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New Cepstrum Based Image Restoration Algorithm for Grayscale Images

Ramteke Mamta G., Maitreyee Dutta

Abstract— ***Optimization is the process that relates to finding the most excellent ways for all possible solutions. From last 2-3 decades, natural algorithms play an important role in improving solutions of various problems. By comparing various meta-heuristic algorithms, researchers can make a choice to the best selection of the meta-heuristic algorithms for the proposed problem. In this particular research, we have applied New Cepstrum based technique of image restoration to find out PSF parameters of motion blurred images as a primary technique. In addition, Genetic Algorithm (GA), Particle Swarm Optimization (PSO), BAT Algorithm and GA-BAT hybrid technique etc. are also applied to optimize the blur parameters for calculated by new cepstrum based technique for blur estimation. This aids in analyzing the performance of each algorithm on the same primary technique. The performance analysis of all four algorithms aid in making the decision on the best meta-heuristic algorithm of the cepstrum based technique and to identify the preciseness of the motion blur. All four methods are applied to the same set of images. The algorithm is tested and compared using grayscale images and the benchmarking freely available online datasets, respectively.***

Keywords: Image Restoration, Genetic Algorithm, Parameter Estimation, Cepstrum.

I. INTRODUCTION

Newly developed optimization algorithms aid to improve the quality of restored images. These also aid researchers to make a proper choice of the selection of the best meta-heuristic algorithm for the better solution of problem. In order to guarantee reasonable comparison between GA, PSO, BAT and GA-BAT hybrid optimization techniques, these four algorithms have been implemented on the same images, same number of iterations, same cost function and the same platform (i.e. MATLAB 16, with 64 bit window operating system). In blind deconvolution problem, Point Spread Function (PSF) is unknown and hence PSF needs to be estimated. Here, the authors have worked on PSF estimation technique for motion blurred images. But simply estimating PSF parameter does not give optimum solution of the problem. The purpose of optimization is to find suitable parameters of PSF and to improve the image restoration quality. In case of motion blur [4], degradation is caused due to loss of high frequency information. PSF estimation technique varies as the approach gets changes. There are various approaches of computing PSF of motion blur like Cepstrum analysis, Radon transform and Hough transform etc. The Cepstrum is used to calculate PSF parameters through its spectrum of an image. Using cepstrum domain, it's possible to apply mathematical technique to estimate the blur parameters correctly. Basically, it helps for the separation of blur component and the image component. The logarithm of the frequency spectrum and square of it, highlight the most powerful frequencies. In this paper, the authors have proposed a new method for calculating blur angle as given in section 3.1 and optimization of these parameters with GA, PSO, BAT and GA-BAT hybrid have been done.. The analysis of these optimizing techniques has been presented in this paper. In all four algorithms, we have taken sharpness as cost function.GA-based stochastic algorithm is the first technique to adopt natural selection which helps to find better a solution. Mutation is the first step which helps random modification. Its purpose is to maintain diversity within the population. The selection step helps to generate appropriate solution by checking fitness function. Another optimization technique, PSO algorithm [7], is population-based technique and it consists of a set of potential solutions which update to reach a desirable solution. It helps to find the global optimum solution. PSO is bio-inspired optimization technique which has many advantages such as (i) it is easy and straight forward to implement, (ii) it is computationally efficient, (iii) it has high convergence rate to get the better solution than GA. It is an intelligent technique that can be used to find estimated solutions for extremely tricky or impossible numeric maximization and minimization problems. PSO is based on the concept of many birds that look for the most excellent food source by sharing their knowledge. BAT inspired algorithm described in [3],[21] is metaheuristic optimization. BAT utilizes its changing pulse rates of loudness capacity and emission which is called echolocation. Echolocation is based on the approach that Bats use to find the way in their surroundings, even in complete darkness. Bats are able to locate their directions and accordingly perceive their surrounding objects and prey. They emit calls out to the environment and then listen to the bouncing back echoes. This helps in spotting the exact position of other objects and impulsively calculates their distance from it by observing the delay in the reverberating sound. The remaining of the paper has been structured as Section 2, which deals with the Literature Work on the topic. Section 3 gives a brief introduction to PSF estimation and proposed algorithms. Experimental results along with discussions are given in section 4. Section 5 presents the conclusion of research work.

