A Shadow Detection and Removal from a Single Image Using LAB Color Space

Ashraful Huq Suny[1] and Nasrin Hakim Mithila[2]

[1]**Department of Computer Science and Engineering, Chittagong University of Engineering and Technology Chittagong 4349, Bangladesh**
[2]**Department of Computer Science and Engineering, Military Institute of Science and Technology Dhaka-1216,Bangladesh**

Abstract

Due to obstruction by an object light from a source cannot reach the area and creates shadow on that area. Shadows often introduce errors in the performance of computer vision algorithms, such as object detection and tracking. Thus shadow detection and removal is a pre-processing task in these fields. This paper proposes a simple method to detect and remove shadows from a single RGB image. A shadow detection method is selected on the basis of the mean value of RGB image in A and B planes of LAB equivalent of the image and shadow removal method is based on the identification of the amount of light impinging on a surface. The lightness of shadowed regions in an image is increased and then the color of that part of the surface is corrected so that it matches the lit part of the surface. The advantage of our method is that removing shadow does not affect the texture and all the details in the shadowed regions.

Keywords: *Shadow detection, shadow removal, LAB color space, illumination.*

1. Introduction

Shadows and shadings in images lead to undesirable problems on image analysis. That's why much attention was paid to the area of shadow detection and removal over the past decades and covered many specific applications such as traffic surveillance, face recognition and image segmentation. A shadow occurs when an object partially or totally occludes direct light from a source of illumination. In general, shadows can be divided into two major classes: self and cast shadows. A self shadow occurs in the portion of an object which is not illuminated by direct light. A cast shadow is the area projected by the object in the direction of direct light. Based on the intensity, the shadows are of two types − hard and soft shadows. The soft shadows retain the texture of the background surface, whereas the hard shadows are too dark and have little texture. Thus the detection of hard shadows is complicated as they may be mistaken as dark objects rather than shadows. Though most of the shadow detection methods need multiple images for camera calibration, the best technique must be able to extract shadows from a single image. This paper gives a simple method to detect and remove shadows from a single RGB image.

2. Previous work

Removing shadows from images can significantly improve and facilitate the performance of certain computer vision tasks, such as tracking, segmentation, and object detection etc. It is therefore of great importance to discover ways of properly detecting shadows and removing them while keeping other details of the original image intact. Finlayson, Hordley and Drew [1] proposed a method which used illumination-invariant image with the original color image to locate the shadow edges. These edges are set to zero and the edge representation is reintegrated to get the shadow-free image. A faster method for shadow removal by averaging the results of reintegration along a few numbers of Hamiltonian paths in the image was proposed in [2]. Fredembach and Finlayson [3] proved that the error propagation during reintegration can be reduced by closing the shadow edges before reintegration.
In [4] the shadow removal is achieved in three stages. A First a 1D shadow-free illumination invariant image is created from which a 2D color representation is derived and then a 3D shadow-free color image is generated. The shadow edges are finally corrected by inpainting. Fredembach and Finlayson [5] suggested that the shadow regions differ from the non-shadow representation by a single constant which can be calculated in a little time. The constant for R, G and B channels are calculated separately. The constant is such that the addition of the shadow region with the constant will reduce the difference between the shadow region and the surroundings.
Xu, QI, and Jiang [6] proposed a method to detect vague shadows in an image using derivatives of the input image. A method to remove the shadows from curved areas retaining the background texture is proposed in [7]. The removal of shadows is achieved by calculating different scale factors for shadow regions and penumbra regions to cancel the effect of shadows.
Finlayson, Drew, and Lu [8] proposed that the shadows can be removed by minimizing entropy. An approach to

