Parallel Imaging Reconstruction by Sense Algorithm

Sachin Dubey*, P Mor and Jag Mohan Keller
Department of physics and electronics Rani Durgavati
Viswwavidyala, Jabalpur, M.P.482001, INDIA
Department of electronics-HCET, Jabalpur MP-482001, INDIA
*Corresponding author
sachinengmba06@gmail.com

Abstract: The problem of image reconstruction from sensitivity encoded data is formulated in a general fashion and solved for arbitrary coil configurations and k-space sampling patterns. To achieve increased acquisition speed in magnetic resonance imaging Special attention is given to the currently most practical case, namely, sampling a common Cartesian grid with reduced density. Scan time was reduced to one-half using a four-coil array in brain imaging.

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I. THEORY

Magnetic resonance imaging (MRI) is an imaging technique used primarily in medical settings to produce high quality images of the inside of the human body. MRI is based on the principles of nuclear magnetic resonance (NMR), a spectroscopic technique used by scientists to obtain microscopic chemical and physical information about molecules. The technique was called magnetic resonance imaging rather than nuclear magnetic resonance imaging (NMRI) because of the negative connotations associated with the word nuclear in the late 1970's. MRI started out as a tomographic imaging technique, that is it produced an image of the NMR signal in a thin slice through the human body. Today MRI has advanced beyond the tomographic Imaging technique to a volume imaging technique.

The acquisition speed of magnetic resonance imaging (MRI) is an important issue. Increasing the acquisition speed shortens the total patient examination time, it reduces motion artifacts and increases the frame rate of dynamic MRI. Parallel MRI is a way to use multiple receiver coils with distinct spatial sensitivities to increase the MRI acquisition speed. The acquisition is speeded up by undersampling the *k*-space in the phase-encoding direction. The resulting data loss and consequent aliasing is compensated for by the use of additional information Obtained from several receiver coils. New theoretical and practical concepts have been presented for considerably enhancing the performance of magnetic resonance imaging (MRI) by means of arrays of multiple receiver coils. The receiver sensitivity generally has an encoding effect complementary to Fourier preparation by linear field gradients. This fact has been used to reconstruct the image and the technique is known as sensitivity encoding (SENSE) Thus, by using multiple receiver coils in parallel, scan time in Fourier imaging can be considerably reduced.

Key words: MRI; sensitivity encoding; SENSE; fast imaging; receiver coil array Parallel Imaging has been developed as a complementary technique for reducing the image scan time, using locally sensitive Multiple receivers. The total number of phase encodings is reduced to decrease imaging time. The image is reconstructed using information in the form of the coil sensitivity profiles to compensate for the lesser data collected in*k*-space compared to the earlier described techniques.

Pulse sequences enable to achieve considerable increase in the imaging speed. They mainly aim at reducing the *TR*. Parallel imaging on the other hand aims at accelerating the imaging speed by reducing the number of *k*-space lines collected by the scanner. From Fourier theory, most of the image information is stored at the center or in the lower frequencies in the frequency domain. Collecting a few lines in center of *k*-space can produce an image but it would not be useful for medical analysis.

Parallel imaging therefore suggests a different ways in which lesser *k*-space lines can be collected and yet a good image can be obtained for diagnosis. The number of lines reduced is determined by the reduction factor or acceleration and its denoted by *R*. A reduction factor of 2 or an acceleration of 2 implies half the usual number of lines was acquired.

II. THEORETICAL BACKGROUND

2.1 Why parallel imaging?

If a design criteria were written for a method for image acceleration, the key features would be that

•It is applicable to all pulse sequences without affecting image contrast;
•It is complementary to all existing acceleration methods;
• It does not introduce aliasing or adversely affect SNR.

Coil encoding scores full marks on the first two bullet points. The last is a complex point deserving of its own section. In general PI does not introduce significant artifacts but it does reduce SNR and this is its weakness. However, as we will see, the benefits are large and when applied intelligently far outweigh this limitation.

2.2SENSE ALGORITHM

Sensitivity encoding (SENSE) is a technique that enables to reduce scan time in magnetic resonance imaging (MRI) considerably. The spatial information related to the coils of a receiver array are utilized for reducing conventional Fourier encoding. In principle, SENSE can be applied to any imaging sequence and k-space trajectories. SENSE can perform -Acquisition of reference images give *coil sensitivity profiles*, Speeds up imaging by a factor as much as the maximum number of phased array coil elements (R: acceleration factor),reduces SNR by at least the same factor however, as the speed is increased Field of view must be larger than the body part to avoid artifacts.

