A-review Compression of Hyperspectral image using Compressive Sensing

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Abstract:* A novel approach for compression of hyperspectral images is described using compressive sensing is adopted in latest signal processing technique for acquiring andrecovering a sparse signal in the most efficient way possible with the help of an incoherent projecting basis. CS is based on sampling theorem which gives batter performance than the Shannon-Nyquist sampling theorem. Hyperspectral images typically demand enormous computational resources in terms of storage, computation, input/output, throughputs particularly when real-time processing is desired so, CS is best approach for compression of hyperspectral images and transforming to different places with acceptable signal –to –noise ratio(SNR) and compression ration than other signal transformation techniques.

Keywords: Compressive sensing (CS), Hyperspectral Images, Image Compression, Lossless image compression, Lossy image compression

I. INTRODUCTION

Hyperspectral image has attracted much attention in wide range of applications such as terrain classification, mineral detection and exploration, pharmaceutical counterfeiting, environmental monitoring, military surveillance so for transforming.

[12]Hyperspectral imaging incorporate the power of digital imaging and spectroscopy. Hyperspectral camera acquires the light intensity for a large number (typically a few tens to several hundred) of contiguous spectral bands for each pixel in an image for thus contains a continuous spectrum and can be used to individualize the objects in the scene with great precision and detail. Hyperspectral images provide much more detailed information about the scene than a normal color camera, which only acquires three different spectral channels corresponding to the visual primary colors red, green and blue. Hence, hyperspectral imaging leads to a vastly improved ability to classify the objects in the scene based on their spectral properties.

Hyperspectral images provide such high spatio-spectral resolution at the cost of extremely large data size.As these data are very important so after transforming reconstruction of original data is also challenge so, they fit perfectly the assumptions underlying CS theory.

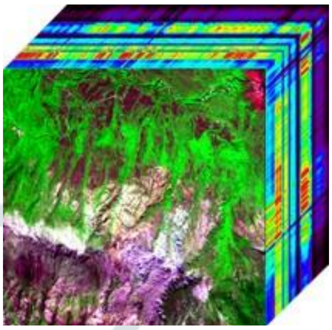

Fig.1 hyperspectral image [10]

In[7], a typical signal processing and imaging system, the samples areobtained through the array of photoelectric sensors and A/D converter which have some inefficienciesin these, it must compress themassive date before transmission and storage. The Nyquist-shannon rate used in imaging data acquisition for remotesensing, is so high that too many samples produced, makingcompression a necessity prior to storage or transmission. Inaddition, even though thecompressed data is less, the initialsamples are larger and all values have to be processed and in order to obtain high-resolution images of different bands,sensors are often expensive and complicated. These problemswill increase the complexity and cost of the imaging acquisition,therefore, it is necessary to study a new acquisition technology of the low-cost, high efficiency and wide application range for remote sensing imaging to effectively acquire the observation data. A new technology is emerged to capture and represent compressible signals at a significantly low rate is called compressive sensing. The use of CS techniques would allow to design sensors requiring a smaller memory buffer, fewer detectors, and a reduced volume of data to transmit.

II. BACKGROUND

Image compression mainly classified in to three types:

1. Lossy image compression
2. Lossless image compression

Fig.2 Lossless and Lossy image compression comparison [11]

Lossy image compression is used when less transmission time is in consideration where quality of image is not important.

Types of Lossy Image Compression:
Block Truncation Coding scheme divides the image into non overlapping blocks of pixels and for each block, threshold and reconstruction values are determined. The threshold is usually the mean of the pixel values in the block. Then a bitmap of the block is derived by replacing all pixels whose values are greater than or equal (less than) to the threshold by a 1 (0). Then for each segment (group of 1s and 0s) in the bitmap, the reconstruction value is determined. This is the average of the values of the corresponding pixels in the original block.

In transformation coding technique data is divided in to square blocks and transforms the raw data to a domain that more accurately reflects the information content ex. Audio file.Discrete Cosine Transform(DCT) is the most recent known transform in the image compression field because of its excellent properties of energy compaction. This method is too simple but needs to implement on large sized data block (typically 8x8 min).

