De-Noising and Contrast Loss Correction in Color Images and Videos

Munmun Ghosal
Research Scholar: Department of Electronics engineering
G.H.Raisoni College of Engineering, Digdoh Hills,
Nagpur, India440016

Abstract
This paper initially deals with the removal of noise from color images and videos. Now-a days video transmission is found in many applications such as surveillance, video conferencing etc. The basic communication problem may be posed as conveying source data with highest possible accuracy. When video sequences are transmitted from source to destination, it actually gets transmitted frame by frame. The interference due to noise degrades the quality of video during its transmission. So in order to improve the quality of video sequences at receiver section, optimum reduction of noise is needed.
Further the mitigation of simple contrast loss due to added lightness in an image which is often caused by optical scattering due to fog or mist.Hence an attempt to improve the quality of image or video is also done.

General Terms
RSST, BPT, GCF.
Keywords
Air-light, mitigation, contrast loss, noise.

1. INTRODUCTION
Noise can be systematically introduced into an image during acquisition and transmission. It degrades the quality of video sequences. A fundamental problem of image processing is to effectively remove noise from an image while keeping its features intact. So in order to improve the quality of video sequences at receiver side, optimum reduction of noise is needed which basically consists of 3 parts: Video shot detection, Key frame detection and Filtering. The nature of the problem depends on the type of noise added to the image. Two noise models can adequately represent most noise added to images: additive Gaussian noise and impulse noise.
In this paper, a framework for creating a universal noise removal filter is introduced that is based on a simple statistic to detect impulse noise pixels in an image. Instead of applying the "detect and replace" methodology of most impulse noise removal techniques, it is shown how to integrate such a statistic into a filter designed to remove Gaussian noise. The behavior of the filter can be adaptively changed to remove impulses while retaining the ability to smooth Gaussian noise. Additionally, the filter can be easily adapted to remove mixed noise.
Further an image of an outdoor scene is often degraded by optical scattering of light. This results in loss of contrast for any still image or video sequence acquired in such an atmosphere, thus resulting in poor perception for the viewer. The algorithm used detects the presence of air-light in an arbitrary image and estimates the level of air-light, given the assumption that it is constant throughout the image .This algorithm is based on finding the minimum of a global cost function and is applicable to both monochrome and color images. This method is robust and in-sensitive to scaling.

2. VIDEO TRANSMISSION

The transmission of motion video over narrow bandwidth is currently limited to relatively small images, which are transmitted with an insufficient number of frames per second to provide the appearance of smooth motion, even with current image compression techniques. Naturally, the wider the bandwidth that is available, the greater the resolution of the frames and the smoother motion simulated by the greater frequency of the frame sequences of the video motion image. The process of frame-to-frame comparison and transmission commences with the first frame in the sequence of a motion video image, which may be transmitted in its entirety. Subsequent frames in the sequence are not transmitted in their entirety, but only the difference in the pixels between each of two frames which are adjacent in the sequence, the comparison data, is transmitted. The latter of the two frames is reconstructed by the receiver from the comparison data and the prior of the two frames, pixel by pixel.

2.1. Improvement of Video Quality by Noise removal.

The basic challenge is to improve the quality of degraded video frame. During video transmission impulse noise affect the quality of video frame so in order to improve the quality, optimum reduction of noise is to be achieved. At present reduction of noise is achieved by many filter such as median filter, bilateral filter and SD-ROM filter. But the optimum noise reduction is possible by using the "trilateral filter" consisting of radiometry, spatiaometry, and ROAD (rank order absolute difference) which show better restoration quality than other used filtering technique.

The trilateral filter used a 5×5 window size and performed multiple iterations, whereby it provided better results. Image boundaries were handled by assuming symmetric boundary conditions. For each method tested, parameters were varied exhaustively to obtain the best possible result. Furthermore, to eliminate the bias created by different manifestations of noise, a standard set of noisy images were created. Five noisy images were created for each test image and noise level which formed the common input to each method.

2.2. Improvement of Video Quality by Contrast loss correction

Different approaches have previously been taken to the problem of imaging in a scattering medium. Temporal-gated sensors and polarization filtering reduce the amount of scattered light in an image. Contrast enhancement methods fall into two groups: non-model-based and model-based. Non-model-based methods analyze and process the image based solely on the information from the image. The most commonly used non model based methods are histogram equalization and its variations [3].For color images, histogram equalization can be applied to R,G,B color channels separately but this leads to undesirable change in hue. However, even this method does not fully maintain color fidelity. Generally all non model based methods have a problem with maintaining color fidelity. They also distort clear images, which is an important limitation.

Model-based methods use physical models to predict the pattern of image degradation and then restore image contrast with appropriate compensations. They provide better image rendition but usually require extra information about the imaging system or the imaging environment like predicting the atmospheric conditions or requires the scene depth to be known [2]. However, all methods require some image analysis to identify sky regions. This is not needed with the method proposed here.