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II. LITERATURE SURVEY

The problem of PSF(Point Spread Function) estimation is the most difficult problem of blind deconvolution [16] in image restoration. In this work, the authors have referred the papers mostly related to cepstrum and added work related to optimization techniques. Detail fundamental work of blur estimation of blind deconvolution was described in [1][11]. Cepstrum domain technique of image restoration described in [2][5] reviewed several important methods of PSF estimation. There are several motivating reasons for the use of cepstrum domain are summarized in [7] for various imaging applications of blind deconvolution. First of all, the cepstrum of an image can be represented as a two-dimensional signal which is used to determine the difference between two sub-areas. Basic method of cepstrum provides various ways to find the angle and length of blur as the technique gives one scenario of computing PSF parameters [12]. Various applications such as the aerospace, military system and medical imaging utilizes the motion blur image restoration techniques extensively to a large number of scientific and technical fields in the current decade. Cepstrum method is giving good result of image restoration done to motion blur images. In analysis of cepstrum, minimum peak has an important role for cepstral analysis but sometimes it is unable to maintain reliability because image gets corrupted due to noise. Hence, optimizing the blur identification using GA based cepstrum technique can increase the reliability of PSF computation. The isophote technique is used as binary mask and anisotropic diffusion to create isophotes [13]. Based on connected components, image is divided into isophotes, where each is having constant intensity. This method creates a best possible connectivity between all disconnected isophotes pairs. For connecting the disconnected isophotes, estimation of the value of the smoothness is needed. This is achieved by the finest chromosomes computed by GA[6]. The GA technique used in [14] computes the PSF directly and later on the deconvolution is done using Richardson Lucy algorithm. The extreme sensitivity of initial conditions falls into local minima, which can make the genetic algorithm easily fall into local optimum, which also causes the defects of slow convergence speed. Hence, this problem was solved by adding properties of chaotic motion as optimization mechanism [15]. The author also added chaotic adaptive genetic algorithm by incorporating mutation probability and crossover probability. For solving the BID problem, support vector regression is used by means of PSO [17] .The method utilizes particle swarm optimization (PSO) [7] with its parameters optimized. This method improved convergence rate. To optimize the weighed parameters, PSO was used to rectify motion blur and the restored images [18]. Anisotropic diffusion is used to smooth the texture. BAT algorithm described is based on Echolocation property which utilizes frequency of sound to find the presence of prey[8][19]. As sound pulse bounces back from the nearby objects, the variation in species changes the criteria of hunting process and pulse rate[9][10][20][21], but we have followed generalized method to define the algorithm. The structural similarity index (SSIM) family [23] is a set of metrics that has demonstrated good agreement with human observers with good approximation of perceived image quality. GMSD metric [22] can predict perceptual image quality accurately and it is much faster than all state-of-the-art IQA metrics. Hence we have incorporated these two metrics to interpret the result of an algorithm. Some recent work used knife-edge function [25] and innovative techniques for the motion blur estimation by clustering kernel [26]. The blur technique [24] has been used as baseline model to develop the concept and to evolve new idea to design cepstrum based proposed system.

III. PSF PARAMETER ESTIMATION AND IMAGE RESTORATION

In this work, the authors have proposed a new cepstrum based method to calculate motion blur parameter. These parameters have been optimized using GA, PSO, BAT and GA- BAT optimization techniques. By using computed PSF and blurred image, restoration is done using Non-blind restoration technique of Richardson Lucy algorithm. To assess the performance of the proposed four algorithms for estimating PSF and their restoration, different standard metrics have been utilized. These are Peak Signal to Noise Ratio (PSNR), SSIM and GMSD, etc.

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1 Proposed algorithm of cepstrum method technique to calculate theta of blur

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S = 0,BLUR = 0;
For theta = 0 to 90
X_{1i} = m/2+m sin (theta)
Y_{1i} = m/2+ m cos (theta)
X_{2i}= m/2+m sin (theta + pi)
Y_{2i} = m/2+m cos (theta + pi)
(X,Y) = points (X_{1i}, Y_{1i}, X_{2i}, Y_{2i})
for j = 1 to p
I_b (X_j, Y_j) =1 *// for respective theta it considered binary image*
End for loop
$I_b = I_b$ & I_{blur} *// AND operation is performed between two images*
If SUM (I_b)> S
S = SUM (I_b)
Thi_{blur} = theta
End if
End for

The angle represents the maximum theta, up to which image can be blurred, but in this work, it has been proposed that theta will be between 0 to 90 degrees. Dimensions of blurred image represented using m, n. X_{1i}, Y_{1i} are the points at imaginary circle where centre is at m/2, n/2 with radius m at $Thi_{blur.}$ X_{2i}, Y_{2i} are the points which are at pi angle from X_{1i}, Y_{1i} on the same *imaginary circle. Points are the function to compute position with respect to x, y at the line which joins (X_{i1}, Y_{1i}) (X_{2i}, Y_{2i}). Thi_{blur} is the blur variable which stores the predicted blur value of the theta.*

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2 GA based Blind Image Deconvolution in cepstrum domain.

