Comparison of Image Enhancement Algorithms for Improving the Visual Quality in Computer Vision Application

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***Abstract*—Computer vision has its numerous real-world applications on Visual Object Tracking which includes human-computer interaction, autonomous vehicles, robotics, motion-based recognition, video indexing, surveillance and security, human-computer interaction, autonomous vehicles, robotics, motion-based recognition, video indexing, surveillance and security. The factors affecting the tracking process is due to low illumination, haze and cloudy environment and noisy environment. In this paper, we aim to extensively review the latest trends and advances in adaptive enhancement algorithm and evaluate the performance using Full reference like, SSIM (Structure Similarity Index Measure), MS-SSIM (Multi-scale Structure Similarity Index Measure), ESSIM (Edge Strength Structural Similarity Index), FSIM (Feature Similarity Index Measure), VIF (Visual Information Fidelity), CW-SSIM (complex wavelet structural similarity), UQI (Universal Quality Index), IEF (Image Enhancement Factor), IQI (Image Quality Index), EME (Enhancement Measurement Error), CVSI (Contrast and Visual Salient Information), MCSD (Multiscale contrast similarity deviation), NQM (Noise Quality Measure), Gradient Magnitude Similarity Mean (GMSM), Gradient Magnitude Similarity Deviation (GMSM) and no-reference image quality measures Perception based Image Quality Evaluator (PIQE), Blind/Reference less Image Spatial Quality Evaluator (BRISQUE), Naturalness Image Quality Evaluator (NIQE), Average Gradient (AG), Contrast, Information Entropy (IE), Lightness order Error (LOE). The main purpose of adaptive image enhancement is to smooth the uniform area and sharpen the border of an image to improve its visual quality. In this paper, fourteen image enhancement algorithms were tested on LoL dataset to benchmark the time taken to process them and their output quality was evaluated. Results from this study will give insights to image analysts for selecting image enhancement algorithms which acts as a pre- processing stage for Visual object Tracking.**

***Keywords*—Tracking; robotics; surveillance; enhancement**

I. Introduction

In weakly illuminated environments, the images and video quality are often degraded. This leads to reduction in the performance of particular systems, such as those used in consumer electronics, visual surveillance and intelligent traffic analysis. For example, the low lighting conditions in nighttime environments can produce images and video with low contrast, which reduces the visibility [1]. Digital images used with contemporary imaging- and vision-related applications [2] and capturing the image in inappropriate lighting environment have a low-light effect, deficient contrast, and improper colors [3]. Therefore, it is very difficult to capture images with high-quality in that the low-light effect environment which may reduce the performance related to image processing and computer vision applications [4, 5], and such images usually comprise of vast dark regions with reduced visibility [6]. Samples of such images are shown in Fig. 1. There exist various image enhancement algorithms for improving the quality of images acquired under cloudy or other conditions.

(a) (b) (c) (d)

Fig. 1. Various Types of Low-light Images. (a) Night Time Image; (b) Unevenly illuminated Image; c) Shadowed Environment Image; d) Image with a Dark Appearance.

Lowlight images are images that have a dark appearance, have uneven illumination, and they are captured in a shadowed environment [7]. The input parameters for these algorithms can vary from very minimal to relatively extensive. Depending on the algorithm the time taken to process an image can also vary. Based on the type of algorithm used and the input parameters specified the output quality of the resultant image will be different. Given with numerously available image enhancement algorithms, it is not feasible to evaluate all of them to determine their suitability. The primary objective of this study is to evaluate a suite of commonly used

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image enhancement algorithms on low-illumination images. In the first phase of this study, fourteen image enhancement algorithms like Improved Type-II Fuzzy Set-based Algorithm, Retinex-based Multiphase Algorithm, Fusion-based enhancing method, Adaptive Image Enhancement Method for Correcting Low-Illumination Images, Fast efficient algorithm for enhancement of low lighting, A Multiscale Retinex, Bio-inspired multiexposure fusion frame work, Deep low light image enhancement, Adaptively Increasing Value Histogram Equalization (AIVHE)) were tested on LOL dataset to benchmark the quality of the output image and the time taken to process them.

Due to the rapid development of image enhancement technology, various enhancement algorithms such as retinex model [9–11], fuzzy theory [12, 13], Fusion based approach [14, 15], Deep learning Approach [16,17], Histogram Equalization based approach [18,19] etc. were developed. For example, as shown in Fig. 2, around 250 literatures on image enhancement algorithms were studied. The methods involved mainly include histogram equalization, Retinex model, Fusion based Approach, Fuzzy based approach and deep learning methods. Each of the image enhancement methods has their own advantages as well as disadvantages. The eye of a human has the ability of filtering the influence of light and obtains the reflectivity of the surface of the object to determine colour. Therefore, the formation of a low-light image can be described as follows:

$$L(x,y)=R(x,y)\cdot B(x,y) \quad (1)$$

where L(x, y) is the original image, R(x, y) is the reflection image, B(x, y) is the illuminance image and (x, y) is the pixel coordinates.

In this paper, we provide the progress of image enhancement algorithms during the past two decades. We mainly introduce the image enhancement methods separately in three aspects based on supervised methods, unsupervised methods and quality evaluation. The block diagram of the whole framework is shown in Fig. 3 in this paper.

The rest of paper is organized as follows. Section III introduces the image enhancement techniques based on Fuzzy based, Retinex based and Fusion based, Histogram based and Deep learning-based approach. Section IV elaborates in detail the image quality assessment using Full-reference, No-reference and Image Error Measurement. Section V deal with the results and discussions. Sections VI elaborates about results and discussions.

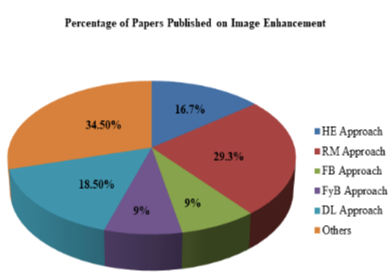

Fig. 2. Statistics of Percentage of Papers Published on Image Enhancement.

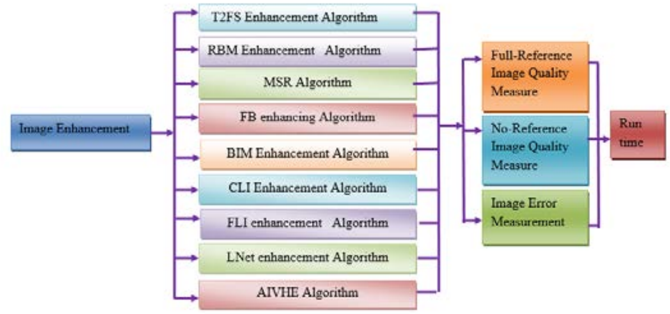

Fig. 3. Block Diagram of the Workflow.

II. Datasets Used

The LOL dataset comprise of 500 low-light and normal-light image pairs and divided into 485 training pairs and 15 testing pairs. Most of the images are indoor scenes. The resolution of all images is 400×600.

