A Review on Video Enhancement Methods and Algorithms for haze removal

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Abstract:

Video enhancement is a very challenge and complex research problem under low light conditions in video processing technology. There are numerous different techniques for enhancing the visual quality of videos/images with different weather conditions especially in day or night time such as foggy, haze,rainy and mist so on. The primary objective of this paper was to discuss a brief review of existing algorithms correlated to enhancement of Videos to removal of fog, haze in order to reduce the effect of fog / haze by using various defogging/ dehazing methods in addition it also gives some research insight with these algorithms.

I. Introduction

Video enhancement is a valuable and complex field of interest in video processing. The primary essential goal is to enhance the poor quality videos in pre-processing stage which indeed to a high resolution quality video as an output at post-processing stage. Video enhancement grapy an active attention in the modern era as field of area research with which scopes of research. The main objective of video enhancement is to enhance fine details which are hidden in a video and to provide "better transform" representation for future automated processing. It provides a conceptual analysis of background images/videos of typical characteristics without human visual inspection requirements. The Applications of digital video processing includes numerous applications in the field of Forensic, Surveillances, medicine and many more.

Haze, which mostly comes from the adversary weather condition, is an atmospheric phenomenon where particles obscure the clarity of scenes. Once taken by a camera, the image suffers from the haziness and makes difficult in some image-based applications. The purpose of haze removal or dehazing scheme is to remove the haziness and to restore visual quality of hazy images. Many haze removal schemes are based on the hazy image model. The challenge issues in modelling of scheme of dehazing with prior estimations such as transmission map and universal atmospheric light which plays a key role in dehazing. One of popular model-based dehazing schemes was proposed by He et al. Which is focused on dark channel prior (DCP) in [1]. With the help of the DCP, the estimation of the transmission map can be manipulated effectively. Based on the simplicity of haze removal on a single image with DCP has attracted many researchers in the specific domain. However, at least four problems can be found in the DCP scheme of [1]. First, artefacts may happen in sky regions. Second, halos may occur in large depth discontinuities. Third, color distortions including color oversaturation and hue distortion are often found in recovered images. Fourth, the soft matting algorithm used to refine the initial transmission map results in a high computational cost. To deal with these problems, lots of variations have been reported recently. Some of them are listed as follows.

II. Video Enhancement Technique

The main objective of the video enhancement is to enhance the fine details of video which include the hidden information and indeed to provide a better transform for future processing. Video enhancement algorithms are classified into two categories such as self enhancement and content –

based fusion enhancement [7]. The Self enhancement perform defogging algorithm frame by frame and do not take in to account of inter-frame correlation information. The content-based fusion enhancement algorithms can exploit the inter-frame correlation information. To preserve the color fidelity of the video can be achieved by fusing the image information of different or adjacent frames for better video enhancement.

