International Journal of Computer Applications (0975 – 8887)
Volume 91 – No.11, April 2014

A Novel Medical Image Compression Technique based on Structure Reference Selection using Integer Wavelet Transform Function and PSO Algorithm

Gaurav Vijayvargiya
Department of CSE
UIT-RGPV
Bhopal, India

Sanjay Silakari, Ph. D
Department of CSE
UIT-RGPV
Bhopal, India

Rajeev Pandey, Ph. D
Department of CSE
UIT-RGPV
Bhopal, India

ABSTRACT
The utility of medical image increases due to serious disease prediction such as brain stroke and lung cancer. The size of medical image required large amount of memory and bandwidth for storage and transmission. For the lossless compression of medical image some standard algorithm are used such as JPEG, composite and Wavelet based. These entire algorithms perform good compression ratio and PSNR value. But the redundant structure of medical image reduces the compression ratio and decreases the value of PSNR and suffered quality of medical image compression. In this paper we proposed a structure reference selection process for collecting redundant frame of structure for compression. The collection of redundant frame structure is performed by particle swarm optimization algorithm. Particle swarm optimization is searching technique. For the generation of structure of frame we used integer wavelet transform function. The proposed algorithm is implemented through MATLAB software and is compared with composite algorithm, SOM algorithm and JPEG compression technique.

General Terms
Integer wavelet transforms, Reference Frame, Image Compression et. al.

Keywords
Medical Image, Lossless Compression, PSO, Wavelet and HCC.

1. INTRODUCTION
The advancement of information technology implied in the medical field for the diagnosis of serious medical disease such as brain stroke, lung cancer and internal part of body through image processing. The process of medical diagnosis produces a huge amount of medical image such as CT, MRI and ECG image [1, 2]. The size of these images is very large take huge amount of memory space and bandwidth for transmission of the medical image. For the reduction of memory space and efficient bandwidth process we used image compression technique. Image compression is collection of lossy compression techniques and lossless compression techniques [3]. The medical images data are valuable data now lossless image compression technique [8] are performed. There are several lossless image compression algorithms like Lossless JPEG, JPEG 2000, PNG, CALIC and JPEG LS. JPEG-LS have excellent coding and best possible compression efficiency [4, 5, and 6]. A digital video passes through numerous processing stages before it finally reaches to end-user. The original video sequence at the transmitter end is passed through an encoder which compresses and restructures the video sequence, which is then passed over a channel [9]. At the receiver end, a decoder decompresses the sequence into a format visible to the end user. Lossless compression includes [18] Discrete Cosine Transform, Wavelet Compression, Fractal Compression, Vector Quantization and Linear Predictive Coding. Lossless image compression schemes often consist of two distinct and independent components which are modeling and coding [10]. The modeling generates a statistical model for the input data. The coding maps the input data to bit strings. Wavelet transformation (WT), vector quantization (VQ), Neural network (NN) and different encoding approaches are generally used in addition to numerous other methods in image compression [11]. The problem with lossless compression method is that, the compression ratio is very less; whereas in the lossy compression method the compression ratio is very high but the quality of the image is lost. Hybrid image compression incorporates diverse compression systems like PVQ and DCTVQ in a single image compression. Image compression is a process of efficiently coding of digital image, to reduce the number of bits required in representing image [12, 13]. Its purpose is to reduce the storage space and transmission cost while maintaining good quality. In this paper proposed a novel method for medical image compression technique using structure reference parameter for redundant frame optimization process. The redundant structure frames are collected by particle swarm optimization technique. Particle swarm optimization technique is bird flock based biological function that function is to estimate the redundant bit of structure for compression. The structure of image block is passes through HCC code matrix and finally image are compressed [15, 16]. The above section discusses introduction of medical image compression technique. In section II we describe integer wavelet transform function, particle swarm optimization and Structure reference. In section III proposed algorithm. In section IV discusses experimental results analysis. Finally conclude in section V.