III. T2FS, RB and HE Based Image Enhancement

A. T2FS[20]

A Type-II fuzzy set (T2FS) based algorithm [20] was introduced for enhancing the contrast of grayscale medical images. This algorithm improves the contrast by Fuzzifying the image. Then, apply the Type-II fuzzy membership function are determined with the lower and upper ranges of the Hamacher t-conorm, where, α is a parameter that controls the amount of contrast enhancement, in that it should satisfy $0 < \alpha \leq 1$, when $\alpha > 0.6$, better contrast enhancement is obtained [20]. An improved type-II fuzzy set (IT2FS) algorithm [21], using Fuzzified image followed by Hamacher t-conorm method and then finally applying Gamma Correction The enhanced output of Improved Type-II fuzzy set-based algorithm with different α values is as shown in the Fig. 4(a) When α is between 0.3.5 and 0.55, the results will be obtained with satisfactory visual quality. When increasing α, the brightness is reduced while the contrast is enhanced selecting the proper value of α leads to desired results. To produce satisfactory results the proper gamma value can be around 0.50.

B. Retinex based Algorithm

Zou, Y et al. [22] and Kallel, F et al. [23] introduced various image enhancement algorithms for contrast enhancement in CT images. There exists different low-intricacy concept which improves the image illumination. Among such concepts, the single-scale retinex (SSR) model proposed by Jobson et al. [24] was examined because it involves simple calculations and improves the illumination of images. In brief, the SSR model works by estimating an illumination image from its degraded counterpart by performing a discrete convolution (*) between a degraded image and a discrete 2D Gaussian surround function (DGSF) [25].

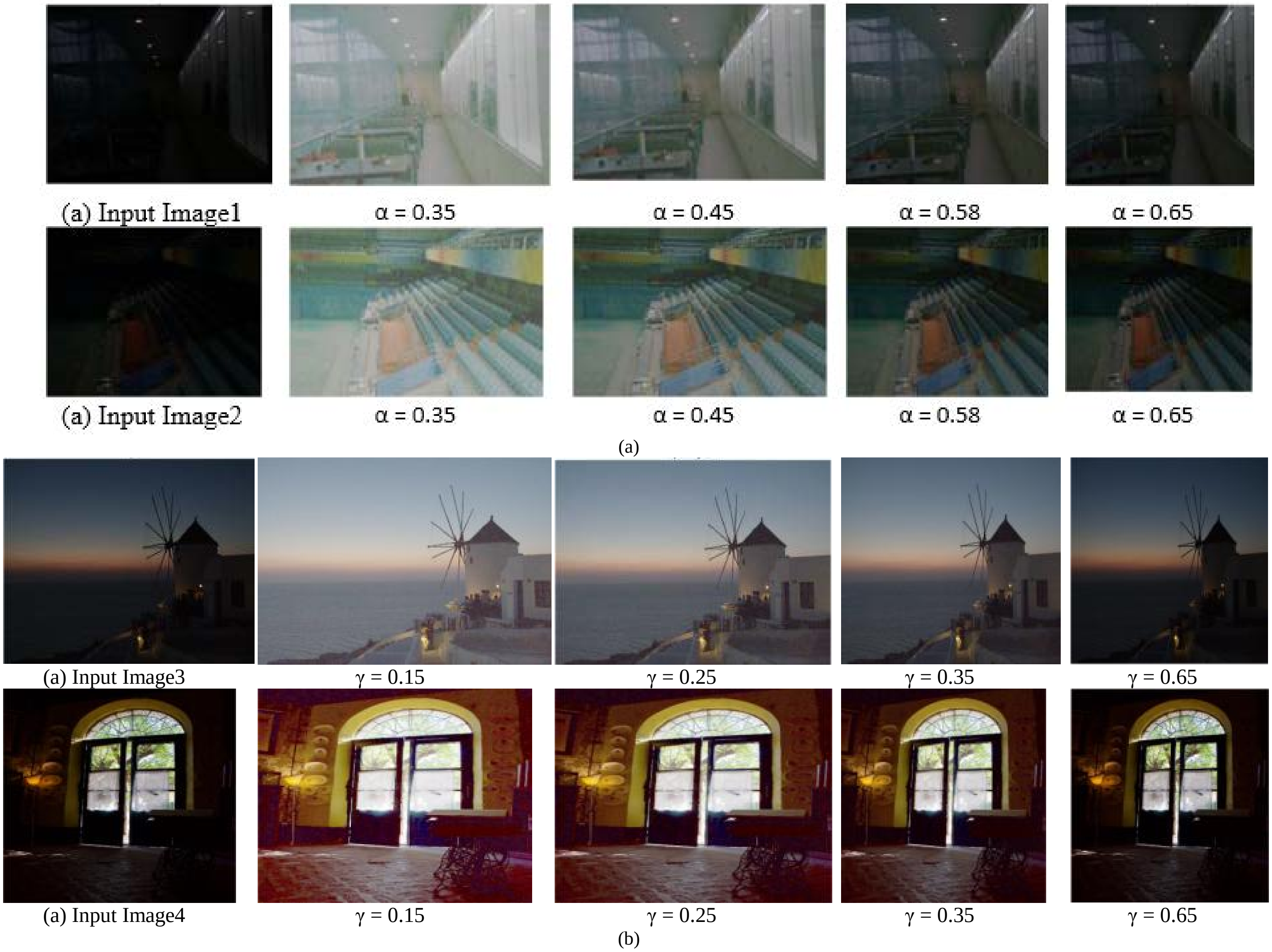

Fig. 4. (a) Type-II Fuzzy Set-based Algorithm with different α Values, (b) Retinex-based Multiphase Algorithm with different γ Values.

1) RBMA [26]: Mohammad Abid et al. [26] proposed RBMA which involves in determining the log of the illumination and the original images followed by computation of GCS (Gama Corrected Sigmoid function) .The enhanced output of Retinex-based Multiphase Algorithm with different values of γ is as shown in the Fig. 4(b).

Intensive experiments reveal that acceptable quality results are obtained when the γ value is between 0.1 and 0.35.

2) FBEM [27]: Xueyang Fu et al. [27] employed an illumination estimating algorithm based on morphological closing image and an illumination image. The two inputs - improved and contrast-enhanced versions of the first decomposed illumination were derived using the sigmoid function and adaptive histogram equalization. Designing two weights based on these inputs, an adjusted illumination is produced by fusing the derived inputs with the corresponding weights in a multi-scale fashion. Through a proper weighting and fusion strategy, the advantages of different techniques are blended to produce the adjusted illumination. The final enhanced image is obtained by compensating the adjusted illumination back to the reflectance.

In this fusion-based framework, images under different weak illumination conditions such as non-uniform illumination, backlighting, and nighttime can be enhanced.

3) AIEM [28]: Wencheng Wang et al. [28] proposed Adaptive Image Enhancement Method for Correcting Low-Illumination Images. The original RGB image is converted to HSV color space, and the V component is used to extract the illumination component of the scene using the multiscale Gaussian function. Then based on the Weber-Fechner law, a correction function is constructed, and two images are obtained through adaptive adjustments to the image enhancement function parameters based on the distribution profiles of the illumination components. Finally, an image fusion strategy is formulated and used to extract the details from the two images. Compared with the classic algorithm, the AIEM algorithm can improve the overall brightness and contrast of an image and the enhanced images appear clear, bright, and natural.

4) FEAE [29]: Xuan Dong et al. [29] proposed a Low lighting video enhancement algorithm by applying the invert operation on low lighting video frames, and then performing haze removal on the inverted video frames, before performing the invert operation again to obtain the output video frames.

