Automatic Detection of Metal Implant Location in Hexagonally Sampled MAVRIC-SL

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PURPOSE: Hexagonal undersampling[1] of MAVRIC-SL[2] scans has been demonstrated to offer decreased scan times when scanning close to metallic implants without affecting image quality[3]. The undersampling creates replicas in otherwise empty regions of the FOV that can easily be removed with knowledge of the implant location. In this work, we demonstrate a simple and robust method to automatically determine the implant location without operator input.

THEORY: In SEMAC[4] or MAVRIC-SL[2], multiple slices (or thin slabs) are excited, each imaged with a 3D volume acquisition, and combined to form a final image. Sampling k-space in a hexagonal (alternatively "checkerboard" or "quincunx") pattern[1] reduces time, and assuming a limited y-extent of the through-slice (z) distortion, results in separated aliased replicas. Adjacent slices usually overlap and also have similar location of distortion. Therefore, if the slices are sampled in a complementary pattern, such that the sampled locations of a particular slice are the skipped locations of the adjacent slice, and the 3D encoded volumes are then added together, the result should look similar to a fully sampled volume (Fig. 1), with somewhat suppressed signal in aliased replicas compared to the primary signal.

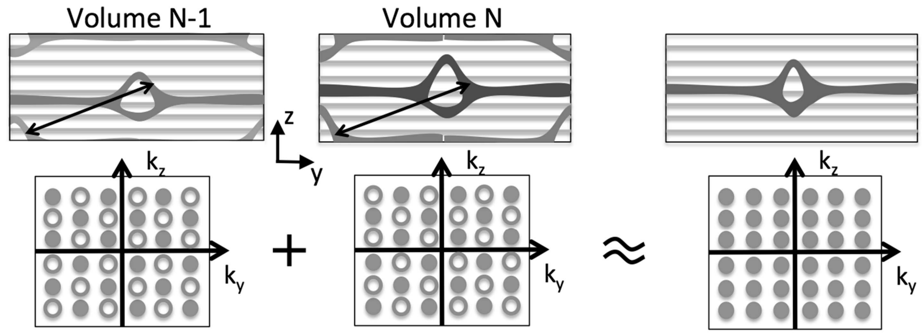

Figure 1: A hexagonally undersampled volume has aliased replicas packed in the same hexagonal pattern. Due to overlap, adjacent volumes have similar image data, so if they are complementarily undersampled and summed, the result should be similar to a fully sampled volume with minimal or substantially reduced aliasing.

METHODS: This procedure was tested on two spine scans (with a 2×1 acceleration factor) from a 3.0T MRI system and two hip scans (with 2×2 acceleration) from a 1.5T MRI system. The k-space data was retrospectively undersampled in a complementary hexagonal pattern and adjacent volumes then combined as described, locating the implant where the combined signal deviated the most in the z-direction (Fig. 2). For the 2×2 cases complentary hexagonal undersampling was only applied in the calibration region, leading to a 20% scan time reduction, while for the 2x1 cases all of k-space was hexagonally sampled, giving a 50% reduction. Parallel imaging was then applied to the whole image, and a cross shaped zeroing mask then centered on the determined location to remove aliases from each volume before combining the volumes.

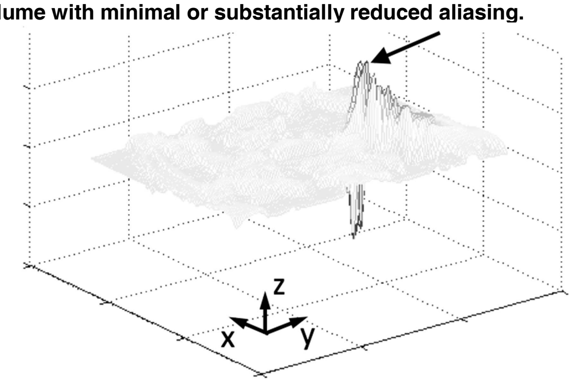

Figure 2: The profile resulting from combining two slices shows a large deviation in z (black arrow) close to the implant.

RESULTS: In all cases, the implant location determined by the algorithm was within the actual range covered by the implant in the phase-encode direction. The masking resulted in images with very similar image quality as those from regular sampling requirements. A sample result from one of the hip scans is shown in Fig. 3. Signal in the difference image is mostly due to minor FFT leakage through-slice, not failure of the current algorithm.

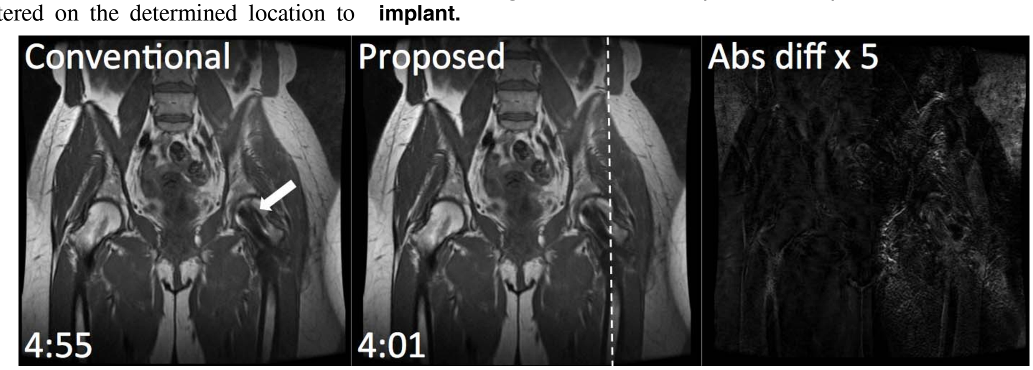

Figure 3: The proposed method compares well to a conventional scan. The white arrow shows a metal implant. The dashed line shows where the mask is automatically centered.

DISCUSSION: The simple and robust removal of aliased replicas by combining adjacent scan volumes obviates the need for user input for accurate processing of hexagonally sampled SEMAC or MAVRIC-SL scans. This makes the method less dependent on the user having any prior knowledge of the location or shape of the implant. Furthermore, the shape of the distortion (Fig. 2) could potentially be used to tailor the shape of the zeroing mask for each volume to reduce noise in the final image.

CONCLUSION: The proposed method allows hexagonal undersampling of MAVRIC-SL scans, resulting in a scan time reduction of up to 50%, without any additional steps during acquisition, providing maximum ease in workflow.

REFERENCES: 1. Kim SMRM 1990, 551. 2. Koch MRM 2011;65:71-82. 3. Sveinsson MRM 2014: 10.1002/mrm.25132. 4. Lu MRM 2009;62:66-76. **ACKNOWLEDGEMENTS:** NIH, GE Healthcare.