Canon

Good to Know MRI

Advanced intelligent Clear-IQ Engine (AiCE)

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WHAT? A deep learning based reconstruction method for MRI that intelligently removes noise while maintaining feature integrity.

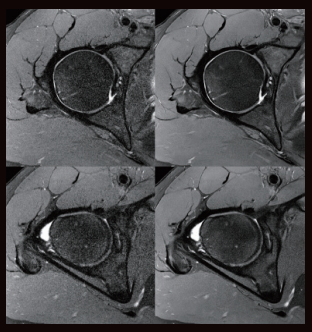
WHY? To increase SNR of the reconstructed images. This increased SNR could be translated to increased resolution and/or shortened scan time. This could also enable high field-like image quality without high-field challenges (e.g. higher cost, B_0 & B_1 inhomogeneity, etc.).

WHEN? Applicable to all anatomies and available at both 1.5T and 3T, for both wide and narrow bore system.

Shoulder (Vantage Galan 3T)

High Resolution image

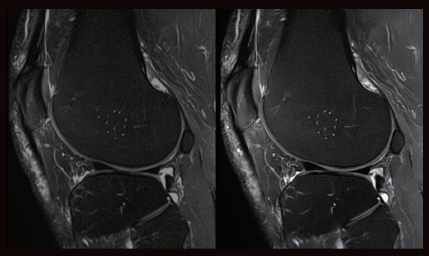
Original | AiCE



FSE 2D
Reso: 0.3x0.3
4:13 min

Knee (Vantage Orian 1.5T)

Conventional | AiCE



192 x 256, 5:14 min

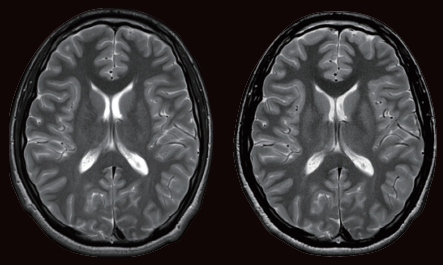
320 x 352, 3:34 min

FSE 2D
FOV: 15x15

Brain

(Vantage Galan 3T vs. Vantage Orian 1.5T)

3T | 1.5T with AiCE



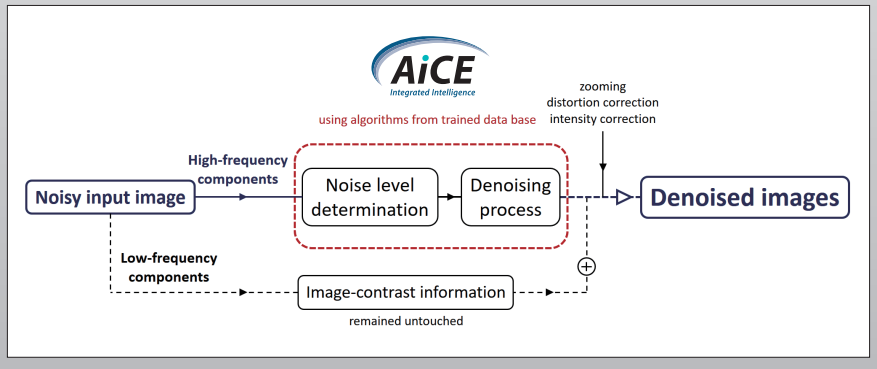
FSE 2D
Reso: 0.6x0.6
2:50 min

HOW?

Advanced intelligent Clear-IQ Engine (AiCE) is a deep learning based reconstruction method, which was trained to differentiate noise from MR signal and then effectively removes noise while maintaining anatomical and pathological integrity. By design, AiCE was trained to remove only noise, which has distinct statistical property compared to that of anatomical and pathological features in MR images. The training data were not simply standard images but they were carefully prepared with 10 averages resulting in high quality training data with exceptional SNR, which would help to maximize AiCE's capability in differentiating noise from signal (features) hence effectively removing noise while maintaining feature fidelity.

As shown in the following figure, AiCE was designed based on the knowledge of MR physics and signal processing in combination with the power of deep learning, which results in an interpretable model with explainable, robust and generalized performance. The denoising is only performed on the high-frequency components while the low-frequency components are untouched. That allows robust performance to contrast and signal variation in input images. The image sharpness, the denoising strength and the edge enhancement are the 3 options that can be tuned by changing the **d0x, AiCE Adjust** and **Edge** enhancement such that the reconstructed images match the users' preference.