5) LIME [30]: Xiaojie Guo et al. [30] proposed an effective low-light image enhancement (LIME) method. More concretely, the illumination of each pixel is first estimated individually by finding the maximum value in R, G and B channels. Further, we refine the initial illumination map by imposing a structure prior on it, as the final illumination map. Having the well-constructed illumination map, the enhancement can be achieved accordingly.

6) BIMEF [31]: Zhenqiang Ying et al. [31] proposed a framework mainly consists of four main components:

The first component, named Multi-Exposure Sampler, determines how many images are required and the exposure ratio of each image to be fused; the second component, named Multi-Exposure Generator, use a camera response model and the Specified exposure ratio to synthetic multi-exposure images; the third component, named Multi-Exposure Evaluator, determines the weight map of each image when fusing; the last component, named Multi-Exposure Combiner, is to fuse the generated images to the final enhanced result based on the weight maps.

7) SRIE [32]: In this paper, a weighted variational model for simultaneously estimating reflectance and illumination is presented. First, by analyzing the characteristic of the logarithmic transformation, we show that the logarithmic transformation is not proper to be directly used as regularization terms. Then, based on the previous analysis, a weighted variational model is introduced for better prior representation and an alternating minimization scheme is adopted to solve the proposed model.

8) NPEA [33]: Shuhang Wang et al. [33] proposed an enhancement algorithm for non-uniform illumination images. In general, this paper makes the following three major contributions. First, a lightness-order error measure is proposed to access naturalness preservation objectively. Second, a bright-pass filter is proposed to decompose an image into reflectance and illumination, which, respectively, determine the details and the naturalness of the image. Third, a bi-log transformation is applied, which is utilized to map the illumination to make a balance between details and naturalness.

9) BPHE [34]: In Brightness Preserving Bi-Histogram Equalization (BBHE) [34], the Input image is splitted into two sub images based on the mean of the input image. Samples of the input image which are less than or equal to mean forms one sub image, the other sub image consists of samples which are greater than the mean. Each of these sub images are independently equalized based on their respective histograms. The first sub image, containing samples less than or equal to mean, are mapped into the range from the minimum gray level to the input mean. The second sub image, containing samples greater than the mean are mapped into the range from the mean to the maximum gray level.

10)MSRA [36]: Daniel J. Jobson et al. [36] extend the designed single-scale center/surround retinex to a multiscale version that achieves simultaneous dynamic range compression/color consistency/ lightness rendition. This extension fails to produce good color rendition for a class of images that contain violations of the gray-world assumption implicit to the theoretical foundation of the retinex. Therefore, we define a method of color restoration that corrects for this deficiency at the cost of a modest dilution in color consistency.

11)LightenNet [38]: The purpose of LightenNet [38] is to learn a mapping, which takes a weakly illuminated image as input and outputs its illumination map that is subsequently used to obtain the enhanced image based on Retinex model. The architecture is LightenNet. LightenNet consists of four convolution layers, *i.e*., patch extraction and representation, feature enhancement, nonlinear mapping, and reconstruction.

IV. Image Quality Assessment

Image Quality Assessment (IQA) is considered as a characteristic property of an image. Degradation of perceived images is measured by image quality assessment. Usually, degradation is calculated compared to an ideal image. Quality of image can be described technically as well as objectively to indicate the deviation from the ideal or reference model. It also relates to the subjective perception or prediction of an image [8], such as an image of a human look. Image Quality Assessment is grouped into two categories based on the availability of a reference image. The categories of Image Quality assessment methods are as shown in Fig. 5.

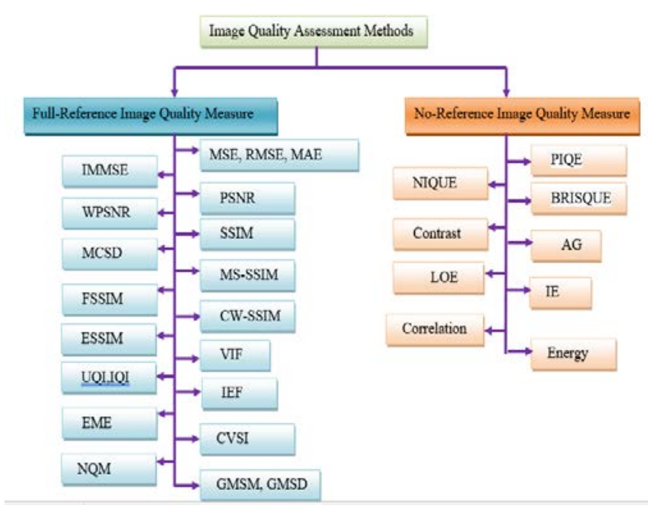

Fig. 5. Categories of Image Quality Assessment Methods.

V. Results and Discussion

A comparison is made with fourteen methods that are, T2FS [20], RBMA [26], FBEM [27], AIEM [28], FEAE [29], LIME [30], BIMEF [31], SRIE [32], NPEA [33], BPHE [34], CAVIEHE [35], MSRA [36], MSRCR [37], LightenNet [38] and the outcomes of such comparisons are evaluated by 30 metrics. Fig. 6 to 9 demonstrates the comparison results. Table I to Table XXIX exhibit the recorded metrics scores and processing times of the conducted comparison. Fig. 6 demonstrates the comparison results. Fig. 10 shows the GMS map for the entire different algorithm (Table I to Table XXIX) exhibit the recorded metrics scores and processing times of the conducted comparison.

(a) Test Img1 (b) (c) (d) (e)
(f) (g) (h) (i) (j)
(k) (l) (m) (n) (o)

Fig. 6. The Comparison Outcomes Test Image1 (a) Real Low-light Image; The following Images are enhanced by: (b) IT2FB [20], (c) RBMA[26], (d) FBEM [27], (e) AIEM [28], (f) FEAE [29], (g) MSRA [30], (h) CAVIEHE [31], (i) LIME [32], (j) BIMEF [33], (k) LNET [34], (l) NPEA[35] [m] SRIE [36] [n]BPHE[37] [o] MSRCR [38].

(a)Reference Image 1 (b)Gradient Magnitude of Reference image (c)Gradient Magnitude of Noisy Image

Fig. 7. Gradient Magnitude of Reference Image1 and Noisy Image.

(a) Test Img2 (b) (c) (d) (e)
(f) (g) (h) (i) (j)
(k) (l) (m) (n) (o)

Fig. 8. The Comparison Outcomes Test Image2 (a) Real Low-light Image; The following Images are enhanced by: (b) IT2FB [20], (c) RBMA[26], (d) FBEM [27], (e) AIEM [28], (f) FEAE [29], (g) MSRA [30], (h) CAVIEHE [31], (i) LIME [32], (j) BIMEF [33], (k) LNET [34], (l) NPEA[35] [m] SRIE [36] [n]BPHE[37] [o] MSRCR [38].

(a)Reference Image 2 (b)Gradient Magnitude of Reference image (c)Gradient Magnitude of Noisy Image

Fig. 9. Gradient Magnitude of Reference Image2 and Noisy Image.

