Orthogonal Fusion; Improving Resolution for Mutispectral Segmentation

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Introduction

The segmentation algorithms which are developed to segment joint structures from a single data set require human interaction and are very labor intensive. Previous studies have shown that accurate segmentation of MRI data of the brain for either 2D or 3D presentation requires the use of multispectral data (1). Several algorithms have been developed to allow the accurate fusion of two or more MR brain data sets (2). To improve the segmentation of musculoskeletal structures we developed an algorithm to register and fuse two orthogonal 3D musculoskeletal MR imaging data sets and tested its feasibility in automatic segmentation of the knee and shoulder structures.

Material and Method

We developed an algorithm where two orthogonal volumetric MR data sets were registered first by maximizing the correlation between gradient magnitude. Once the orthogonal images were registered they were fused to reconstruct a single isotropic high resolution volumetric image. The isotropic image was reconstructed first by assuming that an individual voxel on an MR image is an average of the magnetic resonance (MR properties of an elongated volume). Then we modeled this process as the projection of the MR properties into a single sensor. This model allowed us to derive a set of linear equations that can be used to recover the MR properties of every single voxel of the isotropic volume given only two orthogonal 3D MR images. We used projections on convex sets (POCS) to solve a set of linear equations. The reconstruction of high resolution images from the fusion of the two orthogonal sets using the proposed approach is equivalent to the filtering backprojection algorithm used for the reconstruction of CT images.

MR imaging data sets of two shoulders and three knees were acquired on a 1.5 Tesla Signa Horizon (GE, Milwaukee) clinical imager using either coronal and axial or coronal and sagittal planes with a 10 or 11 cm FOV, 256 x 256 matrix and 1.5 mm slice thickness. TE was adjusted to produce either T1 or T2 star-weighted information. One of the data sets was also fat suppressed. The two data sets were fused and the fused data sets and single fat suppressed image data sets were then segmented using our segmentation algorithm.

The feasibility of the approach was tested on those MR imaging data sets, first using 2-D images and then using segmented 3-D images. In 2-D images the visualization of cartilage and labri in the shoulder and cartilage and menisci in the knee were evaluated and compared to the results when only one data set was used.

In the segmented images the segmentation of the same structures which were used for 2-D evaluation, was evaluated and compared.

Results

In the 2-D data sets the cartilage and the labri of the shoulder were better delineated using two channel data compared to the one channel data. In the fused data sets isotropic volume allowed high resolution visualization of cartilage and the labri in any arbitrary plane. The segmentation of cartilage and the labri from the fused data sets was more accurate than from the single channel data set.

In the knee the fused data sets visualized the cartilage and meniscus more clearly than a single data set. In fused data sets the cartilage and menisci were seen clearly in all arbitrary planes. Also in the knee the segmentation of the cartilage and menisci was more reliable using fused data set.

Conclusion

Fusing two orthogonal 3D MR imaging sets creates the single isotropic volume. This isotropic volume provides higher resolution data than single channel data allowing high resolution 2-D analysis in arbitrary plane. This approach could be useful in the clinical setting when small focal cartilage lesions in knees or wrists or fingers need to be evaluated. The fused data sets improved the segmentation of the anatomic structures including cartilage. Fusing the two orthogonal data sets acquired with different imaging parameters may in the future provide more accurate automated segmentation of musculoskeletal structures, especially for cartilage.

References

1. Vinitski S, Gonzalez C, Mohamed FB, et al. Improved intracranial lesion characterization by tissue segmentation based on a 3D feature map. Magn Reson Med 1997;37:457-469.

2. Vinitski S, Gonzalez CF, Knobler R, et al. Fast tissue segmentation based on a 4D feature map in characterization of intracranial lesions. J Magn Reson Imaging 1999;9:768-776.