Video Images Enhanced by using Sigmoid-Logarithm Transform

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Abstract. It is challenging to enhance contrast in video images, because of the irregularity of contrast and lightness in each frame, and the long processing time to improve. In this research, we suggested a new method relied on sigmoid logarithm transform (SLT). In the video image, the SLT used to enhance lighting component in the HSV color space. To know the ability of enhancement the proposed method was compared with other methods as histogram equalization (HE), Multi Scale Retex with Color Restoration (MSRCR) and non-traditional as Fusion at Weakly Illuminated Images (FWII), Depending on the average Natural Image Quality Evaluator (NIQE), Mean Squared Error for Hue (MSEH), Mean Squared Error for Saturation (MSES) for each video. By analyzing the results, it was found that the proposed algorithm has good results in the contrast and lightness enhancement.

1. Introduction

In everyday life, folks receive data from digital images, videos, music etc., and thus, the human cognition is capable of the dynamic process such as visual data. Many Persons have become interested in digital photography [1]. Improving color images aims to increase clarity, whether it is contrast or lighting. This is done by using many algorithms, which mostly depend on processing the color image in the spatial field and often using color conversions. [2,3,4,5]. Enhancement of digital images is an important topic in image processing. It also includes many applications in detection, classification [6,7]. Image enhancement has been applied in many scopes of engineering and science, like, pc vision, underwater setting, atmospheric sciences, astrophotography, biomedicine [8,9]. In [10] Shuhang Wang et.al are introduced a method to preserve the naturalness enhancement method for non-uniform illumination in the digital images. Generally, they discuss three major issues, Firstly, the lightness order error. Secondly they suggested brighten depending on a pass filter. Thirdly, the bilog mapping is done , from their results we reached to proposed method can achieve good enhancement in the non-uniform illumination image. In [11] Zhenqiang Ying, et.al are proposed an algorithm to enhance the digital images at low color information and light levels. First, they tend to investigate the link between two images with completely different exposures to get the associate degree correct camera response model. Then they restate the illumination estimation techniques to estimate the exposure quantitative relation map. Finally, they used the camera response model to regulate each component to its desired exposure per the calculable exposure quantitative relation map. From their results, They got a good improvement. Furthermore, this algorithm is general to different camera response model and different exposure transform estimation strategies. In [12] Xiankun Sun, et.al suggested an algorithm based on a camera response and weighted least squares strategies. In their method is adjusting every pixel according to the find the exposure transform and Retinex theory. In [5] Nabeel M. Mirza, et.al are suggested method to enhance low lightness images , in their research they using nonlinear filter power function algorithm, its includes three stages sequential: lightness enhancement, contrast enhancement, and color restoration of RGB components. Their algorithm was compared with many algorithms , By analyzing their results, it was found that his suggested method is much better than other methods by using subjective and objective evaluations. In this research the video image is enhanced depending on the SLT using HSV color space, and suggested method is compare the proposed method with several quality methods.
2. Suggested algorithm

In this research SLT is enhance the contrast and lightness in the video images, the maximum value of (RGB) has been taken among many values to represent the lighting according to (HSV) space, calculate the standard value in order to make the function limits between (0-1) by using[13] :

\[ V = g = \max(R, G, B) \tag{1} \]

then the lighting standard or gray component has been converted into nonlinear function by using a sigmoid function[14]

\[ V_t = \frac{1}{1 + \sqrt{\frac{1-g}{g}}} \tag{2} \]

In this mapping function, at low lightness levels of less than half, we notice an increased output lightness value. And at moderate lightness levels, the lightness values remain the same. Whereas at high lightness levels below one, the lightness output becomes lower values, this behavior is shown in Figure (1). The advantage of turning the illumination to the sigmoid makes good enhancement in irregular lighting areas.

![Figure 1](image)

Figure. 1. The relationship between light input and output value for Sigmoid transform, log-sigmoid and normalize log-sigmoid.