1.Get blurred image as an input.

2. Apply FFT to a blurred image.

3. Compute log magnitude of spectrum.

4. Apply improved cepstrum based technique to calculate theta and length.

5. Feed these parameters as an input to GA, as an initial population.

6. Calculate objective function as current population as fitness.

7. Locate the best individuals.

8. The new population is proceeded using crossover and mutation.

9. New values of theta and length are used to calculate PSF.

10. Apply deconvolution using Nonblind Richardson Lucy algorithm and restored the image.

The suggested technique attempts to reconstruct image using the theta and length by using cepstrum domain. The best possible value of length and theta is estimated using GA based optimization method. In GA, population of chromosomes indicates possible solution, each having their fitness value. The chromosomes give random solutions in each generation using selection, crossover and mutation. After some iterations they converge to the optimal solution by giving the best theta and length of blur. The computed PSF using this theta and length, and input blurred image, image will get restored using nonblind Richardson Lucy algorithm.

3 PSO based Blind Image Deconvolution in cepstrum domain.

1. Take a blur image as an input.
2. Apply Fast Fourier Transform on input image.
3. Calculate log magnitude spectrum.
4. Compute the spectrum of length and theta.
5. Add theta and length as input parameters to a PSO.
6. Apply random velocities and positions on the d-dimensional problem space to initialize populations of particles.
7. Evaluate the desired fitness value for each particle.
8. Compare particle's fitness with its pBest. If the current fitness is better than pBest, then the pBest value is set equal to the current value and the pBest location is equal to the current location.
9. Compare the fitness evaluation with overall previous best value of population. If the current value is better than the global best (gBest), then set gBest to the current value of current particle and set the global best position to the position of current particle.
10. Update the parameters location using (1) and (2), respectively

$$V = V + C1 * rand() * (pbest - present\ x) + C2 * rand() * (gbest - present\ x) \quad (1)$$

Present x = present x + V (2)

11. Continue step 7 till encountered a maximum number of iterations.
12. Calculate the PSF.
13. Restore the image using Non-blind Richardson Lucy algorithm

In PSO based cepstrum based method , the same blurred image has been used. Cepstrum method is applied to calculate length and theta using modified cepstrum method as given in algorithm 3.1. Then theta and length are passed as input parameters to the PSO. Initialize the system with the population of random solutions and the update generations to search for the optima. After calculating pbest and gbest, velocity and position of particle are updated and finally retrieved optimized theta and length for calculating motion blur. Lastly, deconvolution is done using Richardson Lucy algorithm.

4 BAT based Blind Image Deconvolution in cepstrum domain.

1. Input motion blur blurred image.

2. Pertain Fast Fourier Transform on it.

3. Calculate log magnitude spectrum

4. Calculate the theta and length of the spectrum.

5. Insert computed theta and length using cepstrum method as input parameters to a BAT

6. a. Define the BAT population s and velocity.
b. Initialize frequency.

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c. Define initial pulse rate pr at s and the loudness.

7. While ($t<t_{max}$)
// by adjusting frequency create new solutions, and revise velocities and location [using equation. 3 to 5]

$$f_i = f_{min} + (f_{max} + f_{min})\beta \quad (3)$$

$$v_i^{t+1} = v_i^t + (x_i^t - x_0)f_i \quad (4)$$

$$x_i^{t+1} = x_i^t + v_i^{t+1} \quad (5)$$

if (random(0,1) < pr_i) *// random function helps to generate new solution*
Within current population select best solution by following best solution, find local solution.
end if
if (random(0,1) <l_i and $f(x_i) < f(x)$)
new solutions is accepted
raise pr_i and lessen l_i
end if
reorder the bats and locate the current best
end while
//it returns optimized value of theta and length

8. Compute the PSF using new value of the theta and length of the spectrum produced by BAT algorithm.

9. Perform the restoration using the Non-blind Lucy Richardson algorithm and computed PSF.

In experimentation of the BAT algorithm, the frequencies were considered as an initial population of bats. Frequencies are randomly selected within the range of f_{min} and f_{max} assigned to each bat along with random initial loudness and pulse emission rate pr ∈ [0, 1]. The frequency, velocity and location of each bat are updated by following step 7. After a random number is selected, which needs to be in the range of 0 to 1, current pulse rate is compared with selected random number. Location of bat is updated, if it is less than or equal to the current pulse rate of bat. After that, the objective function is evaluated at the new location for the bat. If the fitness is improved and a random number drawn is less than the current loudness for the bat, then the location is accepted. Finally the loudness and rate of pulse emission are updated.

