SEMINAR REPORT

Breakthroughs in MRI Scanning Made Possible by Artificial Intelligence

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Introduction

There has been an increase in the number of studies on scanning and image reconstruction techniques in CT and MRI as a part of the latest research on the applications of artificial intelligence (AI) in the field of diagnostic imaging. Canon Medical Systems has focused on the development of deep learning reconstruction (DLR) (WIP), a noise reduction technology for MRI that is based on deep learning, which is an extremely active area of AI research. This report focuses on our clinical experience with DLR.

Outline of denoising with DLR

Denoising with DLR (dDLR) is a technology that employs deep learning to reduce noise, allowing high-SNR images to be generated from low-SNR images. For example, when the conventional smoothing method and the dDLR method are compared in head images, the images obtained using the conventional smoothing method show the outlines of the brain and cranial bones when subtraction images are generated, whereas the images obtained using the dDLR method, which selectively eliminates noise, exhibit extremely high clarity and sharpness.

The main technical feature of the dDLR method is that denoised images are obtained by a two-step deep learning process. The first step is learning processing, in which the characteristics of huge amounts of data are analyzed in order to generate models during the development phase (processing during development). The second step is inference processing, in which newly acquired data is analyzed and processed using the models generated in the development phase (processing in the system). By incorporating dDLR processing into the conventional image reconstruction flow, final images with a higher SNR can be obtained (figure 1).

When the effectiveness of the dDLR method is assessed in actual head images, it can be seen that the images have an extremely high SNR which could normally only be achieved with a much longer scan time (figure 2). With the dDLR method, it is also possible to obtain clear images with minimal noise in abdominal examinations, but further

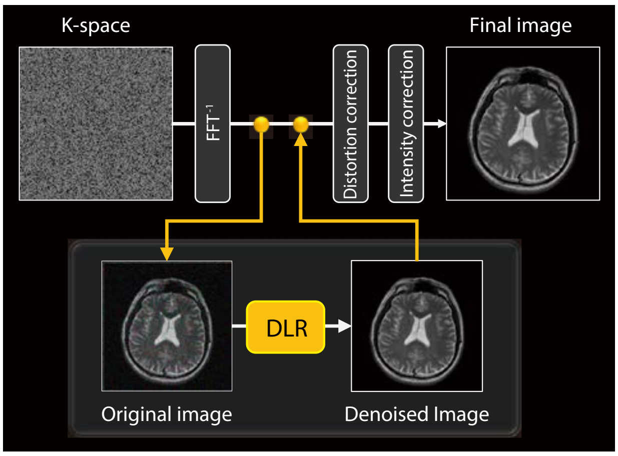

Figure 1 Image reconstruction flow chart incorporating dDLR (WIP).

research is needed to establish the diagnostic usefulness of this method in the abdomen.

Effectiveness of CS+dDLR

In compressed sensing (CS), which is a technology for reducing scan times in MRI, images are retrieved by performing undersampling during data retrieval based on wavelet conversion. However, if the conditions required for undersampling are not satisfied and the SNR of the base images is low, the threshold is raised when denoising is performed by wavelet conversion, resulting in a reduction in image quality. For this reason, when CS is employed, it is essential to ensure a good balance between the scan time and the SNR.

To address this problem, Canon Medical Systems is developing "Multi sensitivity map to Auto calibrating SPEEDER with Compressed Sensing (MeACS)" (WIP), which employs the company's newly developed parallel imaging technique known as "Multi sensitivity map to Auto calibrating SPEEDER (MeAS)" (WIP) in combination with CS. MeAS combines the characteristics of SENSE and GRAPPA. By obtaining a multi-sensitivity map of the coil, unfolding errors in parallel imaging are mitigated. Furthermore, in MeACS, the threshold for denoising related to wavelet conversion is lowered, and the reduction in image quality is therefore minimized. However, although MeACS is used, the image quality is even lower than that of images for which undersampling is not performed, so the use of dDLR in combination allows shorter scan times to be employed while further improving image quality. Actual clinical images are shown in figure 3. Figure 3c shows an image acquired using CS+dDLR (CS acceleration factor 4) with a scan time of approximately 1 minute. Although the scan time was relatively short, the image shows less noise than the image in figure 3a, which required a scan time of approximately 4.5 minutes.

In addition, MeACS+dDLR is suitable for the examination of various regions of the body.

Figure 4 shows dynamic MRI of the abdomen. In the conventional imaging method shown in figure 4b, the margins of the lateral segment of the left lobe of the liver cannot be clearly visualized due to partial volume effects from the stomach and surrounding fat. However, in the image acquired using 3D-CS+dDLR shown in figure 4a, because the spatial resolution is improved, the inferior margin of the liver can be clearly visualized even though the image was acquired in the same scan time. In addition, when 3D-CS images with and without dDLR are compared, it can be seen that image quality is improved in the image with dDLR (figure 5).