Vector quantization technique is lossy data compression method following the principle of block coding. The basic idea behind this technique is to develop a dictionary of fixed-size vectors, called code vectors. A vector is usually a block of pixel values. A given image is then partitioned into non-overlapping blocks (vectors) called image vectors. Then for each in the dictionary is determined and its index in the dictionary is used as the encoding of the original image vector. Thus, each image is represented by a sequence of indices that can be further entropy coded.

Fractal coding methoddecomposes the image into segmentsby using standard image processing techniques such ascolor separation, edge detection, and spectrum and textureanalysis. Then each segment is looked up in a library offractals which contains codes called iteratedfunction system (IFS) codes, are compact sets ofnumbers. Using a systematic procedure, a set of codes for agiven input image are determined, such that when the IFS codes areapplied to a suitable set of image blocks yield an image that isa very close approximation of the original. Thisscheme ishighly effective for compressing images because they have goodregularity and self-similarity.

Subband coding scheme analysed the image to produce the components containing frequencies in well-defined bands, the sub bands. Afterwards, quantization and coding is applied to each of the bands. The advantage of this scheme is that the quantization and coding well suited for each of the sub bands can be designed separately.

Lossless image compression is used when transmission time of data is not important but quality, information, data are important. Most satellite images uses lossless image compression techniques.

Types of Lossless Image Compression:

Run Length Encoding is a very simple compression method used for sequential data and very useful in case of repetitive data. This technique Replaces sequences of identical symbols (pixels), called runs by shorter symbols.

Example:
Uncompressed data: BBBWWBBWWWW
Compressed data: 3B2W2B4W

Huffman Encoding is a matter of course technique for coding symbols based on their statistical occurrence frequencies. The pixels in the image are treated as symbols. The symbols that occur more frequently are assigned a smaller number of bits, while the symbols that occur less frequently are assigned a relatively larger number of bits. Huffman code is a prefix code. This means that the (binary) code of any symbol is not the prefix of the code of any other symbol. Most image coding standards use lossy techniques in the earlier stages of compression and use Huffman coding as the final step.

LZW Coding(Lempel- Ziv – Welch) is a dictionary based coding whose full set of strings is determined before coding begins and does notchange during the coding process. It is used when the message or set of messages to be encoded is fixed and large for instance, an application that stores the contents of a book in the limited storage space.A dictionary is built from old English texts then is used to compress a book.Dictionary based coding can be static or dynamic. In static dictionary coding, dictionary is fixed during the encoding and decoding processes. In dynamic dictionary coding, the dictionary is updated on fly. LZW is widely used in computer industry and is implemented as compress command on UNIX.

Area Coding is an intensified form of run length coding, reflecting the two dimensional character of images. This is a significant advance over the other lossless methods. For coding an image it does not make too much sense to interpret it as a sequential stream, as it is in fact an array of sequences, building up a two dimensional object. The algorithms for area coding try to find rectangular regions with the same characteristics. These regions are coded in a descriptive form as an element with two points and a certain structure. This type of coding can be highly effective but it bears the problem of a nonlinear method, which cannot be implemented in hardware. Therefore, the performance in terms of compression time is not competitive, although the compression ratio is.

III. EXISTING SYSTEM

Compression of hyperspectral images [1] is done by CS in which measurement matrix is used for improving reconstruction quality. In compressive sensing random measurement matrix is used , instead of random measurement matrix optimize measurement is proposed[1] to improve reconstruction quality of hyperspectral images by analysing the mutual coherence between measurement matrix and representation matrix using gradient descant method ,reduces measurement than iterative method.

The proposed method is designed to optimize an initially random measurement matrix to a matrix that presents a smaller coherence than the initial one. The mutual coherence provides a measure of strongest similarity between the different columns of the matrix and is exhibits its higher reconstruction quality compared to those of previous methods.

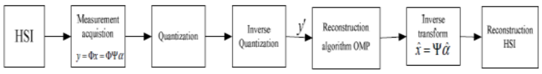

Fig.3 Hyperspectral compression technique[1]

In[2]lossy compression algorithm, increasing bitrate obtain the highest achievable SNR but it has been observed previouslythat a higher SNR may not necessarily correspond to better performance at data-analysis tasks, such asclassification, anomaly detection, linear unmixingso principle component analysis(PCA) is used with JPEG-2000 image compression where removal of lossless storage of anomalous pixels preservation gives batter compression performance than achieved at higher bitrate.

