IMAGE RECONSTRUCTION FROM COMPRESSIVELY SENSE DATA USING MATCHED WAVELETS

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ABSTRACT

This paper proposes a method of image reconstruction by using matched wavelets from compressively sensed images. Matched wavelets provide better reconstruction of images when compared to standard wavelets. The lifting scheme used in this method has advantages such as lower area, less power consumption and less computational complexity. Here a sensing matrix is used to sample the data at sub Nyquist rate which allows reconstructing the signal with fidelity. At the final sage the multilevel L-pyramid decomposition performed ensures performance is improved. This includes the decomposition of wavelets using Laplacian pyramid. At every stage of decomposition image is fused using absolute value rule. The inverse wavelet transform is then applied to all coefficients to produce the reconstructed image in Laplacian pyramid. Finally in the proposed method with sensing matrix, wavelet decomposition and image-matched wavelets gives better results in compressed sense based image reconstruction.

Keywords: compressed sense data, Matched wavelets, lifting scheme, detailed coefficients, coarse coefficients, Laplacian pyramid

I. INTRODUCTION

According to traditional approach for signal reconstruction, Shannon –Nyquist sampling theorem should be obeyed. Theorem states that sampling rate should be twice the maximum signal frequency for efficient recovery of data. But this results in more power consumption, more storage space requirement etc. In compressed sensing (CS) approach signal can be expressed in certain transform domain where fewer coefficients are significant and rest all values are zero. In CS the original signal can be estimated from few coefficients considering sparse property. For performing reconstruction, the coefficients along with their location position is sent to receiver.[1][3]

Salient features of this paper:

1. From compressively sensed image a matched separable wavelet is designed.

2. In compressive sensing application Gaussian matrices are used.

3. A partial canonical matrix is proposed to sample the data at sub Nyquist rate so that sensing time can be reduced

4. Multilevel L pyramid wavelet decomposition is proposed which provides improved reconstruction of image.

II. BACK GROUND

This section explains about the theory of compressed sensing and lifting techniques.

A. Compressed Sensing: Compressed sensing is achieved by first sampling an analog data above the Nyquist criteria and by applying suitable transform techniques. Fourier transforms and wavelet transforms are mainly used. A signal is said to be K sparse means by applying transform techniques around K elements are zero and it follows the power low decay. The retained coefficients along with their location information are sending to receiver. So that signal is reconstructed back at the receiver side. [5]

According to compressed sensing rule the signal can be reconstructed with high probability if the number of linear projection taken such that M≥CK log(N/K) where C is constant and K is sparse of Signal.

B. Lifting concepts: Lifting is a technique in which new wavelets are created from existing wavelets. This allows the perfect reconstruction of signal. This is usually done by the split, predict and update steps. Split step is where the input signal is split into odd and even disjoint sets. In predict step the samples obtained from the split is predicted from the other set samples. It is same as applying high pass filter. [6][7]

$$H_0\ (z) = H_0(z) + H_1(z)S(z^2), \quad \ldots\ldots \qquad \ldots\ldots.(1)$$

$$F_1\ (z) = F_1(z) - F_0(z)(z^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(2)$$

Lastly in the update step predicted step output samples are updated to provide approximate coefficients of the signal.

