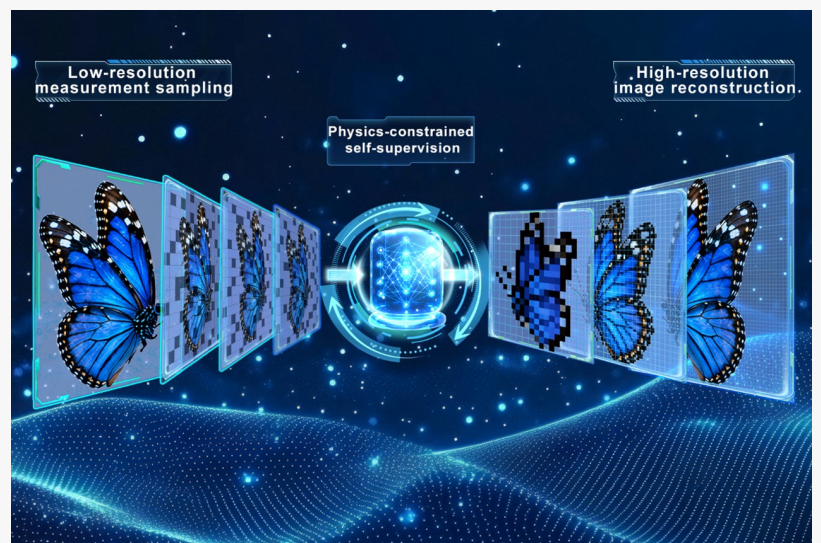


Measurement-Decoupling Strategy Enables High-Pixel-Resolution Single-Pixel Imaging

A self-supervised framework separates measurement and reconstruction resolution to enable high-resolution imaging from low-dimensional measurements

CHENGDU, SICHUAN, CHINA, October 15, 2026 /EINPresswire.com/ -- A collaborative research team from the University of Electronic Science and Technology of China and the Hangzhou Institute of Medicine of the Chinese Academy of Sciences, proposed a novel self-supervised reconstruction framework that decouples measurement sampling resolution from reconstruction grid density to address the trade-off between sampling and imaging in single-pixel imaging. The framework enables high-pixel-resolution reconstruction from the low-dimensional measurements, providing a new strategy for overcoming resolution limitations in conventional single-pixel imaging.



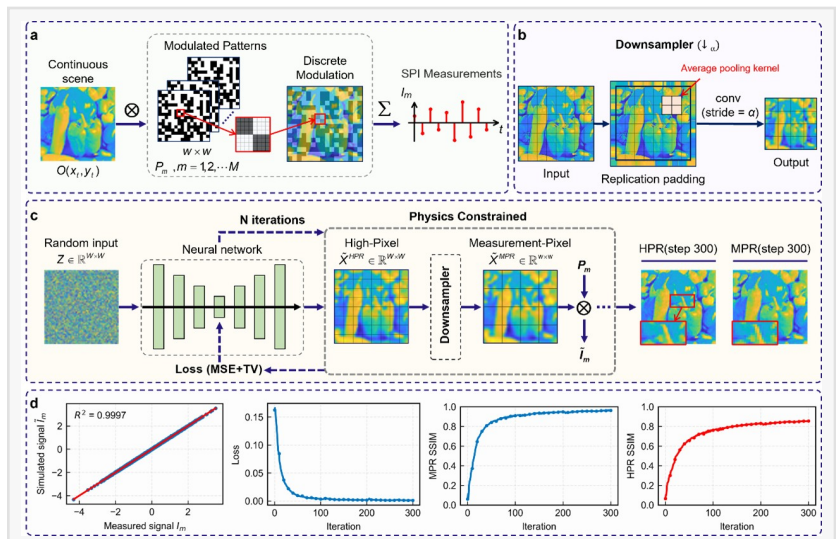
Conceptual illustration of the ARSPI method. A spatially continuous target scene is modulated and sampled using discrete modulation patterns in single-pixel imaging. A physics-constrained self-supervised neural network enables controllable high-pixel-reso

Conventional digital cameras usually rely on large arrays of light-sensitive pixels, such as CMOS or CCD sensors, to directly capture spatial information from a scene. However, these imaging sensors may face limitations in challenging environments, including low-light conditions, non-visible wavelength ranges, and scenes where light is strongly scattered. Single-pixel imaging (SPI) provides an alternative approach by replacing traditional pixel arrays with a single light detector. Instead of directly recording an image, the system projects a series of designed light patterns onto the target object and measures the overall intensity changes collected by the single detector. An algorithm then uses these measurements to reconstruct the hidden image.

