A Comparative Study of Adaptive Lifting based Interactive Artificial Bee Colony Algorithm with Wavelets, Artificial Bee Colony Algorithm and Particle Swarm Optimization Algorithm for Image Compression

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ABSTRACT
Image compression techniques are essential to reduce computational storage or transmittal costs of digital images and multimedia files without degrading the quality of the image/file to an unacceptable level. In this paper, adaptive update lifting scheme with Interactive artificial bee colony algorithm is presented for image compression. Approximation and detail coefficients are extracted from the signal by filtering it in wavelet transform. To increase frequency resolution both approximation and detail coefficients are decomposed further. Artificial bee colony algorithm by local search determines different update coefficients to improve the quality of compressed image by optimally choosing the best update coefficient. Using Artificial Bee Colony algorithm, a considerable size best directional window is determined. Interactive Artificial Bee Colony algorithm (IABC) tool is used to find out the directional window size to give the finest compressed image in terms of both compression ratio and PSNR. The method is compared with existing methods in terms of PSNR.

Keywords
Lifting Scheme, Adaptive Lifting Scheme, Wavelet Transform, Artificial Bee Colony algorithm, Particle Swarm optimization, Image Compression.

1. INTRODUCTION
The wavelet compression methods, efficient lossy image compression methods, are adequate for representing high-frequency components in two-dimensional images. Using wavelet transform a typical image data is decomposed into a many coefficients with small magnitude and few coefficients with large magnitude. As a large amount of the image energy concentrates on the large magnitude coefficients, using coefficients with large magnitude the lossy compression systems can realize high compression ratio and the reconstructed image with good quality at the same time.The efficient construction of the filter banks is allowed by Lifting scheme (LS)[3,4,5,6] for wavelet transforms. The constraint of this structure is that the entire signal filter structure control parameter is fixed. In many applications it is very much pleasing to design the filter banks to shape itself to the signal. Several adaptive Lifting Schemes are proposed in the literature which considers local characteristics of the signal for adapting. Claypole et al[7] introduced a technique of adaptive filtering which enables to select the Prediction operators according to the local properties of the image. Boulgouris et al[8] proposed a technique of defining lifting operators by constraining the sum of coefficients and by reducing the variance of the signal. Shu Chuan et al [9] in the field of swarm intelligence have reviewed some popular algorithms like Stochastic Diffusion Search (SDS),Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), Ant Colony System (ACS), Bacteria Foraging (BF), and so on for problems of optimization. Nishat Kanvel et al [10] has proposed a technique to optimize the prediction function used in the lifting scheme using particle swarm optimization algorithm for image compression. M. Mohamed Ismail and Dr. K. Baskaran [11,12] has implemented ABC algorithm in update process of lifting scheme to get better PSNR. And they have worked on PSO and ABC (Hybrid) algorithm. In their work they have applied PSO to prediction process and ABC to update process. Ramanathan et al.[13] applied ABC algorithm to find the optimal window size to obtain satisfactory compression and quality in the multi-objective manner. PEI-WEI TSAI et al [14] have proposed the Interactive Artificial Bee Colony Optimization algorithm.

Image compression technique using adaptive update lifting scheme and Interactive Artificial Bee Colony algorithm (IABC) is presented in this paper. The results obtained are compared with existing methods. Rest of the paper is described as follows. Section 2 describes general lifting scheme and is compared with the adaptive lifting scheme in which the update step is modified using IABC algorithm. Wavelet transform is reviewed in Section 3 and Section 4, 5, 6 describes the Particle Swarm Optimization Algorithm, Artificial Bee Colony Algorithm, Particle Swarm Optimization and Artificial Bee Colony Algorithm based Hybrid lifting method respectively. Section 7 explains the IABC algorithm and section 8 gives the proposed algorithm..