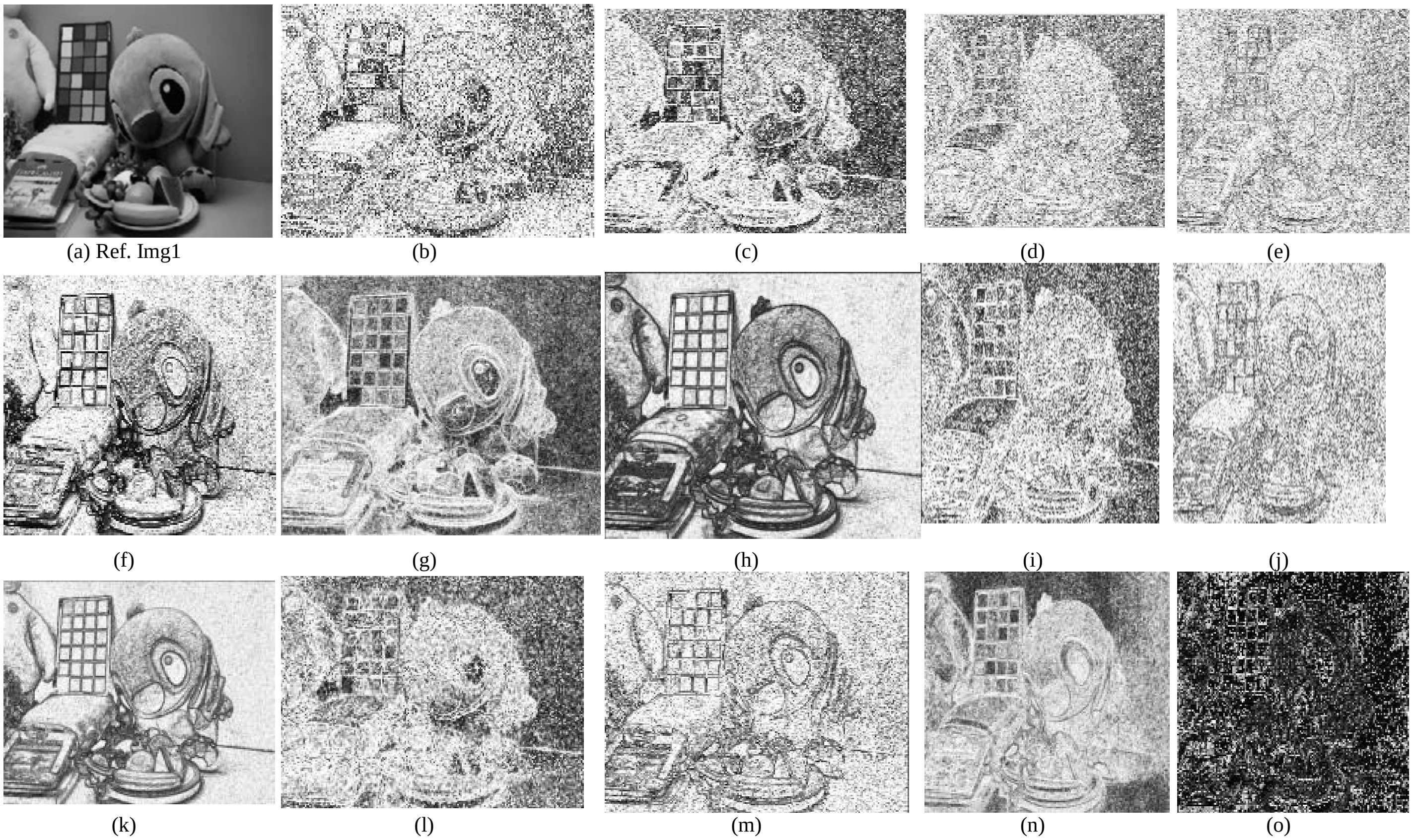

Fig. 10. The Comparison Outcomes Ref. Image1 (a) Reference Image; The following Images are enhanced by: (b) IT2FB [20], (c) RBMA[26], (d) FBEM [27], (e) AIEM [28], (f) FEAE [29], (g) MSRA [30], (h) CAVIEHE [31], (i) LIME [32], (j) BIMEF [33], (k) LNET [34], (l) NPEA[35] [m] SRIE [36] [n]BPHE[37] [o] MSRCR [38].

TABLE I. THE RECORDED MSE SCORES FOR THE COMPARATIVES (LOWEST SCORE IS THE BEST)

Image	**IT2FS**	**RBMP**	**FBEM**	**AIEM**	**FEAE**	**LIME**	**BIMEF**	**SRIE**
TestImg1	0.2957783	0.0933671	0.0285043	0.0764384	0.0578257	0.1863743	0.0378418	0.0137192
TestImg2	0.5330835	0.1811075	0.0440756	0.0213309	0.0116832	0.1065525	0.0159348	0.0069661
TestImg3	0.4311686	0.1884765	0.0257584	0.0761735	0.0856139	0.1251811	0.0475861	0.0212036
TestImg4	0.3250936	0.1169117	0.0256007	0.1254773	0.0850932	0.2084432	0.0461444	0.0220777

Image	**NPEA**	**BPHE**	**CAVIEHE**	**MSRA**	**MSRCR**	**LNET**
TestImg1	0.1084480	0.0078458	0.0429760	0.2861314	0.2885862	**0.0045625**
TestImg2	0.0749098	0.0845492	**0.0009261**	0.3079275	0.2841193	0.0029567
TestImg3	0.0694492	0.0267625	0.0333089	0.3367357	0.3580889	**0.0080669**
TestImg4	0.1519172	0.0239108	0.0644361	0.3583796	0.3300625	**0.0045718**

TABLE II. THE RECORDED RMSE SCORES FOR THE COMPARATIVES (LOWEST SCORE IS THE BEST)

Image	**IT2FS**	**RBMP**	**FBEM**	**AIEM**	**FEAE**	**LIME**	**BIMEF**	**SRIE**
TestImg1	0.5438550	0.3055603	0.1688320	0.2764750	0.2404697	0.4317110	0.1945297	0.1171289
TestImg2	0.7301257	0.4255673	0.2099419	0.1460511	0.1080888	0.3264238	0.1262332	0.0834629
TestImg3	0.6566343	0.4341388	0.1604943	0.2759956	0.2925986	0.3538094	0.2181423	0.1456145
TestImg4	0.5701698	0.3419235	0.1600022	0.3542278	0.2917075	0.4565558	0.2148126	0.1485858

Image	**NPEA**	**BPHE**	**CAVIEHE**	**MSRA**	**MSRCR**	**LNET**
TestImg1	0.3293145	0.0885765	0.2073065	0.5349125	0.5372022	**0.0675460**
TestImg2	0.2736965	0.2907734	**0.0304320**	0.5549121	0.5330284	0.0543757
TestImg3	0.2635322	0.1635924	0.1825072	0.5802893	0.5984053	**0.0898158**
TestImg4	0.3897656	0.1546313	0.2538426	0.5986481	0.5745107	**0.0676148**

TABLE III. THE RECORDED PSNR SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST)

Image	**IT2FB**	**RBMP**	**FBEM**	**AIEM**	**FEAE**	**LIME**	**BIMEF**	**SRIE**
TestImg1	53.4551363	58.4628604	63.6157018	59.3316821	60.5435907	55.4609380	62.3850827	66.7915145
TestImg2	50.8968467	55.5854348	61.7228179	64.8747043	67.4891830	57.8891633	66.1413308	69.7349266
TestImg3	51.8183279	55.4122275	64.0556064	59.3467575	58.8393542	57.1894109	61.3900027	64.9007048
TestImg4	53.0447151	57.4862196	64.0822808	57.1791464	58.8658485	54.9749219	61.5236057	64.7252557

