International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.3, 2015

RESEARCH ARTICLE

ISSN: 2321-7758

RELIC RECTIFICATION IN MRI IMAGES USING ANGLE MODULATION AND RECURRENCE SOLVING

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Article Received: 29/04/2015

Article Revised on:03/05/2015

Article Accepted on:06/05/2015

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ABSTRACT

Now a day Zero-echo Time imaging in MRI is a promising technique for short-T2 tissue nuclei in tissues of the human body for considerable clinical and scientific importance. MRI with zero echo time is achieved by 3D radial centre-out encoding and hard-pulse RF excitation. Conversely, problems such as time delay, blurring and shadow artifacts can arise in ZTE due to the presence of imaging gradient on hard pulse excitation. The time delay between the end of RF transmission and the start of data acquisition yields due to the central portion of K-space is missed, whereas blurring and shadow artifacts in the image will arise due to presence of gradient. To decipher these problems a single point imaging is used similar as in PETRA and allowed high peak power for short pulse duration. Nevertheless, peak power and SAR limitations impose practical limits for in vivo scanning of humans. So a new method is proposed to resolve above problems. In this proposed work the ZTE sequence signal is used which include the flatter excitation profile which is obtained by modulate the hard RF pulse with quadratic phase and efficient algorithms for correcting the artifacts in ZTE imaging. The proposed work is simulated by using MAT LAB tool on phantom Images.

Key Words—Artifacts, K-Space, PETRA, Short-T2, Zero-echo Time Imaging

INTRODUCTION

Magnetic resonance imaging (MRI) is a unique clinical and research imaging technology that enables users to visualize different anatomical, metabolic, and physiological properties of the human body. MRI scanners use magnetic fields and radio waves to form images of the body. The technique is widely used in hospitals for staging of disease and medical diagnosis of diseases and for follow-up without exposure to radiation. The most commonly used clinical MRI techniques for the diagnosis of parenchymal diseases employ heavily T(2)-weighted sequences to detect an increase or decrease in the signal from long T(2) components in tissue. Tissues also contain short T(2) components that are not detected or only poorly detected with conventional sequences. These components are the majority species in tendons, ligaments, menisci, periosteum, cortical bone and other related tissues, and the minority in many other tissues that have predominantly long T(2) components.In routine MRI presence of artifacts in images is part of the practice and some are readily identified, others can be interpreted as Pathology. Artifacts will occur due to

Hardware issues, Software issues, Physiological reasons and Physics. Imaging was performed using a projection acquisition approach, with half radiofrequency excitations and subsequent radial mapping from the center of the k-space. The sequence minimizes the delay between the end point of the excitation pulse and the data sampling, which allows for a reduction of the TE below the limit of clinical detectability provided by conventional gradient echo techniques.

ZTE imaging is consists of the spatial encoding gradient on top of the static magnetic field during non-selective excitation, such that the “sample” has to be spatially encoded such that each point in the “sample” can be uniquely identified; that the “sample” has to be spatially encoded such that each point in the “sample” can be uniquely identified; The sequence variants currently in practice include SPRITE (single-point ramped imaging with T1 enhancement) , WASPI (water- and fat-suppressed proton projection MRI) and PETRA (pointwise encoding time reduction with radial acquisition). Due to the presence of the spatial encoding gradient in ZTE imaging during nonselective RF excitation offers advantages over UTE imaging in terms of faster -space traversal and elimination of artifact from ramp sampling.

In this work, ZTE sequence signal is modelled to include the excitation profile, algorithm as a solution to an inverse problem. A simple pulse sequence is also developed to measure the excitation profile of the RF pulse. To eliminate the zero crossings in the sinc excitation profile and to condition the inverse problem the hard RF pulse with quadratic phase is modulated which produces a flatter excitation profile.