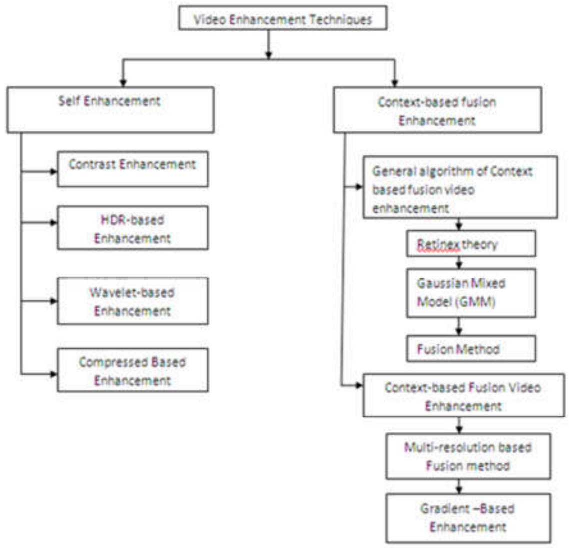

Figure2: Classification of Video Enhancement Techniques

Video defogging are classified into three categories such as frame –based defogging, fusion-based defogging, and universal component-based defogging. In frame-based defogging algorithm which performs on single image defogging algorithm on each frame of the video [4]. This method requires more time consuming to perform for on each frame which indeed results to a color and brightness mutation problem. Therefore frame –based video defogging is will not considered for future research. Fusion-based defogging algorithm which is based on the fusion of enhanced background and foreground images of each video frames. In these fusion-based defogging algorithms initially extract the background and foreground the each frame [10]. Then the single image defogging algorithm is used separately to enhance the background and foreground images. Finally video defogging can be realized by fusing the both enhanced background and foreground images. Frame difference method and CLAHE algorithms are used to extract the background and foreground of the video. The third category of video defogging algorithm is universal component-based defogging algorithm based on the estimation of universal component that can be used in all video frames. Some researcher consider the transmission of the background image of a video as universal component for video defogging which indeed suffers with a problem of edge degradation and halo artefacts [4]. The reason is that the universal transmission is estimated from the background and it is not the real transmission of the subsequence video frames. This problem was solved by Ma et al by combining guided image filtering and fog mask theory. Fog mask can be obtained by subtracting the enhanced image from the foggy image.

III. Video Enhancement Algorithm:

To improve the poor quality videos captures under various weather conditions proposed by the various researches with existing approaches to enhance the visual qualities of videos are discuss.

a. Dehazing algorithms: He etal [10] Proposed a techniques for enhancing an images/ videos in hazing conditions.

The Primary essential is to observe the inverted haze video/image is not much comparable mostly it seems similar.

Assume I be the single low-lighting input frame, which can be inverted using simple math= equation such as:

$$R^{c} = 255 - I_{c}(x) \text{ -----------1}$$

Where, the RGB color channel indicates c.

$I_c(x)$ indicates the intensity of the color channel at lowight video input I.

R^c is intensity of inverted image.

The hazy image obtained following the inversion is given by

$$R(x) = J(x)t(x) + A(1 - t(x)) \text{ -------------------------2}$$

where, A is an implying constant. R(x) is the size of the pixels the sensor detects. J(x) $J(x)$ is the size of events or scenes first.

$T(x)$

shows the amount of light illuminated from the objects. Evaluation of A and $t(x)$ in haze red uction techniques is extremely difficult.

$$T(x) = e^{-\beta d(x)} \text{ ------------------3}$$

Where β is a constant called atmospheric dispersion coefficient d(x), the path of the scene is.

$$t(x) = 1 - \omega \min_{c\in\{r,g,b\}} \left(\min_{C\in\Omega(x)} \left(\frac{R^C}{A^C} \right) \right) \text{ ----------------4}$$

Where ω is 0.8

$\Omega(x)$ is the x-Centered local block. By Equation (2) J(x) can be calculated with equation:

$$J(x) = \frac{R(x) - A}{t(x)} + A \text{ -------------------5}$$

Equation (5) under-enhances the results for low-light regions. So this equation is further algorithm modified to get smoother videos by introducing a $P(x)$ multiplier into (5).

$$P(x) = \begin{cases} 2t(x), 0 < t(x) < 0.5 \\ 1, 0.5 < t(x) < 1 \end{cases} \text{ ---------------------------6}$$

Then J(x), the recovered scene intensity is given by:

$$J(x) = \frac{R(x) - A}{P(x)t(x)} + A \text{ ------------------7}$$

if $t(x)$
<0.5 indicates that the corresponding pixel needs to be boosted. If $P(x)$ is small then $P(x)$ $t(x)$ becomes much smaller and thus increases RGB intensities.

a b

c d

Figure:1 a),c) Haze Image b) ,d)Dehaze Image

b. Video Fusion based on Gradient

The essential objective of an image fusion is to fuse different images of same video which can be more interpretation , human vision system ,perception. The main purpose of Image fusion which extracts the information for some of applications such as image segmentation, feature extraction and object recognition [8]. A numerous methods have been proposed for image fusion. A Pixel based approach to enhance for night time video was proposed by Stathaki et.al with a suitable equations:

$$F(x,y) = A_1(x,y)L_n(x,y) + A_2(x,y)L_{db}(x,y) \quad \text{----------------8}$$

where $F(x,y)$, $L_n(x,y)$, $L_{db}(x,y)$ are resultant illumination component of enhanced video frame, illumination of night time video frame, and day time video.
frame respectively. $A_1(x,y), A_2(x,y)$ are having values in the intervals [0, 1]. The enhancement of background regions have been obtained with this operation. A novel method was proposed to enhancement of the foreground regions by fusion of night time and day time videos which indeed results a pattern of ghost.