2. IWT, PSO AND STRUCTURE REFERENCE

2.1 IWT (Integer Wavelet Transform)
Integer wavelet transform function is useful transform function for lossless data encoding in image processing. The value of transform H(Z) is always whole number and the part of image is lossless. For lossless coding it is necessary to make an invertible mapping from an integer image input to an integer wavelet representation. The lifting scheme is used to construct symmetric bi-orthogonal wavelet transforms starting from interpolating Deslauriers–Dubuc scaling functions. A

family of (N, N) symmetric bi-orthogonal wavelets is derived, where N is the number of vanishing moments of the analysis high-pass filter and N is the number of vanishing moments of the synthesis high-pass filter. The integer version of it, given in [7], is implemented in the first stage of our coding algorithm. In this case, the integer wavelet representation of a one dimensional signal $A^0(n)$ having N nonzero samples is given by

$$\forall n: D^{i+1}(n) = A^i(2n+1) - \left[\sum_k pkA^i(2(n-k)) + \frac{1}{2}\right]$$

$$0 \le i < j, 0 \le n < 2^{-(i+1)}N$$

$$-2 \le k \le 1$$

$$\forall n: A^i(2n) = A^i(2n) + \left[\sum_k ukAD^{i+1}(n-k) + \frac{1}{2}\right]$$

$$0 \le i < j, 0 \le n < 2^{-(i+1)}N$$

$$0 \le k \le 1$$

where[x] represents the integer part of x,j is the number of scales, $A^{i+1}(n)$ and $D^{i+1}(n)$ denote, respectively, the approximation and the detail of the original signal calculated at the scales (i+1), 0≤ I <j. The integer part of transform function gives the better encoding technique. The encoded transform value creates the number of packets and the randomly assigned packet in give dimension for search space.

2.2 PSO (Particle Swarm Optimization)

Particle Swarm Optimization (PSO) was proposed by Eberhart and Kennedy [19]. The PSO is a population based search algorithm, it also based on the simulation of the social behavior of birds, bees or a school of fishes. PSO initially intends to graphically simulate the graceful and unpredictable choreography of a bird folk. Each individual within the swarm is represented by a vector in multidimensional search space. This vector has also one assigned vector which determines the next movement of the particle and is called the velocity vector. The PSO also determines how to update the velocity of a particle. Each particle updates its velocity based on current velocity and the best position in it has explored so far; and also based on the global best position explored by swarm. The PSO process then is iterated a fixed number of times or until a minimum error based on desired performance index is achieved. It has been shown that this simple model can deal with difficult optimization problems efficiently. The PSO was originally developed for real valued spaces but many problems are, however, defined for discrete valued spaces where the domain of the variables is finite.

Algorithm Procedure

1. Initialize Population.
2. Calculate fitness values of particles modify the best particles in the swarm.
3. Choose the best particle.
4. Calculate the velocities of particles.
5. Update the particle positions.
6. Until requirements are met.

Particles are initialized by assigning random positions in the search space. Velocities are initialized randomly in the range [υmin, υmax]. In each iteration a new velocity is calculated for each particle and the new position is determined as the sum of the previous position and the new velocity.

$$x(t+1) = x(t) + \upsilon(t+1)$$

While updating the new velocity, the best position of current particle achieved so far (p(t), particle best) and the best position achieved so far by all particles (g(t), global best) are using this:

$$\upsilon(t+1) = \omega\upsilon(t) + \varphi 1 rand(0, 1)(p(t) - x(t)) + \varphi 2 rand(0, 1)(g(t) - x(t))$$

where ω is inertia weight, which controls the magnitude of the old velocity υ(t), φ1 and φ2 determine the significance of p(t) and g(t), respectively. Furthermore, υi at any time step of the algorithm is constrained by the parameter υmax.