Image	**NPEA**	**BPHE**	**CAVIEHE**	**MSRA**	**MSRCR**	**LNET**
TestImg1	57.8125822	69.2184311	61.8325401	53.5991442	53.5620441	**71.5728084**
TestImg2	59.4194148	58.8937050	**78.4981783**	53.2803149	53.6297926	73.4567085
TestImg3	59.7481264	63.8895391	62.9391988	52.8919083	52.6248905	**69.0977402**
TestImg4	56.3487290	64.3788502	60.0735098	52.6213668	52.9788370	**71.5639629**

TABLE IV. THE RECORDED WPSNR SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST)

Image	**IT2FB**	**RBMP**	**FBEM**	**AIEM**	**FEAE**	**LIME**	**BIMEF**	**SRIE**
TestImg1	11.3176642	16.3443338	21.5312272	17.2358092	18.3756584	13.3539544	20.2668132	24.6841020
TestImg2	8.7625898	13.5024273	19.6510197	22.7892871	25.2990697	15.7966793	24.0579747	27.6668179
TestImg3	9.6761380	13.2787880	31.7233984	17.2394699	16.7057388	15.0955838	19.2632333	22.7914569
TestImg4	10.9035732	15.3530057	21.9893547	15.0685158	16.7149919	12.8668475	19.3981699	22.6181768

Image	**NPEA**	**BPHE**	**CAVIEHE**	**MSRA**	**MSRCR**	**LNET**
TestImg1	15.7201659	27.1490633	19.7112954	11.4881722	14.0373919	**29.4550061**
TestImg2	17.3674225	16.8182650	**36.3993706**	11.1827298	14.5294831	31.3554380
TestImg3	17.6404362	21.9613413	20.8354621	10.7732827	12.5262427	**26.9895351**
TestImg4	14.2447339	22.3875860	17.9577614	10.5024942	13.5243776	**29.5050471**

TABLE V. THE RECORDED SSIM SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST)

Image	**IT2FB**	**RBMP**	**FBEM**	**AIEM**	**FEAE**	**LIME**	**BIMEF**	**SRIE**
TestImg1	0.99785	0.99523	0.98434	0.99278	0.98891	0.99682	0.98747	0.97937
TestImg2	0.98168	**0.99975**	0.99264	0.98822	0.98320	0.99736	0.98685	0.98275
TestImg3	0.97072	0.99230	0.99961	0.99918	0.99866	0.99692	**0.99994**	0.99934
TestImg4	0.99031	**0.99981**	0.99570	0.99967	0.99922	0.99714	0.99822	0.99520

Image	**NPEA**	**BPHE**	**CAVIEHE**	**MSRA**	**MSRCR**	**LNET**
TestImg1	0.97678	0.97538	0.98724	**0.99913**	0.98008	0.97369
TestImg2	0.99597	0.99509	0.97725	0.99625	0.98523	0.97966
TestImg3	0.99932	0.99870	0.99982	0.98041	0.98312	0.99775
TestImg4	0.99893	0.99338	0.99891	0.98940	0.98824	0.98988

TABLE VI. THE RECORDED CW-SSIM SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.74861	0.93698	0.86088	0.94114	0.93022	0.89871	0.88115	0.74399
TestImg2	0.69474	**0.96894**	0.81053	0.68657	0.72691	0.95084	0.57326	0.41762
TestImg3	0.85948	0.94236	0.96641	0.90545	0.86561	0.86520	**0.96931**	0.94301
TestImg4	0.83388	**0.97886**	0.93521	0.91537	0.85188	0.77317	0.96155	0.86016

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.82446	0.76114	0.94778	**0.95962**	0.40466	0.67500
TestImg2	0.78879	0.93743	0.18714	0.95356	0.42400	0.39128
TestImg3	0.88723	0.77239	0.97376	0.80165	0.25599	0.90355
TestImg4	0.86229	0.94870	0.97293	0.84677	0.41263	0.79696

TABLE VII. THE RECORDED VIF SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST)

Image	IT2FB	RBMB	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.19582	0.46423	0.48409	0.79706	0.81646	2.48645	0.38585	0.30754
TestImg2	0.19125	0.71589	0.34668	0.16834	0.12851	0.85126	0.09787	0.06581
TestImg3	0.30926	1.05753	0.90069	1.39086	1.72082	3.19192	0.72948	0.73963
TestImg4	0.22262	0.56422	0.63636	1.41722	1.47031	3.51728	0.61541	0.59447

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	1.03547	0.29112	0.65896	**1.82329**	0.15908	0.17925
TestImg2	0.46828	0.71736	0.00814	**1.09521**	0.09469	0.03815
TestImg3	1.35298	1.82509	0.98186	**4.11126**	0.63433	0.44912
TestImg4	1.82540	1.14454	1.32809	**2.89510**	0.33520	0.31034

TABLE VIII. THE RECORDED UQI SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST

Image	IT2FB	RBMB	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.50275	0.56244	0.36204	0.48627	0.46478	0.47524	0.44116	0.27996
TestImg2	0.24627	**0.37394**	0.28067	0.19893	0.11726	0.34546	0.17189	0.10729
TestImg3	0.39627	0.55050	0.66431	0.60912	0.66688	0.50212	**0.69900**	0.68206
TestImg4	0.46861	**0.61940**	0.51680	0.52719	0.63598	0.43620	0.60771	0.51228

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.48282	0.19056	0.41242	**0.55411**	0.00088	0.16764
TestImg2	0.33060	0.27312	0.02443	0.35001	-0.00078	0.06231
TestImg3	0.60753	0.40463	0.65395	0.36701	0.00070	0.56662
TestImg4	0.48266	0.33248	0.58218	0.41976	0.00084	0.31957

TABLE IX. THE RECORDED IEF SCORES FOR THE COMPARATIVES

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	14.02	6.80	2.18	4.61	3.08	9.00	2.70	1.66
TestImg2	1.38	**36.40**	3.50	2.21	1.56	8.85	1.98	1.52
TestImg3	0.21	0.81	15.15	7.19	4.62	1.92	**66.31**	9.30
TestImg4	1.51	**55.29**	3.58	28.64	17.87	4.36	8.47	3.22

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	6.06	1.39	2.68	**23.19**	0.86	1.30
TestImg2	6.04	5.07	1.15	6.04	0.72	1.29
TestImg3	8.60	4.37	29.63	0.31	0.17	2.84
TestImg4	10.63	2.27	13.12	1.32	0.43	1.54

TABLE X. THE RECORDED IMMSE SCORES FOR THE COMPARATIVES (LOWEST SCORE IS THE BEST)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.29578	0.09337	0.02850	0.07644	0.05783	0.18637	0.03784	0.01372
TestImg2	0.53308	0.18111	0.04408	0.02133	0.01168	0.10655	0.01593	0.00697
TestImg3	0.43117	0.18848	0.02576	0.07617	0.08561	0.12518	0.04759	0.02120
TestImg4	0.32509	0.11691	0.02560	0.12548	0.08509	0.20844	0.04614	0.02208

