



Video Enhancement using Histogram Equalization with JND Model

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Abstract: The paper presents degraded Video contrast enhancement. These videos are taken by camera phones because of the improper illumination or limitation of the capturing devices. The existing enhancement approach may either flop to produce good and distortionless Videos. They do not enhance every area of interest properly, especially in face regions. The paper proposes histogram equalization method (HE) manipulating the noticeable in difference model of the visual system represented as in JND-HE. This will be performed for generic frame that is contrast enhancement. In addition, the said method, JND-HE method is clubbed with the exposer correctivemethod represented by JND-HE-EC for video enhancement of face region. The EC method is to adjust the illumination of the video frame in the face region and obtain suitable illumination in the background. The demonstration result shows that generic videos and faces shall produce pleasant videos other than existing techniques.

Keywords: Contrast enhancement, Histogram equalization, low light video, Human Visual perception, exposer correction.

I. INTRODUCTION

In the present scenario, digital cameras and cellphone cameras have been used generally, the images taken by the people seem to be less satisfactory pictures, the reason may be dim light while capturing or the conditions like bad weather or foggy atmosphere have caused hindrance. Few defects that appear in the real life images include (1) dark pictures because of less illumination (2) the scene would be with the background that is underexposed and the subjects are overexposed (3) the effect of the background light over the dark subject (4) an image in pole contrast owing to the dew and mist. A various methods or picture upgrading approach were developed to solve these problems. The existing methods of video enhancement can be categorized into two main approaches, namely structural domain and transformed domain. Structural domain is associated to the image frame and manipulation of pixels in a frame. In transformed domain processing methods are based on altering the structural frequency spectrum in the image as obtained by image transform [1-2]. Histogram equalization [3] is a structural domain method known generally which is used for contrast image upliftment. HE method is generally used for image contrast improvement. It improves contrast and the goal of histogram equalization is to assign a uniform distribution of intensities. This method will distribute the pixel values that arise regularly and squeeze those values that arise regularly to obtain an image frame of greater contrast. Anyhow HE method has few drawbacks [4].

It is indiscriminate and may increase the contrast of background noise while decreasing the usable image region. Many improved HE methods have been developed to obtain an improved pixel values [5-6]. The HE methods are universal like that of bi-HE and dualistic sub image. HE initially device dependent parameter needs to determine in advance.

Transform based method [7-8] commonly produce an improved frame for either underexposed frames or overexposed frames with the help of choosing proper parameters but these approaches do not produce proper contrast on both areas. The enhancement technique depends on pixels. Power law transformation of every pixel based on the principles of its adjoining picture elements. Anyhow it would be obtained hallow effects in the edges. In paper [9] contrast correction technique presented by Schettini that is dependent on a local and picture based on power-law transformation along with specification calculated naturally through frame statistics, improves over exposed and underexposed areas in concert. The hallow effects can be reduced by the bilateral filter that is used for power-law transformation. At last a contrast improvement model comprising of saturation preserving, clipping and stretching are modified to greater the contrast although under exposed and over exposed area can be enhanced well, the contrast of the entire frame is also reduced [3].

II. PROPOSED VIDEO ENHANCEMENT APPROACH

This research put forth a modern technique that is proposed for improving the degraded videos taken from bad weather situations. Here we are performing a frame wise analysis for low quality videos divides the histogram to dual parts and later applies HE on every sub-histogram. The above said methods preserve the actual light effects of a few regions, which are crucial for electronics product services, but they may produce undesirable artifacts for a few image frames. The local HE method is known as adaptive histogram equalization [6]. Initially, video frames are bisected into numerous parts, and later HE technique is applied to every part. At the end, the improved video frame parts are combined using bilinear interpolation. The disadvantage of HE based methods are may be improved excessively in few areas. In transform based techniques, a transformation function is used to map input luminous values into an output one. Anyhow few

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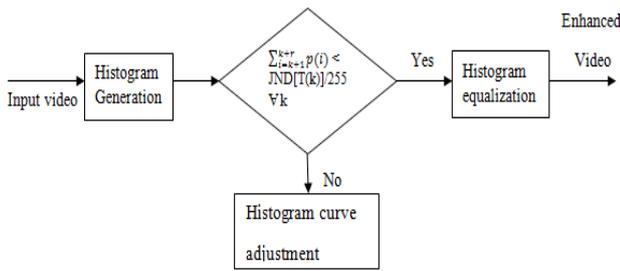


Figure1. Blok diagram of Histogram equalization with JND Model.

