Study of the Nighttime Context Enhancement Algorithms

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Abstract*—Nighttime video enhancement is one of the most important components in video research as many objects can't be seen due to poor illumination of the video. The purpose of video enhancement is to improve the visual appearance of the video. In this paper, an overview of video enhancement algorithms are discussed in which the context of the high quality daytime image is added to low quality nighttime image which thus improves the background of the nighttime image, hence enhancing the foreground of the video. In this paper the advantages and issues of the algorithms are also being discussed and a comparative study is done.

***Index Term*—Video enhancement,Gradients, Denighting, Frame Subtraction.**

I. INTRODUCTION

Nighttime video enhancement is one of the most important component in video research as it plays a crucial role in video processing applications, such as remote sensing, highway surveillance, medical imaging, robot vision, concealed weapon detection, multi-focus image fusion, digital camera application, battle field monitoring. There are several reasons for video enhancement. First is the poor quality of the used video device and lack of expertise of the operator and due to reasons of sensor noises or low luminance, night images appear much noise. Secondly, the brightness distributes unevenly because of the factitious illumination at night [13]. Third is due to low contrast, we cannot clearly extract moving objects from the dark background. As a result, the details in the captured scene get lost. In context of the above issues, the research on the nighttime video enhancement technology is necessary.

II. RELATED WORK

Context enhancement of a video or image can be done through various techniques. Traditional methods of video enhancement are to enhance the low quality video within itself and they do not add any information from the external source. Such as tone mapping, histogram equalization, and power law transform. The other possible access to enhance nighttime video features is by using the information obtained from high-quality daytime video. This process is called image fusion. Image Fusion is a process of combining the relevant information from a set of images into a single image, where the resultant fused image will be more informative and complete than any of the input images.

The image fusion idea was first invented by Marey and Murbridge in 19th century [5], but the main work was done in 2002 by UK ministry of defense to guide the pilots in the night.The first algorithm developed, processes the basic source image which reduces the contrast of the final image. Then pyramid transform was emerged. These transforms have the advantage of providing sharp contrast and also the spatial and spectral information of the pixel is retained [3]. But the problem that may arise with this transform is its inability to work on real time. After that wavelet transforms were emerged such as discrete wavelet transform(DWT),and discrete cosine transform(DCT). The basic limitations includes that theycannot simultaneously enhance all parts of the image very well.When wavelet transform is used alone itdoes not provide good results, however, with Intensity Hue Saturation (IHS) transform the results become smoother[4] IHS, Principle Component Analysis (PCA), filter fusion techniques does not give good results. In 2004, Ramesh Raskar et al. [5] presented a class of image fusion techniques, which automatically combines images of a scene which is captured under different illumination. A gradient domain technique is used that preserves the important features while avoiding the problems like aliasing, ghosting and haloing. A linear combination of intensity gradients is used, hence a smooth blend of input images and preservation of important features is achieved. In 2006, YinghaoCai et al. [7] delivered a novel method of automatically combining images of a scene at different time intervals using Retinex theory. In 2008, Akito Yamasaki et al. [9] had given a new algorithm called Denighting whichuses the illumination ratios of the day-time background and night-time background videos to enhance the night-time videos.In 2011, Jagpal Singh Ubhi et al. [3] gave a new algorithm called FSB (Frame Subtraction Based) image fusion technique. In the given method the images are fused by taking the difference of all the images in order to detect the changes occurring in them, followed by binarization of images by a filter which is used to remove the noise.Jing Li et al. had described a novel bidirectional extraction approach which has the ability to extract and maintenance the meaningful information like highlight area or moving objects with low contrast in the enhanced image, as well as recovering the surrounding scene information by fusing the daytime background image.

In order to get more information during the night time, the use of high resolution cameras everywhere is also not cost effective. Applying the high intensity light sources on the roads pose problems for the drivers in the night [3]. Taking these things into consideration the above proposed algorithms made an effort to improve the image forehand through various processes and then use fusion.

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III. CONTEXT ENHANCEMENT ALGORITHMS

Nighttime images provide very less information due to low illumination, So all the important information of the original low quality nighttime images are combined with the context from a high quality image of the daytime. Thus, the stationary parts in the poor-context night image can be replaced with better quality image context from a high-contrast day image.

There are two basic processes which are common in almost every algorithm. They are

- Foreground extraction
- Background fusion

Algorithm I.Gradient Domain Approach

Step I The horizontal and vertical intensity gradients,G = (GX, GY), across both nighttime and daytime image are computed using a simple forward difference.

$$Gi = \nabla Ii$$

Step II Then an importanceimage (a weighting function) W, is calculated by processing the gradient magnitude $|G|$.