Literature Survey

In 2002, P. D. GATEHOUSE and G. M. BYDDER proposed Magnetic Resonance Imaging of Short T2 Components in Tissue Using these approaches, signals have been detected from normal tissues with a majority of short T2 components such as tendons, ligaments, menisci, periosteum, cortical bone, dentine and enamel well as from the other tissues in which short T2 components are a minority. Use of these techniques has reduced the limit of clinical detectability of short T2 components by about two orders of magnitude from about 10 ms to about 100 ms.In 2007, Damian J. Tyler proposed Magnetic Resonance Imaging with Ultrashort TE (UTE) PULSE Sequences.It is used to detect signals from tissues and tissue components with short T2s, such as cortical bone, using ultrashort TE (UTE) pulse sequences. In 2011, D. M. Grodzki1, P. M. Jakob1, and B. Heismann proposed Ultra short Echo Time Imaging using Pointwise Encoding Time reduction with Radial Acquisition (PETRA) In this work a sequence is presented that achieves the shortest possible TE given by TX/RX switching time and gradientperformance of the MR Scanner. In PETRA (Pointwise Encoding Time reduction with Radial Acquisition) outer k-space is filled with radial half-projections whereas the centre is measured single pointwise on a Cartesian trajectory. This hybrid sequence combines the features of single point imaging with radial projection imaging. No hardware changes are required.In 2012, David Otto Brunner, Benjamin Emanuel Dietrich, Colin Felix Müller, and Klaas Paul Pruessmann 1Bruker BioSpin AG, proposed ZTE Imaging on a Human Whole-Body System in which the ZTE approach has been demonstrated to offer high resolution and signal-to-noise ratio (SNR) yield for the imaging of samples with transverse relaxation times of several hundreds of µs. In 2013, Jiading Gai a, Nady Obeid b, Joseph L. Holtrop a,c, Xiao-Long Wub, Fan Lama,b, and Maojing Fua,b,proposed More IMPATIENT: A gridding-accelerated Toeplitz-based strategy for non-Cartesian high-resolution 3D MRI on GPUs In this paper, they improve IMPATIENT by removing computational bottlenecks by using a gridding approach to accelerate the computation of various data structures needed by the previous routine.

Proposed System

In proposed system the ZTE sequence signal is modelled which include the flatter excitation profile to eliminate the zero crossings in the sinc excitation profile and to condition the inverse problem.The process diagram of the proposed system is shown in fig.1

In proposed system firstly the un corrected ZTE Image which is obtained from MRI Scanner is converted to system matrix by applying the spatial transformation and then performed the non uniform FFT to obtained the radial trajectories of the original image. The NUFFT operator maps the image to k-space radial spokes, with one spoke for each radial trajectory, and another spoke for each

Cartesian point. Each spoke is separated by zero-padding with a factor of 2 , multiplied with the excitation profile and finally restoration of the original vector length. Dirichlet interpolation in the Cartesian portion is performed for mapping the Cartesian coordinates of the single points to coincide with those in the radial spokes. Finally the corrected ZTE image is obtained by perform sampling(PETRA).

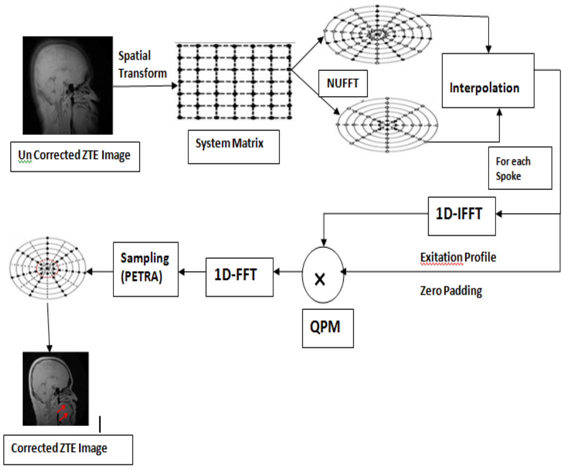

Fig.1.Process Diagram

Inverse problem

The corrected image with hard RF pulse excitation profile fit within the main lobe of the sinc-shaped excitation profile, if not then the amplified noise causes inversion of the ill-conditioned matrix rooted from the zero crossings of the sinc function which corrupts the resulting image. Generally the residual artifacts are appeared in outside of the spherical region defined by the main lobe of the sinc-shaped profile. This is because the null points in the excitation profile cause the system matrix to be singular and make the inverse problem.

