Image Reconstruction in Magnetic Resonance Diffractive Imaging Technique

S. ITO[1], Y. YAMADA[2]

[1]Graduate School of Engineering, Information and Control systems Science, Utsunomiya University, Utsunomiya, Tochigi, Japan, [2]Utsunomiya University, Utsunomiya, Tochigi, Japan

INTRODUCTION A new approach to MR angiography, the NMR diffractive imaging technique, has been investigated. The expression of NMR signals obtained in the NMR diffractive imaging technique is similar to the equation for Fresnel diffraction in light waves or sound waves. Therefore, it is possible to reconstruct images focusing on optional plane in the depth direction using the data scanned two-dimensionally. Since blurred image components out of focal-plane are superimposed on the focal-plane image, we have developed a new algorithm by which blurred image components are effectively removed. These studies demonstrate the possibility of the proposed method as a fast imaging technique for MR angiography.

FRESNEL DIFFRACTIVE IMAGING TECHNIQUE The Fresnel diffractive imaging technique encodes the spatial information of the subject in a manner of diffraction equation as a light or sound wave. A quadratic field gradient, whose field intensity changes in a quadratic form on the *x*-*y* plane, and whose coefficient of the quadratic field gradient varies in the *z* direction by α, $\Delta B = b(1+\alpha z)\{(x'-x)^2+(y'-y)^2\}$, is scanned two-dimensionally in the *x*-*y* plane, where *b* is a coefficient of a quadratic field gradient at *z*=0 and coordinates (x',y') are the center of this quadratic field gradient which can be set to optional places by the field given from outside. The NMR signal equation $v(x',y')$ is given as the following equation[1];

$$v(x',y') = P\iint\int_{-\infty}^{\infty} \rho(x,y,z)\exp\{-j\gamma b\tau(1+\alpha z)[(x'-x)^2+(y'-y)^2]\}dxdydz \quad , \qquad (1)$$

where $\rho(x,y)$ represents the spin density distribution in the subject, γ is the magnetogyric ratio, τ represents its impressed time, and *P* is a constant. Images at any plane for *z*-coordinate can be reconstructed by inverse filtering technique.

EXPERIMENTS Experiments were performed using an ultra-low-field MRI scanner (0.02T) to acquire two-dimensional data in the proposed technique. Figure 1 shows the results of reconstructed images. Even though blurred image outside the focal plane is superimposed on the focal-plane image, the three-dimensional distribution of the subject can be recognized. To improve the accuracy of spatial distribution of the subject, a new deconvolution algorithm which can remove blurred images components on the focal plane image, have been developed. We used the Maximum Likelihood reconstruction method [2] based on the Bayes' theorem for conditional probabilities, as shown in Eq.(2),

$$\rho_{n+1}(x,y,z) = \rho_n(x,y,z)\left[\frac{\rho_{obs}(x,y,z)}{\rho_n(x,y,z) * p_d(x,y,z)} \otimes p_d(x,y,z)\right] \quad . \qquad (2)$$

$\rho_{obs}(x,y,z)$ focused image
$p_d(x,y,z)$ point spread function

Figure 2 shows the results of simulation experiment using a wire-frame image model. Three-dimensional image model is composed of 128×128×16 data matrix. Deconvoluted images with 20 iterations showed almost only focal plane image component. We can reconstruct MIP (Maximum Intensity Projection) image with high fidelity using those focal plane images.

CONCLUSION A new MR fast angiographic imaging technique is presented and demonstrated. It was shown that proposed imaging and reconstruction technique had the capability to provide images focusing on optional plane using the NMR signal scanned two-dimensionally.

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REFERENCES

[1] S. Ito, et. al. `` Magnetic Resonance Diffractive Imaging", IEEE Transaction on Biomedical Engineering, Vol. 49, No.6, pp.574-583 (2002).
[2] F. Tsumuraya, ``Deconvolution based on the Wiener-Lucy chain algorithm: an approach to recover local information losses in the deconvolution procedure", J. Opt. Soc. Am. A, Vol.13, No.7, pp.1532-1536(1996).

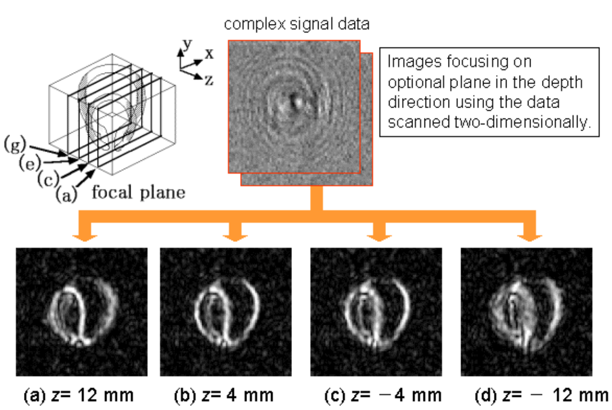

Figure 1 Results of experiment using 0.02T MRI. Water tube phantom was used. Focal plane image was clearly imaged.

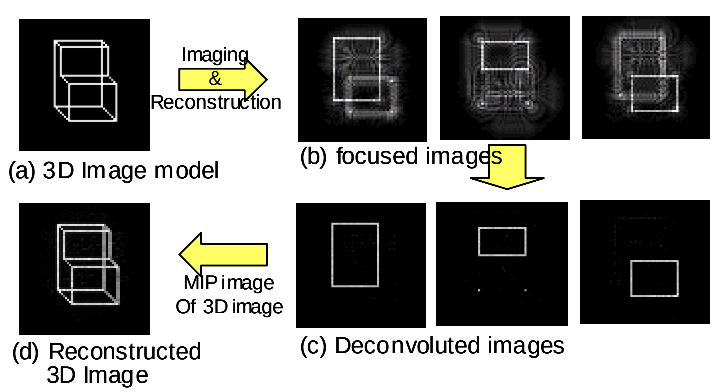

Figure 2 Results of simulation experiment. Blurred imaged were removed well and 3D image model was estimated in fairly good coincidence with the original image model.