5 GA-BAT BASED BLIND IMAGE DECONVOLUTION IN CEPSTRUM DOMAIN.

1 Get blurred image as an input.

2 Apply FFT to blurred image.

3 Compute log magnitude of spectrum.

4 Apply improved cepstrum based technique to calculate theta and length.

5 Feed these parameters as a Seed to GA, for an initial population.

6 Calculate objective function, taken as fitness function with boundaries limits.

7. Crossover and mutation process with step size taken into consideration.

8 Select best chromosomes using selection process.
if (random(0,1) < best chromosomes *// random function helps to generate new solution*
Within current population select best solution
by following best solution ,find local solution
else
New solution is replaced by random solution // *Adding random solution using bat-optimizing technique*.
end if

9 New values of theta and length are used to calculate PSF.
10 Apply deconvolution using Nonblind Richardson Lucy algorithm and restored the image. In experimentation of the GA-BAT hybrid algorithm, utilizes both GA and BAT technique. Here the worst solution in GA is replaced by the random solution using BAT optimization technique, Though the quality of the image has been improved but evaluation time is more in case of GA-BAT algorithm.

IV. RESULTS OF EXPERIMENT

The experiment was performed on Windows 8 with 4 GB RAM and was implemented using a Matlab 16. The online database of gray scale images of 49 images has been used to test the performance analysis of all four algorithms of cepstrum based image restoration using GA, PSO, BAT and GA-BAT hybrid. In all four algorithms cost function is sharpness function and generation size has been taken as 10. Table 1a and 1b shows parameters like PSNR, MSE, SSIM, GMSD, RMSE, CPU TIME etc evaluated.

Table 1a. Compative analysis of the parameters calculation of various images of dataset of GA based cepstrum, PSO based and BAT based cepstrum method

Image name	Parameters	GA based cepstrum	PSO based cepstrum	BAT based cepstrum	GA-BAT Hybrid
Barbara image	psnr	27.9101	29.5187	31.916	34.8845
	optimized theta	32.941	31.207	32.574	25.712
	optimised Length	18.61	16.851	14.728	9.521
	S SIM	0.60514	0.63735	0.69969	0.77009
	GMSD	0.1351	0.1214	0.09567	0.069693
	MSE	105.2123	72.6464	41.8291	21.117
	RMSE	10.2573	8.5233	6.4675	4.5953
	ISNR	0.36745	1.976	4.3733	7.3418
	Eval time:	72.0663	73.3813	16.2039	145.6158

