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# HDMI: A Novel Modeling of Hybrid Dimensionality Reduction Technique for Medical Imaging

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## Abstract

In the present era, the visual quality of medical data has become most significant issues in World Health Organization (WHO) as well as developing countries in the medical field. Currently, the medical data is shared between inter-hospitals using manually. However, the demanding issues are the storage and communication of massive volume of complex medical data. This paper describes a novel concept of hybrid image compression techniques for medical imagining using Compressive Sensing (CS). Here, we implemented a region based compression a scheme such as the Region-of-Interest (ROI) has compressed with lossless compression techniques, and the remaining part of an image has compressed with a lossy compression method like Compressive sensing. So, the challenge is gaining an equal quality of image for both ROI and Non-ROI and overcoming optimized dimension reduction by sparsity into Non-ROI and hence, medical image transmission over limited bandwidth network. The investigational outcomes demonstrations that the extraordinary reliability data storage, reduction in dimension and better visual perception quality of reconstructed data.

**Keywords:** Compressive Sensing, Dimension Reduction, Image Compression, Lossless Compression, Medical Data, Medical Image Processing, Region-of-Interest.

## INTRODUCTION

Medical image processing is a vital importance for fast communication and storage processing of digital data on the internet. Numerous medicinal modalities, for example, CT-scan, PET and MRI, etc., are produces images in digital form [1]. Due to the limited bandwidth and insufficient storage, medical data should be compressed before storage and transmission. In medicine, it's essential to have good visual perception quality of an image in diagnostically significant regions. Hence the ROI image can be compressed with lossless compression techniques, whereas Non-ROI contains the background of a picture and it is not necessary for medicine, so it should compress with lossy compression schemes. There are many applications where digital multimedia transmission has needed over internet or wireless network. One of such application is robot guided remote operations or extreme telesurgery. In such real-time domain, an effective image compression method is needed [2]. Traditionally, there are many successful compression techniques are evolved, but these methods achieve excellent performance but, highly sensitive to channel noise and due to channel noise images are distorted. It has accomplished through a Compressive sensing algorithm. Which aims to minimize the quantity of measurements and also reduce the processing time, reduce the dimension and achieves better visual perception quality of an image. Compressive sensing is an efficient algorithm for signal processing techniques, which has introduced in [3] [4], which possess a sparse representation in basis function. Ideas from different disciplines inspire the mathematical concepts of CS.

Our novel Hybrid Dimensionality Reduction Technique for Medical Imaging (HDMI) scheme performs the combinatorial hybrid image compression for medical images and it achieves better results compared to other traditional methods in terms of visual perceptional quality of image as well as compression ratio. Section II describes the particular research work done by many authors on hybrid medical image compression. Section III briefly introduces the problem identifications of the proposed work. Section IV describes the research methodology applied to develop the system. Section V describes algorithm implementation of the system. Section VI shows the results obtained in this work along with discussion, finally at the end the conclusion and future scope is shows in Section VII.

## REVIEW OF LITERATURE

This section reflects a particular research work done by different researchers in the field of medicinal image processing. There are many various types of compression schemes are developed to resolve the issues present in a medical image. Still, lots of research is carried out by many authors to address the issues in acquiring an image from advanced medical modalities, its storage, and transmission of the image. Our previous work [5] illustrates the various existing compression methods for medical images using compressive sensing algorithm along with the research gap.

Kamargaonkar et al. [6] have presented a novel hybrid compression technique for medical images using SPIHT and Haar transform methods. Where the region of interest is extracted using thresholding scheme of segmentation, then this area is compressed with the lossless compression algorithm, then non-region of interest is compressed with Haar wavelet transform techniques. The outputs achieve better visual perception quality of a reconstructed image. Perumal et al. [7] have designed a novel hybrid compression technique for medical images using Artificial Neural Network and Wavelet Transform methods. The point of this work is to lessen the dimension and improves the quality of a picture. Then the outcomes of this paper are compared with other traditional methods regarding PSNR and CR. Yadav et al. [8] have presented new hybrid compression scheme to enhance the CR and also decrease the computational complexity of the system with a superior reconstructed image. Here, wavelet transform and cosine transform techniques are used to compress the picture. Kumari et al. [9] have demonstrated a secure and fast composite image encoding scheme uses an integration of SPIHT, Huffman encoding scheme and 2D-Fractional Fourier transforms for medical images. Here, a DICOM image has encrypted by applying a Hadamard transform. The experimental outcomes have evaluated using performance parameters like PSNR and MSE, and it shows the projected method achieves better results.