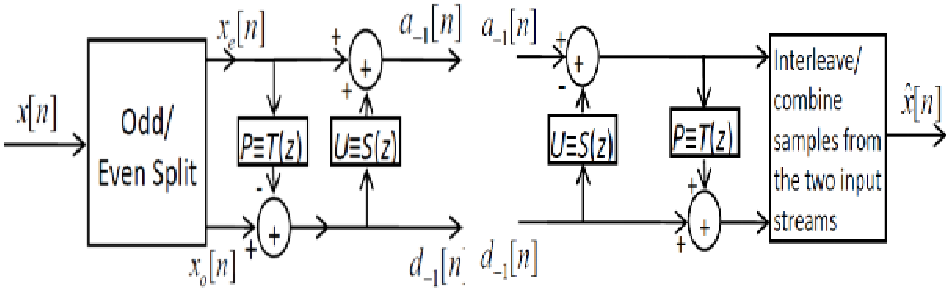

Fig 1 Steps of Lifting: Split, Predict and Update

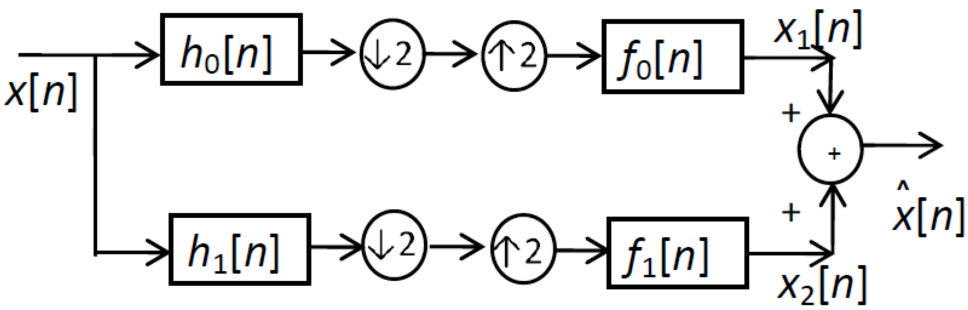

Fig 2 Two Channel Biorthogonal Wavelet System

III. PROPOSED METHOD

A. Compressed sensing of image by using sensing matrix

Nowadays as the image size increases the samples used to represent it also changes. This results in problems like storage, computation, calibration requirements, larger space bandwidth product itself. This process is very time taking as M samples are captured sequentially and also in case of video by the time it captures video scene it will be changed. Other problems related to it are difficult calibration requirements and designing complexity of imaging system with large space bandwidth product. As a solution single pixel camera is proposed. It captures the image

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such that the inner product between the scene and measurement basis evaluated. Camera captures only one pixel and that is repeated M times to get the linear combination of all pixels. These compressive measurements are transmitted to the receiver for image reconstruction.

B. Compressed sensing by partial canonical Identity matrix

Consider an input image of size MxN, instead of sampling all the pixels of the image using sensor array in partial canonical identity matrix M samples of the image is considered. The matrix formed is called Partial Canonical Identity matrix.PCI matrix takes only M samples of input image, this is achieved by turning ON only M samples of sensor array. This reduces sensing time

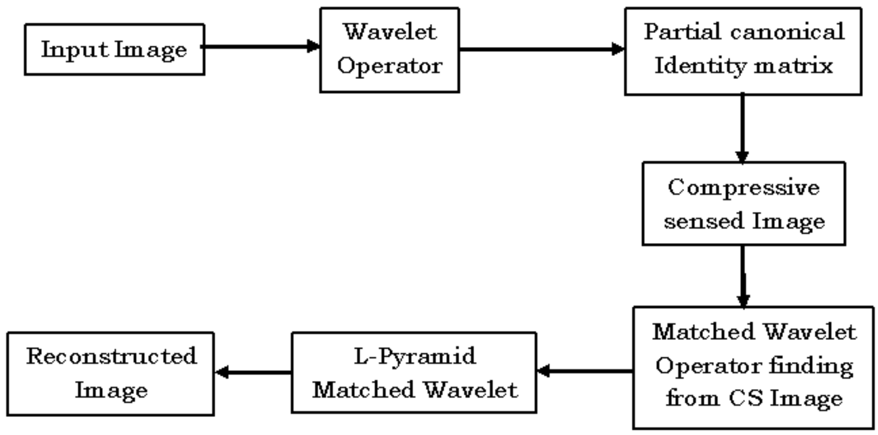

Fig 3 Block diagram for PCI based image reconstruction system

C. L-Pyramid wavelet decomposition method for images

In wavelet decomposition initially 1 D wavelet transform is applied along the column and row wise of image. The I-D wavelet decomposition is named as LL, LH, HL and HH respectively. The steps are followed again on LL part of wavelet transforms to obtain another K level decomposition. This is performed by applying low pass filtering along column wise and high pass filtering along row wise.

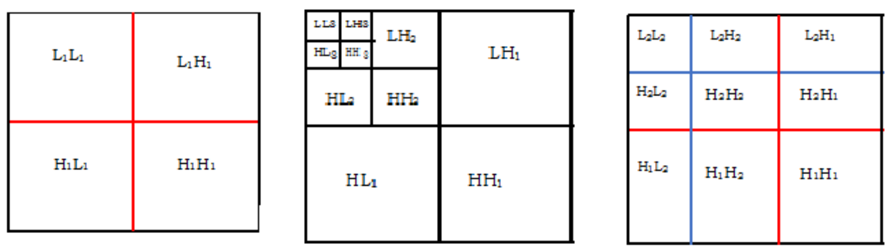

Fig 3 level pyramid and 2 level R pyramid and 2 level L pyramid

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IV. EXPERIMENTS AND RESULTS

Consider Lena image given with 30% sampling ratio through PCI matrix. The non-captured region can be filled with zeroes. Fig 5 and 6 shows reconstruction, in terms of PSNR (in dB) and Gaussian and PCI sensing matrices on image 'Lena'.