Non Uniform FFT Algorithm

When data are sampled on a non-uniform grid with spiral sampling trajectories, the system matrix cannot be approximated by a simple FFT. Although, fast algorithms are developed to leverage the FFT in performing the evaluation. FFT taken to get frequency information at uniformly-spaced nodes in which the results are used to interpolate to desired nodes.Moreover, Several algorithms have been proposed ,the easiest and simple NUFFT algorithm is as follows

1. For k € I_N, Compute W_k=g_k / lNlck(ҫ)
2. For q € $I_{N,}$ Compute by use of the d-variate FFT Wq
   = $\sum_{k€ I_N} Wk\, e^{-2\pi ik\,(n^{-1}\theta q)}$
3. For j=0,……..M-1, Compute
   g(fj)=$\sum_{q€ I_{n,m(x_j)}} W_q\,(f_j - n^{-1}\theta q)$

RF Angle Modulation

The quadratic-phase pulses can be appreciated by matching up to linear-phase pulses. Mostly the magnetisation in the selected bands is turn around simultaneously with a linear-phase pulse. The short main lobe, as its width is inversely-proportional to the bandwidth.

W∞1/B

If quadratic phase modulation is applied to the RF pulse, the excitation profile becomes flatter and lacks a null point. The hard pulse sinc-shaped excitation profile is pure real,to remove the null point, an imaginary part is added into the profile to make it complex. So the magnitude of the profile is no longer singular. The improvement in the reconstructed images is evident. The total of phase modulation applied to the RF pulse where it constitutes a trade-off between the flip angle and the minimum value of the absolute profile. To eliminate the zero crossings of the rectangular pulse excitation profile, a quadratic phase is modulated to the RF pulse waveform

Point wise Encoding Time reduction with Radial Acquisition

It is three dimensional method which offers shorter encoding times over the whole k-space which enables higher resolution for tissue with very short T2.It has very low demands on gradient switching times and is not disturbed by gradient-imperfections like eddy currents and time delays which leads to a problem for UTE-imaging. PETRA in ZTE gives good Signal to noise ratio for tissue with short T2 and good image quality overall.

The outer k-space in Pointwise Encoding Time reduction with Radial Acquisition is filled with radial half-projections whereas the centre is measured single point on a Cartesian trajectory. The crossbreed sequence combines the features of single point imaging with radial projection imaging. No hardware changes are required.

Profile Measurement

A pulse sequence was proposed to measure the excitation Profile, which can be inserted as a pre-scan into the ZTE sequence. Firstly,the profile was obtained by measuring the actual pulse shape with an oscilloscope and then by taking the Fourier transform of the pulse shape. The additional hardware is not required and can be inserted as an optional component into the ZTE pulse sequence. The new sequence is used to measure the spectral profile which gives good agreement with that obtained from simulation. The correction algorithm gives accurate as an input for the profile from the numerical simulation.

Recurrence Solving

Iterative reconstruction is a new concept for the calculation of medical images, based on formulating the reconstruction process mathematically as an inverse problem and solving it with a numerical optimization method. Iterative reconstruction is currently receiving strong interest in the MRI community. Iterating produces an estimate that approximately satisfies both sets of constraints. There are several variations on this idea, depending on how the constraints are applied, and how the iteration is performed.

IV. PROCESSING STEPS OF PROPOSED METHOD

Step1: Transforming the Cartesian form of image into k-space by applying the NUFFT transform.

Step2: NUFFT operator that maps the (Cartesian) image to k -space (full) radial spokes, with one spoke for each radial trajectory, and additionally one spoke for each Cartesian point.

Step3: The P operator acts on each projection separately by zero-padding (by a factor of 2), 1-D IFFT, and multiplication with the excitation profile.

Step4: By applying 1-D FFT, restoration of the original vector length.

Step5: The sampling operator, masks out the fraction of the radial signal that was not acquired (recall that less than half of each radial spoke is acquired) and performs Dirichlet interpolation in the Cartesian portion.

Step6: Application of the NUFFT operator is the most time-consuming process, requiring O(N Log N) computations. The adjoint operator is the reverse process of the above steps.