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.10845	0.00785	0.04298	0.28613	0.28859	**0.00456**
TestImg2	0.07491	0.08455	**0.00093**	0.30793	0.28412	0.00296
TestImg3	0.06945	0.02676	0.03331	0.33674	0.35809	**0.00807**
TestImg4	0.15192	0.02391	0.06444	0.35838	0.33006	**0.00457**

TABLE XI. THE RECORDED MSSIM SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.69711	0.57042	0.61017	0.47714	0.47798	0.29046	0.64615	0.71292
TestImg2	0.49734	0.33369	0.48442	0.60775	0.70339	0.34148	0.67126	0.75477
TestImg3	0.86260	0.75360	0.82702	0.72642	0.66499	0.59373	0.84162	0.84437
TestImg4	0.80867	0.70498	0.69829	0.50175	0.48395	0.34765	0.74615	0.72605

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.39561	0.79282	0.56256	0.33490	0.04524	**0.86121**
TestImg2	0.39457	0.39503	**0.95229**	0.29305	0.04378	0.84538
TestImg3	0.70558	0.61072	0.78073	0.55215	0.05001	**0.90839**
TestImg4	0.40896	0.58566	0.58085	0.38086	0.03150	**0.88989**

TABLE XII. THE RECORDED MAE SCORES FOR THE COMPARATIVES (LOWEST SCORE IS THE BEST)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	.54073	0.28875	0.14273	0.24516	0.19210	0.35733	0.17784	0.09783
TestImg2	0.72464	0.38529	0.17624	0.12211	0.06624	0.26447	0.11178	0.07188
TestImg3	0.65597	0.42867	0.15295	0.26613	0.27547	0.33508	0.21354	0.13846
TestImg4	0.56909	0.33592	0.14793	0.33768	0.26626	0.41688	0.20788	0.13908

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.28849	0.06415	0.17191	0.49991	0.32936	**0.05246**
TestImg2	0.23937	0.21595	**0.02866**	0.52285	0.30042	0.04276
TestImg3	0.25134	0.13097	0.17295	0.56538	0.43635	**0.08162**
TestImg4	0.37019	0.10905	0.23189	0.57767	0.38217	**0.05915**

TABLE XIII. THE RECORDED IQI SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.50275	**0.56244**	0.36204	0.48627	0.46478	0.47524	0.44116	0.27996
TestImg2	0.24627	**0.37394**	0.28067	0.19893	0.11726	0.34546	0.17189	0.10729
TestImg3	0.39627	0.55050	0.66431	0.60912	0.66688	0.50212	**0.69900**	0.68206
TestImg4	0.46861	0.61940	0.51680	0.52719	**0.63598**	0.43620	0.60771	0.51228

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.48282	0.19056	0.41242	0.55411	0.00088	0.16764
TestImg2	0.33060	0.27312	0.02443	0.35001	-0.00078	0.06231
TestImg3	0.60753	0.40463	0.65395	0.36701	0.00070	0.56662
TestImg4	0.48266	0.33248	0.58218	0.41976	0.00084	0.31957

TABLE XIV. THE RECORDED FSIM SCORES FOR THE COMPARATIVES (HIGHEST SCORE IS THE BEST)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.99089	**0.99812**	0.99317	0.99212	0.99144	0.99439	0.99806	0.99367
TestImg2	0.98012	0.99134	0.98658	0.98997	0.97504	0.98937	0.99204	0.98644
TestImg3	0.98496	0.98844	0.99123	0.98093	0.98042	0.99171	**0.99419**	0.99001
TestImg4	0.99346	0.99454	0.98943	0.98195	0.98285	0.99169	**0.99713**	0.98671

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.98372	0.98823	0.99312	0.99382	0.89235	0.99166
TestImg2	0.98348	0.97946	**0.99228**	0.98625	0.85214	0.98798
TestImg3	0.98111	0.97666	0.99254	0.98894	0.87291	0.98457
TestImg4	0.97952	0.97625	0.99633	0.99078	0.88741	0.99364

TABLE XV. THE RECORDED EME SCORES FOR THE COMPARATIVES (LOWEST SCORE IS THE BEST)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	**2.59748**	8.50280	15.49097	13.75025	12.11895	15.35547	10.66295	15.38244
TestImg2	**2.50348**	12.83307	14.85539	14.46187	11.29116	15.08368	13.58085	14.86042
TestImg3	**1.1726**	3.41829	7.41943	6.23491	5.58065	7.42239	4.84588	7.09565
TestImg4	**1.57324**	4.42487	9.87638	8.28385	7.23544	9.67597	6.20972	9.56697

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	14.20973	17.29908	11.87166	10.27982	6.84198	15.63085
TestImg2	14.29100	16.61080	8.13913	9.38662	7.12783	15.13008
TestImg3	6.87650	15.08932	7.21423	5.83274	11.2897	7.50607
TestImg4	9.05361	19.59307	8.44812	7.32125	9.20486	9.88048

TABLE XVI. THE RECORDED BRISQUE SCORES FOR THE COMPARATIVES (LOWEST SCORE GIVES BEST RESULT)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	**19.16849**	26.79686	28.17226	40.12349	36.34488	31.19316	24.76338	27.94361
TestImg2	38.52422	41.81477	39.58667	38.65845	46.63950	41.56760	37.20722	32.93015
TestImg3	**9.30332**	23.98699	29.88640	31.15363	26.12095	34.16256	22.76009	22.46018
TestImg4	**13.33258**	27.60852	27.55335	39.86039	24.63390	32.46380	24.94812	25.84723

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	32.13035	27.45103	29.33331	28.04724	43.45818	29.61410
TestImg2	41.17648	40.32965	**20.65364**	41.47551	43.45818	36.82453
TestImg3	32.11621	35.37021	29.18756	34.10248	43.45818	20.30180
TestImg4	34.58516	26.89832	29.00054	26.91344	43.45818	27.04023

TABLE XVII. THE RECORDED NIQE SCORES FOR THE COMPARATIVES (LOWEST SCORE GIVES BEST RESULT)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	6.87128	7.69587	7.78807	9.30102	**4.77781**	8.65645	7.26530	6.83867
TestImg2	8.85253	9.66738	9.74843	9.22545	**4.51997**	9.62537	8.55000	7.83046
TestImg3	5.48614	6.63134	6.61409	7.71980	**3.35362**	6.89375	6.35760	5.99619
TestImg4	6.28973	7.31890	8.17693	10.12868	**5.31512**	9.25940	7.41547	7.41176

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	8.31067	7.00298	7.80821	8.38040	38.50599	6.34044
TestImg2	9.95520	9.33642	6.45676	9.98429	30.40184	7.27924
TestImg3	6.83652	6.90076	6.91004	7.41921	29.21334	5.64895
TestImg4	9.26341	7.93860	8.48241	8.85040	35.71108	6.64925

TABLE XVIII. THE RECORDED PIQE SCORES FOR THE COMPARATIVES (LOW SCORE GIVES THE BEST RESULT

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	26.42034	32.16037	**7.78807**	41.84593	32.86864	42.84311	26.99954	20.84821
TestImg2	50.00359	60.81876	55.35629	47.18139	44.25742	58.32593	40.86070	33.82644
TestImg3	**16.83733**	25.82195	29.24633	35.53923	26.52064	44.85693	21.50740	20.89448
TestImg4	**16.57803**	26.45110	31.64320	43.47681	18.68615	47.58669	24.56774	28.06270

