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Performance Ansalysis of Sparsifying Transform for the Reconstruction of MRI

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Abstract- **Magnetic Resonance Imaging (MRI) is a medical imaging technology that is used for diagnostic imaging of a wide range of diseases. Image reconstruction is much concentrated with the contrast of possibly the same value as the original. This paper presents the comparison of KarhunenLoeve Transform (KLT) and Walsh Hadamard Transform (WHT) for MR Image reconstruction. The MR image used is grayscale. The original image is reconstructed using Inverse Transform. The performance of each transform is measured by evaluating Peak Signal to Noise Ratio (PSNR), Structural Similarity Index(SSIM) and Mean Square Error(MSE) for the reconstructed gray scale of pixel size 256× 256. The quality measurement for these two transforms is measured in terms of MSE, PSNR and SSIM values. The comparison of PSNR, SSIM, MSE values between the two transforms proves that the reconstructed image using WHT transform has better quality than the KLT transform.**

Index Terms— **MRI,KLT,k-space,WHT, PSNR, SSIM,MSE.**

I. INTRODUCTION

Karhunen Lo`eve Transform (KLT) is known as optimal transformation technique which always results in exactly uncorrelated transformed coefficient. It also has high energy compaction property i.e. it keeps as much energy as possible in few coefficients. The outstanding advantage of KLT is a good de-correlation. KLT into compressive sensing, which can as results improve the compression ratio without affecting the accuracy of decoding. The different signal sample collection has different transformation matrix [1]. One of the drawback of KLT is that requires large computational resources as compared to other transformation techniques. Walsh Hadamard Transform (WHT) is fast method for transformation as it requires only addition and subtraction operations. However, it has very low energy compaction characteristics [2]. It has been found that pattern matching can be performed efficiently in WHT domain. In signal processing the Walsh Hadamard transform is a non-sinusoidal, orthogonal transformation technique that decomposes a signal into a set of basis functions. These basis functions are Walsh functions, which are rectangular or square waves with values of +1 or –1. WH transforms are also known as Hadamard (Walsh, or Walsh-Fourier transforms). WHT uses basis functions and provides piece-wise constant separable image band-limited approximation. R.M. Suliman, et al., [2] applied WHT for low complexity face recognition system. On a fixed-point processor WHT can easily implemented. WHT offers a good compromise between computational burden and identification rates.

II. PROPOSED METHODOLOGY

Transform is applied on an image to convert it from one domain to another. The overview of the proposed algorithm is shown in Figure 1. It mainly involves four stages, namely acquiring the Magnetic Resonance Image (MRI) and applying various transforms like KLT and WHT on it, to obtain the k-space of the image i.e. sparse coefficients. The inverse transform will get back the original MRI image.

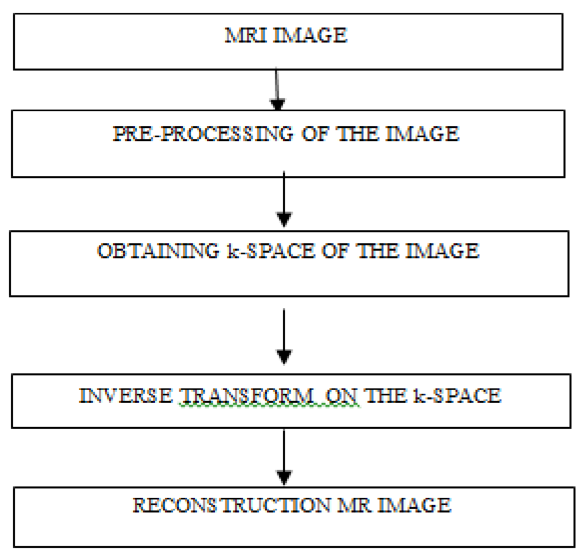

Figure. 1 Overview of the system

A. Magnetic Resonance Imaging

MRI is interesting systems that image the human body non-invasively. MRI images bring a shocking personal satisfaction which will be considerably equal to that of a photo. Because high spatial resolution as well as excellent soft-tissue contrast is offered by MRI. For important measurements the MRI can be used as a suitable method in medical analysis. But extensive acquisition period limits its convention due to expense and considerations for tolerant success. On water molecules the MRI contraption emits a Radio Frequency (RF) beat at the resonant regularity of the hydrogen atoms.

B. k-space

In k-space high frequency values are concentrated around the centre and low frequency values are present at the corner. The size of the k-space selected is 256 x 256 [3]. The higher frequency regions are generally sparse in k-space and majority of the information of an image is available near the central region of k-space.

III. PERFORMANCE METRICS

To evaluate the effectiveness of the proposed work quantitative and qualitative analysis is performed on the reconstructed MR Image. PSNR,MSE and SSIM are measured on the reconstructed image [4].

A. Peak Signal to Noise Ratio

PSNR shows the noise power in the reconstructed image. The quality of the reconstructed image will be good for high value of PSNR. Consider the reconstructed image as aand original MR image as b both of size M x N (256 x 256), then Peak Signal to Noise Ratio (PSNR) between a and b is defined as,

$$PSNR(a,b) = 10\,log_{10}\left(\frac{M^2}{MSE(a,b)}\right) \qquad (1)$$

where$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(a_{ij} - b_{ij})^2 \qquad (2)$

whereaij is reconstructed image of size M x N and bij is original image, 'M' is pixel dimension of reconstructed image.