2. LIFTING SCHEME
Sampled filter banks which contain integer output is implemented using Lifting scheme. The lifting scheme can design the filters, required in the transform algorithms. Lifting scheme is processed in space domain is independent of translating and dilating, needless of frequency analysis. Lifting scheme gives an answer to the wavelet construction algebraic stage, also leads to a quick in-place computation of the wavelet transform, i.e lifting scheme does not require auxiliary memory. implement adaptive lifting scheme based wavelet decomposition. The Lifting Concept developed by Sweden [3] is a construction of biorthogonal wavelets. The three steps of lifting scheme procedure are: Split, Predict and Update (Fig. 1). The inverse Lifting scheme is shown in Fig. 2.

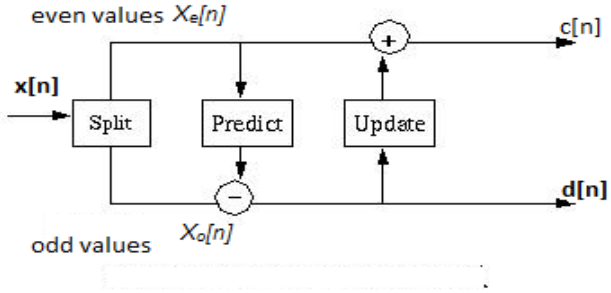

Fig 1: Lifting steps: Split, Predict, Update

Until P and U are chosen for the forward and inverse transforms, the original signal will be perfectly reconstructed. The inverse lifting stage is shown in Fig.2.

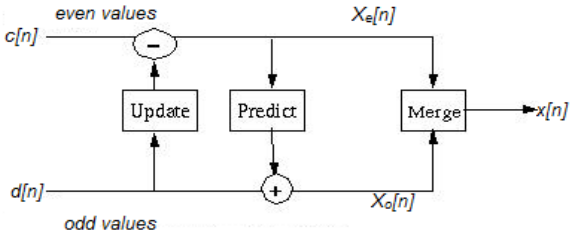

Fig 2:. Inverse lifting steps: undo Update, undo Predict, and Merge even and odd samples.

2.1 Adaptive Lifting Scheme

The classical lifting modification is adaptive lifting scheme. The adaptive update lifting scheme followed by a fixed prediction is shown in Fig.3. At each sample n an update operator is chosen according to a decision function D(x[n],y). As in the classical and space-varying lifting the critical point D(x[n],y) depends on y, but it also depends on the updated sample. In the standard lifting scheme the update operator and the addition are fixed. in the adaptive lifting scheme. The choice of operator such as update and addition depends on the information available locally within the detail signal and approximation signal.

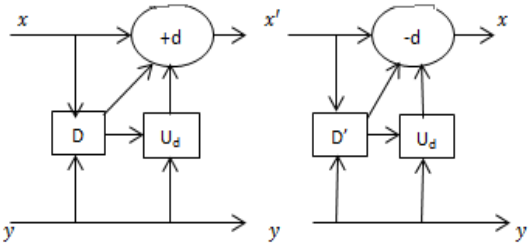

Fig 3: Adaptive update lifting scheme

The adaptive lifting scheme first performs update, and then performs prediction. On the x original signal the decision d_n = D(x,y)(n) depends. On the other hand at synthesis, we do not know but "only" it updates x'. In general, it prohibits the d_n computation and in such cases, perfect reconstruction is unlikely. However, a number of situations exist in which it is still possible to recover d_n from an posterior decision map.

3. WAVELET TRANSFORM

In wavelet transform, first step decomposes a signal into constituent parts in the time-frequency domain on a basis function localized in both time and frequency domains. The image or signal is decomposed into four different frequencies: approximation, vertical detail, horizontal detail and diagonal detail. Up to a level the decompositions are repeated on the approximation coefficients. As details are not decomposed at the high levels and can be described by the small scale wavelet coefficients, wavelet transform is not suitable for images having rapid variations.

4. PARTICLE SWARM OPTIMIZATION ALGORITHM (PSO)

The algorithm based on the social behavior of the nature swarm's individuals while searching for promising food is Particle Swarm Optimization (PSO) algorithm. PSO algorithm is used to find the optimal (or near optimal) solutions to numerical and qualitative problems. Keeping in memory the promising spots already found the individuals explore the space. The information is shared between the rest of the swarm, which adapts its trajectory using all the information present in the individual memory as well as the knowledge gained by the population.

