine transform (DCT) domain, then different percentages of largest 2D DCT coefficients are selected to invert the *Cameraman* images.

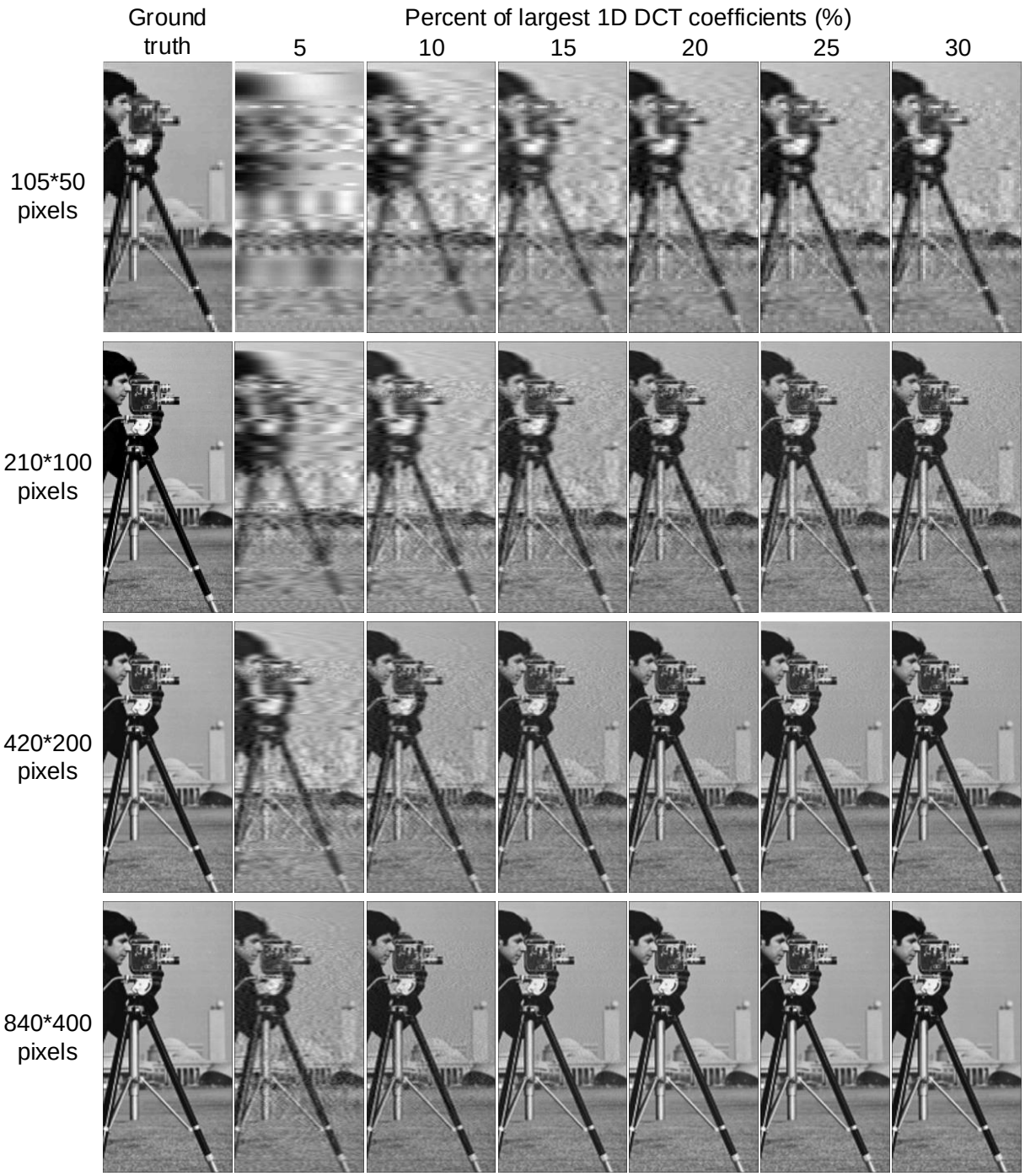

Fig. S7 Each row of the *Cameraman* image is projected into 1D DCT domain, then different percentages of largest 1D DCT coefficients in each row are selected to invert the *Cameraman* image. 4 different images are studied.

