Detection of Shadow and Its Removal along with the Edge Suppression

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Abstract: ***In this paper, we use the transformation of the gradient field for edge suppression which will result into the removal of the shadow and the glass reflections from an image, recovering the foreground layer under varying illumination.***

Keywords: Color image, Edge suppression, Gradient field, affine transformation, Cross projection tensors,

1. Introduction

Detection of shadow and its removal is a significant task when dealing with color images. For edge-suppressing operations on images we intend a technique known as cross projection tensors to attain affine transformations of gradient fields. In order to remove edges in one image based on the edge-information in a second image, we use these tensors. Based on the thresholds image gradients are set to zero and edge suppression is attained. A common application is in the Retinex problem, where by restraining the reflectance edges the illumination map is recovered, assuming it is slowly varying. We present a problem where edge suppression can be a useful tool. These problems consist of evaluating images of the same scene under variable illumination. Instead of just resetting the gradients, the prime idea in our approach is to obtain local tensors using one image and to transform the gradient field of another image using them. Reconstructed image from the modified gradient field shows suppressed edges or textures at the corresponding locations. In our approach all operations are confined and it does not require any global analysis. We demonstrate the algorithm in the perspective of several applications such as foreground layer under varying illumination is recovered, removing shadows from color images and obtaining the illumination map and removal of reflections from glass.

2. Literature Survey

In [1], it is analyzed to derive a 1-d illumination invariant shadow-free image. Then the use of the invariant image together with the original image to establish shadow edges. By setting these shadow edges to zero in an edge representation of the original image, and by consequently re-integrating this edge representation by a method paralleling lightness recovery, They are able to arrive at their sought after full color, shadow free image. A requirement for the application of the method is that they must have a calibrated camera. It has been analyzed that a good calibration can be achieved simply by recording a sequence of images of a fixed outdoor scene over the course of a day. After calibration, only a single image is required for shadow removal. It is shown that the resulting calibration is close to those achievable using measurements of the camera's sensitivity functions. Illumination conditions can confound many algorithms in vision. Like, changes in the color or intensity of the illumination in a scene can cause problems for algorithms which intend to segment the image, or recognize, objects in the scene. One illumination effect which can cause particular problems for these algorithms is that of shadows. The disambiguation of edges due to shadows and those due to material changes is a complicated problem and has a long history in computer vision research In addition; the exploration of shadows as cues for image understanding has an even older lineage. Recently, the significance of understanding shadows has come to the fore in digital photography applications including color correction and dynamic range compression. One possible solution to the confounding problems of shadows is to originate images which are shadow free: that is to process images such that the shadows are removed whilst retaining all other salient information within the image. Recently, a study aimed at lightness computation set out a clever method to attenuate the consequence of shadows in an image. Unfortunately however, this method requires not just a single image, but rather a sequence of images, captured with a stationary camera over a period of time such that the illumination in the scene (specially the position of the shadows) changes noticeably The example used by the author was a sequence of grey-scale images of a fixed outdoor scene, captured over the course of a day. Assuming that material changes are constant in the scene and that shadows move as the day progresses, it follows that the median edge map (for the sequence) can be used to determine material edges (shadow edges since they move are transitory and so do not affect the median). Given the material edge-map it is possible to create an intrinsic image that depends only on reflectance. This reflectance map might then be compared against the original sequence and an intrinsic illuminant map for each image recovered. While this method works well a major limitation of the approach is that the illumination independent (and shadow free) image can only be derived from a sequence of time varying images. In this paper a method has been proposed for removing shadows from images which in contrast to this previous work requires only a single image. The approach is founded on an application of a recently developed method for eliminating from an image the color and intensity of the prevailing illumination. The method works by finding a single scalar function of image an RGB that is invariant to changes in light color and intensity i.e. it is a 1-dimensional invariant image that depends only on reflectance. Because a shadow edge is evidence of a change in only the color and intensity of the incident light, shadows are removed in the invariant image. Importantly, and in contrast to antecedent invariant calculations, the scalar function operates at a pixel and so is not confounded by features such as occluding edges which can affect invariants calculated over a region of an image. As in [2], this has provided a hypothesis test to detect shadows from the images and then the concept of energy function is used to remove the shadow from the image. The algorithm used to remove the shadow. The first step is to load image with shadow, which have probably same texture throughout. By applying contra harmonic filter pepper and salt noise is removed. Effect of shadow in each of the three dimensions of color is determined. And then average frame is computed in order to remove the shadow properly So the colors in shadow regions have superior value than the average, while colors in non-shadow regions have smaller value than the average values. Images are represented by varying degrees of red, green, and blue (RGB). Red, green, and blue backgrounds are selected because these are the colors whose intensities, relative and absolute, are represented by positive integers up to 255. Then, construct a threshold piecewise function to extract shadow regions. The results of the threshold function is a binary bitmap where the pixel has a value of zero if the corresponding pixel is in the shadow region and it has a value of one if the corresponding pixel is in the non shadow region.