The algorithm used gives a way of detecting the presence of air-light in an arbitrary image. It estimates the level of this air-light given the assumption that it is constant throughout the image and is based on finding the minimum of a global cost function and is applicable to both monochrome and color images. The method is robust and in-sensitive to scaling. Once an estimate of air-light is achieved, then image correction is straightforward.

Here, a physics based method is proposed to restore simple contrast loss due to a scattering medium or other source of air-light. It provides accurate contrast restoration of color images in the sense that the processed foggy image is similar to one taken in clear conditions. It is shown that the algorithm gives excellent frame-to-frame stability and color fidelity when applied to video data. The unique advantage of this method over general non-model based approaches is that it does not distort clear images.

The video sequence is recorded and prior to processing the images are converted to double-precision format in MATLAB.

3. METHODOLOGY

3.1. Methodology for Noise Removal

3.1.1. RSST (Recursive Shortest Spanning Tree)

The RSST itself is a hierarchical algorithm in the sense that segmentation starts from the finest level (i.e. single pixel level) to coarsest level (i.e. a user-specified level). For this reason, the final number of regions has to be externally specified by the user thus fixing the merging criterion to that given value. Once it reaches the given value it terminates the region growing process thus resulting a partition with the user-specified number of regions. In this algorithm each pixel in a 2D image is considered to be a region and is mapped onto a node of a graph thereby creating a set of nodes and this set contains a number of regions which is equal to the number of pixels in the image. Each node represents a region and a link is created using 4-adjacent regions initially. For each link a link-cost or a distance measure between the two corresponding regions is calculated using its luminance, chrominance and area information according to the equation given below thereby defining the merging order.

$$d(R_i, R_j) = \{[Y(R_i) - Y(R_j)]^2 + [U(R_i) - U(R_j)]^2 + [V(R_i) - V(R_j)]^2\} \text{ x } [\{N(R_i) \text{ x } N(R_j)\} / \{N(R_i) + N(R_j)\}]$$

Where,

R_i and R_j are two candidate regions and

Y(R), U(R), V(R) represents their luminance and chrominance values.

N(R) represents the number of pixels in a region.

The two regions that correspond to the lowest link-cost are merged first. The color and area information of the newly formed region are calculated and the new region is represented using mean color values (Y,U and V) and sum of number of pixels of the two regions. This process removes the above link from the graph thereby constructing a spanning-tree of the initial graph. Due to this spanning, the affected links are updated with new region nodes and hence new link-costs. Repeating the same process reduces the number of regions to the user specified value. In this algorithm the mean color is used as the region model.

3.1.2.BPT (Binary Partition Tree)

The BPT creation process starts from a given initial partition. [9]The regions belonging to the initial partition are represented in the leaves of the tree. The rest of the remaining nodes of the tree correspond to the regions created by the merging process. The merging of two regions at a time is done according to a defined merging order while maintaining the "Father" and "Children" nodes relationship. By keeping track of merging order of each region a final tree is created and each region is assigned a level thereby facilitating a hierarchical representation of the original image.

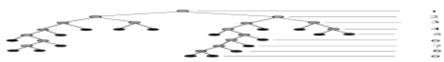

Fig 1. A BPT

Fig 2. A BPT (A) original image (B) a region belonging to level 4 (C) a region belonging to level 3

3.1.3. ROAD (Rank order absolute difference)

The ROAD statistic provides a measure of how close a pixel value is to its four most similar neighbors. The logic underlying the statistic is that unwanted impulses will vary greatly in intensity from most or all of their neighboring pixels, whereas most pixels composing the actual image should have at least half of their neighboring pixels of similar intensity, even pixels on an edge[10]. Fig.3 shows examples from the Lena image comparing a typical impulse noise pixel to an edge pixel. Notice that the edge pixel has neighbors of similar intensity despite forming part of an edge, and thus has a significantly lower ROAD value.

The main characteristics of trilateral filter are:
a)Stronger removal of mixed Gaussian and impulse noise.
b)Better performance for many visual applications.
c) Removing cuts and edges.
d) High accuracy.
e) Display high contrast images & de-noising 3D mesh model.
f) Easily extend to N- dimensional signal both Discrete & Continuous valued.
g) Better approximate scene illumination as a sharply bounded piecewise smooth signal with locally constant gradient. [11]

3.2. Methodology for Contrast loss correction

3.2.1. Statistical Model

An image may be represented as a collection of regions with each region corresponding to some kind of visible surface, or randomly placed objects with those in the front occluding those in the back. Within each region, there is a variation in brightness that is mainly due to macroscopic variations in local surface orientation. This consideration of an image gives a basic, but useful model for image fluctuation. The fractional variation in brightness may be quantified in various ways and is sometimes referred to as "local contrast" in the literature. Any offsets due to air-light will change this feature and so are detectable.