Min et al. [10] have proposed concepts of hybrid compression schemes using standard lossless compression strategies for restorative of medical images to achieve an efficient compression ratio and decompression rate. Fayadh et al. [11] have suggested a novel hybrid image compression scheme for therapeutic image compression and reproduction utilizing Vector Quantized (VQ) and Singular Value Decomposition (SVD) strategies. It contains an efficient gradient method in the longitudinal area, which uses an input image and three AC coefficients of DCT to results in the excellent fidelity of compressed data. The outcomes indicate the real visual perception quality and large PSNR values compared to other traditional methods. Asraf et al. [12] have analyzed various characteristics associated with multiple therapeutic images. The point of this work is to gauge various statists of a therapeutic picture and encode using lossless technology. It plays an important role to achieve significant compression ratio compared to other existing methods. Ibraheem et al. [13] have enhanced nature of clinical quality of image for symptomatic purposes utilizing cross breed logarithmic DWT strategy. This proposed technique has thought about on speed and quality of the picture with classical approaches. The evaluation has done by SSIM and PSNR.

Jaafar et al. [14] have demonstrated the novel hybrid technique for medical imaging applications using 3-D DWT and distributed arithmetic framework. This structure was synthesized using HDL and FPGA hardware, Spartan-3 kit. The experimental outcomes show improvement in overall throughput, power consumption and latency of an image. Pizzolante et al. [15] have defined a novel hybrid approach to handling the efficiency in both compressions as well as the security for 3-D medical images. Where author uses the lossless compression method to compress and image an efficient technique to insert within image digital watermark. Liu et al. [16] have proposed a novel 4-D reconstruction method for optical tomography using Karhunen-Loeve transformation algorithm. It uses the hybrid of both x-ray and optical tomography imaging structure. The conclusions of advanced work provide better reconstruction quality, and it has compared with conventional techniques. Mirarab et al. [17] have presented a cloud-based image compression for medical image processing. Where the author has reviewed the cloud computing benefits in medical image processing and develops a novel method using Eucalyptus as cloud infrastructure for an advanced genetic algorithm to allocate and distribute resources.

The above-deliberated methods are achieved better compression ratio as a well good visual perception in a reconstructed image. But, its overall success will be essential to should further investigated to evaluate their full fledge applicability on region based therapeutic image compression and reconstruction.

## PROBLEM IDENTIFICATION

From the earlier section, we can identify that after reviewing the current research work associated with hybrid compressed techniques. There are many open research issues about medical image compression such as (i) Less number of suitable compression methods are exists, where it causes better compression at the same time cost of the recovery signal is more. (ii) Very less typical studies have claimed to provide superior quality of compression over medicinal imaginings. The shortcomings of current research works are, evaluating the work on single data sets; there are no more hybrid compression techniques to perform comparative analysis. (iii) Less focus on optimized dimensionality reduction method within the limited bandwidth. So, there is a loss of reconstructed image quality. This trade-off provides most significant barriers towards future research directions. (iv) More emphasis on ROI and less attention on N-ROI, in a definite diagnosis of illnesses and abnormality circumstances, may require both ROI as well as N-ROI part of the reconstructed image to decide the problems in the patient. Such condition, an entire full image has to send through the internet. Unfortunately, current works are not suitable to consider this sort of therapeutic picture compression. The subsequent section deliberates the adopted novel research methodology to overcome the issue in medical image compression.