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Bee image	psnr	29.0198	31.3844	32.7133	34.4805
	optimized theta	31.375	28.225	29.965	25.256
	optimisedLength	18.509	6.496	15.405	10.727
	SSIM	0.57674	0.63005	0.66098	0.72212
	GMSD	0.12375	0.10907	0.10533	0.082064
	MSE	81.4892	47.2755	34.8139	23.1758
	RMSE	9.0271	6.8757	5.9003	4.8141
	ISNR	0.47316	2.8378	4.1666	5.9338
	Eval time:	72.0924	71.5425	16.3252	145.5344
Cameraman image	psnr	25.8279	26.8066	28.5161	30.3689
	optimized theta	33.144	30.217	31.044	24.589
	optimised Length	18.651	17.35	15.546	11.047
	SSIM	0.48933	0.50924	0.54586	0.6092
	GMSD	0.1686	0.16209	0.15011	0.12027
	MSE	169.9395	135.648	91.5103	59.7296
	RMSE	13.0361	11.6468	9.5661	7.7285
	ISNR	0.24958	1.2284	2.9378	4.7906
	Eval time:	72.3706	72.0251	15.8534	142.8648
Crane image	psnr	31.2678	32.3641	34.452	38.0133
	optimized theta	32.331	30.283	29.549	24.725
	optimized Length	18.574	17.486	15.981	9.759
	SSIM	0.63503	0.65785	0.72293	0.81608
	GMSD	0.09787	0.08693	0.06687	0.042055
	MSE	48.5628	37.729	23.3284	10.2742
	RMSE	6.9687	6.1424	4.8299	3.2053
	ISNR	0.44605	1.5423	3.6302	7.1916
	Eval time:	72.369	72.0898	15.875	142.8055
Godhill image	psnr	28.0413	30.4052	31.1884	34.4376
	optimized theta	29.655	29.696	29.564	24.548
	optimisedLength	18.751	16.697	16.136	10.604
	SSIM	0.58021	0.65638	0.68584	0.7908
	GMSD	0.13336	0.11023	0.10336	0.067921
	MSE	102.0829	59.2321	49.4581	23.4055
	RMSE	10.1036	7.6962	7.0326	4.8379
	ISNR	0.20979	2.5738	3.357	:6.6061
	Eval time:	71.2971	72.7386	15.8744	142.8979
Living room image	psnr	27.5601	30.1911	31.091	32.9669
	optimized theta	30.822	28.552	29.47	24.439
	optimisedLength	18.722	16.412	15.664	10.563
	SSIM	0.53083	0.61355	0.6438	0.7045
	GMSD	0.13708	0.11156	0.10376	0.088494
	MSE	114.043	62.2259	50.5798	32.839
	RMSE	10.6791	7.8883	7.1119	5.7305
	ISNR	0.26977	2.9007	3.8007	5.6766
	Eval time:	71.4783	73.1813	16.1891	145.1758
Lena image	psnr	28.3666	30.0805	30.8132	32.2539
	optimized theta	31.639	30.221	29.223	25.161
	optimisedLength	17.35	15.72	15.158	10.612
	SSIM	0.60072	0.64726	0.66841	0.71923
	GMSD	0.13681	0.1203	0.11478	0.10056
	MSE	94.7157	63.8313	53.9214	38.6986
	RMSE	9.7322	7.9894	7.3431	6.2208
	ISNR	0.48167	2.1956	2.9283	4.3689
	Eval time:	72.6426	73.1394	16.1056	145.5699

	theta	30.212	28.736	29.586	24.713
	optimised Length	17.526	16.367	14.996	9.548
	SSIM	0.57995	0.61819	0.65772	0.7213
	GMSD	0.12563	0.116	0.10313	0.0812
	MSE	72.5844	55.9844	40.1005	28.447
	RMSE	8.5196	7.4823	6.3325	5.3332
	ISNR	0.45563	1.5834	3.0326	4.5244
	Eval time:	71.6316	71.6004	15.8311	142.145
bridge Image	psnr	26.2299	30.0106	30.6376	34.181
	optimized theta	31.382	29.778	29.068	25.014
	optimised Length	18.435	15.452	14.999	9.238
	SSIM	0.59556	0.71245	0.73019	0.8291
	GMSD	0.14413	0.10268	0.09666	0.0591
	MSE	154.915	64.866	56.1457	24.803
	RMSE	12.4465	8.0539	7.493	4.9801
	ISNR	0.39188	4.1727	4.7997	8.3481
	Eval time:	71.6561	71.5763	15.6839	142.56
butterfly image	psnr	28.0668	31.0696	32.2225	36.127
	optimized theta	35.389	33.075	33.426	26.037
	optimised Length	18.584	16.18	15.11	9.564
	SSIM	0.67751	0.75761	0.78394	0.8747
	GMSD	0.11951	0.089279	0.07976	0.0482
	MSE	101.482	50.8298	38.9792	15.868
	RMSE	10.074	7.1295	6.2433	3.9829
	ISNR	0.18906	3.1919	4.3448	8.249
	Eval time:	72.0483	73.2989	16.2449	144.99
boat image	psnr	26.3707	28.9457	31.5967	34.838
	optimized theta	34.829	30.553	32.184	27.838
	optimised Length	19.605	17.976	15.406	10.431
	SSIM	0.52777	0.58241	0.65917	0.7347
	GMSD	0.14007	0.11388	0.08819	0.0749
	MSE	149.971	82.8919	45.0206	21.344
	RMSE	12.2463	9.1045	6.7097	4.6196
	ISNR	0.41689	2.9918	5.6429	8.8849
	Eval time:	81.8786	81.6142	15.9383	145.83
airplane image	psnr	27.0762	29.0248	31.8225	35.273
	optimized theta	34.967	33.774	34.307	27.755
	optimised Length	18.696	16.753	14.245	9.945
	SSIM	0.53769	0.58753	0.66671	0.7569
	GMSD	0.13691	0.11894	0.09254	0.0557
	MSE	127.483	81.3963	42.7392	19.301
	RMSE	11.291	9.022	6.5375	4.3936
	ISNR	0.27644	2.225	5.0228	8.4746
	Eval time:	72.2418	72.0238	16.2561	146.28
Superstition mountain image	psnr	26.3827	29.4141	31	31.556
	optimized theta	35.1	30.494	32.47	26.607
	optimised Length	18.695	16.093	14.228	11.14
	SSIM	0.52707	0.62183	0.67592	0.7061
	GMSD	0.15177	0.11646	0.10284	0.0999
	MSE	149.557	74.4174	51.6517	45.457
	RMSE	12.2294	8.6266	7.1869	6.7423
	ISNR	0.23109	3.2624	4.8483	5.403
	Eval time:	71.2998	71.0831	15.8337	141.85