Step III The weighted combination of input gradients is then computed.

$$G(x; y) = \Sigma\, Wi(x; y)Gi(x; y) = \Sigma\, Wi(x; y)$$

Step IV Reconstruction of image I'from gradient field G is done and pixel intensities in I'are normalized to closely match$\Sigma WiIi$.

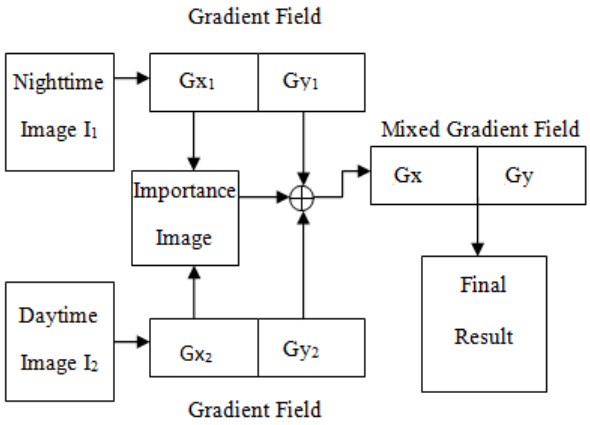

Fig.1 Block Diagram of Gradient Domain Approach[5]

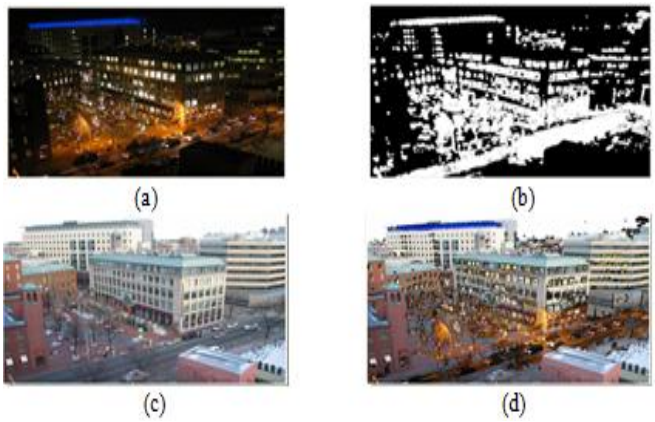

Fig. 2 (a) Night time image, (b) Mask, (c) Day time image, (d) Simple Pixel Blended Image[5]

Fig. 3 Pixel Gradient blended image[5]

Algorithm II. Frame Subtraction Approach

Step I Images are first stored in an array and difference of images is calculated in backward direction in order to detect the change among the images, the change then is removed in order to get fixed background for fusion.

Step II After thatBinarization and Filtration is performed. In Binarization the images are converted into black and white having the pixel values of 0 or 1 via thresholding. Filtration is performed in order to remove noise from the image.

Step III After filtration the images are multiplied with the first image from the array and are summed to get one final image containing all changes occurring in the images. This is how daytime and nighttime image reference image is extracted.

Step IV Extraction of foreground and background is done by multiplying the new image with the nighttime and daytime image respectively where enhanced background is changed black in color.

Step V At last both the foreground and enhanced background are fused to get the final image.

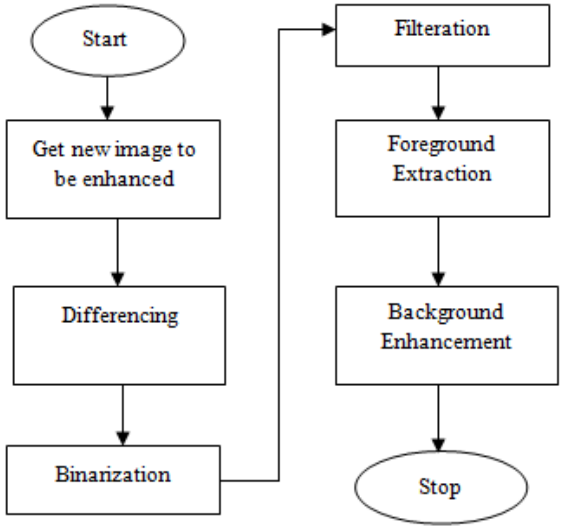

Fig. 4Flow Chart of Frame Subtraction Approach[3]