Because 3D-CS provides almost perfectly isotropic data, it is considered that MPR images can be generated as easily as in dynamic CT imaging when the image quality is improved by dDLR. As a result, it is expected that the time required for setting the scan protocol in dynamic studies can be reduced and that it may be possible to clearly visualize extremely small lesions in Gd-EOB-DTPA-enhanced MRI.

In addition, in high-resolution shoulder images obtained with CS+dDLR, the detailed structure of the target region could be visualized with minimal noise and with no loss of anatomical information. The greatest benefits of employing CS+dDLR in MRCP are that 3D images can be acquired during a single breath-hold and that high-quality images can be obtained with minimal noise.

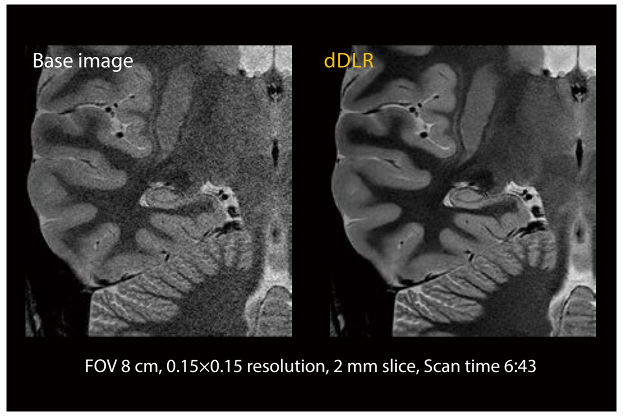

Figure 2 Effectiveness of dDLR (WIP) in head imaging.

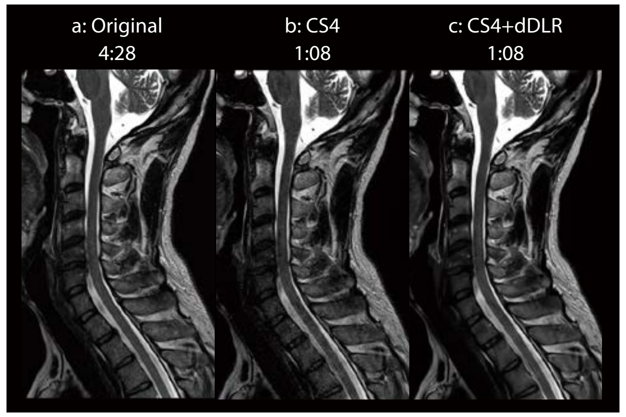

Figure 3 Effectiveness of MeACS+dDLR (WIP).

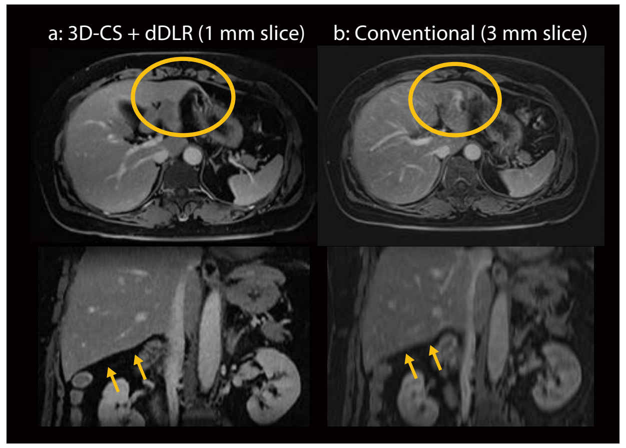

Figure 4 Dynamic abdominal MRI using the conventional method and 3D-CS+dDLR (WIP)

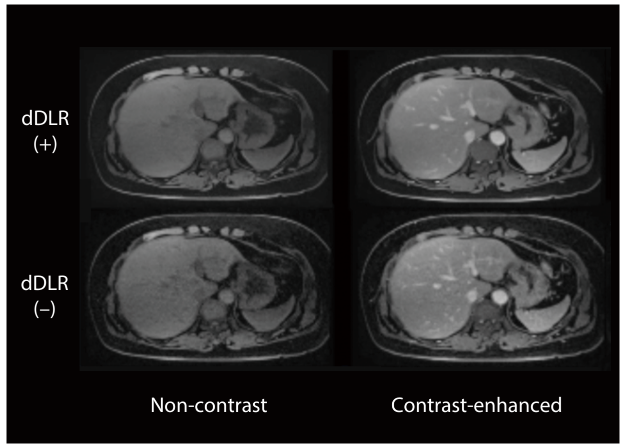

Figure 5 3D-CS with and without dDLR (WIP).

Conclusions

dDLR can be used with a variety of scan sequences. This technique helps to improve problems related to image quality, particularly in sequences that are designed to reduce the MRI scan time, and allows images with higher SNR to be obtained.

Acknowledgments

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