## PROPOSED METHODOLOGY

The present experimental study is an extension of our earlier research works [18] [19] [20]. Where a simple and an efficient work of image compression towards medical imaging done using compressive sensing algorithm has redefined for perfect compression performance. This section deals with the study of hybrid image compression for medical imaging using compressive sensing to achieve better visual perception quality of image, compression rate and ratio. This research work in the way to encompass our previous effort towards accomplishing more compression on both clinically important region as well as the less significant region of an entire image.

The proposed work is implemented using analytical research approach. For better outcome assessment, we considered various types of biomedical images from a dataset. Initially, the pre-processing operation is performed on images, such as RGB to gray conversion, resizing followed by improved accuracy by double. The proposed investigation of novel method considers both diagnostically important region as well as non-region of interest part of the image using different compression methods. The ROI part has compressed with lossless compression techniques as well as non-ROI have compressed with compressive sensing method. The decompression techniques are the reverse process of the encoding method. It starts with decoding over encoded bits and dictionary created by encoding framework.

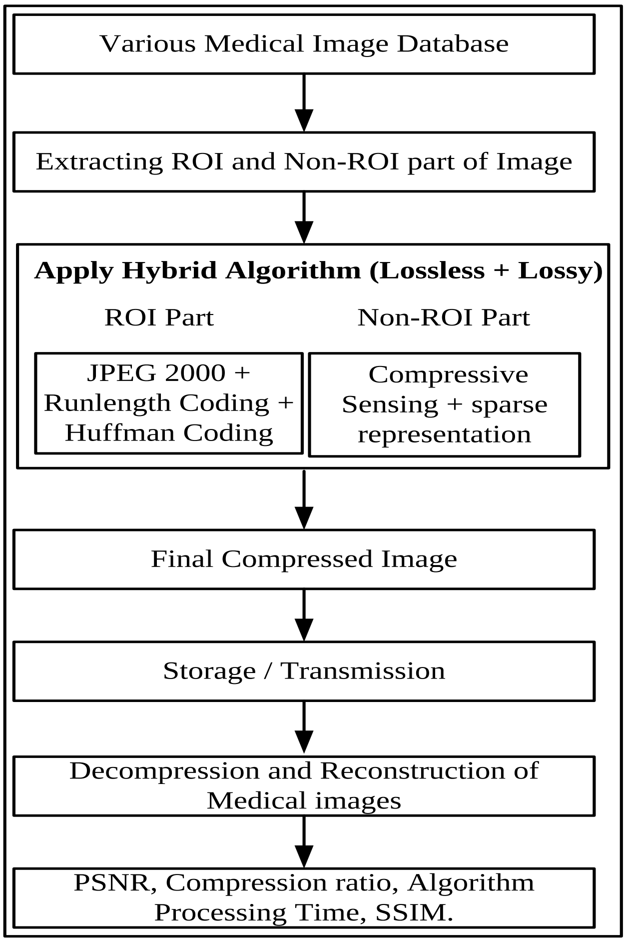


**Figure 1.** Proposed framework for HDMI system

The assessment of consequences in anticipates work is carried out by two performance parameters, and also it has compared with the existing methods. Fig.1 demonstrates the proposed framework of the presented system. The first sort of performance parameters is an estimation of some bits, compression ratio, and visual perception of reconstructed image and at last the algorithm processing time for reconstruction of medical images.

## ALGORITHM IMPLEMENTATION

This section discusses about the algorithm that has been implemented for accomplishing an effective transmission of multimedia using compressive sensing discussed in prior section. The algorithm initially takes the input of medical images which may be of any formats. As the implementation is carried out using *Matlab 2015a*, so the input image should be of conventional image formats (e.g. *bmp, jpg, png, tif, jpeg*, etc). However, different unsupported formats have to be transformed in order to make it suitable for further processing. In order to make the computational easier, any forms of colored image is converted to grayscale in the first hand. The next step after selection of the input image is to select the region of interest using *roipoly* method in Matlab using an inbuilt polygonal tool for surrounding the input image. The precision maintained for performing selection of region of interest is kept as unsigned integer of 8 bits. The prime reason behind it is that this attribute maintain the whole image's data type in the range of 0-255, which is highly essential to carryout lossless compression in medical image. The next part is to carry out transformation over the number of rows that is extracted from the size of the input image. The steps included in the algorithm are as follow:

**Algorithm for HDMI Algorithm:**

***Input:*** *s (signal), T (random number), N (number of column), X1 (sparse representation of pixel)*

***Output:*** $c_{img}$ *(Compressed image), Ar (final reconstructed image).*

***Start***

*1.* ***init*** *s, M, T, N, R*

*2. Generate Y→Y←rand(M, nr)*

*3. Generate [Y Y0]=R*X1*

*4. round(Y), m1→argmin(Y)*

*5. m2→argmax(Y-m1)*

*6. Y→round(255*Y/m2)*

*7.* ***For*** *i =1 to nc*

*8. Ar =Algorithm-3(Y(i), R, nc)*

*9. cimg → Ar*

*9.* ***End***

*10.* $c_{img} = \omega' . \Delta(cimg) . \Omega$

*11.* ***For*** *t=1 to M/4*

*12.* ***For*** *c=1:N*

*13. prodI→|TI'*s|*

*14.* ***End***

*15. [v, p] ←argmax(prod)*

*16. at←[em, T(p)]*

*17. ay←[at'*at](-1)*at'*s*

*18. rn = s-(at*ay)*

*19.* ***If*** *(norm(rn)<9)*

*20. break;*

*21.* ***End***

*22.* ***End***

*23. hy←ay*

*24.* ***END.***

This algorithm acts as an intermediate process once the sparse representation of an image is ready to be compressed. The algorithm takes the input of sparse representation of signal, random number, and number of column which after processing yields compressed image. This compressed image is further subjected to second algorithm to obtain better version of compressed image. A loop is created that starts from lower random value of *1* to maximum size of coefficient of compressive sensing (*M)*. The product of all columns is empirically computed for all the number of columns *N* for extracting the maximum arguments of this product that is further mapped with two variable *v* and *p*. This is followed by extraction of two more variables of signal. Finally a composite signal *rn* is constructed by multiplying both *ay* and *at*. The system aborts when the normalized value of *rn* is less than *9*. Finally, the compressed image *Ar* is obtained from the variable *ay*. Hence, a completely new form of compressive sensing strategy is applied that maintains better form of reconstructed image.

## RESULTS AND DISCUSSION

This section deliberates about the simulation results obtained in proposed method. The evaluation of the projected scheme was carried out on more than 1000 standard medical image datasets of Cornell University [21]. It uses various types of medical images for consistent evaluation of outcomes. The simulation results of the proposed work would access using PSNR and Compression ratio.

**Table 1.** Implementation Scenario for Benchmarking

| Scheme | Encoding Scheme on | |
|---|---|---|
| | ROI part of Image | Non-ROI part of Image |
| Sulthana [22] | Arithmetic encoding | EZW |
| Kathirvalavakumar [23] | Arithmetic encoding | SOM |
| HDMI (Proposed method) | JPEG-2000 + Arithmetic + Huffman | Compressive Sensing |

The study results of the proposed method would compare with existing work carried out by Sulthana [22] and Kathirvalavakumar [23]. Sulthana has applied lossy compression technique like Embedded Zero Tree (EZT) to N-ROI part of an image and a lossless compression scheme like Arithmetic encoding is used to ROI part of a picture. Kathirvalavakumar has utilized a lossy method like Self-Organizing Map (SOM) and DWT for compressing N-ROI and lossless method like Arithmetic encoding for ROI part of an image.