2.3 Structure Reference

Structure reference is a method for finding the similar block of packet in integer wavelet transform applied in medical image. Initially the medical image input in 2D IWT transform function [7], these transform function decomposed the given image into number of layers and these layers produce the transform value in terms of whole number. The distribution and collection of these entire packets consider as the reference structure of wavelet packet is searched in group v (r1, r2). In the case of non reference structure packet the value take 0 [14]. In the 2D IWT, packet reference in terms of v (P, R) = 0 since points P and R are same reference packet, and v (P, Q) =1 and v (R, Q) = 1 since Q is redundant structure of packet from dissimilar to P and R. In general, for any pair of packets r1 and r2, v (r1, r2) is 0 if and only if the packet belongs to same reference packet.

$$(r1, r2) = exp\left(-\int_{r1}^{r2} \emptyset(r)\right)$$

Under the assumption that the packet reference f(r) and the redundant structure m(r) are linearly proportional to the wavelet packet transform at the corresponding total number of packets, the total packets in non-redundant as;

$$m(ri) = \int v(ri, r)$$

Where m (ri) is the redundant packet in ri packet.

3. PROPOSED METHODOLOGY

In this section describe the proposed algorithm for image compression using wavelet transform and particle swarm optimization technique. Basically, in this proposed algorithm PSO are used for removal of redundant structures of packet in common similar blocks and create separate blocks and after that both blocks supply to HCC matrix and finally image are compressed. For the searching of redundant structure block and non-redundant structure block used fitness constrains function, those structure satisfied the given constraints are called non redundant structure else redundant structure. The proposed algorithm is a combination of integer wavelet packet transform function, particle swarm optimization and HCC matrix. Now the process of proposed algorithm is divided into three sections. Section first discusses the generation of packet, section two discusses the optimization of packet and section three discusses the HCC code matrix for compression.

Section First

1. Input the medical image.
2. Apply 2D IWT transform function and decomposed the image into number of layer in terms of details and approximate.

3. The approximate part of transform is further exploded in high level.
4. Compute the value of horizontal transform, vertical transform and diagonal transform value.
5. The block coefficient value of transform form a series of packets p1…………Pn.
6. These packets pass through PSO algorithm and find an optimal set of structure.

Section Two

1. In this phase initialized the population set N=100.
2. Define the fitness constrains selection for similar structure and dissimilar structure.

$$\text{Fitness}= v(r1,r2)/m(ri)$$

3. Load the packet in terms of particle in search space.
4. Define the velocity parameter by difference of structure r1-r2=x.
5. For every packet ri in V.

   x=0;

6. For every packet in ri in V.

   xij =x (ri, rj)

7. if(x=1) then packet is redundant;
8. else
9. Packet is redundant.
10. Two block code are generate one is redundant and another is non redundant.

Section Three

1. The sorted packet of redundant and non-redundant input the HCC matrix [13].
2. Image compressed.
3. Find CR value.
4. Find PSNR value.
5. Exit.

4. EXPERIMENTAL RESULT AND ANALYSIS

The proposed compression algorithms are implemented using MATLAB software. For the performance of the proposed algorithm used medical CTA image as well as on a sequence of images. The sequence used is gray-scale MRI images taken from local hospitals. The images in these sequences are of dimension 512*512 with 8-bit gray-scale image for the empirical evaluation used following parameters. For the validation of proposed algorithm compared with SOM algorithm, JPEG algorithm and composite algorithm. In this used two different set of image in terms of CTA image and MRI image [17].

$$\text{PSNR}= 10log_{10}\left\{\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}(F(i,j))^2}{\sum_{i=1}^{N}\sum_{j=1}^{N}(f(i,j)-F(i,j))^2}\right\}$$

where R is maximum fluctuation in the cover image=512.

$$\text{Compression Ratio}(CR) = \frac{Original\ Image\ Size}{Compressed\ Image\ Size}$$