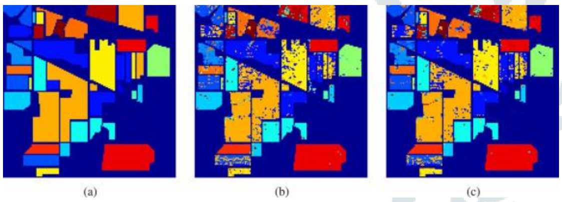

Fig. 4 Classification maps for Indian Pines (a) Ground-truth map (b) Map from classification using the original dataset (c) Map fromclassification using the dataset reconstructed with bitrate[2]

Compressive sensing and unmixing[3](CSU) scheme for hyperspectral data processing does not require forming or storing any full size data cube for hyperspectral data processing.CSU consist mainly three major steps:

- Data acquisition by CS is spectral signatures of the endmembers are either precisely or approximately known
- Dataprepossessing by SVD (Singular Value Decomposition) is used for reducing size of observation matrix(number of band to number of endmember)
- Data unmixing by solving a compressed unmixing model with TV regularization on abundant fractions

This method shows that compressive acquired data of size ranging from 10% to 25% of the full size can produce satisfactory results highly agreeable with the ‘ground truth’.

Fig. 4 Endmembers[3]

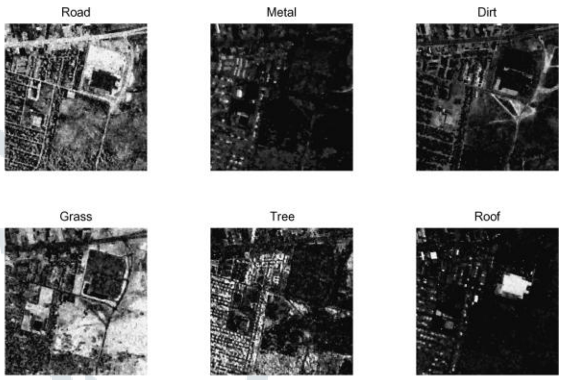

Fig. 5 Computed Abundance[3]

In [4], described that acquiring hyperspectral images with less samples than the actual number of pixels, in a low dimensional representation.This scheme provides structured measurement matrix and sparse matrix is used than reconstruction of images performed by simple inverse transform.

In first Step Compressive sensing captures hyperspectral images, captures truly sparse signals in less samples.In next step adaptive direct sampling (ADS) can be applied to hyperspectral imaging which provide structured, deterministic measurement increases image quality.In last step a novel sampling scheme maintain queue that contain indexes for all coefficient that are to be sampled. Steps follows:

(a)A coefficient is captured whose parents have largest absolute value

(b)The children of this sample are determined

(c) Sorted in to the ordered queue

(d)The tree is balanced

(e) The index of the sample found in the right most leaf will be captured next and therefore removed from *Q*

In this approach the reconstruction of the image is doneby simply an inverse transform and reconstruction is faster,easier and less expansive compared to CS.

In [5], presented algorithm for the lossless compression of hyperspectral images based on distributed source coding. It performed on a small block size unit to take advantage of the local correlation of the hyperspectral images which is beneficial for achieving a high compression performance. In this data sources encoded by separate encoder and lossless compression is performed on each source separately.Distributed source coding only transmit the label of the coset to which pixels belongs.Decoder side pixel is reconstructed in the coset and indexed by receiver coset label.Distributed source coding gives low complexity and less error.

In[8], proposed compression technique which use historical data as a reference.The nonlinear elastic method is based on the general relationship to predict adaptively current image from a previous reference image without loss of any information.Main feature of this method is to find best prediction for each pixel brightness value individually.Satellite images are collected over a regular period of time so rather than transmitting a complete image every time, the difference between the current and previous image data are transmitted.Nonlinear elastic model for flexible prediction of remotely sensed multitemporal images is novel approach. It accommodate batter individual brightness relationship between two date image data sets due to changes of ground cover types during imaging interval. It gives lossless compression.

In[7] compressive sensing method is proposed for acquisition and reconstruction of remote sensing images which have too high resolution so used sensors are complex and expensive.Images are so high that for data acquisition too many samples are there and prior compression is necessary to storage and transmission.Proposed method does few measurement directly instead of traditional sampling and compression so, sampling rate is low and computational complexity transferred from data acquisition to data reconstruction.Compressive sensing method reduce complexity of data acquisition and provides low cost, high efficiency, low complexity, efficient signal acquisition. Compressive sensing method is able to effectively keep original remote sensing image information.