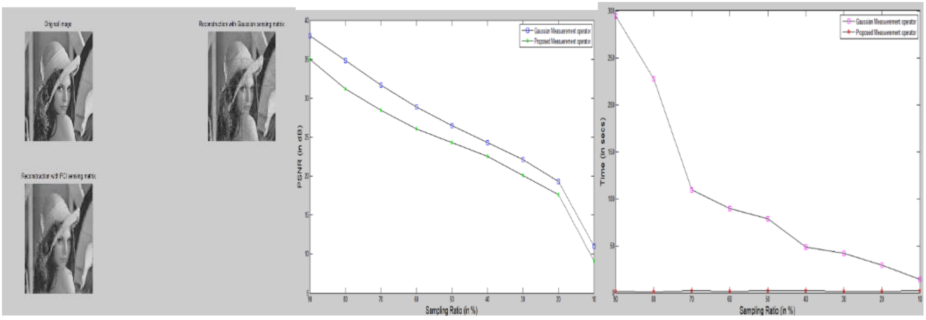

Fig 5 shows Reconstruction, with accuracy in terms of PSNR (in dB) and Gaussian and PCI sensing matrices on image 'Lena'

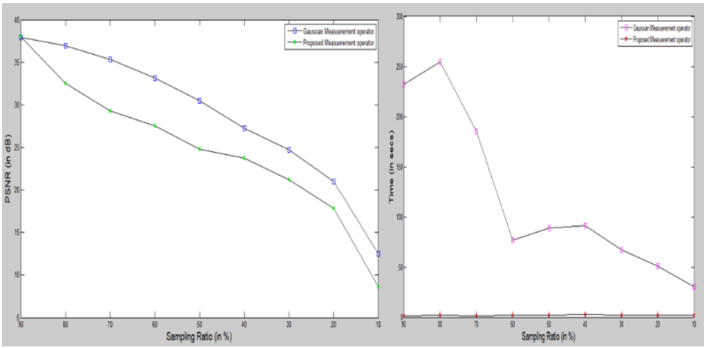

Fig 6 Reconstruction, (a) accuracy in terms of PSNR (in dB) and (b) time, for Gaussian and PCI sensing matrices on image 'House'.

Fig 7 shows accuracy interms of PSNR when 10 iterations are done.the figure shows the proposed method gives improvement over the existing strategy.

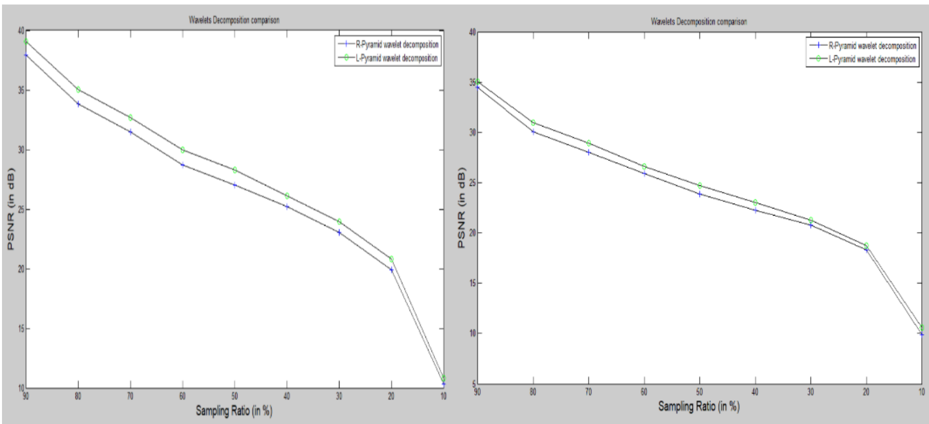

Fig 7 Reconstruction accuracy in terms of PSNR (in dB) for PCI sensing matrix using R-Pyramid and L-Pyramid wavelet decomposition methods for image 'Lena' and cameraman

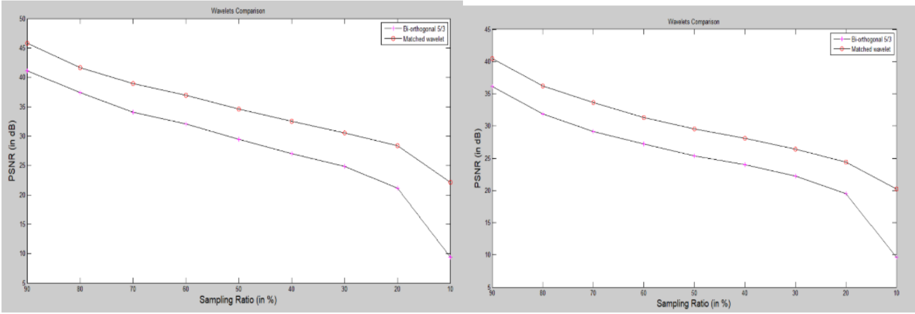

Fig 8 Reconstruction accuracy in terms of PSNR (in dB) for PCI sensing matrix using Bi-orthogonal 5/3 and matched wavelets for image Boat and House

V. CONCLUSION

In this paper, matched wavelets are designed from compressively sensed images.it is also used for the perfect reconstruction of images. When partial canonical identity matrix is used along with the CS based reconstruction better results are obtained. The performance degradation happened due to PCI matrix is overcome by the matched wavelet design. Wavelet decomposition adopted in proposed method is more efficient when compared to conventional wavelet decomposition method.

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