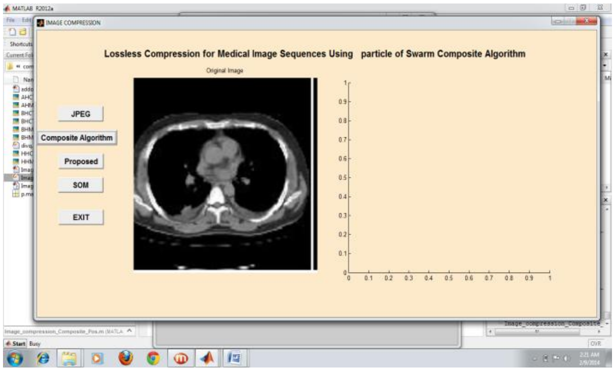

Figure 1 Shows the input image of head front side CTA image for the processing of 2D wavelet transform function after that image are decomposed.

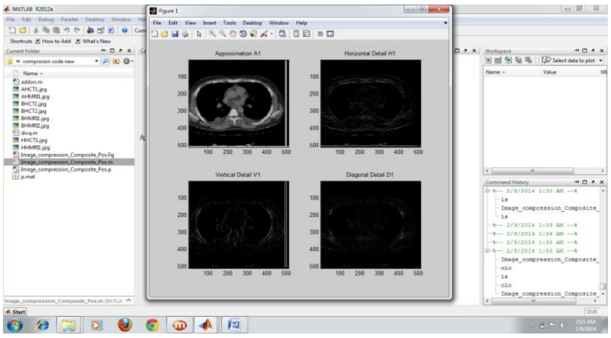

Figure 2 Shows that processing of wavelet transform function in terms of horizontal, vertical and diagonal part of image in approximate part of transform function. After that packet formation is completed and applies PSO for similarity and dissimilarity.

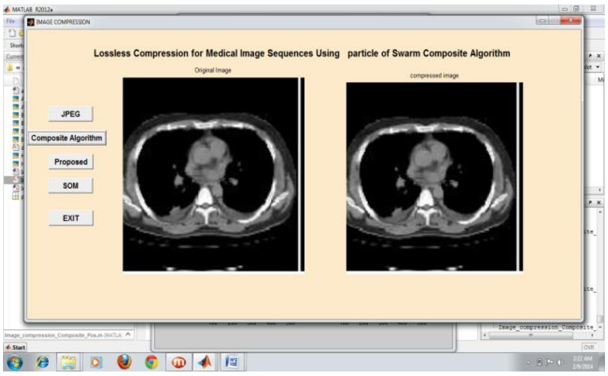

Figure 3 Shows that a compressed image using proposed algorithm. The value of PSNR is better than composite algorithm, JPEG and SOM algorithm and also improves the CR value in proposed algorithm.

Table 1 Show the PSNR and Compression Ratio (CR) value of all method applied on Head MRI image resolution 512* 512.

Compression Method	PSNR	Compression Ratio	Image Type
JPEG	42.499	5.387	HEAD MRI
COMPOSITE ALGORITHM	49.485	8.884	HEAD MRI
SOM	52.457	14.373	HEAD MRI
PROPOSED METHOD	52.981	15.876	HEAD MRI

Table 2 Show the PSNR and Compression Ratio (CR) value of all method applied on Head front CTA image resolution 512* 512.

Compression Method	PSNR	Compression Ratio	Image Type
JPEG	37.43	4.746	Head front CTA
COMPOSITE ALGORITHM	43.59	7.826	Head front CTA
SOM	46.21	12.664	Head front CTA
PROPOSED METHOD	46.67	13.983	Head front CTA

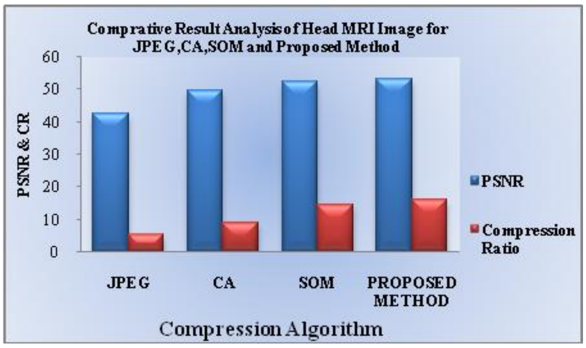

Figure 4: The comparative analysis of compression ratio and PSNR value of MRI image. In case of proposed algorithm the value of PSNR and CR are increases in compression of another algorithm.