Each individual, named as a 'particle', is a candidate solution to the problem. In the search space each particle is a point. It maintains the track of the coordinates with the best solution that it has ever been found until that moment. During each iteration, the particle's fitness value is evaluated. If the particle has achieved the best value, the particle stores the location of that value as "pbest" (particle best). Another value stores the location of the best fitness value achieved by the any particle during any iteration. This value is stored as "*gbest*" (global best).

However, choosing a coefficient of global update does not give better quality and compression ratio, but to get best quality of compressed image an algorithm artificial bee colony uses local search to find different update coefficient, finally optimally choose the best update coefficient .

5. ARTIFICIAL BEE COLONY ALGORITHM

Artificial Bee Colony (ABC) optimization algorithm introduced by Karaboga [22] uses the recruitment and abandonment modes of the foraging process. The different phases of the algorithm are Employed bees, onlooker bees and scout bees. In the employed bees' phase, a local search is conducted in the neighborhood of each solution by turn and the better one is kept. In the onlooker bees' phase, a local search is conducted in the neighborhood of the solutions chosen depending on the probability values calculated based on the fitness values. In the scout bees' phase, exhausted sources are determined and a random new solution is inserted in the population instead of the exhausted source. To decide whether a solution is exhausted or not, a counter is used to store the number of times that was exploited. In other words the counter holds the number of the local searches in the neighbourhood of that solution.

6. PARTICLE SWARM OPTIMIZATION AND ARTIFICIAL BEE COLONY ALGORITHM BASED HYBRID LIFTING METHOD

In the hybrid lifting based image compression scheme using PSO & ABC, decomposing the image is done using wavelet lifting scheme and then PSO is applied for prediction process and artificial bee colony algorithm is applied in the update process to obtain considerable quality.

7. THE INTERACTIVE ARTIFICIAL BEE COLONY (IABC)

In general, the ABC algorithm works well to find better solution of the object function. However, the onlooker bee's movement only considers the relation between the employed bee, which is one selected randomly and selected by the roulette wheel selection. Hence, it is not strong enough to maximize the exploitation capacity. Based on the structure of ABC algorithm the Interactive Artificial Bee Colony algorithm is proposed. By employing the Newtonian law of universal gravitation described in the below equation ,

$$F_{12} = G\frac{m_1 m_2}{r^2_{21}}\hat{r}_{21}. \quad (1)$$

the universal gravitations between the selected employed bees and onlooker bee are exploited. The Flow chart of IABC algorithm is shown in fig.4.

The IABC process can be described as below:

Step 1. Initialization: In the solution space spray ne percentage of the populations, and next calculate their fitness values, which are called as nectar amounts, the employed bees to the total population is represented by ne. They are called as the employed bees when these populations are located into the solution space,.

Step 2. Move the Onlookers: Using equation below, selecting a food source probability is calculated,

$$P_i = \frac{F(\theta_i)}{\sum_{k=1}^{s} F(\theta_k)}. \quad (2)$$

where θi denotes the position of the ith employed bee, S represents the number of employed bees, and Pi is the probability of selecting the ith employed bee. Select a food source to move using roulette wheel selection for every onlooker bees and then nectar amounts of them is calculated. The movement of the onlookers follows the below

$$x_{ij}(t+1) = \theta_{ij}(t) + \sum_{k=1}^{n} \tilde{F}_{ikj} \cdot [\theta_{ij}(t) - \theta_{kj}(t)]. \quad (3)$$

where xi denotes the position of the ith onlooker bee, t denotes the iteration number, θk is the randomly chosen employed bee, j represents the dimension of the solution and $\tilde{F}_{ik}$ is the normalized gravitation.

Step 3. Move the Scouts: For a continuous predetermined number of iterations the fitness values of the employed bees do not be improve, which is called "*Limit*", such food sources are discarded, and these employed bees become the scouts. The movement of scouts takes place according the equation given below.

$$\theta_{ij} = \theta_{ij_{min}} + r \cdot (\theta_{ij_{max}} - \theta_{ij_{min}}). \quad (4)$$

Step 4. Best Food Source found so far is updated: The best fitness value and the position, which are found by the bees is memorized.