extract shadows from an image using the information supplied by the user is proposed in [9]. The image is segmented and the shadow, non-shadow and background regions are interactively specified by the user. The shadow removal is achieved by graph cut algorithm.
Zhu et al. [10] proposed a method to detect the shadows in single monochromatic image using a shadow invariant, shadow variant and near-black features.
A region-based approach to detect and remove the shadows from an image was proposed by Guo, Dai, and Hoiem [11]. The segmented regions in the image are classified based on relative illumination and using a graph-cut, the labeling of the shadow and non-shadow regions is done. The lighting of shadow-pixels is done to recover a shadow-free image.
A method to detect the shadows in a single image using a Tricolor Attenuation Model (TAM) was proposed in [12].
Salvador, Cavallaro, and Ebrahimi [13] proposed a method to identify and classify the shadows in color images. Luminance and color information are used to detect shadows. In [14] the shadow removal is done by illuminating the shadow region till it gets the same illumination as the surroundings. The texture is retained. The shadow removal is done using energy function in [15], assuming that the lighting needed in the shadow region is a constant.
Most of the works on shadow removal need multiple images and calibrated camera. Methods like reintegration using Poisson equation are time intensive. Also, dark objects are often mistaken as shadows. A simple method to detect and remove the shadows from a single RGB image is proposed in this paper.

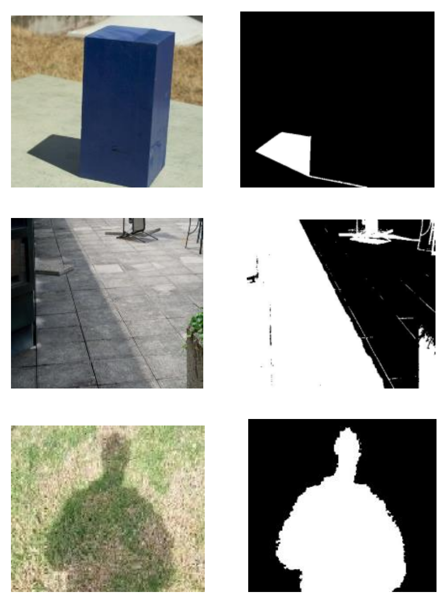
3. Shadow Detection

To detect shadow initially the RGB image is converted to an LAB equivalent image. The LAB color space has three channels where L is the Lightness channel, A and B are the two color channels. The L channel has values ranging from 0 up to 100, which corresponds to different shades from black to white. The A channel has values ranging from −128 up to +127 and gives the red to green ratio. The B channel also has values ranging from −128 up to +127 and gives the yellow to blue ratio. Thus, a high value in A or B channel represents a color having more red or yellow and a low value represents a color having more green or blue.

Since the shadow regions are darker and less illuminated than the surroundings, it is easy to locate them in the L channel since the L channel gives lightness information. The B channel values are also lesser in the shadow areas in most of the outdoor images. Thus combining the values from L and B channels, the pixels with values less than a threshold are identified as shadow pixels, and others as non-shadow pixels.

To detect shadow first a RGB image has to be converted to a LAB image. Then the mean values of the pixels in L, A and B planes of the image have to be computed separately. Now if mean (A) + mean (B) ≤ 256, then the pixels with a value in L ≤ (mean (L) – standard deviation (L)/3) can be classified as shadow pixels and others as non-shadow pixels. Otherwise the pixels with lower values in both L and B planes can be classified as shadow pixels and others as non-shadow pixels [16].

This pixel-based method may classify some non shadow pixels as shadow pixels. Cleaning, a morphological operation can remove isolated pixels. The misclassified pixels are removed using dilation followed by erosion. Also area-based thresholding is done, so that only regions with a number of pixels greater than a threshold can be considered as shadow regions. All these morphological operations thus help to eliminate misclassification of pixels. Fig. 1 gives the shadow area detected using the proposed method.



(a)Original image (b) Detected shadow region

Fig. 1 Shadow area detected as white using the proposed method

4. Shadow Removal

The shadow removal technique used in [16] is done by multiplying the shadow regions by a constant and finally the shadow edge is corrected by using filters. The problem with this approach is that dark objects may be considered as shadow and after removing the shadow some shadowed surfaces in the image still do not look similar to the non-shadow parts. This problem can be improved by the proposed method.

The intensity of light differs from the shadow region to the non-shadow region of an image. Actually the intensity of the shadowed regions gradually increases from shadow to light. We can say there may be two kinds of shadow region: partially lit region and non-lit region. So by lightening the shadow region can slightly remove the shadow from the image but not completely.