B. Structural Similarity Index Measurements

The SSIM value near to '1' indicates a high degree of similarity between the original image and reconstructed image.

$$SSIM = \frac{(2\mu_{I_r}\mu_{I_f} + C_1)(2\sigma_{I_rI_f} + C_2)}{({\mu^2}_{I_r} + {\mu^2}_{I_f} + C_1)({\sigma^2}_{I_r} + {\sigma^2}_{I_f} + C_2)} \qquad (3)$$

where μ_{I_r}, μ_{I_f}, σ_{I_r},σ_{I_f}, and $\sigma_{I_rI_f}$, represents the local means, standard deviations, and cross-covariance of images I_r, I_f, $C_1 = (0.01 * L)^2$, $C_2 = (0.03 * L)^2$ where L indicates specified dynamic range value of a pixel.

IV. EXPERIMENTAL RESULTS

The algorithm is implemented in MATLAB 2013a. The MRI image to be measured is of size 256 x 256. The database of single person is obtained from "MR_tip site". and is shown in Figure. 2.

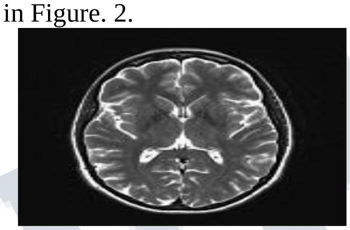

Figure. 2 original MR Image

A KarhunenLoeve Transform

The input MRI image which is to be sampled is shown in Figure 3(a). This image is converted to grayscale using rgb2gray command which is shown in Figure 3(b). Then apply the KL Transform on the image to get under sampled image i.e. sparse coefficient shown in Figure 3(c). Inverse transform is applied on sparse coefficients to obtain the original image as shown in Figure 3(d).

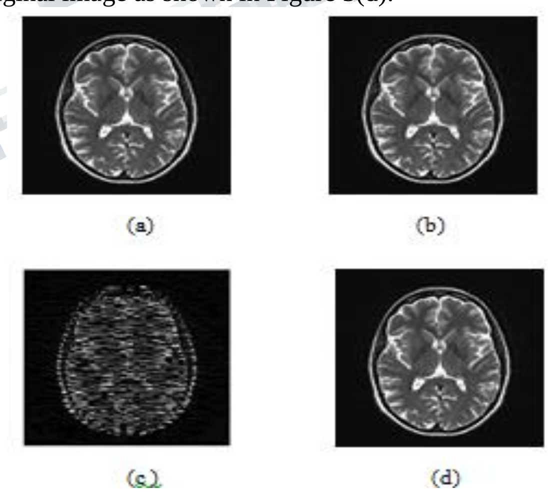

Figure 3: Sampling k-space using KL Transform (a) MRI brain image (b) Grayscale image (c) Sparse coefficeints (d) Reconstructed image

B. Walsh Hadamard Transform

The brain MRI image which is to be sampled is shown in Figure 4(a). This image is converted to grayscale using rgb2gray command which is shown in Figure 4(b). Then apply the WH Transform on the image to get sampled image i.e. sparse coefficient shown in Figure 4(c). Inverse transform is applied on sparse coefficient to obtain the original image shown in Figure 4(d).

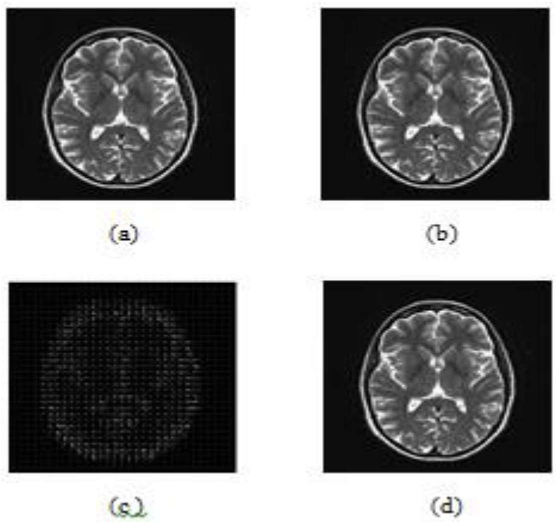

Figure. 4: Sampling k-space using WH Transform (a) MRI brain image (b) Grayscale image (c) Sparse coefficeints (d) Reconstructed image

TABLE I
RECONSTRUCTION RESULTS IN TERMS OF PSNR, MSE AND SSIM

TRANSFORMS	PSNR	MSE	SSIM
KL TRANSFORM	32.35	38.07	0.6277
WH TRANSFORM	54.94	0.21	0.9999

PSNR and MSE are used to compare the squared error between the original image and the reconstructed image. It can be observed there is an inverse relationship between PSNR and MSE. The higher PSNR indicates that the quality of reconstruction is good. TABLE I gives PSNR, MSE and SSIM for KL and WH Transform. The MR image reconstruction using KL transform has high MSE than the PSNR value, which shows the poor reconstruction quality. For WH transform the PSNR value is higher than the MSE value which implies that the reconstruction quality is better. The SSIM value for KL transform is very low and for WH transform the value is near to 1. Hence, reconstruction quality is high for WH transform compared to KL transform.

V. CONCLUSION

The KL Transform and WH Transform are applied on the MR Image. Visual inspection shows that the reconstructed image is same as that of the original image. The quantitative analysis on these two transforms is performed in terms of MSE, PSNR and SSIM values. Based on quantitative analysis values the WH transform has high PSNR and SSIM value compared to KL Transform. Hence, the reconstruction quality is better in WH transform.

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