Step 5. Termination Checking: whether the amount of the iterations satisfies the termination condition is checked. If the condition for termination is satisfied, program is terminated and results are outputed; else go back to the Step 2.

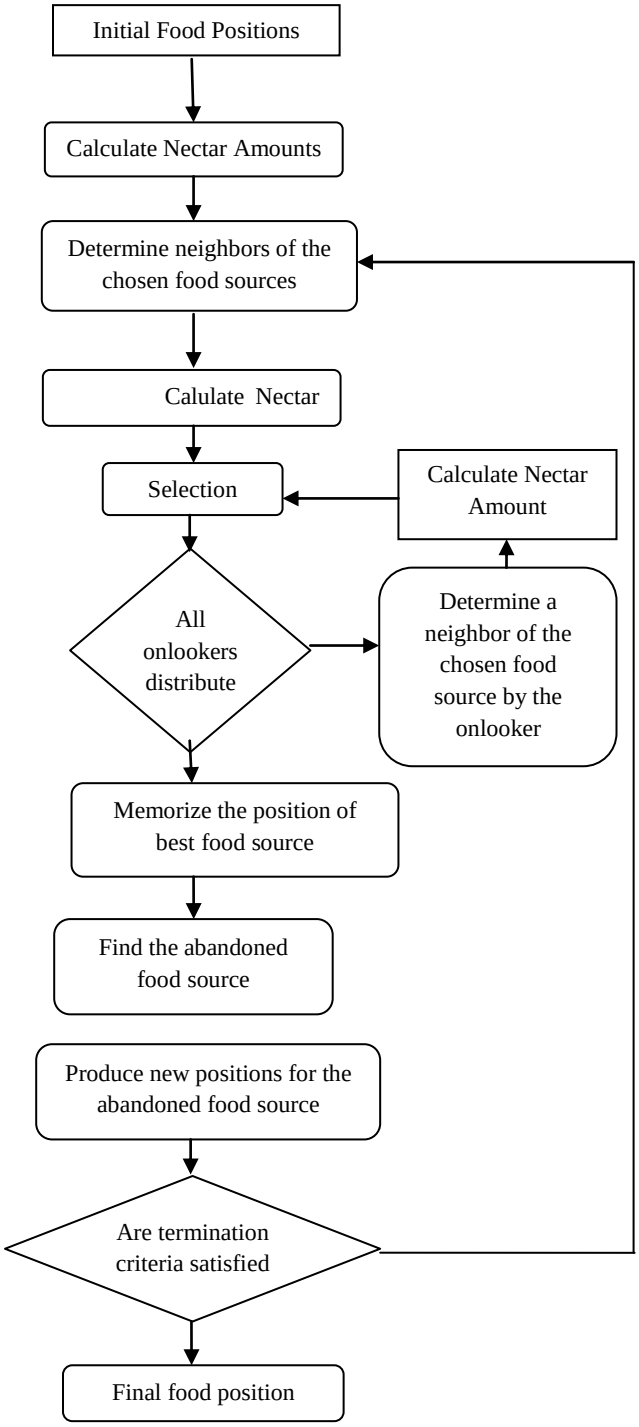

Fig 4: IABC Algorithm flow chart

8. PROPOSED ALGORITHM

Using wavelet lifting scheme the input image is decomposed and then to get considerable quality in the update process the Interactive artificial bee colony algorithm is used.

8.1 Algorithm Steps

Step 1: Gray scale Image is input.

Step 2: Image is split into odd and even pixel regions.

Step 3: For next prediction step decompose the image as (odd-even).

Step 4: Fix the 'M' as maximum coverage size and initialize 'K=0' for prediction co-efficient. Here, M is maximum window size, up to which, for each center pixels it will do local search. In this algorithm, maximum window size is 5.

Step 5: In the decomposed image for each scanned pixel its present fitness value and compression ratio is calculated.

Step 6: For all 8-direction combination to predict 'a' and 'b' call direction finding algorithm co-efficient. The 8- direction combinations are a1,a2,b1,b2,c1,c2,d1,d2.