"Delighting" algorithm was given by Yamasaki et.al [8]. The approach can be explained with suitable mathematical expressions for enhancement of videos such as

$$L(x,y)=\frac{L_{db}(x,y)}{L_{nb}(x,y)}L_n(x,y) \quad \text{--------------------9}$$

where $L(x,y)$ indicates enhanced illumination component of enhanced video frame, $L_{nb}(x,y)$ represents illumination component of the enhanced night time background images, and L_n denotes illumination component of the night time background images. The main limitation of this method is the proportion of illumination components of background corresponds to day time video frames and of night time video frame should be less than 1 (one) then enhanced video frame will lose its static illumination.

Rasker et al. proposed an efficient method based on gradient fusion to enhance details hidden in various video frames by extracting illumination dependent properties. This technique become an efficient tool to develop surrealist create images and videos for artists [8]. This method fuses high illuminated background of the daytime with low illuminated foreground of night time video frame. This can be given by expression:

$$G(x,y)=N_i(x,y)*w_i(x,y)+D(x,y)*(1-w_i(x,y)) \quad \text{-----------10}$$

where G(x, y) indicates mixed gradient field, Ni denotes gradient of the night time video, D(x, y) is the gradient of daytime background and w_i denotes the importance of the image. This algorithm eliminates visual artefacts as ghosting, aliasing and haloing. The main limitations of this algorithm are computational complexity and color shifting problem as shown in Figure 3.

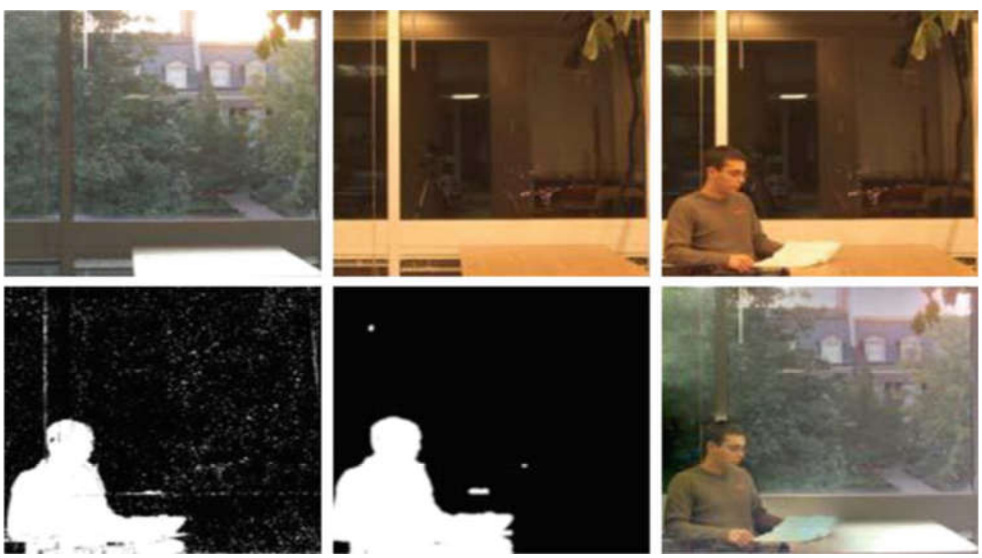

Figure. 3 First row images are high illuminated daytime image, a night time image, and with a foreground image with person.
Second row A simple monochromatic mask obtained by subtracting (removal) of reference from foreground, the resultant image obtained by gradient based fusion algorithm.

