

# (SD2019-220) Spatiotemporal resolution enhancement of biomedical images

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## BACKGROUND

Cardiac MRI is the clinical reference standard for visual and quantitative assessment of heart function. Specifically, cine balanced steady-state free precession (SSFP) can yield cardiac images with high myocardium–blood pool contrast for evaluation of left ventricular (LV) function. However, MRI suffers from long acquisition times, often requiring averaging across multiple heartbeats, and necessitates a trade-off among spatial resolution, temporal resolution, and scan time. Clinically, radiologists are forced to balance acquisition time with resolution to fit clinical needs, and certain applications such as real-time imaging may require small acquisition matrices. Image scaling is typically performed by using conventional upscaling methods, such as Fourier domain zero padding and bicubic interpolation. These methods, however, do not readily recover spatial detail, such as the myocardium–blood pool interface or delineation of papillary muscles.

## TECHNOLOGY DESCRIPTION

Researchers from UC San Diego have shown that convolutional neural network (CNNs) can recover high-frequency spatial detail from low-resolution MRI scans. Each of the CNNs they evaluated (SRNet and Unet) outperformed traditional zero padding and bicubic image upscaling strategies. This patent-pending technology shows the feasibility of super-resolution methods to improve the speed of MRI acquisition. In particular, for cardiac MRI, it is often challenging to acquire high-quality images in patients with arrhythmia. A real-time strategy that combines multiple techniques including CNN super-resolution might make this more feasible.

## APPLICATIONS

Accelerating MRI acquisition, improving spatial detail in CT.

Deep learning image super resolution can consistently outperform conventional image upscaling methods and can infer high-frequency spatial detail from low-resolution inputs.

## ADVANTAGES

## CONTACT

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## OTHER INFORMATION

### CATEGORIZED AS

- ▶ **Imaging**
- ▶ Medical
- ▶ **Medical**
- ▶ Diagnostics
- ▶ Imaging
- ▶ Software

### RELATED CASES

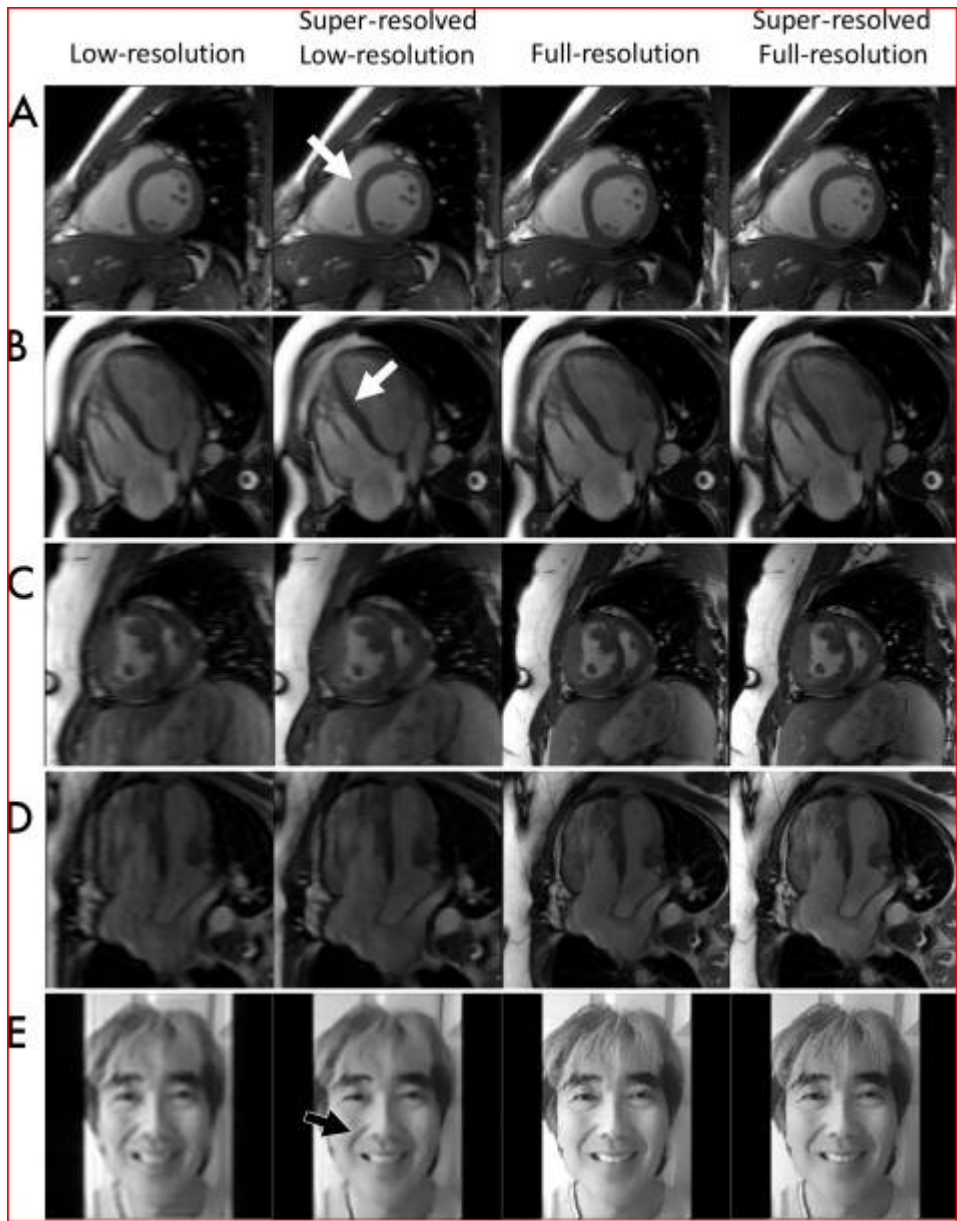
2021-Z08-1

When trained with Fourier downsampled data, deep learning consistently outperformed Fourier domain zero padding and bicubic interpolation at upsampling factors of two to 64.

Trained purely in image space, both single-frame and multiframe super-resolution convolutional neural networks (CNNs) showed filling of outer k-space, indicating CNN inference of high-frequency spatial detail.

Super-resolution of small-matrix acquisitions from 10 patients yielded ventricular volumes comparable to measurements from full-resolution images with improved image detail.

STATE OF DEVELOPMENT



Images demonstrate proof-of-concept assessment of super-resolution methods. Low-resolution input, full-resolution reference, and k-UNet super-resolved images are shown for five experiments: A, short-axis cine steady-state free precession (SSFP) in a 27-year-old healthy male volunteer at 3.0 T, B, four-chamber cine SSFP in a 26-year-old healthy male volunteer at 3.0 T, C, short-axis cine SSFP in a 36-year-old patient with transposition of the great arteries after Mustard switch, D, four-chamber cine SSFP in the same patient as in, C, and, E, photographs of a human face. The k-UNet network appears to improve myocardium–blood pool delineation, especially along the septal wall. Although trained only with short-axis images, the k-UNet network appears to generalize to long-axis images and digital photographs, sharpening details. This network also appears to further enhance detail of low-resolution images and full-resolution reference acquisitions.

INTELLECTUAL PROPERTY INFO

UC San Diego is looking for partners to commercialize this technology. US Patent rights are available for licensing.

RELATED MATERIALS

University of California, San Diego

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