A. Histogram equalization

One among the well-known contrast enhancement techniques is histogram equalization [3]. Histogram equalization is the method by which the dynamic range of the histogram of an image is increased. It improves degraded the image and HE is to obtain uniform histogram. Histogram Equalization (HE) increases the contrast of each video frame using a non-linear mapping function. Generally, for color videos, HE is applied to the histogram of the intensity of the pixel is 'Y'. Intensity value can be extracted from the color components of the pixels of each video frame using the given equation:

$$Y(u, v) = 0.299.R(u, v) + 0.587.G(u, v) + 0.114.B(u, v) \tag{1}$$

Here R (u, v), G (u, v) and B (u, v) represent the RGB colour components of a pixel located at (u, v) regions. Consider variable l denotes intensity value between 0 to 255. Then the probability occurrence of the intensity value l is p(l) and is given by:

$$P(l) = \frac{n_l}{N} \tag{2}$$

Here N represents the sum of pixels in the video frame and n_l is the sum of pixels with intensity value l. The transformation law T that maps an intensity value l converted for reconstruction intensity values are as follows:

$$s = T(l) = 255 \sum_{i=0}^l p(i) = 255 \sum_{i=0}^l \frac{n_i}{N} \tag{3}$$

Enhanced values of l and l + r can be expressed as T(l) and T(l + r). So from Eq. (3), the difference between T(l) and T(l + r) is given as:

$$d_E(l, r) = T(l+r) - T(l) = 255 \times \sum_{i=l+1}^{l+r} p(i) = 255 \times \sum_{i=l+1}^{l+r} \frac{n_i}{N} \tag{4}$$

Thus, the space d_E(l, r) among the improved values T(l) and T(l+r) is directly corresponding to the additional probability between l + 1 and l + r respectively. If few p(i), for i ∈ {l+1...l+r}, is unusually greater in values, a larger gap d_E(l, r) shall be produced. False contours would appear in the improved frame as a result. Particularly, for a degraded video frame in which many pixels have least intensity values, Histogram Equalisation with contrast stretching result would excessively improve the lower intensity region and push the medium-intensity values toward the larger parts. Thus the noises hidden in the dark areas would be increased in size and the entire image illustrates a washed-out appearance as an overall outcome. So that the histogram of a video frame has great peaks at some particular values or concentrates in low levels, this fails to produce pleasingly improved videos. The problems can be minimised by the JND model of the Human Visual System would be combined with HE to obtain better-improved video frames.

B. JND-HE Approach

Normally, a video enrichment technique should not simply generate high-contrast video frames, but also has to avoid any noticeable distortion. So that we proposed just noticeable difference model with histogram equalization (JND-HE) method, an estimation function is used, this would be placed by the JND model of the human visual system (HVS), to measure if HE would present some noticeable disturbance in the improved videos. JND model is an assessment for differentiating the illumination variation noticed through the HVS. An alternative JND provides a high variation in the intensity values that could be noticed in the visual system. This article presents, the JND system developed by Chou and Li [10] would be employed to find the estimation work. The perception work for finding the visual requirement of the JND model can be defined as to the formula given below:

$$JND(l) = \begin{cases} T_0 \left[1 - \left(\frac{l}{127} \right)^{0.5} \right] + 3, & l \leq 127 \\ \gamma(l - 127) + 3, & \text{otherwise} \end{cases} \tag{5}$$

