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Rectification of Noise, Background Illumination and Shadow Artifacts

Employing filtering, morphological opening and entropy minimization

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***Abstract*— Enhancing the image quality is a requisite as the presence of noise, non-uniform background illumination and shadow artifacts make it unsuitable for extracting desired information or data, often leading to false detection. So an image needs to be rectified and restored for desired application. In this paper, comparative evaluation of two techniques employing neighborhood comparison for noise removal is discussed. The illumination variations correction is done using morphological opening and background subtraction. Shadow is removed by finding an intrinsic direction and applying entropy minimization. Results show that these methods are highly robust techniques to restore these degradations.**

***Keywords*— Morphological opening, entropy minimization, edge detection, histogram equalization, invariant direction, chromaticity**

I. INTRODUCTION

Computer vision operates on images that come in the form of arrays of pixel values. When these images are transformed to obtain another image (or corrected to remove artifacts), we say that image processing is performed. The pixel values in the input image are invariably affected by noise, and it is needed to clean the images somewhat with a filter before they are further processed. Depending on the type of noise, a linear or nonlinear filter may be more appropriate. These filters may merely suppress fine detail so as to remove as much noise and as little useful signal as possible.

Second problem is non- uniform illumination in an image, which often leads to diminished structures and inhomogeneous intensities of the image due to different texture of the object surface and shadows cast from different light source directions. Non-uniform illumination can be due to many reasons like aging filaments, faulty reference voltages, contaminated apertures or non-uniform support film fabrication. Techniques such as segmentation, edge detection and contrast or brightness enhancement using Histogram Equalization could not differentiate between some of the particles and their background or neighboring pixels. This effect is adverse in case of biological images. This paper is aimed to remove these problems in microscopic image processing by removing the problem of non-uniform background illumination from the image using Morphological Opening and background subtraction for particle analysis.

Third problem is shadow detection and removal when dealing with color outdoor images. Shadows are generated by a local and relative absence of light. Shadows are, first of all, a local decrease in the amount of light that reaches a surface. Secondly, they are a local change in the amount of light rejected by a surface toward the observer. In this work, instead of a camera calibration we aim at finding the invariant direction from evidence in the color image itself. Specifically, we recognize that producing a 1D projection in the correct invariant direction will result in a 1D distribution of pixel values that have smaller entropy than projecting in the wrong direction. Hence we seek that projection which produces a type of intrinsic, independent of lighting reflectance-information only image by minimizing entropy, and from there go on to remove shadows.

The remainder of this paper is organized as follows: Section II gives the overview of the related work. Section III describes the proposed methodology for noise removal, illumination variation correction and for shadow removal. Implementations and performance are analyzed in section IV. Section V contains the concluding remarks and future enhancement.

II. OVERVIEW OF THE RELATED WORKS

Many of the computer vision problems are approached by constructing models based on Markov Random Field (MRF) or Conditional Random Field (CRF) energy functions and obtaining the solution through an optimization procedure [1]. The optimization is one of the available MRF/CRF Maximum A Posteriori (MAP) inference algorithms such as gradient descent, Belief Propagation, Graph Cuts, Iterated Conditional Modes, etc. However, such an approach faces challenges when applied to real world problem. Many de-noising techniques were proposed for on-line tracking using Gaussian and Median filters [2]. The primary endeavors of these filters are to strain out the high frequency components from the image's pixels. The edges of the image tend to be blurred when the aforesaid filters are utilized. Literature [3] discusses an enhanced averaging filter which is found better than averaging filter. In paper [4], author proposes median filtering technique for removing salt & pepper noise from various types of compound images.

A new algorithm, the Spatial Median Filter, is introduced and compared with the current image smoothing techniques [5]. Experimental results demonstrate that the proposed algorithm is comparable to popular image smoothing algorithms. In [6], an algorithm is designed to remove the impulsive noise (salt and pepper) from corrupted gray scale and color images. This algorithm considers first order neighborhood pixels for detecting the noisy pixel and mean filter is used for de-noising. Color images are also de-noised by extracting the R, G and B pixels from noisy image and then they are de-noised separately and then merged together again to form the color image. The presented algorithm in this paper shows better results than Standard Median Filter (SMF), Adaptive Median Filter (AMF), Progressive Switched Median Filter (PSMF), Decision Based Algorithm (DBA), Modified Decision Based Algorithm (MDBA), Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF), and Modified Non-Linear Filter (MNF). In [7] [8], a segmentation procedure recovers shadow regions with photometric gain smaller than unity roughly constant. In these cases, a priori assumptions are made, so that the approach detects only shadows occupying a large area with respect to the object.