Table 1b. Comparative analysis of the parameters calculation of various images of dataset of GA based cepstrum, PSO based and BAT based cepstrum method

Image name	Parameters	GA based cepstrum	PSO based cepstrum	BAT based cepstrum	GA-BAT Hybrid
Mendrill image	psnr optimized	29.5224	30.6501	32.0993	33.591

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Accuiel image	psnr	26.5173	29.433	31.5923	33.219
	optimized theta	31.905	28.487	30.238	24.057
	optimised Length	19.682	16.708	14.798	10.228
	SSIM	0.59991	0.67395	0.72435	0.7715
	GMSD	0.1428	0.10848	0.08889	0.0738
	MSE	144.995	74.0933	45.0657	31.014
	RMSE	12.0414	8.6077	6.7131	5.5692
	ISNR	0.2066	3.1223	5.2817	6.9042
	Eval time:	71.4785	71.976	15.6969	141.65
Trillium lake image	psnr	28.2056	31.7703	32.4846	34.667
	optimized theta	30.298	28.275	29.774	24.648
	optimised Length	18.555	15.709	15.265	10.619
	SSIM	0.57803	0.67753	0.68705	0.7523
	GMSD	0.11735	0.089943.2565	0.08791	0.0709
	MSE	98.2915	6.577	36.6964	22.198
	RMSE	9.9142	3.995	6.0578	4.7115
	ISNR	0.43039	72.6394	4.7093	6.8924
	Eval time:	73.1377		16.0895	145.03

PSNR computed by cepstrum is found to be same by all three methods in every image. Figure 1a and 1b show graphical representation of comparative analysis of PSNR. It is found that PSNR is better in case of BAT than in case of GA and PSO.

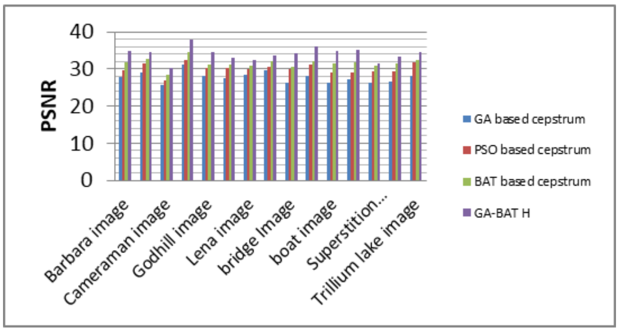

Figure.1 Comparative analysis of PSNR cepstrum method using GA, PSO and BAT

GMSD provides gradient magnitude similarity deviation used to measure the image quality. GMSD of restored image using GA, PSO and BAT is given in figure 2. The restored image output depends on the correctness of theta and length of cepstrum. GMSD have been calculated using the equation (5). It is observed from Figure 2, GMSD computed for all the three algorithms confirms that BAT based cepstrum is having lowest GMSD and GA based cepstrum having the highest GMSD. But PSO based cepstrum has the GMSD less than the GA based cepstrum. The value of GMSD reflects the range of distortion severities in an image. Higher the GMSD value, greater the distortion range. Hence BAT based cepstrum gives better perceptual quality.

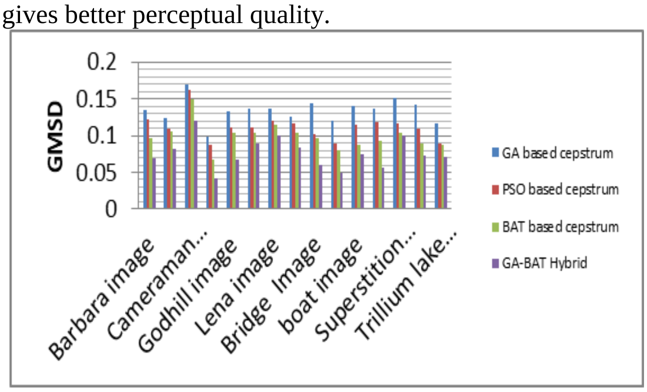

Figure. 2 Comparative analysis of GMSD cepstrum method using GA, PSO and BAT

The similarity between two images can be computed using Structural Similarity (SSIM) index. It is a matrix to predict the quality. From Figure 3, it is clear that SSIM of BAT and PSO based cepstrum will have almost same the SSIM which is much better than GA based cepstrum.