In figure (2,a,b) illustrated the role of the sigmoid function in converting the value of lightness. to improvement the contrast in the gray image by used logarithm, that is circulated by replacing normalized lightness component \( V_t \) by the value of logarithm transform \( v_{t\text{log}} \):

\[ V_{t\text{log}} = \log(vt + 1) \tag{3} \]

In this eq(3) . A value of 1 has been added so that the value remains positive and then stretch value by using:

\[ v_s = \frac{(v_{t\text{log}} - \min(v_{t\text{log}}))}{(\max(v_{t\text{log}}) - \min(v_{t\text{log}}))} \tag{4} \]

This makes the range of \( v_s \) between (0,1).

The process of improving contrast using a logarithm transform is shown the figure (2,d).
The enhancement Factor gave by:

\[ \alpha = \frac{V}{vs} \]  \hspace{1cm} (5)

And then the final enhancement proceeding getting by multiple enhancement Factor by color image In order to retrieve the colors by using:

\[
\begin{align*}
R_{en} & = \alpha R \\
G_{en} & = \alpha G \\
B_{en} & = \alpha B
\end{align*}
\]  \hspace{1cm} (6)

The process of improvement after the retrieval of colors is shown in Figure(2,e), the flowchart of this algorithm as shown in the figure (3), and the proposed algorithm can be shortened according to the following steps:

1. Input video \( c \).
2. Initialize \( n \) frame from \( c(x,y,i,n), i=r,g,b \).
3. Extract lightness component \( V(x,y,n) \) by using eq.(1).
4. Convert \( V(x,y,n) \) by using sigmoid transform to get \( V_t(x,y,n) \).
5. Apply logarithm transform on \( V_t(x,y,n) \) to get \( V_{t_{log}} \).
6. Using stretch to \( V_{t_{log}} \) to get \( vs\) \( (x,y,n) \).
7. Finding enactment factor \( \alpha \) by using \( V(x,y,n) / vs \) \( (x,y,n) \).
8. Finally the output video enhancement get from \( (\alpha \times c(x,y,i,n)) \).
3. Quality Assessment

There are many non-reference standards used to measure image quality without a reference as:

3.1 Natural Image Quality Evaluator (NIQE)

A non-reference quality meter used to measure the quality of color images. It measures the degree of contrast and the degree of clarity in these pictures without reference. Mathematically this scale is based on statistical features and multivariate Gaussian (MVG) model. These properties are calculated for each part of the image after dividing it into several regions and at a fixed size. Best patch sizes ranges is 32×32 to 160×160[14]. Thus, the quality of digital image, D, being the distance between the quality-aware feature model and the MVG model by using[15]:

$$D = \sqrt{((R_1 - R_2)^T \frac{S_1 + S_2}{2})^{-1}(R_1 - R_2)}$$

(7)

Where $R_1, R_2$ are the mean vectors and $S_1 + S_2$ covariance matrices of the natural MVG model and the MVG of the distorted image, respectively. The minimal value of NIQE gives a high quality.
3.2 Normalize Mean Squared Error

In this part, we calculate the MSE for hue (H) and saturation (S) using the following equations[3]:

\[
MSE_H = \frac{1}{M} \sum_{X=1}^{M} (H_E(X) - H_O(X))^2 \\
MSE_S = \frac{1}{M} \sum_{X=1}^{M} (S_E(X) - S_O(X))^2
\]

Where: \((H_o\) and \(S_o\)) represent hue and saturation for the original image with size \((M)\), and \((H_E\) and \(S_E\)) represent the hue and saturation for an enhanced image respectively.

4. Results and discussion

In this research, we suggested a new algorithm to improve the video clips. we took 4 video clips as shown in the figure (4) and demonstrated its characteristics in the table (1) each video contains almost (30) frames per second and all these clips are suffering from low lighting and contrast. Matlab Ra2018 has been used to improve those video clips, knowing that more than 914 images per video clip. Other methods have been used to improve video clips. like HE, MSRCR and FWII method in order to compare them with the SLT. First, four images (frames) were taken from the first video sequence (1, 305, 457 and 914) and enhancement as shown in the figures (5,6,7 & 8) explaining the distribution of histogram. Through the subjective assessment, we can find that the best enhancement of lighting and contrast was the proposed method SLT, followed by methods (FWII, HE), respectively, this behavior was reflected on the distribution of histogram, where widened and included levels of illumination medium and high, especially for the two methods SLT and FWII.