Literature [9] is aimed to remove problems in microscopic image processing by removing the problem of non-uniform background illumination from the image using Morphological Opening, Adaptive Histogram Equalization and Edge detection techniques for particle analysis. The paper shows a comparative study of above mentioned techniques. In [10] [11], entropy minimization using invariant direction is well implemented by the author. The entropy, written in this embodiment, has the advantage that it is more insensitive to quantization. The resulting algorithm is quite reliable, and the shadow removal step produces good shadow-free color image results whenever strong shadow edges are present in the image. In most cases studied, entropy has a strong minimum for the invariant direction, revealing a new property of image formation.

III. PROPOSED METHODOLOGY

In real-life, due to the external environmental effects, capturing image always has some sort of noise occluded. In outdoor systems, the change in illumination with the time of day alters the appearance of the scene and causes deviation from the background model. This results in a drastic increase in the number of fallaciously detected foreground regions. Presence of objects shadows might also pose difficulty because of the illumination change in the shadow region that has to be removed. Images become distorted due to the presence of random noise, illumination and shadow. Only after the correct handling of these issues, the sophisticated objects will be detected, which can then be segmented for tracking and classification. This section presents the methods used for this purpose.

A. Noise Removal

Due to imperfection during acquisition unwanted pixels called noise often degrade the quality of the image. The presence of noise effect objects detection in a negative manner and hence has to be handled carefully. We implement two filtering methods, namely averaging filtering and median filtering for removal of certain types of noise. A comparison is made among averaging and median filtering for noise removal.

Averaging filter is useful for removing grain noise from a photograph. Because each pixel gets set to the average of the pixels in its neighborhood, local variations caused by grain noise are reduced. With median filter, the value of the output pixel is determined by the median of the neighborhood pixels, rather than the mean. The median is much less sensitive than the mean to extreme values (called outliers). Median filtering is therefore better able to remove these outliers without reducing the sharpness of the image. The steps to be performed are as discussed:

Step 1: First we take an initial color image and read it.

Step 2: Now in the second step the pixel is read and processed by using the following steps:-

Firstly check whether the pixels are in 0 to 255 ranges or not, here two cases are generated. If the processing pixel lies in between 0 and 255 ($0 < I(i, j) < 255$) then Case 1 is followed otherwise Case 2 is followed. Here I (i, j) is the image processing pixels.

Case 1- If Pixels are between $0 < I(i, j) < 255$ then, they are noise free and move to restore the image.

Case 2- If the pixels does not lie in the range then they are moved to step 3.

Step 3: In the third step we will work on noisy pixel of step2, now select a window W (i, j) of size 3 x 3. Assume that the processing noisy pixels are X (i, j), that is processed in the next step

Step 4: If the preferred window contains not all elements as 0's and 255's. Then remove all the 0's and 255's from the window, and send to restore the image. Now find the average and/or mean of the remaining pixels. Replace X (i, j) with the average and/or mean value. This noise removed image restores in de-noised image at the last step.

Step 5: Finally the X (i, j) components are merged to get the final de-noised image.

B. Illumination correction

In real-life systems, the change in illumination with the time of day alters the appearance of the scene and causes deviation from the background model. This results in a drastic increase in the number of fallaciously detected foreground regions. The steps for rectifying the non-uniform background illumination are as discussed:

- Read the image on which rectification is to be performed.
- Use morphological opening to estimate the background.
- View the background approximation as a surface
- Subtract the background image from the original image.

C. Shadow Removal

Presence of objects shadows, might also pose difficulty because of the illumination change in the shadow region and hence has to be uninvolved. To overcome this problem a technique based on entropy calculation and minimization is used.

The proposed method consists of the following steps. Instead of a camera calibration, first it is aimed at finding the invariant direction from evidence in the color image itself. Then, 1D projection in the correct invariant direction is obtained. It is observed that it results in pixel values that have

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smaller entropy than projecting in the wrong direction. After obtaining the minimized entropy, the last step is removal of shadow. In most of the cases, entropy has a strong minimum for the invariant direction, revealing a new property of image formation.