To ensure safety and efficacy, AiCE underwent a rigorous validation process including bench testing, model observer study, and human observer study. Additionally, AiCE's performance could be assessed by comparing images with and without AiCE side-by-side and by inspecting the subtracted image. AiCE's model interpretability and transparency would allow the users to understand, trust, and confidently incorporate AiCE into clinical practice.



Precautions

AiCE should not be blindly applied to existing protocols. It is recommended to work with Canon clinical application specialists to identify the needs (whether throughput or SNR or resolution or a combination) and to understand how AiCE works and then to optimize the protocols so that it would maximize AiCE capacity and meet the desired expectation.

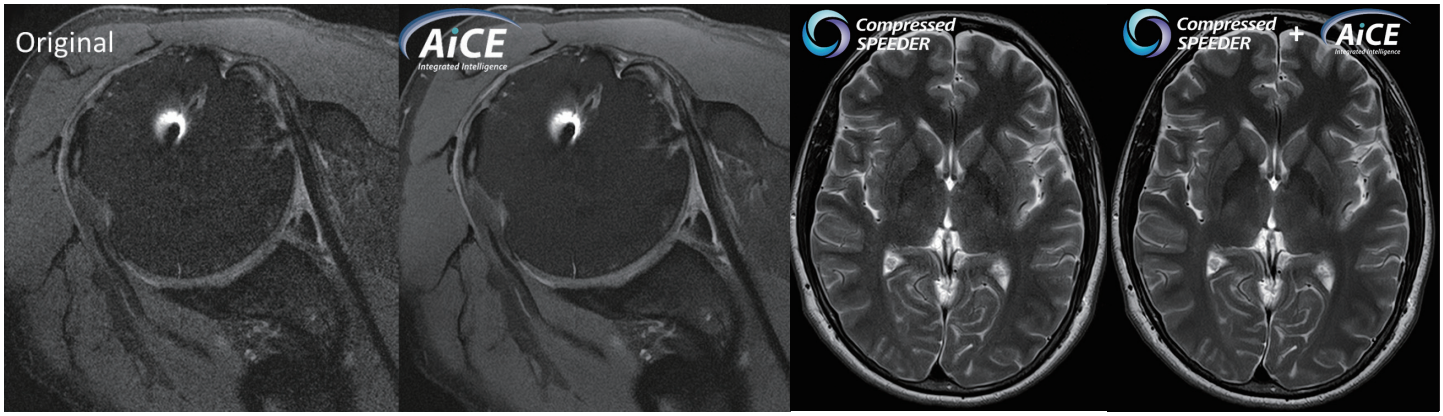
Tips, Tricks and Best practice

- **d0x Factor:** Adjust the image sharpness with a range of values from d01 (strong retention of natural sharpness) to d05 (weak retention of natural sharpness).
- **AiCE Adjust:** Determine the denoising strength. The AiCE Adjust could be set by the user to a lower or higher than the default value for weaker or stronger denoising, respectively.
- **Edge-enhancement:** The edges are sharpened through an additional unsharp masking. It is generally recommended to turn ON but must be turned OFF when performing image subtraction or when there are excessive motion artifacts.

Questions from the field?

Q. ***Does AiCE work when there are abnormalities such as pathologies and artifacts ?***

A. By design, AiCE was trained to only remove Gaussian noise so AiCE does not remove pathological features and (motion/metal) artifacts that has distinct statistical property compared to that of the noise.



Q. ***Does AiCE work with undersampled data?***

A. AiCE does not directly transform undersampled data into the final output but AiCE is integrated into the reconstruction pipeline so that it could be combined with SPEEDER and Compressed SPEEDER, which directly reconstruct undersampled data for AiCE's inputs.

Q. ***Does AiCE preserve quantitative measurement such as T1, T2, etc.?***

A. AiCE has been shown to improve SNR and CNR without changing quantitative values of T1, T2, and FA. See Prevost et. al., ISMRM 2020, Abstract #1878 for more detail.

Q. ***Is it possible to re-reconstruct AiCE with different parameters after the data is acquired?***

A. Yes, as long as the raw k-space data is stored. The raw data is automatically retained for 48h, however, if the user would like to keep the raw data for longer period of time, please "lock" raw data option such that the raw data is stored until the "lock" option is un-selected.

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