For complete removal of shadow we have to consider not only intensity but also hue and saturation of the shadow region. The chromaticity values of the image need to be corrected for this reason. In this paper, we use LAB color space and refer to a* and b* values in this color space as the chromaticity attributes. Applying a mean shift algorithm we segment the entire image according to its color values. Now the segments of the shadow region, P are certainly adjacent to a non-shadow region. Among all the neighbor segments, we choose the one that is closest in chromaticity to our segment of interest. This segment is further denoted as L. Afterwards, we rescale the shadowed segment's chromaticity values so that the average of the chromaticity in that segment P matches the average of the chromaticity in the aforesaid non-shadowed segment L.

$$a_P^*=a_P^* \frac{<a_L^*>}{<a_P^*>}$$

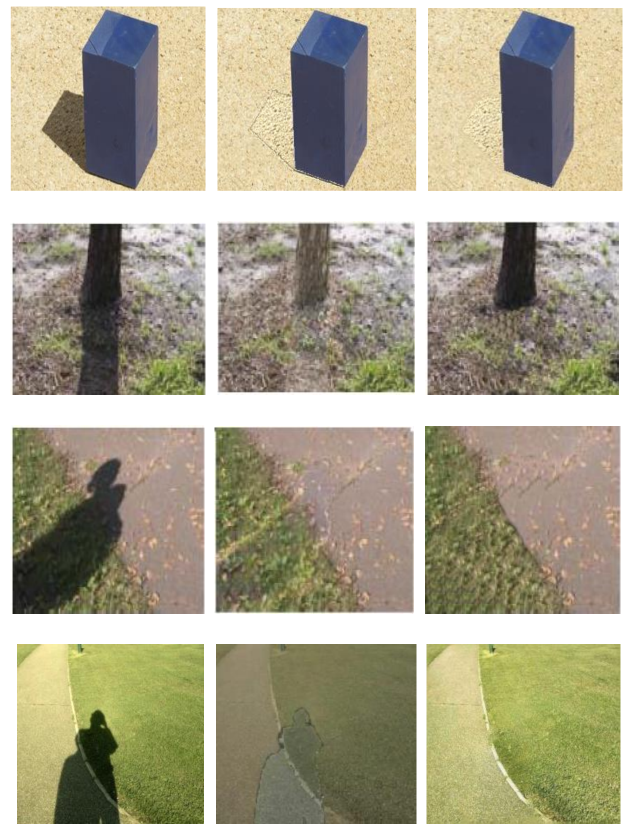
$$b_P^*=b_P^* \frac{<b_L^*>}{<b_P^*>}$$

Where a_P^* and b_P^* are a* and b* attributes of the corresponding segment and < • > is the average operator. The chromaticity correction is valid for the surfaces that are partly lit and partly under shadow. For such regions, the chromaticity can be corrected so that the shadow part of the surface will have the same chromaticity as the non-shadow part of the surface.

Changing the chromaticity values of the surfaces which are completely under shadow to the closest adjacent non-shadow segment will introduce wrong colors. To prevent this effect, if the chromaticity difference between P and L is not small enough, the chromaticity value of segment P will not be changed. Using same process we continue to rescale the chromaticity values of non-lit regions. Finally, all boundaries between shadowed regions and neighboring non-shadow regions are smoothed by convolving them with a Gaussian mask. Thus, we introduce a uniform transition between shadowed regions that were lightened and neighboring non-shadowed regions.

4. Results and Discussion

Fig. 2 shows the result of applying our method on some images. The results are compared to the shadow removal method used in [16].
It can be clearly seen from column 'c' of Fig 2 that the texture of the surface that was under the shadow is preserved to a good extend and no harsh transition between the shadowed parts and non-shadowed parts can be seen. It is the main advantage of this paper.



(a) (b) (c)
Fig. 2 Column (a) shows the original image; Column (b) shows the shadow removed area using [16]; Column (c) shows the removed shadow region using proposed method

4. Conclusions

This paper describes a shadow removal method for real images based on increasing the lightness of shadowed regions in an image. The color of that part of the surface is then corrected so that it matches the lit part of the surface. Our algorithm worked successfully in removing both partially lit and non-lit regions.

References

[1] Finlayson, G.D., S.D.Hordley, M.S.Drew, "Removing Shadows from Images", In: Proceedings of 7th European Conference on Computer Vision – Part IV, ECCV'02, London, UK, Springer- Verlag, 2002, 823-836.