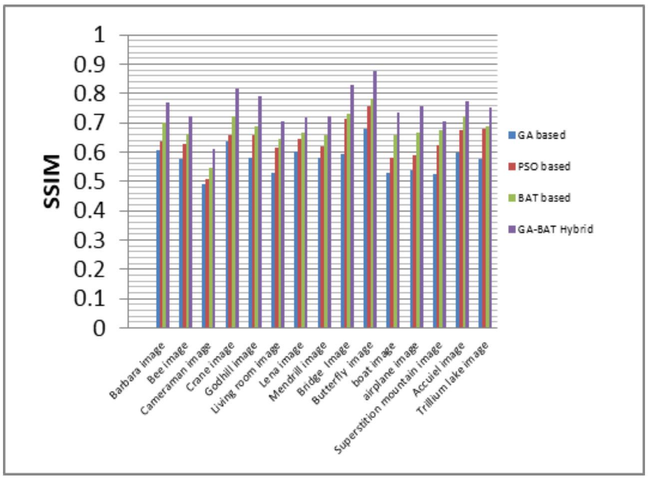

Figure. 3 Comparative analysis of SSIM cepstrum method using GA, PSO ,BAT and GA-BAT hybrid

Execution time of BAT based cepstrum method is the least among four algorithms. Figure 4 shows the running time of four algorithms on all images of dataset. All algorithms were run on Pentium processor with Intel® core(TM) i5-3210@ 2.50 GHZ 4 GB RAM, 64 BIT window operating system.

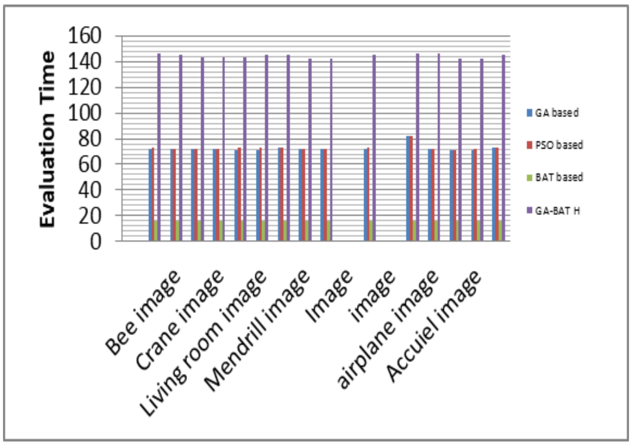

Figure.4 Comparative analysis of Evaluation time cepstrum method using GA, PSO , BAT and GA-BAT hybrid (1)

It is observed that the all four methods GA based cepstrum, PSO based cepstrum and BAT based cepstrum method and GA-BAT based cepstrum method provides different converging rate. Figure.5 shows that the fitness function is converging fast in case of BAT than in case of GA and PSO. Whereas in GA-BAT hybrid technique, fitness function is converging at the fastest rate. It converges at highest value in minimum number of iteration amongst four techniques.

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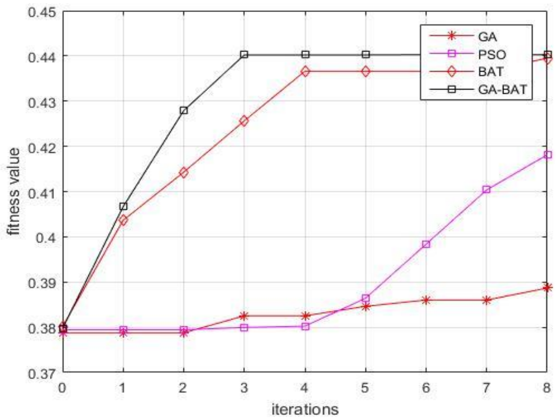

Figure. 5 Cost function cepstrum method using GA, PSO and BAT

All four algorithms of cepstrum methods using GA, PSO, BAT and GA-BAT hybrid have applied on the dataset of motion blurred images. Visual appearance found to be better in case PSO and BAT as shown in Figure 6.