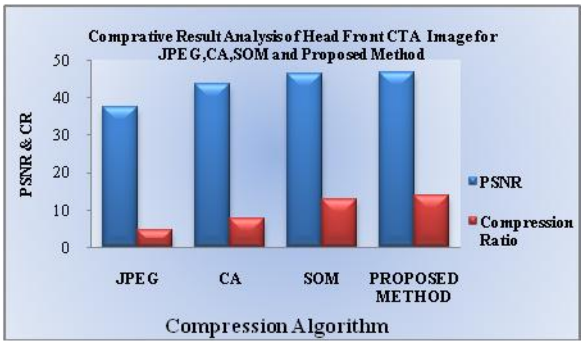

Figure 5: The comparative analysis of compression ratio and PSNR value of CTA image. In case of proposed algorithm the value of PSNR and CR are increases in compression of another algorithm.

5. CONCLUSION AND FUTURE WORK

In this paper proposed a reduction of non structured packet in integer wavelet transform function. The all transform packet divided into two group redundant structure and non redundant structure packet with the help of structure reference method. For the collection of similar and dissimilar packet used particle swarm optimization technique. The particle swarm optimization process defines the fitness constraints according to the difference value of structure reference packet. If differences of the packets are zero value assigned 1 and the difference of packets get some value rather than zero assigned 0. Both similar and dissimilar packet collects in two different units and passes through HCC matrix and after that image is compressed. Our empirical evaluation of PSNR and compression ratio shows that better performance instead of another method used in the experimental process. The searching of redundant packet structure consumes more time and increase the computational time, in the future reduces the computational time for compression.

6. REFERENCES

[1] MFerni Ukrit, G.R.Suresh "Effective Lossless Compression for Medical Image Sequences Using Composite Algorithm" International Conference on Circuits, Power and Computing Technologies, IEEE 2013. Pp 1122-1127.

[2] Andreas Weinlich, Johannes Rehm, Peter Amon, Andreas Hutter, Andre Kau" Massively Parallel Lossless Compression of Medical Images Using Least-Squares Prediction and Arithmetic Coding" IEEE 2013. Pp 1680-1685.

[3] Eugen Wige, Gilbert Yammine, Peter Amon, Andreas Hutter, Andre Kaup "Pixel-Based Averaging Predictor for Hevc Lossless Coding" ICIP, IEEE 2013. Pp 1806-1811.

[4] Gary J. Sullivan, Jens-Rainer Ohm, Woo-Jin Han, Thomas Wiegand "Overview of The High Efficiency Video Coding (Hevc) Standard" IEEE Transactions On Circuits And Systems For Video Technology, VOL. 22, 2012. Pp 1649-1668.

[5] Gwenole Quellec, Mathieu Lamard, Guy Cazuguel, Christian Roux, Beatrice Cochener "Case Retrieval in Medical Databases by Fusing Heterogeneous Information" IEEE Transactions on Medical Imaging, 2011. Pp 1-18.

[6] Anush Krishna Moorthy, Kalpana Seshadrinathan, Rajiv Soundararajan, Alan Conrad Bovik "Wireless Video Quality Assessment: A Study of Subjective Scores and Objective Algorithms" IEEE Transactions on Circuits and Systems for Video Technology, Vol. 20, 2010. Pp 587-599.

[7] A.Benjamin Joseph, Dr. R. Baskaran "Edge Preserved Image Compression Technique Using Wavelet and Edge Based Segmentation" International Journal of Computer Science & Informatics, 2011. Pp 80-85.

