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Reconstruction in NMR by the Method of Signal Matrix Pseudoinversion

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Abstract—Tomogram reconstruction in NMR tomography is based on the calculation of the spatial distribution of spin density or relaxation characteristics of the signal. The Fourier reconstruction method is frequently used for solving inverse problems. The present paper proposes a new alternative method of reconstruction based on data pseudoinversion. The method operability and efficiency was tested by using a mathematical model.

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The tomogram reconstruction in NMR tomography is based on the calculation of spatial distribution of spin density or relaxation characteristics of elements of the object under investigation. In recent years much attention has been given to the development of new reconstruction techniques and optimization of existing ones. This paper deals with optimization of the regularization technique of Tikhonov's construction using the quantitative tools in parallel NMR. The sense-reconstruction method was also considered; its quality does not depend on the nature of parallel NMR, but degrades as a result of inversion. This problem can be solved by optimizing the design geometry of coils of the receiving system or using new optimization techniques of reconstruction for improving the state of the inversion matrix. It is just the Tikhonov regularization that represents an effective method of reconstruction optimization. The method efficiency was estimated by using the perceptual difference model (PDM), i.e., computerized estimation model of visible difference between the reconstructed test image and the sample, in this case it corresponds to the images that are rapidly obtained by sampling from the *k*-space and images of the complete sample [1]. The problems and methods of reconstruction for improving the NMR – visualization resolution were also considered. This paper proposed a new approach and algorithm of super-resolution reconstruction (SRR) for subpixel images [2]. The method of diffusion tensor imaging (DTI) represents a technique for investigating the diffusion of deep internal tissues. This is the method used for investigating changes in the integral microstructure of brain related to specific illnesses. In order to determine the exact changes, a sufficiently low noise level is required. The accuracy of measurements in the DTI method depends on the gradient coding scheme. A new gradient coding scheme is proposed for the noise minimization in DTI method for fibers with specific orientation [3]. A proper attention was also given to the reconstruction algorithms, such as fast entropy–minimization algorithm, for correcting the magnetic bias in NMR, changes were made in a conventional reconstruction algorithm for 2D images, and the image reduction occurs at each section by the method of simple averaging without variation of the number of sections [4]. This paper proposes a new alternative pseudoinverse method of reconstruction. This method is based on pseudoinversion of discrete data and allows the image reconstruction in terms of the incomplete set of discrete data. The operability and efficiency of the proposed method of reconstruction was tested by setting an inverse problem and performing mathematical simulation for solving this problem.

SOLUTION OF THE INVERSE PROBLEM

The signal obtained during the scanning process in NMR tomography can be presented in the following form:

$$S(t) = \sum_i \rho_i \exp(ikx_i t) \exp(-t / T_{2i}), \quad (1)$$