

# FAST 3D MAGNETIC RESONANCE IMAGING USING UNDERSAMPLED PROJECTIONS

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Magnetic resonance imaging (MRI) is a well-proven modality for numerous clinical applications. One of the primary limitations of MRI remains the time required to image at high-resolution and adequate spatial coverage, especially for time restricted applications such as single breath-hold imaging, contrast-enhanced arterial phase imaging, or multiple-phase cardiac imaging. With three-dimensional (3D) Fourier techniques, the length of the scan is often shortened by acquiring fewer slice or phase encodes at the expense of spatial coverage or resolution.

Projection k-space sampling, where data are acquired along radial lines, does not necessarily have the same constraints between imaging time and resolution. The resolution of the final image acquired with projection sampling is set only by the readout resolution of each projection, whereas the total number of projections determines the artifact-free field-of-view. If the artifacts introduced by azimuthal undersampling are acceptable, higher resolution per unit time can be acquired.

This thesis describes several methods of 3D imaging using projection techniques and also presents clinical applications. The first method uses projection trajectories in one imaging plane and Fourier encoding in the slice direction. This hybrid acquisition is shown to be advantageous for phase-contrast and cardiac imaging, decreasing the acquisition times relative to Fourier scans by a factor of four or more. The phase-contrast application introduces an interleaved method for velocity encoding. The cardiac application uses a contrast agent to increase the signal of blood so that time-resolved images of ventricular volume or coronary artery vasculature can be completed in a single breath-hold.

The second method extends the benefits of PR imaging into three dimensions. The volume coverage and level of artifact can be substantially improved by using a true 3D projection trajectory, where the resolution in all three spatial directions is set by the readout resolution. By vastly undersampling the number of projections to limit the scan time, this technique is demonstrated to acquire large, high-resolution volumes a factor of 4 faster than Fourier techniques with clinically insignificant levels of artifact. The applicability of the technique to both T1-weighted and SSFP imaging is demonstrated.