In the second stage, the results were analyzed for each video (four video segments were used) separately using the (NIQE , MSEH , MSES) scale, taking into account the time of execution, and according to the tables (2,3,4,5) which represent the (NIQE , MSEH , MSES) values as the average and the time of execution of the improved videos. Where we note that the lowest value of the (NIQE , MSEH , MSES) rate was for a method (SLT) followed by (FWII) and the highest values were for (MCRCR). The average implementation time was the shortest time for the proposed method followed by (HE,SLT) and the greatest implementation time was the method (MCRCR,FWII).
Figure 4. The Video clips used in this study.

Table (1): Specifications video.

| video | Duration (sec) | Bits Per Pixel | Frame Rate | Height | Video Format | Width |
|-------|----------------|----------------|------------|--------|--------------|-------|
| a.mp4 | 30.21          | 24             | 30.03      | 480    | RGB24        | 640   |
| b.mp4 | 30.34          | 24             | 30.07      | 480    | RGB24        | 640   |
| c.mp4 | 31.34          | 24             | 30.02      | 480    | RGB24        | 640   |
| d.mp4 | 30.45          | 24             | 30.02      | 480    | RGB24        | 640   |

Table (2): Implementation time for videos enhancement.

| Video | HE | MCRCR | FWII | SLT |
|-------|----|-------|------|-----|
| a     | 10.25 | 376.95 | 262.35 | 11.25 |
| b     | 8.64  | 266.50 | 251.28 | 9.62 |
| c     | 9.11  | 367.13 | 306.65 | 10.30 |
| d     | 8.82  | 261.41 | 294.53 | 10.13 |

Table (3): NIQE average for videos enhancement.

| Video | HE | MCRCR | FWII | SLT |
|-------|----|-------|------|-----|
| a     | 3.64 | 3.82  | 3.92 | 3.31 |
| b     | 3.91 | 3.62  | 4.03 | 3.77 |
| c     | 3.30 | 3.82  | 3.41 | 3.24 |
| d     | 3.88 | 3.89  | 4.18 | 3.73 |

Table (4): MSEH average for videos enhancement.

| Video | HE | MCRCR | FWII | SLT |
|-------|----|-------|------|-----|
| a     | 0.07 | 0.08  | 0.00 | 0.00 |
| b     | 0.12 | 0.06  | 0.00 | 0.00 |
| c     | 0.08 | 0.11  | 0.00 | 0.00 |
| d     | 0.07 | 0.08  | 0.00 | 0.00 |

Table (5): MSES average for videos enhancement.

| Video | HE | MCRCR | FWII | SLT |
|-------|----|-------|------|-----|
| a     | 0.03 | 0.09  | 0.00 | 0.00 |
| b     | 0.10 | 0.17  | 0.00 | 0.00 |
| c     | 0.02 | 0.07  | 0.00 | 0.00 |
| d     | 0.05 | 0.11  | 0.00 | 0.00 |
Figure 5: In (a) original image in a frame 1 in the first video that is enhancement by different algorithms (in b, c, d and e), and in (f, g, h, i, and j) the histogram distributions respectively.

Figure 6: In (a) original image in a frame 305 in the first video, that is enhancement by different algorithms (in b, c, d and e), and in (f, g, h, i, and j) the histogram distributions respectively.
Figure 7: In (a) original image in a frame 457 in the first video, that is enhancement by different algorithms (in b, c, d and e), and in (f, g, h, i, and j) the histogram distributions respectively.

Figure 8: In (a) original image in a frame 914 in the first video, that is enhancement by different algorithms (in b, c, d and e), and in (f, g, h, i, and j) the histogram distributions respectively.
5. Conclusion

By analyzing the results for enhancement of videos that have been improved using the proposed method (SLT) and methods, HE, MSRCR and FWII, we can conclude that the best results were for the proposed method, where it succeeded in the recovery of contrast and lightness, as well as had the minimum value of the rate of (NIQE, MSEH, MSES). One of the most important characteristics of the proposed method is its low implementation time compared to MSRCR and FWII enhancement methods.

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