Step7: The image reconstruction algorithm was implemented in Matlab (Mathworks, Natick, MA, USA) with NUFFT algorithm as a mex function written in C.

V. EXPERIMENTAL RESULTS

The uncorrected ZTE image from MRI scanner is processed through RF phase modulation the corrected image is obtained as shown in Fig.4.The maximum artifacts is reduced by processing the un corrected image in to number of iterations. The fig.5 and fig.6 shows the 30 & 100 iterations.

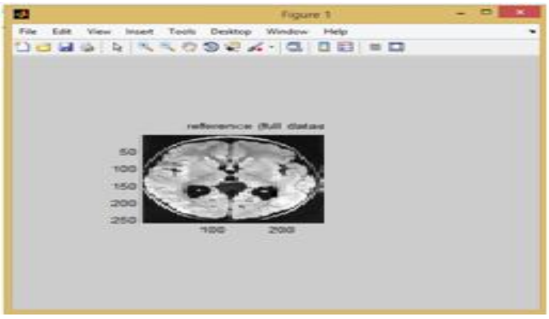

Fig 2: Un-corrected ZTE image

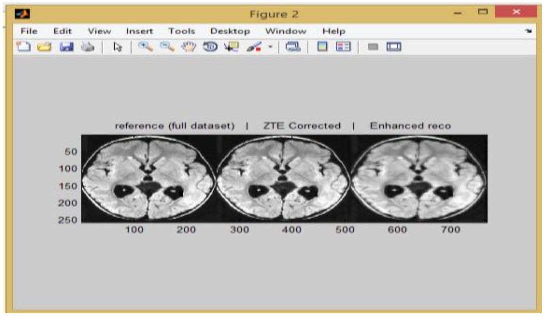

Fig 3: ZTE corrected Image

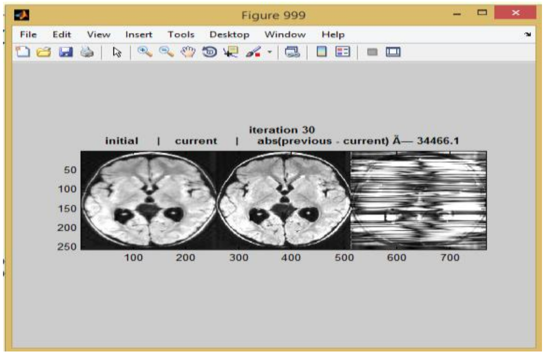

Fig 4: Amount of artifacts after 30 Iterations

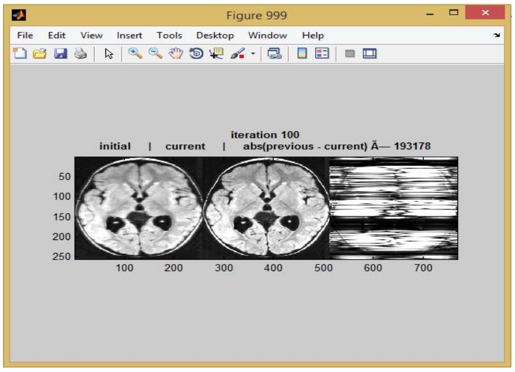

Fig 5: Amount of artifacts after 100 Iterations

The statistical values for the corrected image in 30 & 100 Iterations is as shown in Table.1

Table.1:Statistical values

S.No	**Parameter**	**Statistical Value For 30 Iterations**	**Statistical Value For 100 Iterations**
1	Mean Square Error	3.2515e+003	1.7224e+003
2	Peak Signal to Noise Ratio	13.0100	15.7694
3	MN Normalized Cross-Correlation	0.9270	0.9871
4	Average Difference	-5.3624	-2.4307
5	Structural Content	0.9436	0.9926
6	Maximum Difference	227	147

VI. CONCLUSION

In this method, a new technique is implemented for reducing the arelics in MRI images. In this work the sequence of signals is used which include the flatter excitation profile which is obtained by modulate the hard RF pulse with quadratic phase and efficient algorithms. In this work the iterative reconstruction is implemented for reduction of artifacts and also performed the simulation results .If the iterations is increased the artifacts is reduced.

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