Diffusion Signal-to-Noise Ratio (SNR)

Diffusion signal-to-noise ratio (SNR) refers to the **quantitative measure of signal strength relative to background noise** in diffusion-weighted magnetic resonance imaging (dMRI). It is a key determinant of image quality and **tractography accuracy**.

Definition

Mathematically:

• SNR = Mean Signal Intensity / Standard Deviation of Noise

In diffusion imaging, the signal is affected by diffusion gradients and becomes lower than in standard (non-diffusion) MRI sequences, making **high SNR more difficult to achieve**.

Importance

- High SNR → clearer visualization of diffusion anisotropy → more accurate fiber orientation modeling.
- Low SNR → increased noise, leading to:
 - Spurious tracts
 - Unreliable fractional anisotropy (FA) values
 - Reduced confidence in tracking small or curved fibers (e.g., cranial nerves)

Factors Affecting SNR

- Field strength (e.g. 3T vs. 7T MRI)
- Voxel size (larger voxels = higher SNR, but lower spatial resolution)
- Number of signal averages (NSA)
- Gradient strength and b-value
- Acquisition time and patient motion

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