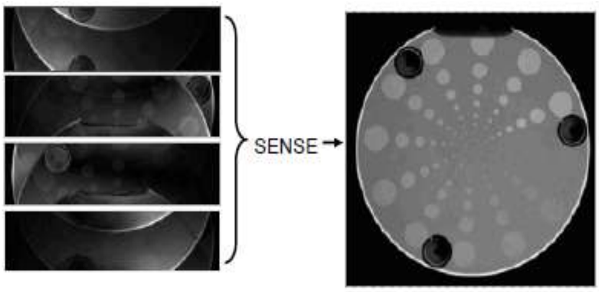

Fig 1.3.2 Data acquired from each PA coil element goes into reconstruction of whole image – Reduces imaging time, reduces SNR, reduces uniformity.

Thus in MR imaging with the SENSE technique

1) For a reliable sensitivity mapping of each coil element, a reference measurement scan is obtained using the coils and related images acquired with the homogeneous quadrature body coil.

2) SENSE data are acquired with a reduced number of phase-encoding steps resulting in an aliased or back-folded image with a reduced field of view .Scan time is reduced by decreasing the number of phase-encoding steps. This reduction is defined by the SENSE reduction factor *R* (the SENSE scan time equals the full scan time divided by *R*).

3) Unlike phased array coils, the coil elements are not used to cover separate anatomic regions to increase the signal-to-noise ratio (SNR) but are used to simultaneously measure the same region for scan-speed increase. The SENSE reconstruction algorithm separates the superimposed signals using information on the individual coil sensitivities and restores the full field-of-view image.

III. IMPLEMENTATION

The objective of the present paper is to reconstruct the unaliased image from the aliased image by using SENSE algorithm. The use of four receiver coils to augment the time consuming Fourier encoding reduces acquisition time significantly. This increase in speed comes at a time when other approaches to acquisition time reduction were reaching engineering and human limits.

The step wise implementation of the technique may be described as under -

It consists of following steps with given simulated figures-

1) Create from sample FFTS images
   a) Assume original image & sesitivity maps.
   b) Construcrt reciver view by dot product of original images and sensitivity maps.
   c) Compute FFT of above reciever views.
   d) Sample above FFT's.
2) To Reconstruct (SENSE ALGORITHM)
   a) Compute inverse FFT of sampled FFT's. (thus getting alised images)
   b) Run sense algorithm pixel by pixel to reconstruct the alised free image.

Fig 1.4.1 Assume sensitivity map- 1

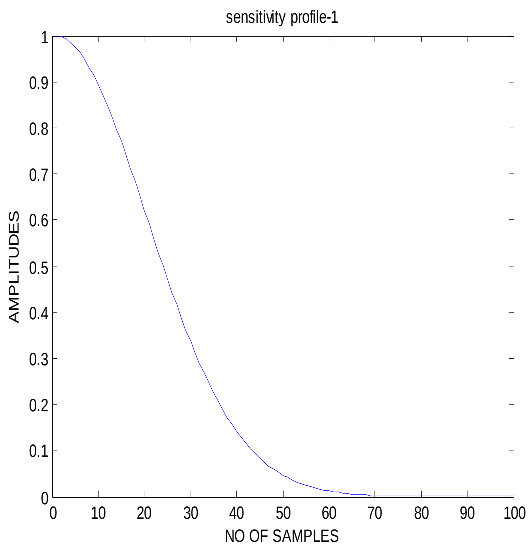

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Fig 1.4.2 Assume sensitivity map- 2

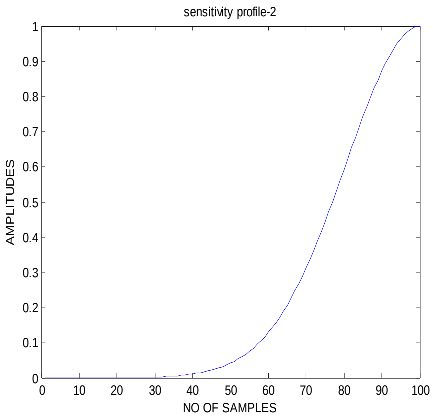


Fig1.4.3 Original sine wave signal

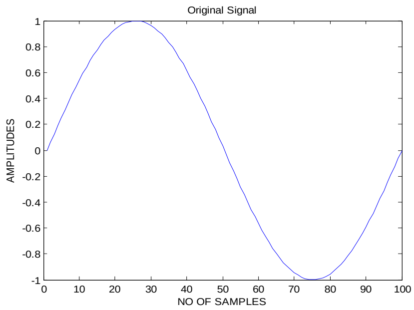


Fig 1.4.4Construcrt reciver view (S1)by dot product of original image andsensitivity map

