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Investigative Protocol Design of Layer Optimized Image Compression in Telemedicine Environment

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Abstract

Telemedicine in India is expanding and thus it is essential for application to reduce storage and transmission bandwidth. The prime objective in this paper is to demonstrate an investigative protocol for medical image compression in telemedicine. The method is based on Integer Wavelet Transform (IWT) and Huffman's Coding for image compression with an added novelty of machine learning terminology for extracting the region of image based on pixel density and optimized layering for neighboring pixel ratio analysis. The experimental results are evaluated and demonstrated on open medical datasets and has acquired minimal predictive error, improvised Signal to Noise Ratio (SNR) with respect to Compression Ratio (CR) ratio and optimized bandwidth under transmission.

Keywords: Image Compression; Medical image processing; Telemedicine; Compression ratio;

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1. Introduction

Medical imaging plays a vital role in diagnosis and consultation in a developing country like India. Today, a majority of medical practitioners are dependent on medical imaging and instrumental data for decision making. In recent past, Telemedicine is evolved as a lifesaver for rural communities. The major engineering challenge of Telemedicine is the size of medical datasets with respect to the space complexity and transmission over the real-time channel from remote locations with respect to time complexity. [1] Has discussed a detailed preview of Telemedicine and Information and Communication Technology (ICT) role in Indian community. The study has also proposed major challenges influencing the growth and sustainability of remote medical data transmission and diagnosis. Typically, bandwidth is a major factor influencing quality of service rendered via various infrastructures.

Through communication media, various medical files such as EEG, ECG, diagnosed images (MRI, CT) and EHR records are transmitted. Due to unsaturated channels and third party optimization, the medical datasets are tampered with respect to quality and originality of the content. Thus various researchers have proposed methodologies to handle image compression and transmission, such as Content Based Image Retrieval (CBIR), Image compression and segmentation. In this proposed paper, a detailed analysis on medical image compression is discussed using pixel density based learning method. This method involves a machine learning approach for layer extraction with respect to Region of Interest (ROI) until no successive layers are formed. The overall methodology appends a relational evaluation of neighbouring pixels with respect to multiple clustering in a single layer forming n number layer.

This paper is organized with literature reviews in section 2 followed by a methodology and mathematical modelling in section 3 and 4 respectively. Experimental results and outcomes is projected in section 5 followed by conclusion and reference to design the manuscript.

2. Literature Reviews

Bandwidth is a major concern and hence the medical datasets under transmission are optimized and compressed to meet the requirements of minimal bandwidth for transmission. In [2] a systematic reduction of image compression is discussed under a modified approach of IRS-FFT feature extraction technique. This CBIR technique has built a primary infrastructural references and bench marks for image compression in telemedicine environment. In [3] a medical image compression based on threshold DCST (Discrete Orthogonal Stock well Transformation), the paper is compared with signal to noise ratio (SNR) with respect to Compression ratio (CR), this approach has primarily considered the performance ratio of CR and FOM and hence a secondary focus is listed on transmission bandwidth. [4] and [5] has widely discussed with wavelet based image compression for optimizing the medical images through clinical assistance.

Medical image processing on extremely sensitive datasets and arbiter parameters has become a challenge under low bandwidth channels for communication in Indian Telecommunication spectrum. In the proposed paper the following contribution is highlighted

- Image compression based on pixel density classification and clustering under region of interest extraction
- Image layering and summarizing optimized clustering to form a most stipulated image bit streams using Huffman Coding.
- SNR ration with respect to compression ratio improvisation for dataset reduction which is suitable for low bandwidth channel transmission

Typically, the paper makes a clear distinction using Machine Learning techniques for extracting features on each pixel values and thus making a pattern for cluster formation. Theses clusters are internally lined to form a layer and layering summarization is repeated until the lowest optimized image bit streams are achieved. Huffman's coding is performed on optimized image sample to retrieve bit streams.

3. Methodology

The medical image compression techniques discussed previously are correlated to independent parameters for evaluation and thus a significant interest for inter connectivity is at stack. Thus, proposed methodology retrieves the processing and formulates dependency matrix for evaluation. The novelty is appended with machine learned layering for each clustered datasets for an instance of iteration, such repeated layering with respect to threshold values are overlapped with one another to formulate a heap of multi dependent optimized layers.