[2] Fredembach, C., G.D.Finlayson, "Fast Re-Integration of Shadow Free Images" , In: Proceedings of 12th Color Imaging Conference: Color Science and Engineering Systems, Technologies, Applications, CIC'2004, 9 November 2004, Scottsdale, Arizona, USA. IS&T – The Society for Imaging Science and Technology, 2004, 117-122.

[3] Fredembach, C., G.D.Finlayson, "Hamiltonian Path-Based Shadow Removal", In: Proceedings of 16th British Machine Vision.

[4] Finlayson, G.D., S.D.Hordley, C.Lu, M.S.Drew, "On the Removal of Shadows from Images", IEEE Trans. Pattern Anal. Mach. Intell., Vol. 28, January 2006, No 1, 59-68.

[5] Fredembach, C., G.D.Finlayson, "Simple Shadow Removal", In: Proceedings of 18th International Conference on Pattern Recognition, ICPR'06. IEEE Computer Society, 2006, 832-835.

[6] Xu, L., F.Qi, R.Jiang, "Shadow Removal from a Single Image", In: Proceedings of 6th International Conference on Intelligent Systems Design and Applications, Vol. **2**, 2006, 1049-1054.

[7] Arbel, E., H.Hel-Or, "Texture-Preserving Shadow Removal in Color Images Containing Curved Surfaces", In: CVPR IEEE Computer Society, 2007.

[8] Finlayson, G.D., M.S.Drew, C.Lu, "Entropy Minimization for Shadow Removal", Int. J. Comput. Vision, Vol. **85**, October 2009, No 1, 35-57.

[9] Miyazaki, D., Y.Matsushita, K.Ikeuchi, "Interactive Shadow Removal from a Single Image Using Hierarchical Graph Cut", In: Proceedings of 9th Asian Conference on Computer Vision, Berlin, Heidelberg, 2010, Springer-Verlag, Volume Part I, ACCV'09, 234-245.

[10]Zhu, J., K.G.G.Samuel, S.Z.Masood, M.F.Tappen, "Learning to Recognize Shadows in Monochromatic Natural Images", In: CVPR, IEEE, 2010, 223-230.

[11]Guo, R., Q.Dai, D.Hoiem, "Single-Image Shadow Detection and Removal Using Paired Regions", In: CVPR, IEEE, 2011, 2033-2040.

[12]Rani, K.E.E., G.Jemilda, "Shadow Detection in Single Still Images Using TAM Based Multi Step Algorithm", IJCST, Vol. **2**, 2011, Issue 4.

[13]Salvador, E., A.Cavallaro, T.Ebrahimi, "Shadow Identification and Classification Using Invariant Color Models", 2001.

[14]Germain, A., N.Salamati, S.Susstrunk, "Removing Shadows from Images Using Color and Near-Infrared", In: Proceedings of 18th IEEE International Conference on Image Processing ICIP'11, 2011, 1713-1716.

[15]Kumar, S., A.Kumar, "Shadow Detection and Removal in Color Images Using Matlab", International Journal of Engineering Science and Technology, Vol. **2**, 2010, No 9, 4482-4486.

[16]Saritha Murali, V.K.Govindan, "Shadow Detection and Removal from a Single Image Using LAB Color Space", Cybernetics and Information Technologies, Vol. 13, 2013, No 1, Online ISSN: 1314-4081

Ashraful Huq Suny will receive B.Sc. degree in Computer Science and Engineering (CSE) from Chittagong University of Engineering & Technology (CUET), Chittagong, Bangladesh in July, 2013. Currently he is a final year student Dept. of CSE. His research interest includes Digital Image Processing, Computer Vision.

Nasrin Hakim Mithila has received B.Sc. degree in Computer Science and Engineering (CSE) from Military Institute of Science and Technology (MIST), Dhaka, Bangladesh in 2012, December. Currently, she is employed as a Lecturer in Daffodil International University, Bangladesh and pursuing her M.Sc. from Bangladesh University of Engineering & Technology (BUET). Her research interest includes Wireless Networking and Digital Image Processing.