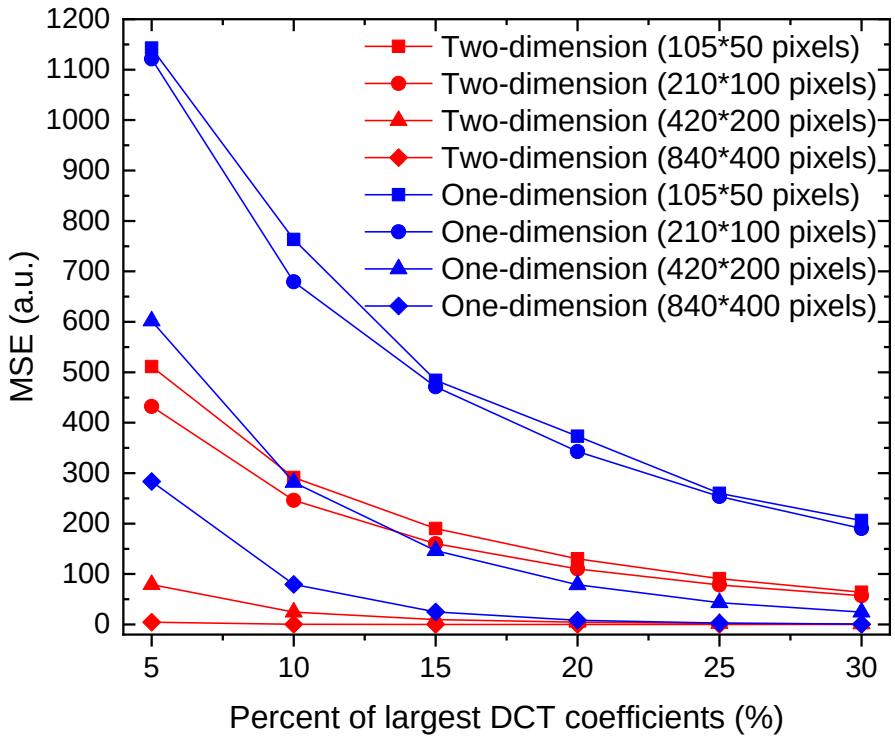

Fig. S8 MSE of the reconstructed *Cameraman* images based on the ground truths in **Figs. S6** and **S7**.

Definition of coherence value

In the compressive sampling process, the sampled signal **H** can be expressed as

$$\mathbf{H} = \mathbf{AS} = \mathbf{A\Psi\theta} = \mathbf{D\theta}$$

where **A** is the measurement matrix, **S** is the original signal to be retrieved, **Ψ** is the sparse matrix, **θ** is the sparse signal, and **D** = **AΨ** (**D** = [$\boldsymbol{d}_1$, $\boldsymbol{d}_2$, …, $\boldsymbol{d}_n$], where n is the original signal size) denotes the equivalent dictionary. The coherence value is defined as[1-3]

$$\mu(\mathbf{D}) = \max_{\substack{1\le i,j\le n \\ i\ne j}} \left| \frac{\boldsymbol{d}_i^{\mathrm{T}} \boldsymbol{d}_j}{\|\boldsymbol{d}_i\|_2 \|\boldsymbol{d}_j\|_2} \right|$$

The smaller the coherence value is, the higher probability for the successful reconstruction in CS.

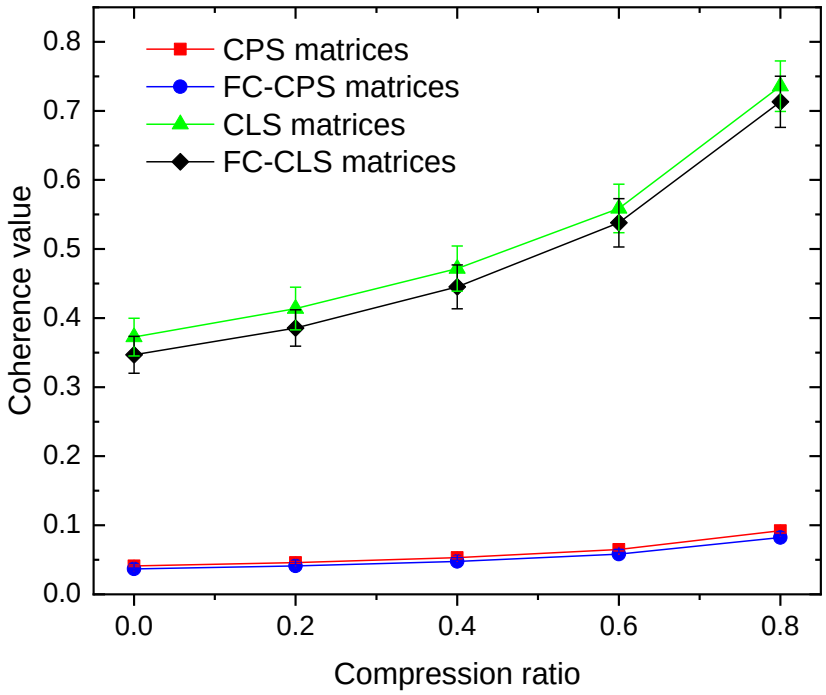

Fig. S9 Coherence values between 4 kinds of compressed sampling matrices and the DCT matrix as the sparse matrix. The sampling matrices were generated for the image size of 210*100 pixels. For the compressed line sampling, 100 pixels is the number of line positions, while 210 pixels along the line direction. Each group of matrices contains 300 independent sampling matrices. The generation of full-coverage compressed point sampling (FC-CPS) and full-coverage compressed line sampling (FC-CLS) matrices is similar with the FC-CLRI measurement matrices in the main text, which indicates that each point or line is constrained to be sampled at least once in each set of CS sampling.

References

1. J. M. Duarte-Carvajalino and G. Sapiro, *IEEE Trans. Image Process.*, 2009, **18**, 1395-1408.
2. L. Stankovic, D. P. Mandic, M. Dakovic and I. Kisil, *IEEE Signal Process. Mag.*, 2020, **37**, 152-162.
3. Z. Wei, J. Zhang, Z. Xu and Y. Liu, *Mathematical Problems in Engineering*, 2020, **2020**, 7979606.