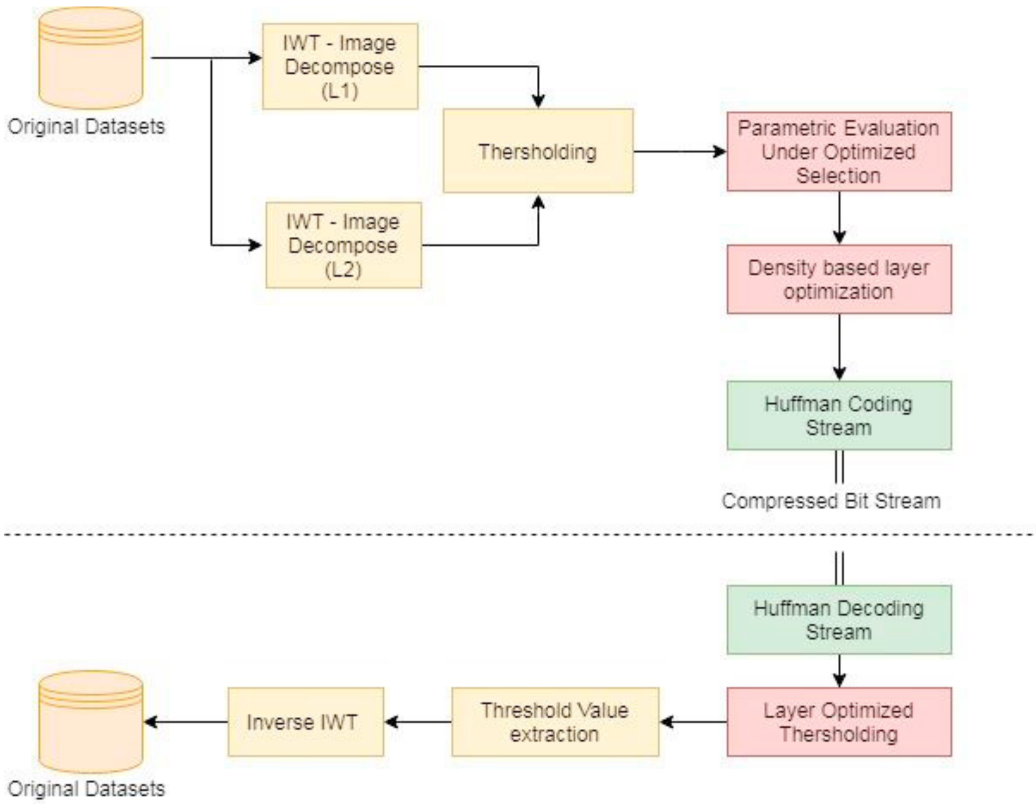

Fig. 1. System Architecture for Image compression using Machine learned pixel clustering approach

3.1. Pre-processing and IWT based image decomposing

The original datasets are collected from open medical data sources and processed with integer wavelet transformer (IWT) as shown in Fig 1. In general, the medical datasets are processed appended parallel with dual IWT image decomposition L1 and L2, each of it producing a generalized threshold value. Thersholding makes the system more stable and optimistic under the selection of most accurate decomposed image for compression. Thersholding also eliminates shallow images from decomposing and noise elimination is another important improvisation. The image with generic thersholding value of auto correction 0.4 to 0.7 is considered for parametric evaluation to generate optimized layering.

3.2. Parametric evaluation for optimized layering.

On thersholding, the decomposed image matrix is processed with the extraction of parameters such as pixel ration and density. The resultant matrix M is processed with a region of interest segmentation to provide an improvised compression. Thus correlated pixels formulate a cluster and results in K cluster formulation at layer

Li and the cycle is repeated until no similar cluster values are extracted. The detailed description in discussed in Fig 2a and Fig 2b. The proposed system preforms this step as a novel approach using machine learning for systematic pattern based clustering in an instance of layer. Using layering of images provides the stability on de-compression of images using previous layer to form current layer until the overall patterns are recovered.

3.3. Huffman's Coding Stream

The pixel matrix of medical dataset is erected via a binary sorting tree for pixel density segregation to form a balanced stream of bits. The process of clustering makes the system more reliable and efficient towards internal dependency removal of clustered pixels. The technique of Huffman is enhanced with pixel density mapping.

4. Design and Validation of Mathematical Model

The proposed architecture diagram in Fig 1 describes the modules and step by step procedure for successful evaluation and generation of compressed medical images, ready for minimal bandwidth transmission under Indian Telemedicine environment,

Input image x is composed using an optimized thersholding value for m×n matrix of pixel shown in Fig 2 (Left). Based on ratio of pixel, density of each pixel is mapped and extracted based on thersholding values obtained from the best processing of IWT. The generated threshold (T) for each of process T1 and T2 is processed to select the optimized thersholding value (ΔT)