To overcome the limitations of above mentioned methods an efficient method based on gradient fusion enhancement was proposed by Yumbo et al [7]. In this technique, gradient of video frames corresponds to background of day time are fused with gradient corresponds to foreground of night time video frames. As a result of this a high quality video results. Sobel operators are used to compute gradient of the video frame in the horizontal and vertical directions. This algorithm includes mainly two conditions to obtain enhanced video frame: one is fusing of gradient corresponds to background of day time and the gradient corresponds to night time video frames along horizontal and vertical directions whish can be expressed as:

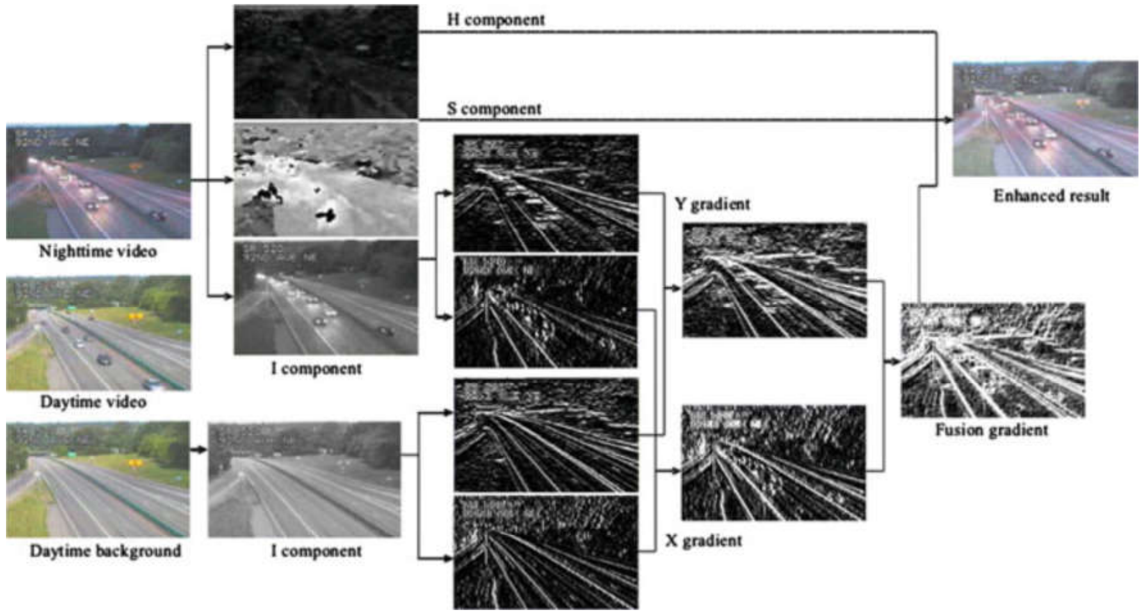

Fig. 4 Block diagram of gradient based fusion algorithm

$$G'_{x/y} = \begin{cases} G'_{x-db} + G'_{x-nvideo} \\ G'_{y-db} + G'_{y-nvideo} \end{cases} \text{---------------11}$$

where G'_x, G'_y represents gradient of enhanced night time video frame in the horizontal and vertical directions respectively. Second, is the fusing of gradient of G'_x, G'_y components.

$$G'_{enhancement} = \begin{cases} \xi.G'_x + (1-\xi).G'_y, G'_x \geq G'_y \\ (1-\xi).G'_x + \xi.G'_x, G'_x \leq G'_y \end{cases} \text{------------------12}$$

where $G'_{enhancement}$ t is resultant gradient enhanced video, ξ is the weighting factor combining both daytime and night time gradient as shown in Figures 4-6.

c. Dark Channel Prior

In order to remove fog from the images He et.al [10] proposed a novel defogging algorithms for single image which are for outdoor images.