IV. IMPLEMENTATION AND PERFORMANCE ANALYSIS

A. Noise Removal

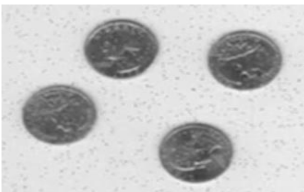
For implementation of noise removal methodology, I have taken three images as the example images which are noisy. Figure 1(a), (b), (c) shows the three example images used. Now, these images are de-noised using averaging and median filtering. The resulting images after application of averaging filtering are shown in figure 2(a), (b), (c) and output images of median filtering is shown in figure 3(a), (b), (c). The level of noise in images before and after application of filtering can also be represented using histogram. Figure 4 shows the histogram of example image 1(a) when noisy, and after application of both the filtering.

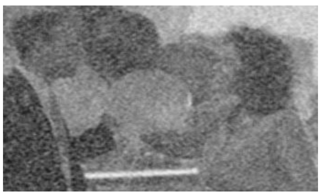

(a)


(b)


(c)

Fig.1. Input noisy image


(a)


(b)

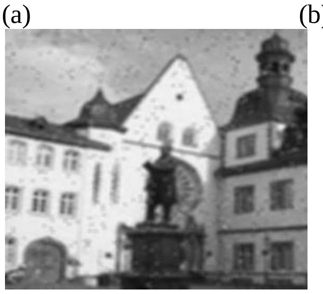
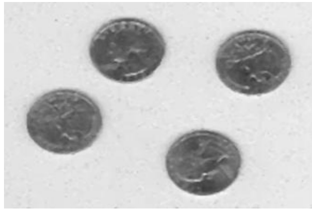

(c)

Fig.2. Noise removal by averaging filtering


(a)


(b)

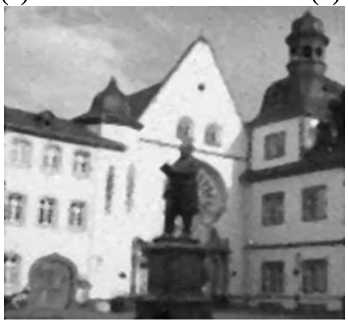
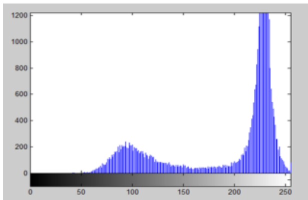
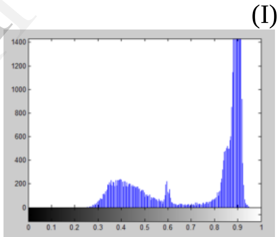

(c)

Fig.3. Noise removal by median filtering


(I)


(II)

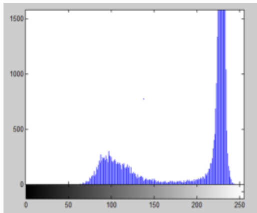

(III)

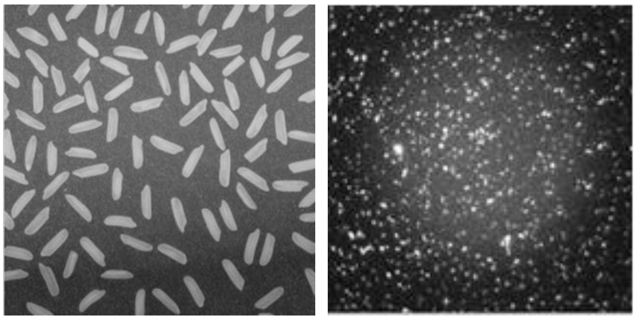
Fig-4: Histogram of image 1(a). (I) noisy image (II) after averaging filtering (III) after median filtering

B. Illumination correction

For implementation of illumination correction method, I have taken three images suffering from non-uniform background illumination. All the three images are corrected using morphological opening and background subtraction. The non- uniform background is approximated as a surface and then rectified. Figure 5 shows the images with non-uniform background. Figure 6 shows the approximation of background as a surface. In figure 7 we obtain the images with uniform illumination. It can be seen that the method corrects the non-uniform illumination efficiently.