	LD		TV	RD	
		LD	TV		
LH	LH	LH	X	RH	RH
	DD	DD	DV	BD	
DD			DV		BD

Fig 5: Directional coefficient for center pixel 'x'

Where to be update x is an center pixel

LH is predicted coefficient in horizontal left direction

RH is predicted coefficient in horizontal right direction

TV is predicted coefficient in vertically top direction

DV is predicted coefficient in vertically down direction

LD is predicted coefficient in diagonally left top direction

RD is predicted coefficient in diagonally right top direction

BD is predicted coefficient in diagonally left bottom direction

DD is predicted coefficient in diagonally right bottom direction

Step 7: Calculate update weight and find PSNR for given compression ratio for each direction prediction by using Update lifting formula

A measure of the peak error is represented by the Peak Signal to Noise Ratio(PSNR) and is expressed in decibels. PSNR is defined by

$$PSNR = 10.log\_10\left(\frac{255^2}{MSE}\right) \quad (5)$$

Step 8: The best individual is memorized by CR and its direction using IABC local search.

Step 9: To predict and update the best value for different range of window size, Iiterate K from (0 to M)

step 10: The best window size is memorized using IABC local search in terms of its CR and MSE for each pixel referred .

9. EXPERIMENTAL RESULTS

On standard images the proposed algorithm is tested for different image formats such as jpg, png & tif. The results obtained using Interactive Artificial Bee Colony are compared with different image compression Scheme such as Adaptive lifting Based Image compression scheme Using Particle Swarm Optimization Technique [10], Artificial Bee Colony Algorithm [11], Hybrid Lifting Based Image Compression Scheme using Particle Swarm Optimization Technique and Artificial Bee Colony Algorithm[12]. Thus the proposed method achieved better compression ratio when compared with existing methods. The results are given for various images in Table (1). The Reconstructed images are shown in figure 6.

(a) **(b)**

Fig 6: Reconstructed Images with lifting with IABC (a) Original Image (b) Output of lifting scheme with IABC.

Table. 1. Comparison table for different Image compression technique.

Sl.No	Image	Referred Method	Compression Ratio	PSNR
1	Pepper Image	Wavelet Transform	30	27.556
			40	25.056
			50	23.556
			60	20.956
		Lifting Scheme using ABC	30	38.90
			40	37.78

			50	35.97
			60	34.42
		Normal Lifting	15	32.85
			25	30.93
			35	29.97
			45	28.34
			55	27.52
		Adaptive Hybrid Lifting (PSO & ABC)	15	43.00
			25	41.84
			35	40.93
			45	32.78
			55	30.53
		Propose Method [Adaptive lifting scheme using IABC]	15	42.60
			25	42.33
			30	40.835
			35	38.10
			40	38.10
			45	38.02
			50	37.85
			55	34.00
			60	34.57
2	Cameraman Image	Wavelet Transform	30	33.13
			40	29.63
			50	27.13
			60	25.63
		Lifting Scheme using ABC	30	40.52
			40	38.11
			50	36.03
			60	35.86
		Propose Method	30	41.78
			40	38.92
			50	38.63
			60	34.26
3	Lena Image	Without PSO	45.25	35.23
			58.98	24.12
			65.58	18.25
			70.57	15.27
		With PSO	45.25	38.32
			58.98	30.34
			65.58	24.12
			70.57	19.54
		Normal Lifting	15	41.35
			25	35.18
			35	32.18
			45	31.34
			55	30.16
		Propose Method [Adaptive lifting scheme using IABC]	15	43.94
			25	43.81
			35	39.49
			45	39.49
			45.25	39.49
			58.98	33.18
			65.58	33.98
			70.57	33.31

10. CONCLUSION AND FUTURE ENHANCEMENTS

In this paper A Novel Method for Adaptive Lifting Based Image Compression Scheme Using Interactive Artificial Bee Colony Algorithm is proposed and results are compared with other image compression techniques. Using IABC algorithm for image compression this method optimize the prediction function used in lifting scheme. In the lifting scheme IABC algorithm is implemented in update process to get better PSNR. From the experimental results, we can conclude that method proposed gives higher PSNR when compared with the methods existing in the literature. The method proposed gives

the way to decrease the data to represent the image and thereby decreases the transmission bandwidth.

