A novel artificial intelligence technique for generating through-plane super-resolution MRI images

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A team of UCLA researchers has been developing new artificial intelligence techniques to use multi-slice two-dimensional MRI scans to produce high-resolution MRI images in orthogonal imaging planes other than the one used to acquire the original 2D slices. Each slice of a multi-slice 2D MRI image has high resolution in its own imaging plane, but its slice thickness or through-plane resolution is much thicker (e.g., 3-6 mm), yielding low-resolution multi-planar reformation with staircase artifact due to elongated voxels. This shortcoming can be addressed by acquiring images in multiple planes — axial, coronal or sagittal — but that is time-consuming, making them less clinically efficient.

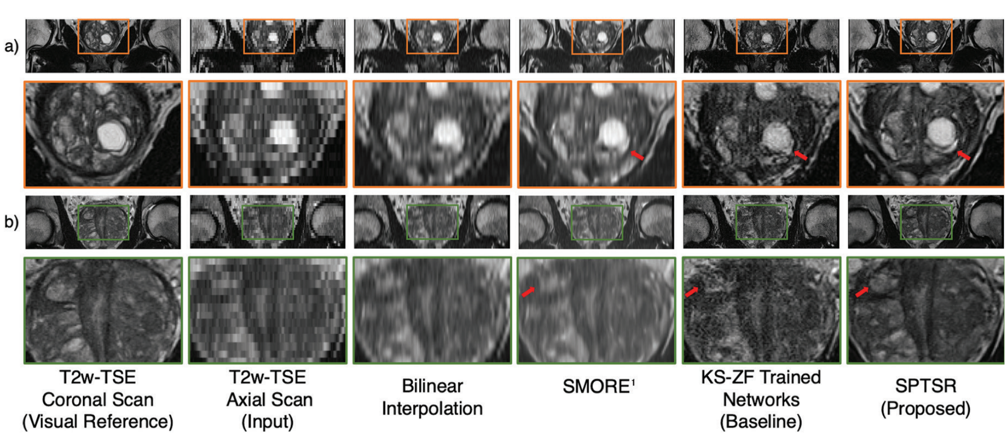
Combining deep learning with super-resolution MRI, the UCLA team has developed a novel technique for generating through-plane high-resolution MRI images that can meet the clinical needs of radiologists in evaluating patients with suspected pathologies. "By using these techniques to produce high-resolution MRI images from multiple 2D scans done in a single imaging plane, we can achieve three-dimensional isotropic super-resolution with high time efficiency via deep generative artificial intelligence," explains Kyung Sung, Ph.D., Associate Professor of Radiological Sciences at UCLA.

Known as slice-profile transformation-based super-resolution (SPTSR), a pair of coronal and axial MRI scans were used to train deep generative networks to generate through-plane super-resolution MRI images. In particular, approximately 5,000 pairs of axial and coronal turbo spin-echo (TSE) prostate MRI scans — including scans from a variety of MRI scanners — were used in training the deep generative adversarial networks. Validation and testing were done using independent scan pairs from a further 430 subjects.

To test their SPTSR method, the team turned to two genitourinary radiologists who read prostate MRIs in their routine clinical practices. The two compared the quality of the SPTSR through-plane super-resolution MRI images with separate orthogonal in-plane scans that served as a visual reference. In addition to SPTSR, the testers evaluated images produced by other state-of-the-art image-enhancement methods, including bilinear interpolation, SMORE, and KS-ZF AI algorithms. Testers evaluated the images on sharpness, artifacts, noise and overall quality. The proposed STPSR method received an almost perfect overall image-quality score, with both testers ranking SPTSR highest overall in all testing cases. As a result of the through-plane high-resolution images, SPTSR produces thinner virtual slices, generating 110 compared to 20 slices in the original scans.

"If you compare the output of our SPTSR method to the reference image of in-plane imaging, they are very comparable to each other," says Dr. Sung. "Some of the visual differences between the SPTSR output and the reference in-plane scan are due to the fact that they were acquired at different times, and some patient movement can be included. The fact that a structure seen on the reference scan doesn't have an exact corresponding structure on the AI output doesn't indicate a failure of the AI process. If we see a lesion in the reference image, we should see one in the SPTSR image as well, but the exact shape and location may vary."

Through-plane super-resolution imaging has been a very challenging problem in MRI for a long period of time. Dr. Sung and his colleagues believe that it can be overcome at last with the aid of artificial intelligence. "We're proposing a new artificial intelligence method that can improve the through-plane resolution of MRI better than existing AI methods." Dr. Sung also points out that the technical advances they've demonstrated in prostate MRI using SPTSR can be applied to other MRI applications. "We are showing and validating the proof of concept," explains Dr. Sung, "but there is more potential to explore in various imaging applications." R



Comparison of STPSR to available through-plane imaging methods. Rows a and b are slices from two of 30 testing subjects, in full-frame and cropped to the area of interest. The first two columns show the in-plane coronal scan used as a visual reference and the unenhanced through-plan axial image. The final four columns show the four through-plane methods being tested, with the UCLA team's SPTSR images in the right column. SPTSR produces through-plane images that are closer to the reference image than the other methods tested.

[1]Zhao C. IEEE TMI. (2021)