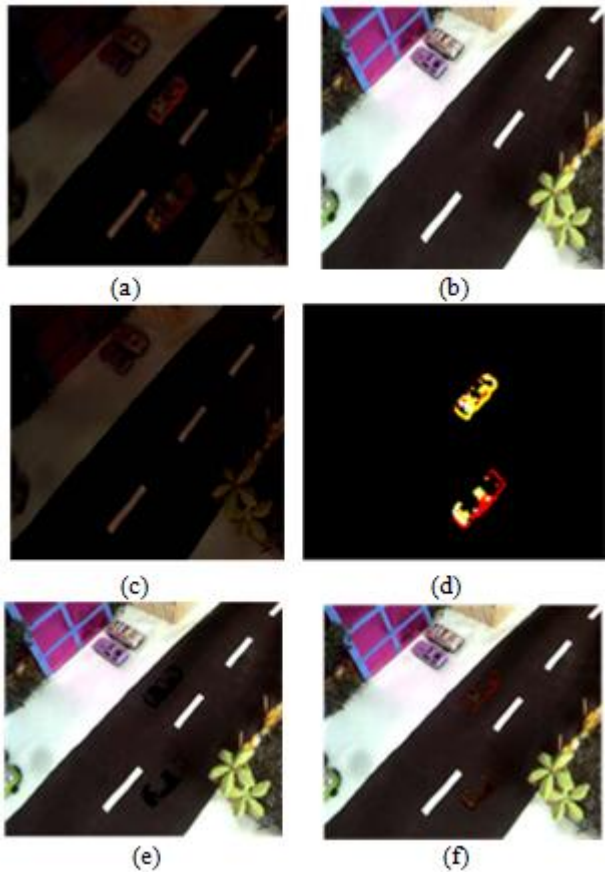

Fig. 5 (a) Nighttime Image, (b) Day time Reference image, (c) Nighttime Reference Image, (d) Foreground Extraction, (e) Base Enhancement, (f) Fused Image[3]

Algorithm III.Denighting Approach

In this algorithm enhancement of the image is done in two sections i.e. offline and online.

Online process

Step I The image is first decoupled in color and intensity. The color layer is given by dividing the input pixel values by the intensity I (such as r Red/I).

Step II The intensity is further decomposed into illumination and reflectance and enhancing only the illumination part of the nighttime image.

Step III The illuminance is assumed to be the low frequency component of an image I, and is estimated by using a low-pass filter such as bilateral filter.

Offline process

Step I Nighttime and daytime background of the same scene is calculated by using large number of sample frames.

Step II Then the nighttime and daytime illuminances are calculated by from the respective background images.

Step III The enhancement of input nighttime image is done by considering the ratio of illumination of day and nighttime background.

IV. ISSUES

The above described context enhancement techniques possess certain concerns. The Gradient domain technique may cause observable color shifts and bleeding. The

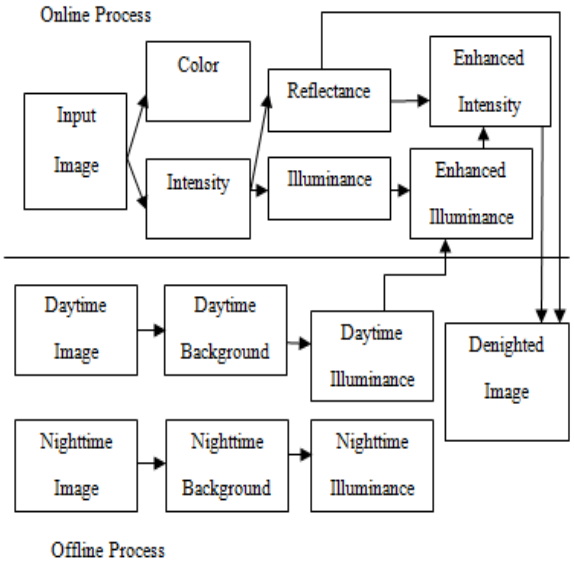

Fig. 6Block Diagram of DenightingApproach[9]

Fig. 7 (a) Nighttime Image, (b) DenightedImage[9]

Delighting method results in artefacts like 'lights off', 'illumination ratio variation and sensitivity', 'foreground artifacts' because of the illumination ratio of the day and night time backgrounds. Whereas in Frame subtraction method the main problem observed is of thresholding.

V. CONCLUSION

Nighttime image context enhancement is one of the crucial areas in image processing. In this paper, three techniques have been discussed and their enhanced image results have been shown as well. The enhanced images of all the above techniques can be judged on qualitative grounds. Based on quality metrics best results are obtained in the Gradient domain method. It possesses the problem of color shift which is due to improper maintenance of a valid vector field and also due to the difficulty in maintaining the high contrast in a single image due to different exposure of light of day and night time images. Another issue is of capturing a high quality background. The Frame subtraction technique is also a good technique as it is reliable, fast, cost effective and also consumes less memory. The issues have also been discussed so that important measures can be taken for further enhancement in the algorithms.

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