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AN IMPROVED ALGORITHM FOR 3-D MRI FILTERED BACK-PROJECTION

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INTRODUCTION

MRI (Magnetic Resonance Imaging) offers the possibility of direct 3-D reconstruction, that is 3-D images obtained directly from raw data. On the other hand, in CAT (Computer Aided Tomography), a 3-D reconstruction is only indirectly possible, using two-dimensional reconstructed images [1].

Several methods have been proposed for 3-D MRI reconstruction. These can be classified in two major categories: projection reconstruction and Fourier methods. Projection reconstruction offers the highest sensitivity [2] but needs significant processing time. This method of reconstruction is recommended in several applications demanding high S/N ratio. We propose a new, faster and more precise 3-D projection reconstruction algorithm, which implements the space filtering using convolution. This mathematical evaluation of the convolution improves the image quality.

THE ALGORITHM

The unknown function f(x,y,z) can be expressed as

$$f(x,y,z) = \int_0^{\pi}\int_0^{\pi}\int_{-\infty}^{\infty} P(k,\theta,\phi)\, k^2 \sin\theta \exp(2\pi jkr)\, dk\, d\theta\, d\phi$$

where $P(k,\theta,\phi)$ is the F.T. (Fourier Transform) of the projection $p(r,\theta,\phi)$ and (r,θ,ϕ) shows the orientation of each plane projection in spherical coordinates

The inner integral represents the filtering process of the projections while the outer ones describe the procedure of back projection. The filtering is approximated in the space domain by differentiation. We were able to show that the convolution filtering in the discrete case can be implemented by

$$p^*(i) = p(i)/(12w^2) + (1/(2w^2\pi^2)) \sum_{\substack{j \\ i \neq j}} (-1)^{(i-j)} p(j)/(i-j)^2$$

where $w = 1/2k_m$ and k_m is the maximum spatial frequency. We assumed that the function f(x,y,z) is bandlimited and consequently the projections $p(r,\theta,\phi)$ are band limited as well.

RESULTS AND DISCUSSION

We are presenting comparative results obtained for the convolution filtering reconstruction (c.f.r) method and the differentiation filtering reconstruction (d.f.r) method. The phantom used was the 3-D head simulation proposed by Shepp [3].

Comparing the reconstruction it is straightforward to see that the c.f.r method, provides more accurately reconstructed images, having higher contrast and less reconstruction noise. This improvement becomes more evident when using smaller reconstruction matrices, because in the d.f.r. method the approximation of the projections' second derivative becomes worse.

CONCLUSIONS

In this paper we presenting a new algorithm for the 3-D reconstruction of an object from its projections. This algorithm implements the filtering of projections in a more precise way than the currently existing methods. The new algorithm evaluates the direct convolution of projections. The results demonstrate the improved performance of the new algorithm (higher-contrasted images, more accurate reconstruction) over the previous methods, especially at lower resolution matrices.

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