Here l is the intensity value in between (0, 255) and the guideline T₀ and γ rely upon the viewing distance among a tester and the monitor. T₀ represents the visibility threshold when the background grey level is 0, and γ represents the slope of the line that models the JND visibility threshold function at upper background intensity. From this analysis, T₀ and γ are set to 17 and 3/128, placed on the abstract examinations. It should be noted that the visual requirement calculated in the analysis, recognizes only to the result of typical background intensity, without considering structural masking. Generally, by considering both background intensity and structural masking are taken, the calculated visibility threshold will be greater than that represented. Though, it is not possible to make use of the structural masking idea in the HE method and account that HE maps pixels of the equivalent value into similar productive values without taking their structural reference. So that integrates the JND model with the HE directly, the clarity requirement can be assessed through typical background intensity approach. In equation (4), the distinctness d_E(l, r) among the improved principles T(l) and T(l + r) of two adjacent principles l and l + r denotes the increased adverse principle obtained in HE techniques. If the distinctness between l and l + r is lesser than the JND requirement principle calculated on l [that is, r < JND(l)], l and l + r cannot be differentiated by the visual system. The prevention of high adverse stretching, d_E(l, r) should be lesser than the JND requirement principle assessed on T(l), for 0 ≤ l ≤ 255. The motive would make sure, each adjacent intensity principles, the respective increased adverse principle would be not distinguished by human eyes. Thus, estimation work can be represented as below:

$$d_E(l, r) < JND[T(l)] \forall l, 0 \leq l \leq 255, 1 \leq r \leq r_{max} \tag{6}$$

Or alternatively

$$\sum_{i=l+1}^{l+r} p(i) < \frac{JND[T(l)]}{255} \forall l, 0 \leq l \leq 255, 1 \leq r \leq r_{max} \tag{7}$$

Computed by using Eq. (4), where r_{max} is the least visibility threshold estimated for all intensity values; that is,

$$r_{max} = \min_{0 \leq l \leq 255} JND(l) \tag{8}$$



For in, $r_{max} = 3$, computed using Eq. (5). The JND estimation work could assist to find if soft areas in the improved video would display any observed noise or not. This presentation presents, the evaluation function can be used to find if HE could be directly occupied for video enrichment. When the JND estimation function is satisfied for all intensity value l , HE technique would be used to acquire an improved video. Otherwise, the improved output will surely show a few observable artifacts. Thus, an adjustment of the histogram curve would be designed to produce proper histogram curve before NND- Histogram Equalization approach.

C. Histogram Curve Adjustment

Generally, the JND estimation work would be fulfilled if the high principles in the histogram are removed. Based on the concept, the greatest heights in the histogram can be removed and systematically redistributed the respective dismissed principles among every histogram constituents. This change would enlarge the highly concentrated probabilities at few histogram constituents above the other ones along least probabilities. The process for histogram curve modification contains in three different stages. Those are in sorting, in shifting, and in redistribution.

i. Sorting

The occurrence probability of luminance value l (0, 255) is denoted as $p(l)$. Considering the sum of histogram elements as 'L', and the numerals of a cycle as 'n' in the histogram curve adjustment procedure. At first value of 'n' is taken as 1. Initially, in the descending order, the histogram is sorted. Consider index 'i' represent the index of the i^{th} sorted element. Hence, indices with the highest and the least probability values are represented as an index (1) and index (L) respectively.

ii. Shifting

Initially, 'n' value is taken as zero. If $n = 2$, index (1) and index (2) values are taken as zero. i.e. $p[index(1)] = p[index(2)] = 0$. Then, by 'n' principles each sorted histogram element is shifted. i.e., last n principles are reset to zero and each sorted component value would be changed by using the next n^{th} sorted component value.

$$p_n^{shift}[index(i)] = \begin{cases} p[index(i+n)], & 1 \leq i \leq L-n \\ 0, & otherwise \end{cases} \quad (9)$$

iii. Redistribution

As in the new shifted histogram few histogram component values are evaluated, the aggregate total of the rest of the component values will be less than one. To stay away from this sort of issue, consistently redistribute the overall evaluated to all histogram components as given below,

$$p_n^{redis}(i) = p_n^{shift}(i) + p_{avg}^{redis}, \quad 1 \leq i \leq L, \quad (10)$$