In future work, in the thresholding process Interactive Artificial Bee Colony algorithm shall be implemented to reduce the number of coefficient representing the image by optimally choosing the thresholding value to get considerable improvement in compression ratio and quality. If we can use two or more optimization algorithms together for the compression with more image samples, the results might have been better as compare to particular optimization algorithm.

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12. REFERENCES

[1] **S**ubramanya A. "Image Compression Technique," potentials IEEE, Vol. 20, issue 1,pp19-23, Feb-March 2001.

[2] Rafael C. Gonzalez, Richard Eugene; " Digital image processing", Edition 3, 2008,page 466.

[3] W. Sweldens, "The lifting scheme: A new philosophy in biorthogonal wavelet constructions", in Proc. SPIE, vol. 2569,1995,pp. 68-79.

[4] W. Sweldens, "The lifting scheme: A construction of second-generation wavelets", SIAM J. Math. Anal., vol. 29, no. 2, pp. 511-546,1997.

[5] A.R. Calderbank, I Daubechies, W. Sweldens, and B-L Yeo, "Wavelet transforms that map integers to integers", J. Appl. Comput. Harmon, Anal., vol.5, no. 3, 1998.

[6] M. Adams and F. Kossentini, "Reversible Integer-to-Integer Wavelet Transforms for Image Compression: Performance Evaluation and Analysis", IEEE Trans. On Image Processing, vol.9, no.6, pp. 1010-1024, Jun 2000.

[7] R.L. Claypoole, G.M. Davies, W. Sweldens and R.G. Baraniuk, "Non-linear wavelet transform for image coding via lifting", IEEE Trans. Image Processing, Vol.12,pp. 1449-1459, Dec. 2003.

[8] N.V Boulgouris, D. Tzovaras, and M.G. Strintzis, "Lossless image compression based on optimal prediction, adaptive lifting, and conditional arithmetic coding", IEEE, Trans. Image Process., vol. 10, no. 1,pp. 1-14, Jan. 2001.

[9] Shu-Chuan Chu, Hsiang-Cheh Huang, John F. Roddick, and Jeng-Shyang Pan - Overview of Algorithms for Swarm Intelligence, International Conference on Computer and Computational Intelligence(ICCCI 2011) , Part I, LNCS 6922, pp. 28 41, 2011. © Springer-Verlag Berlin Heidelberg 2011.

[10] Nishat Kanvel, Dr. S.Letitia, Dr. Elwin Chandra Monie, " Adaptive Lifting Based Image Compression Scheme with Particle Swarm Optimization Technique", International Journal of Engineering Science and Technology, vol. 2(9),2010,4886-4895.

[11] M. Mohamed Ismail, Dr. K. Baskaran, "Adaptive Lifting Based Image Compression Scheme Using Artificial Bee Colony Algorithm", International Journal of Electronics Communication and Computer Engineering, Vol. 4, Issue 1, ISSN(print):2278-4209, 2013.

[12] M. Mohamed Ismail, Dr. K. Baskaran, " Hybrid Lifting Based Image Compression Scheme Using Particle Swarm Optimization Algorithm and Artificial Bee Colony Algorithm", International Journal of Advanced Research in Computer and Communication Engineering, Vol. 3, Issue 1, January 2014.

[13] R. Ramanathan, K. Kalaiarasi, D. Prabha, "Improved wavelet based compression with adaptive lifting scheme using Artificial Bee Colony algorithm", International Journal of Advanced Research in Computer Engineering & Technology, Vol 2 , Issue 4, April 2013.

[14] Pei-Wei Tsai, Jeng-Shyang Pan, Bin-Yih Liao, and Shu-Chuan Chu," Enhanced Artificial Bee Colony Optimization", International Journal of Innovative Computing, Information and control, vol.5, no.12, pp.1-12, Dec. 2009.

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