[8] N. Senthilkumaran, J. Suguna "Neural Network Technique for Lossless Image Compression Using X-Ray Images" International Journal of Computer and Electrical Engineering, Vol.3, 2011. Pp 17-23.

[9] S .S. Panda, M.S.R.S Prasad, MNM Prasad, Ch SKVR Naidu " Image Compression Using Back Propagation Neural Network" International Journal of Engineering Science & Advanced Technology, Vol-2, 2012. Pp 74-78.

[10] Ilya Sutskever, James Martens, Geoffrey Hinton "Generating Text with Recurrent Neural Networks" International Conference on Machine Learning, 2011. Pp 1-8.

[11] M.Ferni Ukrit, A.Umamageswar, G.R.Suresh "A Survey on Lossless Compression for Medical Images" International Journal of Computer Applications, Vol-31, 2011. Pp 47-50.

[12] N Nazari, R Shams, M Mohrekesh, S Samavi, "Near-lossless Compression for High Frame Rate Videos," Proceedings of 21st ICEE Electrical Engineering (ICEE), 2013, Pp 1-5.

[13] A. Alarabeyyat, S. Al-Hashemi, T. Khdour, M. Hjouj Btoush, S. Bani-Ahmad, R. Al Hashemi "Lossless Image Compression Technique Using Combination Methods" Journal of Software Engineering and Applications, 2012, Pp 752-763.

[14] M.Ferni ukrit, G.R.Suresh "Lossless Compression for Medical Image Sequences Using Combination Methods" Proceeding of NCIEEE, 2013. Pp 14-18.

[15] Emmanouil Darakis,Marcin Kowiel, Risto Nasanen, Thomas J. Naughton "Visually lossless compression of digital hologram sequences" Image Quality and System Performance, 2010. Pp 1-8.

[16] S.Bhavani, K.Thanushkodi "A Survey on Coding Algorithms in Medical Image Compression" International Journal on Computer Science and Engineering, vol.2, 2010. Pp 1429-1435.

[17] Kamrul Hasan Talukder, Koichi Harada "Haar Wavelet Based Approach for Image Compression and Quality Assessment of Compressed Image" IAENG International Journal of Applied Mathematics, 2007. Pp 1-8.

[18] Gaurav Vijayvargiya, Dr. Sanjay Silakari and Dr. Rajeev Pandey,"A Survey: Various Techniques of Image Compression" IJCSIS, vol.11, no.10, 2013.Pp 1-6.

[19] J.Kennedy and R.C.Eberhart, Particle swarm optimization, IEEE International Conference on Neural Networks, vol. 4, 1995, Pp 1942–1948.

Gaurav Vijayvargiya received his Bachelor's degree in Computer Science & Engineering from BIST-Bhopal, India in 2010.

At present he is pursuing his M.E. degree in Computer Science & Engineering from UIT-RGPV, Bhopal, M.P. India. His research areas are Image Processing, Image Compression, and Image Authentication.

Dr.Sanjay Silakari received his Bachelor's degree in Computer Science & Engineering from SATI, Vidisha in 1991. M.E. (Computer Science & Engineering) from DAVV, Indore in 1998. Ph.D. (Computer Science & Engineering) in 2006 from B.U. Bhopal, M.P. India. He is a member of IEEE.

At present, he is working as Prof. & Head in UIT-RGPV, Bhopal since 2007.

Dr. Rajeev Pandey received his Bachelor's degree in Computer Science & Engineering from IET, DR. B.R.A. University Agra, U.P. India.M.E. (Computer Science & Engineering) from Dr. B.R.A. University, Agra in 2004. Ph.D. in 2010 from Dr.B.R.A. University, Agra, U.P. India. He is also Pursuing Ph.D. (Computer Science & Engineering) from RGPV, Bhopal, M.P. India.

At present; he is working as an Assistant Prof. in UIT-RGPV, Bhopal since 2007.