Here p_{avg}^{redis} represents the mean of the removed component principles given by:

$$p_{avg}^{redis} = \frac{1}{L} \sum_{i=1}^n p[index(i)] \quad (11)$$

So that moved and redistributed histogram seems to be smoother than the previous one. Finish the histogram adjustment process and the HE mapping process as in equation (3), if the JND assessment work is fulfilled as in Eq. (7), to obtain the enhanced video. If not, setting $n = n+1$ with the moving and redistribution activity again and again until a better histogram is achieved. The smoothed histogram is obtained if the value of the cycle number 'n' is high. Since if 'n' has high value, many histogram peaks are

removed. Finally, a better histogram can be achieved which fulfill the JND assessment function after various cycles.

D. Over adjustment Prevention

It is possible to get a better-enhanced video by repeating the histogram adjustment procedure again and again. And hence the resulted video shows no more visible distortions. But to prevent the over adjustment fact, a new function called interpolation histogram can be designed with the help of weighted mean of the moved histograms resulted by using the present cycle and the past cycle as follows:

$$p_n^{int}[index(i)] = xp_n^{shift}[index(i)] + (1 - x)p_{n-1}^{shift}[index(i)], \quad 1 \leq i \leq L, \quad (12)$$

Here $0 \leq x \leq 1$. In this concept, $p\{index(i)\} = p\{index(i)\}$, $1 \leq i \leq L$. It is clear that the total aggregate of each segment values of the interpolation histogram isn't equivalent to one. In this way, the mean difference can be consistently joined to every interpolation histogram particles to obtain the qualified interpolation histogram constituents:

$$p_n^{cint}[index(i)] = p_n^{int}[index(i)] + p_{avg}^{int}, \quad 1 \leq i \leq L \quad (13)$$

Where p_{avg}^{int} is the typical difference and is given by $p_{avg}^{int} = \frac{1}{L} \{1 - \sum_{i=1}^n p[index(i)]\}$. (14)

E. Reconstruction of Color

Reconstruction of the R, G, and B color values are calculated as follows:

$$R^r(u, v) = \frac{1}{2} \left\{ \frac{Y_{JND-HE}(u,v)}{Y(u,v)} [R(u, v) + Y(u, v)] + R(u, v) - Y(u, v) \right\} \quad (15)$$

$$G^r(u, v) = \frac{1}{2} \left\{ \frac{Y_{JND-HE}(u,v)}{Y(u,v)} [G(u, v) + Y(u, v)] + G(u, v) - Y(u, v) \right\} \quad (16)$$

$$B^r(x, y) = \frac{1}{2} \left\{ \frac{Y_{JND-HE}(u,v)}{Y(u,v)} [B(u, v) + Y(u, v)] + B(u, v) - Y(u, v) \right\} \quad (17)$$

III. JND-HE-EC ENHANCEMENT APPROACH

In day to day life videos, the appearance areas are generally the vital areas of hominal observation. Existing video enhancement methods fail to generate well-enhanced face regions in proper lighting condition. Because of this, the face region shows a washed-out look or abnormal look. Therefore, a new technique which enhances face regions in the video is designed by combining JND-HE technique with the EC technique, i.e, JND-HE-EC, to get enhancement at the same time both in the face and nonface regions. By using the EC method an enhanced video Frame, Y_{EC} is obtained with the help of the average luminance value of each identified face skin pixels. In the meantime, one more enhanced video frame, Y_{JND-HE} is obtained by using JND-HE approach [11]. At last, to combine Y_{EC} and Y_{JND-HE} together a distance map is calculated and finally enhanced video frame $Y_{JND-HE-EC}$ is obtained.