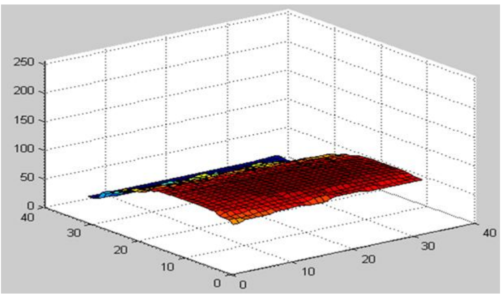
C. Shadow removal

For implementation of shadow removal method, I have used an image of mountains having shadow of clouds as shown in figure 8. Figure 9 is the chromaticity image of figure 8. Figure 10 shows a grey scale shadow removed image and figure 11 shows a RGB image with no shadow. It can be seen that the method rectify the shadow problem efficiently.

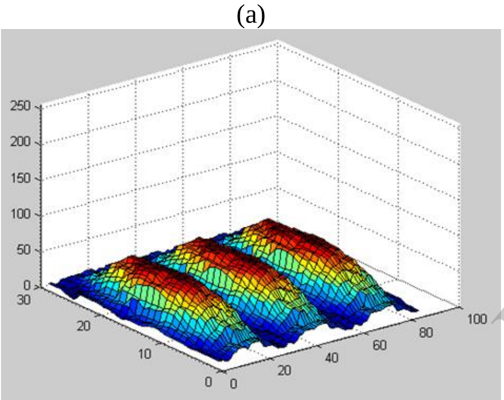


(a) (b)

Fig.5. Non-uniform background illumination images

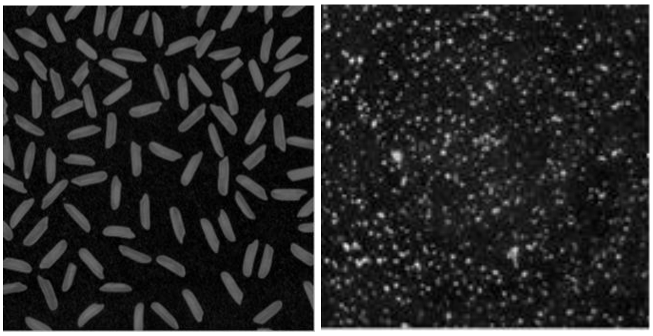


(a)



(b)

Fig.6. Background approximation as a surface



(a) (b)

Fig.7. Uniform background illumination

Fig.8. Shadow image

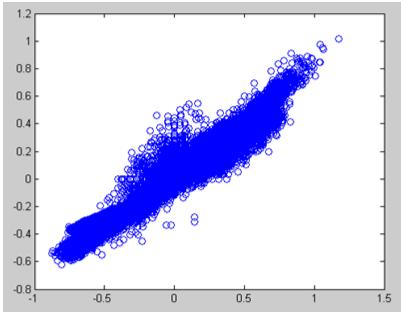


Fig.9. Chromaticity image

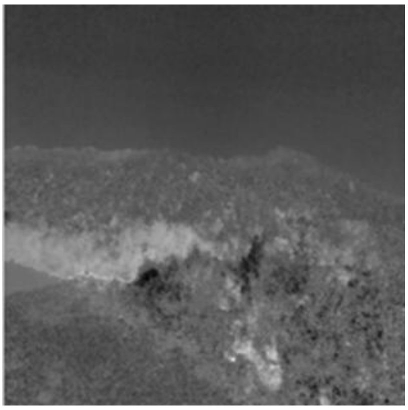


Fig.10. Gray scale shadow-less image

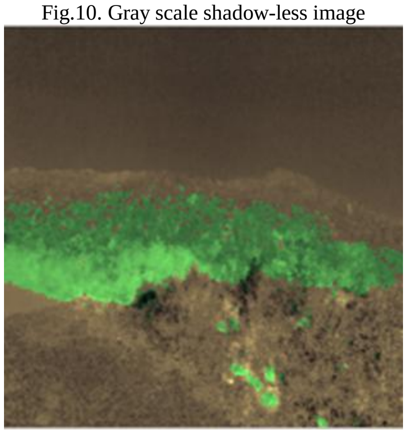


Fig.11. RGB shadow-less image

V. CONCLUSION

In this paper, filtering based de-noising, illumination variation correction and shadow discrimination and removal methods were proposed. These approaches have been implemented and evaluated on real-life images. The experimental results of each artifact proved that all the methods were robust and enhanced the recognition of objects in images. The results prove that median filtering has an edge over averaging filtering for noise removal. It is seen that morphological opening and background subtraction gets a properly illuminated image. The method based on entropy minimization for shadow rectification appears to work quite well, and leads to good re-integrated full-color images with shadows greatly attenuated.

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