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	42.58162	16.01919	27.02401	42.62543	89.59252	11.76635
TestImg2	59.50193	55.91969	**31.78153**	62.50870	91.13846	20.94066
TestImg3	39.86982	48.48490	32.36529	46.31817	90.00533	17.35385
TestImg4	46.15295	38.91951	36.72036	44.24773	93.80261	11.13506

TABLE XIX. THE RECORDED SCC SCORES FOR THE COMPARATIVES (HIGHEST SCORE GIVES BEST RESULT)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.94437	0.96385	0.94473	0.94454	0.94763	0.93273	0.96627	0.93963
TestImg2	0.89702	0.93781	0.92440	0.92948	0.85067	0.91688	0.94332	0.91973
TestImg3	0.90259	0.92460	0.95753	0.90317	0.89467	0.96179	0.96355	0.94373
TestImg4	0.93555	0.94975	0.93647	0.90874	0.92014	0.94416	0.96413	0.92855

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.87421	0.90175	**0.95252**	0.90587	0.03840	0.92522
TestImg2	0.89164	0.89831	**0.95326**	0.87015	0.02420	0.91458
TestImg3	0.87771	0.87153	**0.95395**	0.90131	0.01632	0.93460
TestImg4	0.82583	0.89521	**0.97046**	0.89288	-0.02249	0.94405

TABLE XX. THE RECORDED CVSI SCORES FOR THE COMPARATIVES

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.06229	0.01437	0.03058	0.03095	0.04164	0.03950	0.01836	0.04131
TestImg2	0.12598	0.03197	0.04038	0.04257	0.13080	0.05623	0.02703	0.03347
TestImg3	0.11777	0.04921	0.02574	0.04486	0.04792	0.02469	0.02188	0.02985
TestImg4	0.08689	0.03801	0.05750	0.07298	0.07639	0.07271	0.02013	0.03138

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.04705	0.10903	0.05969	0.03166	**0.13403**	0.09452
TestImg2	0.05480	0.09028	0.03139	0.06614	**0.15729**	0.07505
TestImg3	0.04386	0.05375	0.03633	0.04424	**0.14413**	0.04457
TestImg4	0.09107	0.09174	0.03113	0.08400	**0.15153**	0.06126

TABLE XXI. THE RECORDED MCSD SCORES FOR THE COMPARATIVES SCORE:DEGREE OF DISTORTION-LEAST GIVES BEST RESULT

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.00004	0.00002	0.00002	0.00003	**0.00001**	0.00008	0.00002	0.00003
TestImg2	0.00006	**0.00001**	0.00004	0.00006	0.00009	0.00003	0.00008	0.00002
TestImg3	0.00002	**0.00001**	0.00002	0.00002	0.00002	0.00003	0.00004	0.00003
TestImg4	0.00003	0.00001	0.00002	0.00003	0.00002	0.00007	0.00001	0.00001

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.00002	0.00004	0.00002	0.00003	0.00051	0.00005
TestImg2	0.00003	0.00003	0.00014	0.00002	0.00054	0.00011
TestImg3	0.00002	0.00002	0.00002	0.00007	0.00057	**0.00001**
TestImg4	0.00002	0.00002	0.00001	0.00006	0.00057	0.00002

TABLE XXII. THE RECORDED NQM SCORES FOR THE COMPARATIVES (LEAST SCORE GIVES THE BEST) (REFERENCE AND DENOISE)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	5.72822	10.90554	9.18275	13.25518	12.31878	5.95895	8.26158	6.81954
TestImg2	5.21723	14.94767	7.43430	5.31561	5.02503	11.64804	4.12727	3.28481
TestImg3	4.50081	8.47573	13.19743	6.02085	4.20663	1.85097	14.00744	10.91840
TestImg4	4.78090	12.59009	9.60334	7.75522	4.82721	0.69335	12.12942	9.03722

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	10.05271	5.74568	10.79705	10.65045	-4.19388	**4.89679**
TestImg2	8.25344	9.38074	1.68181	11.24193	-2.71410	**3.14435**
TestImg3	**3.55751**	1.97678	11.71896	1.03840	-12.47818	9.22515
TestImg4	**4.68356**	5.96796	11.60276	1.77181	-8.87400	6.73111

TABLE XXIII. THE RECORDED GMSM SCORES FOR THE COMPARATIVES (HIGHER THE SCORE GIVES GOOD QUALITY

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.7755	0.8126	0.8048	0.7657	0.8248	0.6780	**0.8284**	0.8050
TestImg2	0.7179	0.6582	0.7187	0.7539	0.6794	0.6614	**0.7597**	0.7455
TestImg3	0.8649	0.8753	0.8897	0.8404	0.8837	0.7385	**0.9106**	0.9069
TestImg4	0.8275	0.8406	0.8262	0.7037	0.8458	0.5951	**0.8599**	0.8377

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.7182	0.7511	0.8094	0.7114	0.3007	0.7517
TestImg2	0.6626	0.6718	0.6316	0.6228	0.2666	0.7165
TestImg3	0.8213	0.6868	0.8698	0.7111	0.3000	0.8970
TestImg4	0.6381	0.7080	0.7877	0.6315	0.3038	0.8507

TABLE XXIV. THE RECORDED GMSD SCORES FOR THE COMPARATIVES

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.8806	0.9015	0.8971	0.8751	0.9082	0.8234	**0.9101**	0.8972
TestImg2	0.8473	0.8113	0.8477	0.8683	0.8242	0.8132	**0.8716**	0.8634
TestImg3	0.9300	0.9356	0.9432	0.9167	0.9400	0.8594	**0.9542**	0.9523
TestImg4	0.9097	0.9169	0.9089	0.8389	0.9197	0.7714	**0.9273**	0.9153

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.8475	0.8666	0.8997	0.8434	0.5483	0.8670
TestImg2	0.8140	0.8197	0.7947	0.7892	0.5163	0.8465
TestImg3	0.9062	0.8287	0.9327	0.8433	0.5478	0.9471
TestImg4	0.7988	0.8414	0.8875	0.7946	0.5511	0.9223

TABLE XXV. THE RECORDED AG SCORES FOR THE COMPARATIVES (HIGHER THE SCORE GIVES GOOD QUALITY)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	0.10996	0.15797	0.15792	0.21128	0.14827	0.33065	0.13524	0.11716
TestImg2	0.13219	0.22952	0.14650	0.09817	0.03967	0.20956	0.07968	0.06527
TestImg3	0.06604	0.11923	0.11339	0.14094	0.11490	0.20601	0.09822	0.09938
TestImg4	0.07574	0.11887	0.13126	0.20760	0.15153	0.30025	0.11576	0.12324

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.24745	0.10121	0.02154	0.30972	0.78260	0.08131
TestImg2	0.19189	0.18526	0.02162	0.27452	1.08063	0.04200
TestImg3	0.14384	0.18717	0.11866	0.22959	0.85070	0.07664
TestImg4	0.24331	0.17288	0.17302	0.28082	0.94841	0.07655

TABLE XXVI. THE RECORDED CONTRAST SCORES FOR THE COMPARATIVES (HIGHER THE SCORE GIVES GOOD QUALITY)