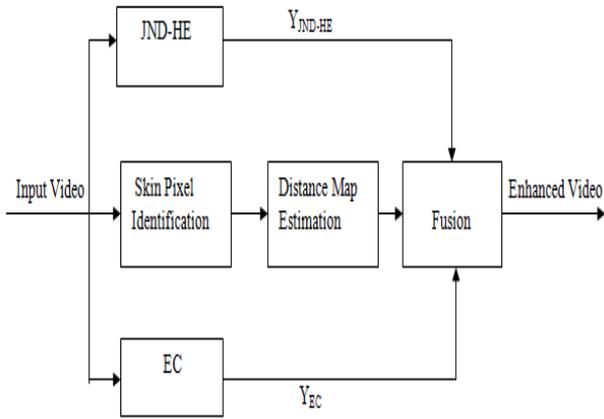


Figure 2. The block diagram of the proposed JND-HE-EC approach

A. Pixel Identification in a Face Skin

In the proposed methodology, the skin locus model is used to identify the face skin pixel, which is strong over several illumination sources or incompatible lighting surroundings. This module is derived by considering the (r, g) plane which can be acquired from R, G, and B color components of all pixel and is given as $r = R/(R+G+B)$ and $g = G/(R+G+B)$. Based on the numerical study on the color allocation of skin pixels, a couple of quadratic equations are defined as follows:

$$g_{upper}(r) = -1.3767r^2 + 1.0743r + 0.1452 \quad (18)$$

$$g_{lower}(r) = -0.7760r^2 + 0.5601r + 0.1766 \quad (19)$$

A skin pixel is marked if a pixel's r and g values fulfil the below condition:

$$0.2 < r < 0.6 \text{ and } g_{lower}(r) < g < g_{upper}(r) \text{ and } X > 0.0004 \quad (20)$$

Where $X = (r - 0.33)^2 + (g - 0.33)^2$ is provided to avoid from grouping snowy pixels as skin pixels. Therefore, a face skin plot, M_{fs} , is obtained to indicate the presence of face skin pixel. If it is a human appearance face skin pixel, then $[M_{fs}(u, v) = 1 \text{ else } M(u, v) = 0]$.

B. The Exposer Correction Method

In the EC method [1] illumination in each video frame is changed depending on the variation among the mean brightness of every referred pixel and the original brightness principles. The exposure level is adjusted by using the camera response curve. This response curve depends upon light value 'q' and pixel value 'I' is given by:

$$I = f(q) = \frac{255}{(1 + e^{-Aq})^c} \quad (21)$$

Here the shape of the curve can be controlled by the parameters A and C. In this way the actual light capacity q taken from a referred intensity principle using the reverted transformation of the camera resultant curve f. From this, the mean intensity all faces skin pels values are calculated as the referred intensity principle. Initially, the typical intensity Y_{avg} of detected face skin pels is calculated. To measure the light capacity distinctness between Y_{avg} and a predicted nominal intensity principle Y_{ideal} can be calculated from the simulated camera response curve f.

$$q_{offset} = f^{-1}(Y_{ideal}) - f^{-1}(Y_{avg}) \quad (22)$$

The intensity value of all pels can then be altered using the equation as follows:

$$Y_{EC}(u, v) = f\{f^{-1}[Y(u, v)] + q_{offset}\} \quad (23)$$

C. Distance Map Estimation

To combine together the independently improved video frames Y_{EC} and Y_{JND-HE} into one frame, a voluminous sum of the two frames are used. From this study, the weight by combining the two frames that is based on a distance path, represented as M_{dist} , which contains the path between each pixel and its nearest pixel of appearance skin. Therefore the distance path between each pixel (u, v) and its nearest skin pixel is given by

$$M_{dist}(u, v) = \min_{1 \leq i < S} M_{dist,i}(u, v) \quad (24)$$

To calculate the distance map, region algorithm is used to label the connected components of the face region. S represents the connected components [11].

D. Integration of the Independently Improved Video Frame

The combined intensity principle of the pixel placed at the region (u, v) and $Y_{JND-HE-EC}(u, v)$, is a weighted sum of $Y_{EC}(u, v)$ value. The $Y_{JND-HE}(u, v)$ value is given as follows:

$$Y_{JND-HE-EC}(u, v) = x(u, v)Y_{JND-HE}(u, v) + [1 - x(u, v)]Y_{EC}(u, v) \quad (25)$$

Here the voluminous principle w (u, v) is given by

$$x(u, v) = \left[\frac{M_{dist}(u, v)}{T+1} \right]^\beta \quad (26)$$

So that, if $M_{dist}(u, v)$ is smallest value, this improved results tends very closer to $Y_{EC}(u, v)$. Here parameter $\beta = 0.4$ so that this adjustment could path a narrow range of distance principles into a broader range of voluminous principles. Therefore, the border areas between face and non-face regions would become very acute and would not produce any nimbus effect [11].

