PROCEEDINGS

SECOND EUROPEAN CONFERENCE ON ENGINEERING AND MEDICINE

Stuttgart / Germany, April 25 - 29,1993

Editors: Jan E. W. Beneken and Uwe R. Faust

A PARAMETRIC ALGORITHM FOR MRI BACK-PROJECTION RECONSTRUCTION

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ABSTRACT: **Attempts to parametrically model MRI data sets have shown limited success. This is due mainly to inadequate multidimensional algorithms. Projection techniques make feasible the use of one dimensional models, which constitute an area with a variety of robust and well performing algorithms. Furthermore, projection techniques have recently gained much attention because they offer certain advantages over the traditionally used Fourier techniques.**

I. INTRODUCTION

The currently predominant technique in magnetic resonance imaging (MRI) is Fourier imaging (spin warp). The data collected by this technique are literally a sample set of the Fourier transform (FT) of the image. Thus, the image is reconstructed using discrete Fourier transforms (DFT) techniques [1].

Parametric models offer an alternative approach to Fourier transforming. Their use in the quantitative analysis of the one dimensional (1D) NMR spectroscopic signal has been studied extensively. There, they proved to be advantageous over the DFT in many aspects [2].

Parametric modelling of two dimensional (2D) MR data sets has been proposed to cope with deficiencies that arise from using the DFT on finite rows or columns of data [3]. However, these techniques have shown very limited success [4], because mathematics for 2D data sets is less complete than for 1D [5].

II. OBJECTIVE

Parametric models offer the following advantages as compared to the DFT [6]

a. Higher resolution
b. Signal to noise ratio (SNR) improvement
c. Immunity to truncation errors
d. Potential reduction of storage space.

The objective is to take advantage of their superior performance in MR imaging as is already done in MR spectroscopy.

III. METHODS

Projection reconstruction techniques have recently gained much interest in MRI because they offer imaging of short-T_2 species and they demonstrate excellent robustness to motion and flow effects in manifestations [7].

In MRI filtered projection reconstruction techniques (MRFPR) the magnitude of the DFT of the data of each acquisition is a projection of the imaged object that is back-projected to reconstruct the final image. FT estimation using modelling offers all the advantages of the parametric approach and on the same time, it does not exhibit any of the existing drawbacks of the 2D estimators.

The parametric projection reconstruction technique consists of the following steps

1. Filtering of each echo
2. Estimation of the 1D parametric model of each echo and calculation of the corresponding spectrum
3. Back projection.

Steps 1 and 3 are kept the same as in traditional projection reconstruction algorithms.

IV. RESULTS AND DISCUSSION

There is a variety of algorithms which may be used to estimate the parameters [6]. The most computationally efficient, the Burg method, has proven not to be adequate for MR data because it leads to highly spiked images and quantitative interpretation of the reconstructed spectra is difficult as the relative intensities and linewidths of the peaks are altered [3].

Autoregressive-moving average (ARMA) models are more appropriate, because the MRI spectrums (i.e. the imaged objects) are usually smooth without great peaks or valleys. This theoretical assumption has been verified experimentally. We used the Marple algorithm for the estimation of the ARMA parameters.

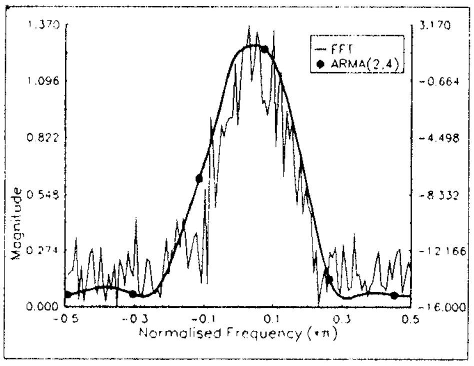

Fig.1. Comparison of the DFT and parametric approaches on a data set of poor SNR.

We tested our algorithm with two different data sets, one of poor SNR and one of high SNR. We constructed a phantom of one tube filled with tap-water. Data were acquired in our Brucker 0.15T magnet with home built RF and acquisition hardware. In fig. 1 we show one projection of this data set calculated once with the DFT and then with an ARMA(2,4) model. Averaging was not used resulting to a poor SNR. Use of the model results to an obvious improvement of it.

As a cross example, we used data from a phantom of two tubes; one filled with tap-water and the other with olive oil, acquired in a CISCO 4.7T magnet (Queen Mary's College, London, UK). Four averages were used resulting in a high SNR. In fig.2 one projection is showed calculated once with the DFT and then with an ARMA(5,5) model. The two results do not perfectly match. A better convergence is achieved by increasing the model order, but only at the cost of additional false peaks.

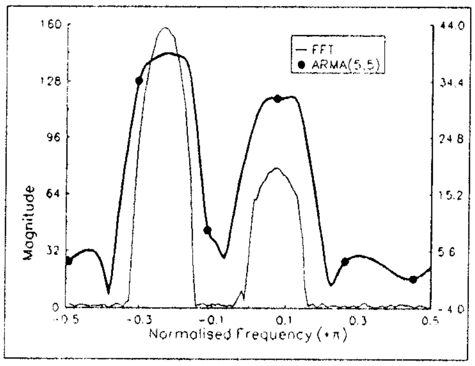

Fig.2. Comparison of the DFT and parametric approaches on a data set of high SNR.

CONCLUSIONS

The use of parametric models for MR image reconstruction has been demonstrated. Such models were initially considered because they offer an important immunity to truncation error artifacts. We show here that they also offer a potential SNR improvement. They proved to be more useful in low field strength magnets, with long echo times and/or fast imaging techniques (e.g. echo-planar imaging, Turbo-FLASH) where the SNRs are poorer.

Additionally, they may serve as data compressors, because only a small number of coefficients (10-20) need to be stored, instead of the 128 or 256 data points of the DFT.

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