**Table 2.** Analysis of PSNR

| Medical Images | Sulthana Approach | Kathirvalavakumar Approach | HDMI (Proposed work) |
|---|---|---|---|
| X-Ray | 16.91 | 19.86 | 26.68 |
| MRI | 19.21 | 18.69 | 24.39 |
| Fingerprint | 14.02 | 22.03 | 28.69 |
| Spine | 16.35 | 20.14 | 24.65 |
| Chest | 19.00 | 19.99 | 25.87 |
| Hand | 18.01 | 20.58 | 28.15 |
| Mammogram | 17.83 | 20.18 | 27.69 |
| Ankle | 16.99 | 21.02 | 26.99 |
| Histopathology | 15.98 | 21.56 | 28.65 |

The projected work did a minor amendment in the current system to increase the radiological image visual perception of recovered image, reduce dimension of image and the compression ratio by using a novel lossy compressive sensing algorithm for N-ROI part and JPEG-2000, Huffman and Run length encoding for ROI part of an image. Table. 1 show the minor changes should implement in existing approaches with its encoding methods with implemented combinatorial method regarding its performance parameters. Table. 2 highlights the comparative analysis of proposed method with existing methods regarding PSNR. Table 3 shows the analysis of the structural similarity index measurement. The PSNR outcomes of proposed work are 26.96 dB, while that of Sulthan is 17.19 dB and Kathirvalavakumar is found to be 20.46 dB. Fig. 4 shows the proposed framework offers larger compression ratio compared to other existing methods. The outcome of numerical analysis was proficient after using ten various modalities of database i.e. figure print, MRI, Histopathology, X-ray, Chest, Spine, etc.

**Table 3.** Analysis of Structural Similarity (SSIM)

| Medical Images | Sulthana Approach | Kathirvalavakumar Approach | HDMI (Proposed work) |
|---|---|---|---|
| X-Ray | 0.510 | 0.499 | 0.618 |
| MRI | 0.578 | 0.398 | 0.698 |
| Fingerprint | 0.505 | 0.435 | 0.835 |
| Spine | 0.618 | 0.387 | 0.758 |
| Chest | 0.454 | 0.449 | 0.658 |
| Hand | 0.588 | 0.500 | 0.789 |
| Mammogram | 0.417 | 0.489 | 0.887 |
| Ankle | 0.428 | 0.498 | 0.789 |
| Histopathology | 0.476 | 0.397 | 0.659 |

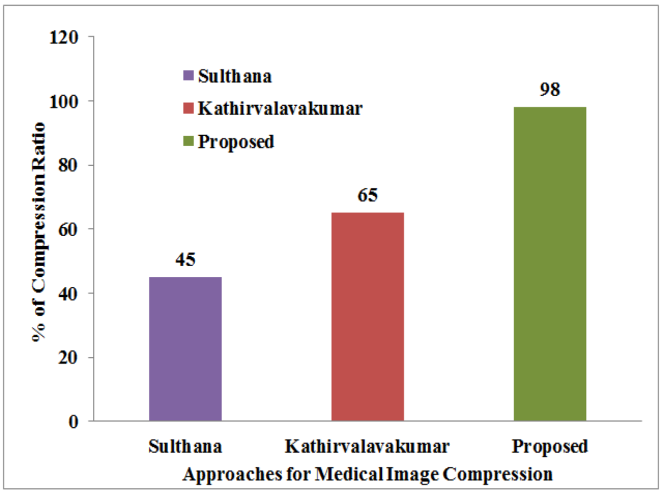


**Figure 3.** Comparative Analysis of Compression ratio

Our investigational outcomes demonstrate the projected algorithm accomplishes better compression ratio and good quality of the reconstructed image. The planned approach also proves faster response rate on Core i7-i3 processor with typical windows system, and it displays the direct applicability over medical image compression**.**

## CONCLUSION AND FUTURE WORK

Our proposed work demonstrated that a novel Hybrid Dimensionality Reduction Technique for Medical Imaging technique to improve the visual perception quality of a reconstructed image, to reduce the dimension and better compression ratio. It uses a lossy compressive sensing algorithm for N-ROI part of a medical image and lossless compression approaches for ROI portion of an image. The suggested method has evaluated over various medical images with different modalities. The study outcome of the proposed work was compared with similar existing hybrid compression algorithms to find that proposed method outperforms the current techniques on PSNR and Compression ratio. In future, it can be extended to use multiple modality systems at the same time to reduce the cost and computational complexity of the scheme.

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