IV. EXPERIMENTAL ANALYSIS

To verify the quantitative and qualitative analysis of the proposed method on synthetic videos, we perform experiments on an Intel Core i3 - 2.30GHz CPU and 4.00 GB RAM. We use different video data sets are downloaded from internet. We compare the performance of the proposed method with three types of video sets such as night videos, foggy videos and low light videos. Experimental results are tabulated in table 1. The performance parameters viz, Signal to noise ratio (SNR), peak signal to noise ratio (PSNR) and structure similarity index module (SSIM) values are calculated and tabulated in table 1. The original degraded videos and respective improved videos are as shown in figure 3.



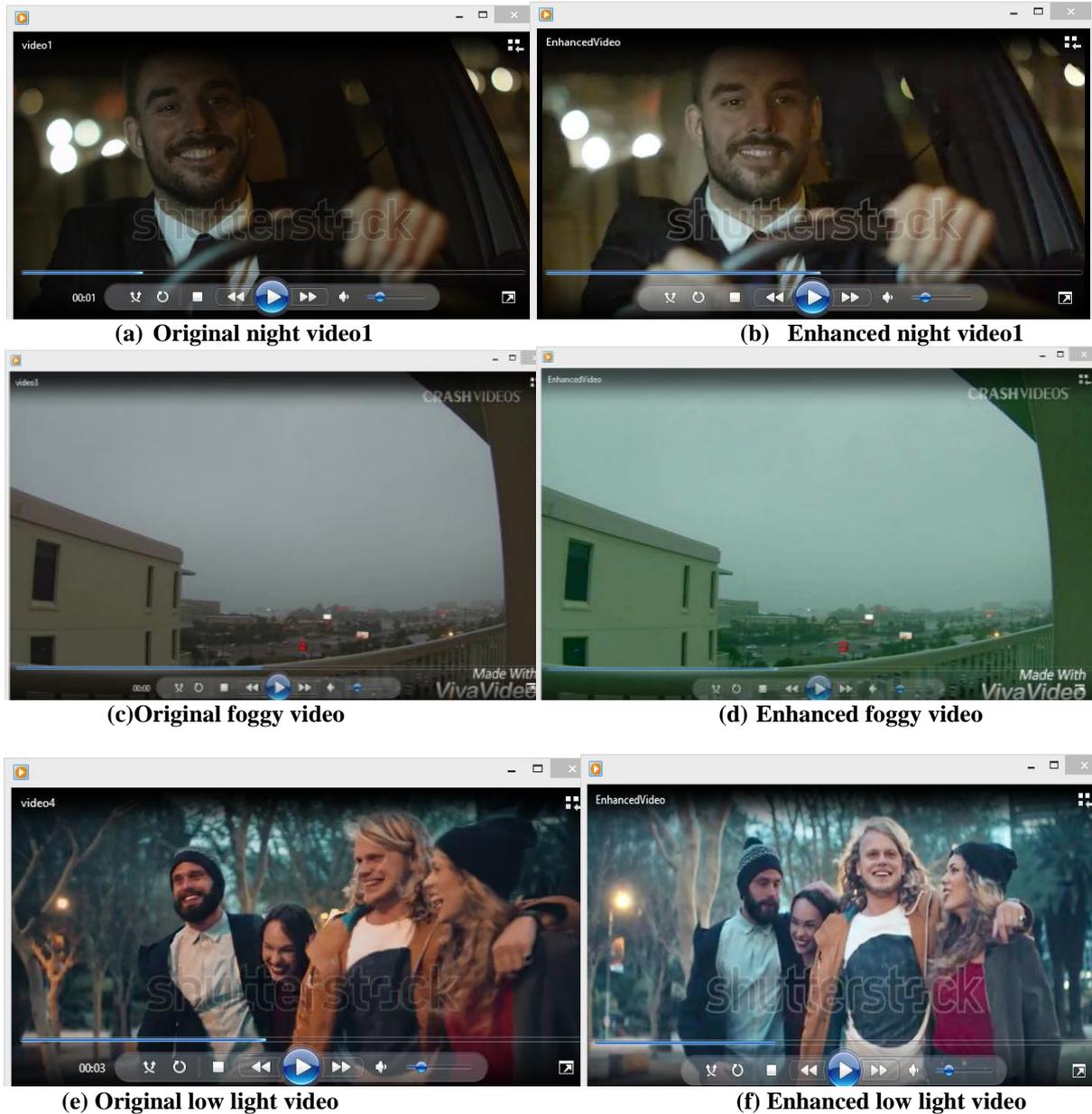


Figure 3. Enhanced Videos for different degraded Videos.

Table 1. Enhancement results for HE, JND_HE and JND-HE-EC methods with low light, night and foggy videos.

Videos	HE			JND-HE			JND-HE-EC		
	SNR	PSNR	SSIM	SNR	PSNR	SSIM	SNR	PSNR	SSIM
Low light 1	19.0092	21.7203	0.8183	27.9799	30.1546	0.9842	28.292	30.4849	0.9826
Low light 2	12.1341	14.867	0.6447	21.2985	26.131	0.9298	21.4925	26.3612	0.9353
Night 1	13.8369	16.5735	0.4651	22.6707	24.0096	0.8616	23.5378	24.9478	0.8891
Night 2	17.9765	20.7121	0.8406	20.9083	25.0306	0.9521	20.7594	24.8936	0.9988
Foggy1	12.8968	15.6274	0.7578	22.093	26.7796	0.7561	22.5744	27.303	0.7835
Foggy2	13.064	15.7988	0.7661	19.7811	25.1924	0.701	19.7711	25.2014	0.7142

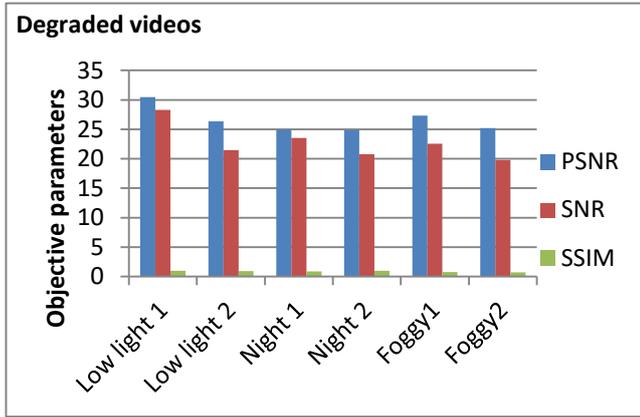


Figure 4. Graphical analysis of the proposed method with different degraded videos.

From the table 1, we can see that SNR, PSNR and SSIM values of JND-HE-EC are more compared to JND- HE and JND-HE are more compared to HE for low light videos and less for night time videos. These approaches are not suitable for rainy videos. The Graphical analysis is a method of analyzing the different input data from the tabular result by using graph. Figure 4 gives the graphical representation of the proposed approach for different types of videos. The objective parameters are plotted in three different types of videos. In this graphical analysis Low light1 video showing high PSNR and SNR value compared to other videos. Night 2 video has comparatively low PSNR value.

V. CONCLUSIONS

The experimental results show that the proposed method is suitable to achieve visually pleasant enhancement effects. The over-enhancement and saturation artifacts are avoided. Compared with Histogram equalization, JND-HE with Exposer correction shows well-enhanced contrast and little artifacts, while being natural looking. The proposed JND-HE-EC method is computationally simple and suitable for processor implementations. We tested the proposed JND-HE-EC concept on three different degraded videos and achieved satisfactory results. The results can be observed that in the JND-HE method relies on intensity principles of frame pels, not all color values. Furthermore this work will try on JND model with histogram equalization of the chrominance components in order to gain improvement in the degraded video frames.

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