According [6]Hyperspectral images have been proved to be effective for wide range of applications but they have large volume and redundant information so it brings lots of inconvenient. By selecting the band from given hyperspectral images and removing redundant component without compromising the original content from the raw image cubes. Hyperspectral band selection by multitask sparsity pursuit (MTSP)is group wise band selection technique which divided in these three parts:

- A smart yet intrinsic descriptor for efficient band representation
- An evolutionary strategy to handle the high computational burden associated with groupwise-selection-based methods
- A novel MTSP-based criterion to evaluate the performance of each candidate band combination

Experimental results on three real-world hyperspectral images demonstrate that the proposed framework can lead to a significant advancement in these two applications compared with other competitors.

Table 1. Literature review of different methods

Sr No.	Paper Title	Method Used	Advantages	Disadvantages
1	Measurement matrix design for hyperspectral image compressive sensing	Measurement matrix optimization	Improved reconstruction quality, good computational speed	Reconstruction accuracy
2	An Operational Approach to PCA+JPEG2000 Compression of Hyperspectral Imagery	PCA+JPEG2000	High data detection accuracy	Algorithm may not work at low bitrate
3	A Compressive Sensing and Unmixing Scheme for Hyperspectral Data Processing	CSU(Compressive Sensing and Unmixing)	Minimize total variation, low complexity	Endmember spectral signatures are either very rough, highly incomplete, or even totally missing
4	Compressive sensing and adaptive direct sampling in hyperspectral imaging	Compressive sensing and adaptive direct sampling	Reconstruction is faster , easier and less expensive	Loss of information
5	Lossless and near-lossless compression of hyperspectral images based on distributed source coding	Distributed source coding	Low complexity , batter performance	Large block size leads to a poor performance
6	Nonlinear Elastic Model for Flexible	Nonlinear Elastic Model	Lossless compression	For high bit images comput

	Prediction of Remotely Sensed Multitemporal Images			ational load high
7	Compressive Sensing based Acquisition and Reconstruction Technique for Remote Sensing Image	Compressive Sensing	High efficiency, low complexity, low cost, efficiently acquiring data	Based on Computer simulation only

Compressive sensing[9]: It is based on the recent understanding that a small collection of non-adaptive linear measurements of a compressible signal contain enough information for reconstruction and processing.It is a signal processing technique for efficiently acquiring and reconstructing a signal.

Compressive sensing (CS) allows to reconstruct sparse signals from a smaller number of measurements than the Nyquist –Shannon criterion.Main propertie for CS is Sparsity. Sparse means most of the elements are zero or close to zero. The fraction of zero elements in a matrix is called the sparsity matrix. Sparse data contain many coefficients close to or equal to zero.As well sparsity means elements are should be in some uniform correlation.

Compression of hyperspectral images using compressive sensing gives good performance and during compressive sensing process if optimize measurement matrix is used than reconstruction quality is improved[1]. Compressive sensing works as follow[9]:

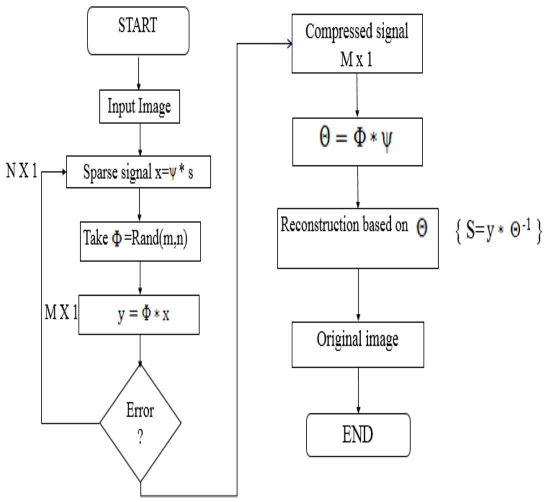

Fig. 4 Flowchart for Compressive sensing

IV. Concussion

According to literature survey number of technique and algorithm available using Compressive sensing (CS) or hyper spectral images try to improve PSNR ratio, reduces time for computation,gives higher quality. In future try to improve quality of images using CS with proposed work.

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