4. SYSTEM BLOCK DIAGRAM

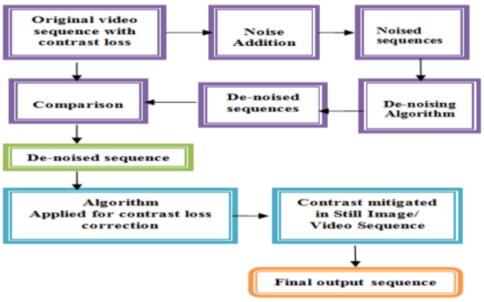

Fig 4: Block diagram for de-noising and correction of contrast loss in images and videos.

Fig 4 explains the various steps which are implemented for the de-noising and correction of contrast loss in images and videos. Initially the noise is removed and then the correction of contrast loss is performed using various algorithms stated earlier.

5. SIMULATION RESULTS

5.1. De-noising of Video sequence

5.1.1. Video Input for Removal of Noise

Fig 5: GUI showing the loading of the video input sequence.

By clicking on "open video" button ,the path for the video of .avi format is provided as shown in Fig 5.

5.1.2. Shot Detection for Video Sequence

A shot is an unbroken sequence of frame captured by a camera without changing its location.
By clicking on "shot detection" button the various shots in a video can be detected as shown in Fig 6.

Fig 6: GUI showing the calculation of no. of shots.

5.1.3. Addition of Noise in a Video Sequence

Variable percentage of noise can be added into the key frames of the video by the noise preset.

After selecting the desired percentage of noise, it can be added into the key frame of the video by using "Add Noise" button as shown in Fig 7.

Fig 7: Addition of noise to video sequence

5.1.4. Removal of Noise from Video Sequence

Fig 8: GUI showing the video sequence with removed noise.

5.2. Contrast correction of an Image

5.2.1. Input Image

Fig.9: GUI showing opening of an image

5.2.2. Contrast Mitigated Image

Fig.10: GUI showing contrast mitigated image

6. CONCLUSION

Thus the ROAD statistic into the bilateral filtering is incorporated by adding a third component to the weighting function. The new nonlinear filter is called the trilateral filter, whose weighting function contains spatial, radiometric, and impulsive components. The radiometric component combined with the spatial component smoothens away Gaussian noise and smaller impulse noise; while the impulsive component removes larger impulses. Henceforth, the air-light level in digital images is determined using the minimization of a scalar global cost function with no region segmentation. Once the air-light level has been obtained, contrast loss is easily corrected. The accuracy of the air-light estimate is insensitive to the scale and contrast of the image fluctuation and the level of variation in image brightness. The method is applicable to both black and white images and color images.

7. REFERENCES

[1] Roman Garnett, Timothy Huegerich, Charles Chui, Wenjie He, "A Universal Noise Removal Algorithm with an Impulse Detector",*Member, IEEE.*

[2] N.S. Kopeika and J. Bordogna," Baground Noise in Optical Communication System", proc.IEEE, vol.58. No.10,pp. 1571-1577.

[3].S. G. Narasimhan and S. K. Nayar, "Contrast restoration of weather degraded images," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 25, no. 6, pp. 713–724, Jun. 2003.

[4]Alper Yilmaz , Mubarak Ali Shah, "Shot Detection using Principal Coordinate System", University of Central Florida, USA.

[5] Saman Cooray, Noel O'Connor, Sean Marlow, Noel Murphy, Thomas Curran,"Semi-Automatic Video Object Segmentation Using Recursive Shortest Spanning Tree and Binary Partition Tree".

[6] Gonzalez & Woods, R., C., 1987." Digital Image Processing". Addison Wesley Publication. Comp, USA.

[7] Prasun Choudhury and Jack Tumblin,"The Trilateral Filter for High Contrast Images and Meshes".

[8] P Oakley and Hong Bu, "Correction of Contrast Loss in Color Images", John IEEE transactions on image processing, Vol 12, No. 2,Feb 2007.

[9] Yi Luo; Celenk, M.*,"Fast binary partition tree based variable-size block matching for video coding.*Image Processing (ICIP*), 2009 16th IEEE Conference.*

[10] Sai Ho Kwok; Constantinides, A.G.; Wan-Chi Siu,"An efficient recursive shortest spanning tree algorithm linking properties",Circuits and Sysyems for Video Technology.Volume: 14 , Issue: 6 .

[11] Liu Ying-hui; Gao Kun; Ni Guo-qiang,"An improved trilateral filter for Gaussian and impulse noise removal", Industrial Mechatronics and Automation(ICIMA),2010 2nd International Conference.Volume 2.