# A Novel Reconstruction Method for Axial 3D Data Acquisition during Continuous Table Movement

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## Introduction

Moving table MR imaging techniques have successfully been evaluated for whole-body tumor staging and metastasis screening [1], [2]. In this context, a stack of axial thin slices was acquired permitting arbitrary reformats that facilitate image reading. In the case of 2D slice selective excitation the resolution in longitudinal direction, however, is limited by SNR requirements. 3D slab selective excitation with lateral read-out potentially overcomes this restriction and provides the most efficient *k*-space coverage when the longitudinal FOV is limited [3]. In this work, a novel reconstruction method for axial 3D data acquisition during continuous table movement was derived from [4] and was fully integrated into the Siemens reconstruction architecture.

## Theory

In 1999 Dietrich and Hajnal [4] proposed a reconstruction algorithm for continuously acquired data during longitudinal table movement and slab selective RF excitation. In this setup, the read-out is oriented left-right, which is the $x$ direction in the scanner coordinate system. The directions of phase encoding are oriented in $y$ and $z$ direction. In a straight forward implementation of the algorithm, each *k*-line is first copied into an empty matrix. The sparse matrix is then Fourier transformed and position corrected. In the present study, a reconstruction algorithm was developed which avoids Fourier transformations of sparse matrices. The algorithm features data processing exclusively in *k*-space so that Fourier transformation can be performed for the entire collection of phase encoding steps at one time.

In a thought experiment the sparse matrix can be upsampled by a factor of two in the $z$ direction. Assuming that the table translation during one full cycle of phase encoding steps equals the slab thickness, all shifted partial images are located in the upsampled image matrix. Since the discrete Fourier transformation is being employed, the input and output signals are inherently periodic. Thus, the periodic repetition of each partial image in the upsampled dataset needs to be suppressed by a dedicated filter before collecting the partial images of the full set of *k*-lines.

A *k*-space implementation of this algorithm is the most efficient. In this case, the computational cost for one cycle of phase encodes amounts to $O(N_x \cdot N_y \cdot (2 \cdot N_z^2 + 2 \cdot N_z \cdot log_2(2 \cdot N_z)))$, representing the processing of all read samples $N_x$ and phase encoding steps $N_y$ times the convolution of the filter with the upsampled dataset in the z direction. Subsequently, the FFT is performed along the phase encodes in the direction of upsampling. The Fourier transformation in the remaining two directions reconstructs one sub-FOV.

## Methods and Results

Imaging was performed on a 1.5-T Magnetom Avanto (Siemens Medical Solutions, Erlangen Germany) with high performance gradients. The scanner was equipped with a full matrix of surface coils which connect to 32 receiver channels. The algorithm was fully integrated into a standard Siemens reconstruction program. The filter for suppressing periodic signals was developed in time space by simply multiplying the Fourier transformed of a rectangular window with a Gaussian window ($\sigma = 0.5$). No further corrections with respect to gradient nonlinearity or field inhomogeneity were considered. Spoiled Gradient echo MR imaging with slab selective axial excitation (TR/TE = 3.1/1.43 ms, $\alpha$ = 25°, slab width = 120 mm, partial Fourier 6/8) was performed during continuous table movement (v = 6 mm/s). In Fig. 1 the central slice of a stack of 125 coronal planes reformatted form this dataset is presented. The volunteer was advised to breathe shallowly while traveling through the isocenter. To prevent aliasing from the object outside the desired slab 20% symmetric oversampling was performed. The imaging volume was extended to 400 x 250 x 1800 mm$^3$ with isotropic 2 x 2 x 2 mm$^3$ voxels. 192 pixels in left-right direction were acquired during every single read-out. The total acquisition time was 280 seconds. Although the reconstruction can overall be considered to accurately reflect the anatomy, image quality was affected by Gibbs ringing at the transitions of subsequent partial FOVs.

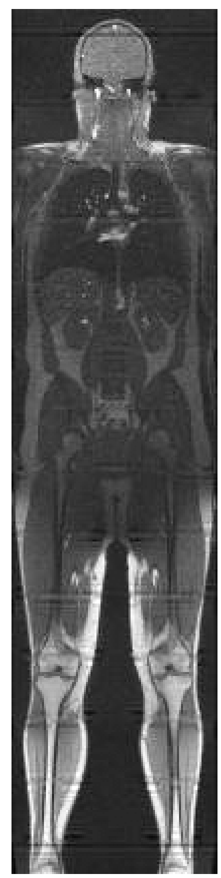

**Fig. 1 Central plane of a coronal reformatted whole-body 3D data set. The total acquisition time was less than 5 minutes. Good image quality is obtained over the anatomy except at the transitions of subsequent partial FOVs. Artifacts will diminish when the FIR filter is optimized.**

## Discussion and Conclusion

The presented algorithm enables highly efficient reconstruction of continuously acquired large FOV images with surface coil image quality. Improved through-plane resolution compared to slice selective excitation will notably facilitate whole-body tumor staging and screening applications. The development of an optimized FIR filter with imperceptible transition effects will be the subject of future investigation. Last not least, when working on a state of the art short bore scanner with a small homogeneous volume, the unlimited FOV will ease a variety of routine examinations.

## References

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