He et al.[10] studied a large amount of clear outdoor images and found that in most areas of a clear outdoor image (except for the sky area and white area), there is a particular channel in which the pixels whose minimum value of zero. This is also called the dark channel prior theory [9]. The dark channel of an image can be evaluated by

$$J^{dark}(x) = \min_{c\in\{r,g,b\}}\left(\min_{y\in\Omega(x)}(J^c(y))\right) \text{---------13}$$

where Ω denotes a square window centred at pixel x, and r, g, and b are the red, green, and blue components, respectively. For a clear image except for the sky area and white area, $J^{dark}(x) \approx 0$. According to their findings, He et al. first proposed a dark channel prior (DCP) theory to estimate the transmission for image restoration by taking the following min operation in the local area on Eq.(3)

In terms of Eq.(12) and Eq.(13), coarse transmission t˜ is

$$\min_{c\in\{r,g,b\}}\left(\min_{y\in\Omega(x)}\left[\frac{I^c(y)}{A^c}\right]\right) = t(x)\min_{c\in\{r,g,b\}}\left[\frac{\min_{y\in\Omega(x)}(J^c(y))}{A^c}\right] + (1 - t(x)) \text{-------------------14}$$

$$\tilde{t} = 1 - \min_{c\in\{r,g,b\}}\left[\frac{\min_{y\in\Omega(x)}(J^c(y))}{A^c}\right] \text{-----------------------15}$$

Because of the use of the min filtering in the local area of the dark channel image, the dark channel image will have block artefacts (halo artefacts). This will also cause the restored image to have block artefacts.

The original DCP defogging algorithm used a soft matting operation to optimize the transmission to solve the block artefacts. In the original DCP algorithm, atmospheric light value A_∞ was also obtained via the DCP theory. He et al. first selected a local area in the dark channel image which had the top 0.1% brightest pixels, and then simply chose the pixel with the highest intensity of the original foggy image in the selected area as atmospheric light A_∞. Finally, restored image J was obtained using

$$J = \frac{I(x) - A_\infty}{\max(t(x), t_0)} + A_\infty \text{----------16}$$

where t denotes the optimized transmission via soft matting and t_0 is a small constant used to prevent the zero denominator.

The DCP based defogging algorithm can effectively eliminate the fog from any outdoor foggy image. Gibson et al. provided a mathematical explanation why the DCP theory works well for image defogging [8]. The more color information's of the foggy image will have better the restoration effect will be. But if the image has a large sky area, large white area, or dense fog and inhomogeneous fog, the DCP theory will fail.

In addition, the soft matting algorithm is time consuming to optimize the transmission and can not be used in practical applications. Nevertheless, if we use the coarse transmission for image defogging, the resulting image will have halo artefacts caused by the patch-based min filtering.

d. Modified DCP Algorithm:

The proposed MDCP scheme is described here. For any given image in the RGB color space, the implementation steps required for the proposed Modified DCP Algorithm scheme are given as follows.

Assume that the fixed scaling factor w=0.95 is inappropriate to estimate the initial transmission map, $\tilde{t}(x)$ in the DCP scheme, since $\tilde{t}(x)$ is often underestimated and thus degraded recovered image results.

Find the initial pixel-based dark channel as $I_1^{dark}(x) = \min_c \left[I_c(x) \right]$,-----------17

Find the maximum in $I_1^{dark}(x)$

Find the initial block –based dark channel is $I_\Omega^{dark}(x) = \min_{c \in \{r,g,b\}} \left(\min_{y \in \Omega(x)} (I^c(y)) \right)$--------18

Calculate the normalized dark channel is $I_\Omega^{\sim dark}(x) = \min_{c \in \{r,g,b\}} \left(\min_{y \in \Omega(x)} \left[\frac{I^c(y)}{A} \right] \right)$---------19

Obtain the initial transmission map as $\tilde{t} = 1 - \omega_a I_\Omega^{\sim dark}(x)$----------------20

Find the final transmission map t(x) through refining $\tilde{t}(x)$ by the Guided Image Filter (GIF) where the guide image is $I_1^{dark}(x)$ and the window size N=20 and smoothing parameter $\in$=0.001.

Recover the scene radiance as $J_c(x) = \frac{I^c(x) - A}{\max(t_0, t(x))} + A$ -------------------21

where t_0=0.1.

IV. Conclusion

Video enhancement main purpose to enhance the visual quality of the images/videos is an challenging active research area under different weather conditions with a low light conditions especially dark nights, foggy ,rainy and hazy images/videos. This paper presented an overview of video enhancement and the existing algorithms which are implemented by various researches for low light and weather conditions such as fog and haze.

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