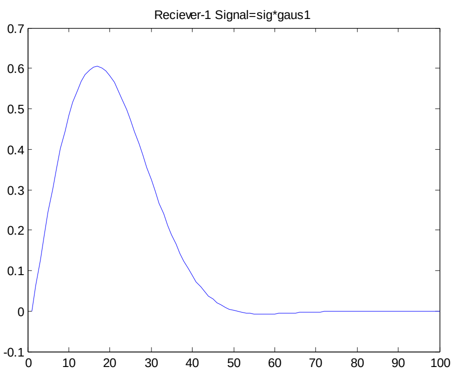


Fig1.4.5 Construcrt reciver view (S2) by dot product of original image and sensitivity map 2.

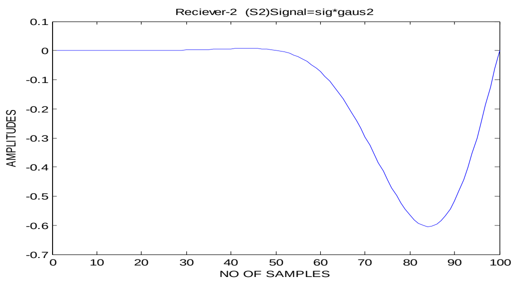


Fig 1.4.6 Addition of dot product oforiginal image and sensitivity map 1(S1) and original image and sensitivity map 2(S2) (S1+S2) .

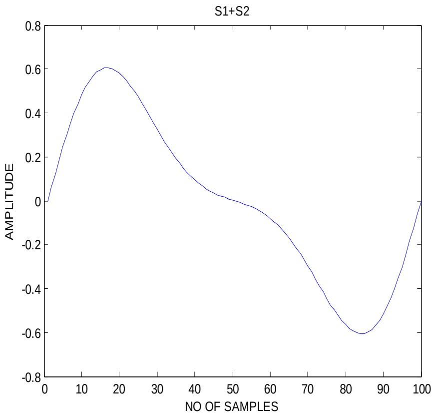


Fig 1.4.7 Compute Fast Fourier Transform of reciever viewS1.

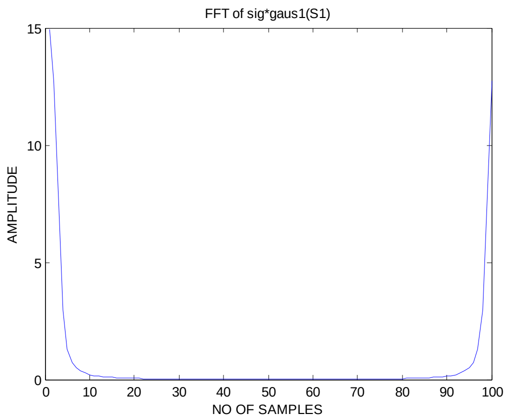


Fig1.4.8 Compute Fast Fourier Transform of reciever view S2.

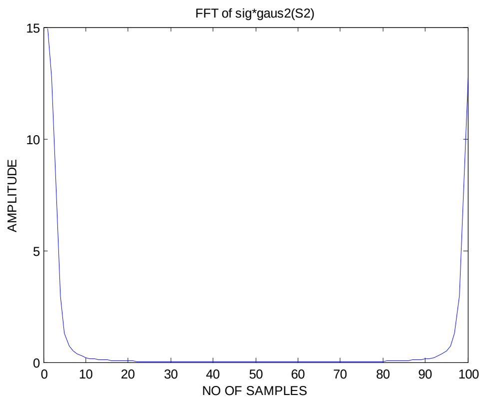


Fig 1.4.9 SAMPLERS (Sampler Samples above FFT's.)