4.1. Parametric evaluation under optimized solution

Since the patterns are extracted, the input images is grouped under cluster *(C_K)* forming the cluster value of datasets. Each image *I* generates *N* clusters as $C = \{C_1, C_2, C_3 \ldots C_N\}$ satisfying the universal condition of Eq. 1

$$\forall C_i \in C_U / I_i^C \ni I \quad (1)$$

Where C_i is the cluster dataset with random selection and C_U is the universal cluster set from which the clusters are extracted. The extracted clusters shown in Fig 2 (Right) is demanded to satisfy the Eq. 1 as a subset of an extracted pixel from image *(I)* such that, the extracted pixel belongs to the given input image cluster C_K

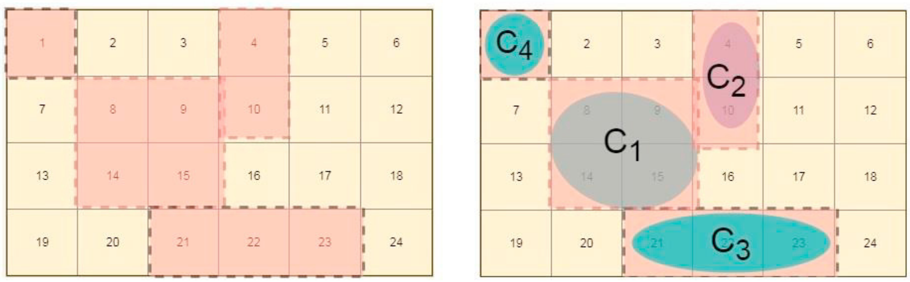

Fig. 2. Image matrix section (Left) and Image matrix clustering based on learned patterns (Right)

From Eq. 1, a successful clustering solution is framed with respect to datasets, image and clusters values, thus an emulated cluster dataset *(C)* is generated. Thus the machine learning approach of maximum selection is appended to replace each cluster value with pixel ratio value. Hence each of C_i has a class of pixel as $C_i = \{x_i, x_{i+1}, x_{i+2}, x_{i+3}, \ldots\}$. The extracted cluster values *(C_i)* are dependent on relatively equivalent pixel values with respect to thersholding sequence, thus grouping each cluster to form a cluster set of value is Eq. 2

$$C = \sum_{i=0}^{n} C_i \quad (2)$$

Where the dependency parameter of C_i is represented as Eq. 3 for clear representation

$$C_i = \frac{\partial(x_i)}{\partial p} \tag{3}$$

Where the partial differential of each cluster set x_i is processed to retrieve the overall clustering set as shown in Eq.4

$$C = \sum_{i=0}^{n} \frac{\partial(x_i)}{\partial p} * C_i \tag{4}$$

4.2. Density based layer Optimization

Since the normalization cluster values is extracted to each cluster set as a data folding operation is carried out, resulting in the formation of layers (L), where each layer formation is represented as an infinity (∞) as the layer folding depends on dynamic cluster learning as $L = \{L_1 , L_2 , L_3 \dots L_A \dots \infty\}$ as each layer is satisfied with respect to Eq. 5 to achieve Fig 3.

$$L = \int_0^{\infty} C \rightarrow L_o = \sum_{i=0}^{\infty} L_i \therefore L_A \, is \, an \, optimized \, layer \tag{5}$$

5. Experimental Results and Discussions

The processed datasets is compiled under MATLAB 2014R version for experimental cum environment setup. The results are tabulated in Table 1; the computational difference is achieved in a greater improvement towards the compression ratio of modified IWT approach by appending a layered mechanism of clustering pixel to extract a pattern and feature. Thus the comparative study is made with respect to DCST, IWT (Typical Version) and IWT (Modified Version).

Table 1. Comparative Results from Different Algorithms

	Uncompressed		**Compressed**		
	SNR	**Time (ms)**	**SNR**	**CR**	**Time (ms)**
DCST	8.173	72.8	4.012	9.005	54.2
IWT (Typical)	8.672	72.5	4.271	8.175	59.6
IWT (Modified)	7.321	67.9	3.74	12.23	48.873

6. Conclusion and Future Enhancement

For a better diagnosis and justification on remote consultation, medical practitioners prefer a generic image with content rich features, such as higher resolution, quality and magnitude of sample. Thus, image compression is processed to achieve the same. Since the samples are transferred under a minimal bandwidth channel, it is essential to retune compressed images as per the channel spectrum to maintain the Quality of Service (QoS). In this paper, IWT based image decomposition is improvised and proposed with an enhancement ratio of 37% compared to IWT typical methodology. The work has also demonstrated a machine learning patterns for cluster grouping thus making the technique dependable and optimized with respect to layers.

This technique generates image bit streams for higher magnitude and lowers SNR and optimized CR values. The algorithm was demonstrated on open clinical datasets in support from UCL library and live samples of image recording centres. In near future, this technique is to be extended with bio-medical audio signal processing with respect to image samples on multi-objective clustering.

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