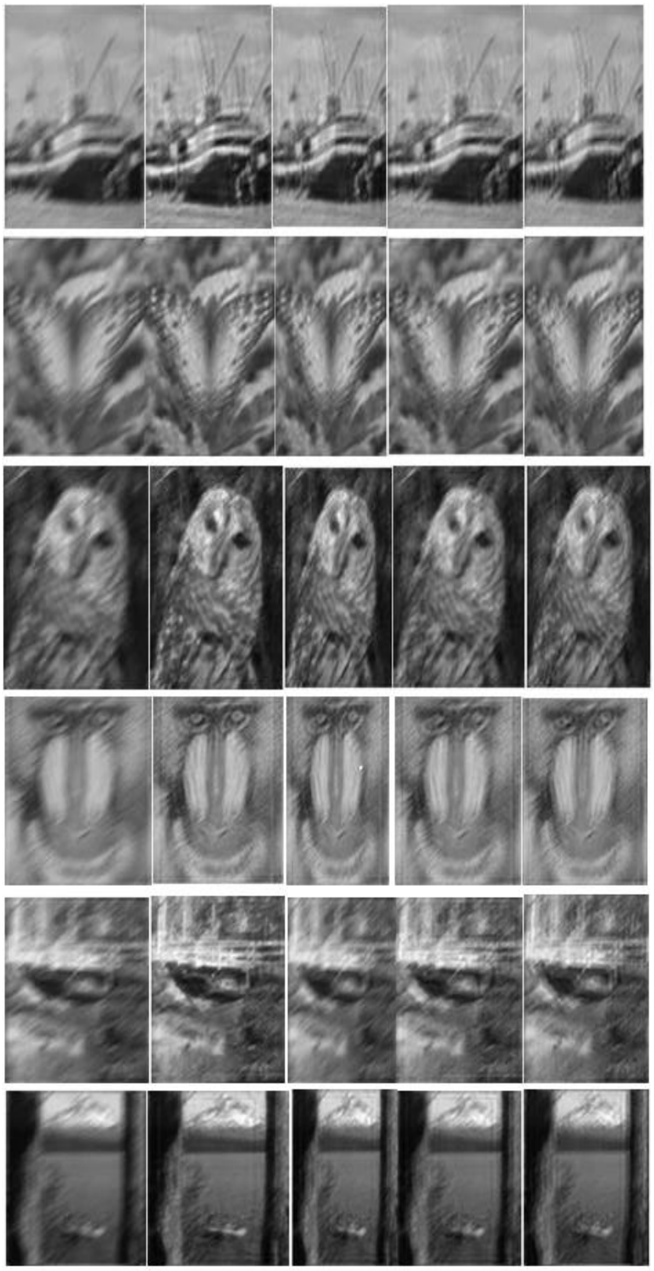

Figure 6(A) Motion blurred Camera image (B) Restored using method GA(C) Restored using PSO (D) Restoration using BAT on the dataset created using standard images. (E) Restoration using GA- BAT Hybrid on the dataset created using standard images.

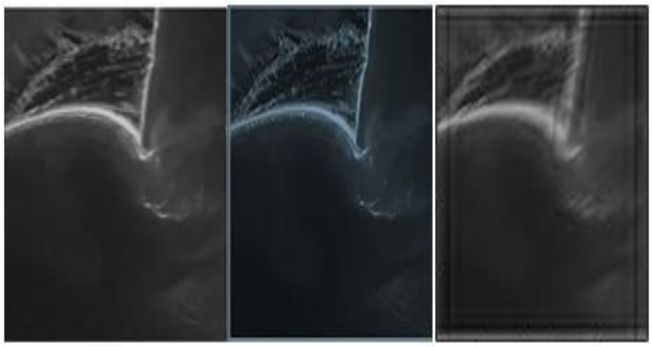

Fig7. (a) Motion Blurred image (b)Restored image by Wang M ***et al*** **[25] of PSNR 30. (c)Restored image by proposed system Of PSNR 32.3786.**

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V. CONCLUSION

In this paper, we have tried to improve the basic proposed technique of parameter estimation given in section 3.1 using various optimization techniques. The comparative analysis of cepstrum based PSF estimation method of motion blur has been done using GA, PSO, BAT and GA-BAT hybrid. Using all four methods, we have precisely estimated the blur parameters of motion blur. The quality of output restored image found using PSO and BAT is almost the same. The quality is improved using GA-BAT hybrid technique, but the evaluation time needed is much greater. It is clear that the evaluation time of BAT is minimum compared to the other three cepstrum based methods. This analysis can be helpful for researchers for further improvement of PSF parameter estimation.

Compliance with Ethical Standards:

Conflict of interest: All the authors declared that they have no conflict of interest.Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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