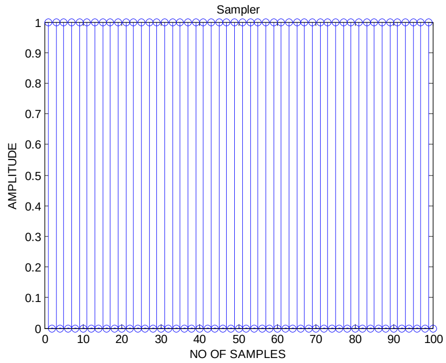


Fig 1.4.10RECONSTRUCTION (SENSE ALGORITHM) - Compute inverse FFT of sig*gaus1 of sampled FFT's. (thus getting alised images)

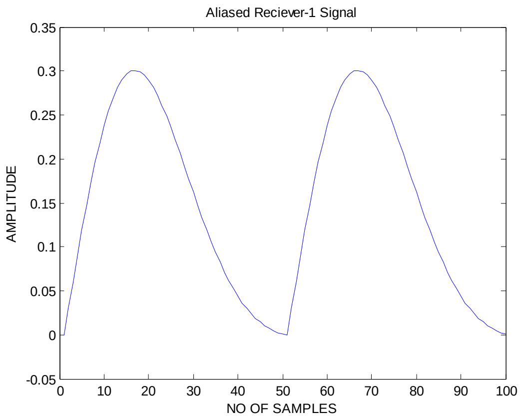


Fig 1.4.11 Compute inverse FFT of sig*gaus2 of sampled FFT's. (thus getting alised images)

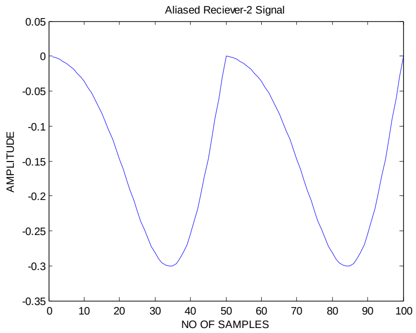
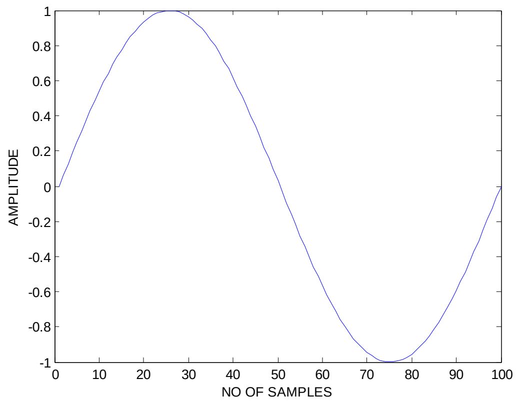


Fig1.4.12 we will run algorithm pixel by pixel to reconstruct the alised free image.

ORIGINALLY RECONSTRUCTED SINE WAVE SIGNAL



IV. CONCLUSION

Parallel MRI is a technique that increases the acquisition speed. This is advantageous for dynamical imaging and it also increases the number of patients examined per day and, thus, makes the MRI examination more available. In this thesis, we have addressed the topic of parallel MRI **SENSE** reconstruction method. We have formulated the problem of parallel MRI reconstruction from the undersampled *k*-space data and provided the necessary theoretical background that is essential for a thorough understanding of the problematic. The state-of-the-art of parallel MRI was written to summarize the main reconstruction algorithms with references to literature.

REFERENCES

[1] P. Lauterber and Z. Liang, Principles of Magnetic Resonance Imaging: A SignalProcessing Perspective, New York: IEEE Press Series in Biomedical Engineering,2001, chap. 9, pp. 291–311.

[2] S.M. Wright, M.P. McDougall, "Single Echo Acquisition Imaging using RF Encoding,"? NMR in Biomedicine, vol. 22(9), pp. 982-993, 2009.

[3] Z. Liang, "Improved algorithms for image reconstruction from sensitivity encoded data ," in Proc. of the Second Joint EMBS/BMES Conference, Houston,TX, USA, October 23-26, 2002.

[4] K. Pruesmann, M. Weiger, M. Scheidegger and P. Boesiger, "SENSE: Sensitivity encoding for fast MRI," Magnetoc Resonance in Medicine, vol. 42, pp. 952–962,November 1999.

[5] A. Sodickson, "Breaking the magnetic resonance speed barrier: Implications of parallel imaging," www.appliedradiology.com, Accessed: April, 2005.

[6] S. Wright, M. McDougall and D. Brown, "Single echo acquisition of MR images using RF coil arrays," Proc. of the Joint EMBS/DEMS Conference, Houston,TX, USA, October 23-26, 2002.

[7] Ashish Raj , Yi Wang , Ramin Zabih "A Maximum Likelihood Approach to Parallel Imaging With Coil Sensitivity Noise