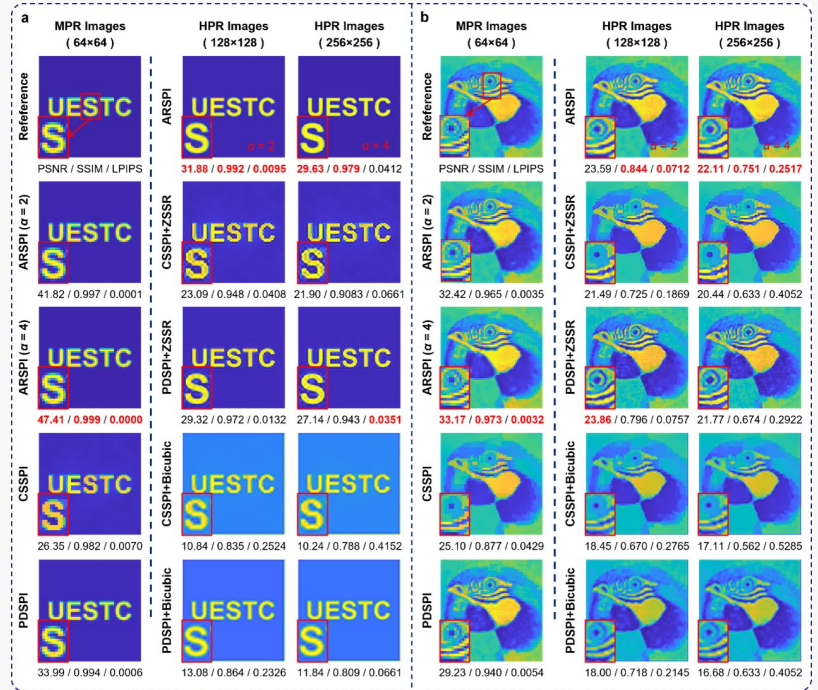
Due to the high sensitivity, broad spectral response, and relatively simple detection structure of single-pixel detectors, SPI has attracted increasing attention in applications such as three-

dimensional imaging, low-light imaging, infrared and terahertz detection, and imaging through scattering environments. In recent years, advances in computational algorithms, especially the combination of physical imaging models and deep learning methods, have further improved the reconstruction quality of SPI. Among these approaches, self-supervised methods have gained interest because they can optimize reconstruction directly from measured data without requiring large external image datasets, making them more adaptable to different imaging conditions.

Despite these developments, SPI still faces an important challenge: balancing image resolution and measurement efficiency. In conventional SPI systems, the resolution of the reconstructed image is closely linked to the sampling resolution. Increasing the number of sampling pixels can improve image details, but it also requires more measurements and reduces sampling efficiency under limited acquisition conditions. On the other hand, improving the hardware modulation resolution can increase system complexity and cost. Previous studies have explored computational strategies that first reconstruct a low-resolution image and then enhance it using super-resolution algorithms. However, the quality of the final image strongly depends on the initial reconstruction. Missing information or reconstruction artifacts may be amplified during the enhancement process, making it difficult to recover accurate details. These



(a) Schematic diagram of the signal acquisition process in single-pixel imaging. (b) Downsampling operator: performs image downsampling according to the adjustable scaling factor α . (c) The proposed ARSPI algorithm. A fixed random noise tensor is used to



Reconstruction results of (a) binary "UESTC" and (b) grayscale "bird" images under 64×64 measurements with the sampling rate of $SR = 100\%$. The measurement-pixel-resolution (MPR) and high-pixel-resolution (HPR) reconstructions with scaling factors of $\alpha =$

limitations motivated researchers to explore new reconstruction strategies that can improve image resolution while maintaining measurement efficiency.

To overcome this bottleneck, a novel self-supervised high-pixel-resolution reconstruction framework for SPI is proposed based on measurement decoupling. The proposed method enables adjustable-pixel-resolution image reconstruction for single-pixel imaging (ARSPI), providing a new strategy for improving the pixel resolution of SPI systems. The work, entitled “Self-supervised high-pixel-resolution reconstruction for single-pixel imaging via measurement decoupling,” was published in [Opto-Electronic Advances](#) in 2026.

Unlike conventional SPI approaches, where sampling resolution and reconstruction grid density are closely linked, the proposed method introduces a new reconstruction framework that separates these two aspects. By employing random modulation patterns to acquire compressed linear measurements, the algorithm generates images directly at a higher reconstruction resolution and then uses the physical imaging process of single-pixel systems to ensure that the generated results remain consistent with the measured signals. In this way, the method can recover higher-pixel-resolution images from the same set of low-dimensional measurements, reducing dependence on the original measurement grid.

The proposed approach combines physical modeling and deep-learning-based optimization. Instead of relying on large external datasets, the method adopts a self-supervised strategy that optimizes reconstruction using only measured data. By incorporating an attention-enhanced neural network, the framework improves the ability to represent image structures and details while maintaining consistency with the underlying optical measurement process. Compared with traditional approaches that first reconstruct low-pixel-resolution images and then apply super-resolution enhancement, this method avoids the accumulation of errors caused by missing information in the initial reconstruction stage.

The researchers evaluated the method through both numerical simulations and optical experiments, including standard test images, the USAF 1951 resolution target, and biological samples. The results demonstrate that the proposed framework can produce images with clearer structures and higher pixel density under limited measurement conditions. The method provides a computational strategy for improving image quality without requiring substantial changes to the existing optical hardware, which may benefit imaging systems where detector performance, acquisition time, or hardware complexity are important considerations.

The proposed framework could support biomedical microscopy, industrial inspection, infrared and terahertz sensing, and low-light imaging. Future work will assess robustness under low sampling and noise, while exploring integration with artificial intelligence and advanced optical imaging platforms.

Reference

Title of original paper: Self-supervised high-pixel-resolution reconstruction for single-pixel imaging via measurement decoupling

Journal: Opto-Electronic Advances

DOI: [10.29026/oea.2026.260133](https://doi.org/10.29026/oea.2026.260133)

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Funding information

National Natural Science Foundation of China (NSFC) (62675042).

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This press release can be viewed online at: <https://www.einpresswire.com/article/949806735>

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