Image	IT2FB	RBMP	FBEM	AIEM	FEAE	LIME	BIMEF	SRIE
TestImg1	**0.07470**	0.04234	0.02362	0.03674	0.02989	0.05101	0.02811	0.01785
TestImg2	**0.09490**	0.05139	0.02453	0.01756	0.01028	0.03579	0.01622	0.01108
TestImg3	**0.09416**	0.06499	0.02966	0.04412	0.04521	0.05306	0.03742	0.02774
TestImg4	**0.07958**	0.04960	0.02541	0.04981	0.04052	0.05981	0.03320	0.02438

Image	NPEA	BPHE	CAVIEHE	MSRA	MSRCR	LNET
TestImg1	0.04230	0.01353	0.01243	0.06943	0.04037	0.01205
TestImg2	0.03262	0.02960	0.01678	0.06900	0.03820	0.00734
TestImg3	0.04213	0.0268	0.0248	0.08262	0.05564	0.02049
TestImg4	0.05392	0.02023	0.02123	0.08055	0.04698	0.01408

TABLE XXVII. THE RECORDED IE SCORES FOR THE COMPARATIVES (HIGHER THE SCORE GIVES GOOD QUALITY)

Image	**IT2FB**	**RBMP**	**FBEM**	**AIEM**	**FEAE**	**LIME**	**BIMEF**	**SRIE**
TestImg1	15	**15.87423**	15.66459	15.75404	15.54836	15.63918	15.80531	15.64746
TestImg2	**15.98439**	15.80274	15.53808	15.53808	15.30713	15.57657	15.74564	15.68848
TestImg3	**15.99621**	15.97231	15.89987	15.93132	15.88706	15.89043	15.94712	15.89795
TestImg4	**15.99558**	15.97075	15.79935	15.92798	15.88523	15.89030	15.94342	15.89896

Image	**NPEA**	**BPHE**	**CAVIEHE**	**MSRA**	**MSRCR**	**LNET**
TestImg1	15.73456	15.49749	15.37739	15.83352	-14.71573	-15.56715
TestImg2	15.72043	15.52732	15.42732	15.82062	-14.49740	-15.57494
TestImg3	15.91559	15.64596	15.54596	15.93316	-14.87595	-15.86741
TestImg4	15.92207	15.57102	15.43202	15.94793	-14.50907	-15.85952

TABLE XXVIII. RUN TIME FOR ALL ALGORITHMS

Images	**IT2FS**	**RBMP**	**FBEM**	**AIEM**	**FEAE**	**LIME**	**BIMEF**	**SRIE**
TestImg1	0.345445	0.379292	6.800890	7.571706	3.968177	0.163928	**0.256611**	17.412172
TestImg2	0.362200	0.3528	14.746129	6.500533	1.919185	0.148863	**0.233173**	12.652796
TestImg3	0.199488	**0.196766**	23.093706	6.120637	1.797364	0.180001	0.223248	6.430840
TestImg4	0.203637	**0.164310**	13.216258	7.291177	1.810248	0.143545	0.250914	9.901286

Image	**NPEA**	**BPHE**	**CAVIEHE**	**MSRA**	**MSRCR**	**LNET**
TestImg1	9.307077	0.262238	0.912000	1.343199	2.893714	8.809306
TestImg2	9.362168	0.194414	0.478139	1.264595	2.800885	5.862136
TestImg3	9.325342	0.221893	0.732831	1.166960	2.739701	6.661681
TestImg4	10.921751	0.289308	1.464919	1.209983	2.707332	7.045211

TABLE XXIX. RUN TIME EVALUATION OF ALL ALGORITHMS

Sl.No	**Algorithm**	**Run Time (sec) 400x600**	**Run Time (sec) 701x1052**	**Run Time (sec) 3264x2175**
1	IT2FB	0.350821	0.641391	6.538643
2.	RBMA	0.318945	0.7460	4.922583
3.	FBEM	12.994208	18.771755	92.741121
4.	AIEM	4.134789	6.267442	10.84552
5.	FEAE	1.953480	3.367680	12.701537
6.	LIME	**0.146787**	**0.529567**	**4.343078**
7.	BIMEF	0.215428	0.582480	5.241805
8.	SRIE	17.259832	25.738757	695.323839
9.	NPEA	9.267901	28.419136	427.278078
10.	BPHE	0.304741	0.598509	5.122004
11.	CAVIEHE	0.974524	2.187483	35.554106
12.	MSRA	1.354881	2.706997	17.385311
13	MSRCR	2.815200	8.631183	150.519389
14	LNET	7.112936	15.468000	45.789045

VI. Conclusion and Future Work

Low Light image enhancement formulas are more helpful for various vision applications. It can be found that many of the existing scientific study have neglected a lot of issues; i.e. no technique is precise for different circumstances. The review has demonstrated the undeniable fact that shown methods have neglected the methods to reduce the noise concern which can be shown within the output images of the image enhancement algorithms. The issue of uneven and also over illumination may also be an issue for enhancement methods. So it will be expected to change the prevailing methods in this manner that altered strategy may continue steadily to function better. In near future, to eliminate the issues of present research a different integrated algorithm is going to be proposed.

Table XXX shows the performance evaluation of all Algorithms. In this paper fourteen Image enhancement algorithms were compared and finally LNET gives the best output quality image and LIME method gives the least run time.

TABLE XXX. Performance Evaluation of All Algorithms

Sl.No	**QM**	**TestImg1**	**TestImg2**	**TestImg3**	**TestImg4**
1	MSE	LNET	CAVIEHE	LNET	LNET
2.	RMSE	LNET	CAVIEHE	LNET	LNET
3.	PSNR	LNET	CAVIEHE	LNET	LNET
4.	WPSNR	LNET	CAVIEHE	LNET	LNET
5.	SSIM	MSRA	RBMP	BIMEF	RBMP
6.	CW-SSIM	MSRA	RBMP	BIMEF	RBMP
7.	VIF	MSRA	MSRA	MSRA	MSRA
8.	UQI	MSRA	BIMEF	MSRA	RBMB
9.	IEF	MSRA	RBMP	BIMEF	RBMP
10.	IMMSE	LNET	CAVIEHE	LNET	LNET
11.	MSSIM	LNET	CAVIEHE	LNET	LNET
12.	MAE	LNET	CAVIEHE	LNET	LNET
13	IQI	RBMP	RBMP	BIMEF	FEAE
14	FSIM	RBMP	CAVIEHE	BIMEF	BIMEF
15	EME	IT2FB	IT2FB	IT2FB	IT2FB
16	BRISQUE	IT2FB	CAVIEHE	IT2FB	IT2FB
17	NIQE	FEAE	FEAE	FEAE	FEAE
18	PIQE	FBEM	CAVIEHE	IT2FB	IT2FB
19	SCC	CAVIEHE	CAVIEHE	CAVIEHE	CAVIEHE
20	CVSI	MSRCR	MSRCR	MSRCR	MSRCR
21	MCSD	FEAE	RBMP	RBMP	LNET
22	NQM	LNET	LNET	NPEA	NPEA
23	GMSM	BIMEF	BIMEF	BIMEF	BIMEF
24	GMSD	BIMEF	BIMEF	BIMEF	BIMEF
25	AG	MSRCR	MSRCR	MSRCR	MSRCR
26	C	IT2FB	IT2FB	IT2FB	IT2FB
27	IE	RBMP	IT2FB	IT2FB	IT2FB

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