3. Methodology

In this paper to design edge-suppressing operations on images is our goal. Shape and reflectance of the objects in the scene and the scene illumination are the factors on which the image formation depends. For example, the analysis of Scene involves factoring the image to recover the reflectance or illumination map. One of the common method to preserve (or suppress) image gradients at known locations so that in the recovered map, corresponding edges and textures are conserved (or suppressed) in techniques that use local per-pixel operations. Edge suppression by using Gradient field transformation approach can also be used to remove multifarious scene structures such as reflection layers due to glass. While photographing through glass, flash images (images under flash illumination) usually have adverse reflections of objects in front of the glass. It can be used to illustrate how to recover such reflection layers. A gradient projection technique has been projected to remove reflections by taking the projection of the flash image intensity gradient onto the ambient image intensity gradient. The gradient projection algorithm is a unique case of this approach, and introduces color artifacts which can be removed by our method. Other methods for reflection removal include changing polarization or focus and Independent Component Analysis (ICA). Background subtraction is used to segment moving regions in image sequences taken from a static camera [11, 12]. There exists vast literature on background modeling using adaptive/non-adaptive Gaussian mixture models and its variants. See review by Piccardi [13] and references therein. Layer separation in presence of motion has been discussed in [14, 15]. We show how mutual edge-suppression can be effectively used for foreground extraction of opaque layers. Here gradient-based approach relies on local structure rather than absolute intensities and can handle significant illumination variations across images. Local structure tensors and diffusion tensors derived from them have been used for spatio-temporal image processing and optical flow.

Intrinsic images are projected as a useful depiction of the scene of the average level of Barrow and Tenenbaum [3]. The observed image is measured to be the product of reflectance image and an illumination image [6, 16]. Our approach can be used to abolish complex scene structures such as layers of reflection due to glass. While photographing through the glass, flash photography usually have the unwanted reflections from objects in front of the glass. We show how to recover such layers of reflection. Agrawal et al. [1] proposed a gradient projection technique to remove reflections for the projection of the gradient of the flash intensity image on the ambient image intensity gradient. We show that the gradient projection algorithm is a special case of our approach, and presents color artifacts that can be eliminated by our method. Other methods for the elimination of reflection include change of polarization or the approach [9, 11] and Independent Component Analysis [5]. Local structure tensors and diffusion tensors derived from them were used for image processing and space-time optical flow [7], and regulation of PDE-based image [2, 12, 13, 15]. These approaches are based on the modification of image intensities by nonlinear diffusion equation

$$F_t = \mathrm{div}\,(D_f \nabla F) \quad (1)$$

Where divergence operator is represented by div, ∇F is the gradient of the image and the D_f represents the diffusion tensor. In comparison, our approach is a gradient based domain transformation of the gradient field ∇F using. Recently, gradient domain algorithms have been used for Poisson image editing [10], and the perfect image stitching [8]

Affine Transformation on Gradient Fields

Let F (p, q) of image intensity and $\nabla F = \begin{bmatrix} h_p \\ h_q \end{bmatrix}$ denotes the gradient vector for I each pixel. The smoothed structure tensor H_σ is defined as [12]

$$H_\sigma = (\nabla F \nabla F^T) * C_\sigma = \begin{bmatrix} h_p^2 & h_p h_q \\ h_p h_q & h_q^2 \end{bmatrix} * C_\sigma \quad (2)$$

Where * is a convolution operator and is a core C_σ normalized 2D Gaussian of variance σ. The H_σ matrix can be decomposed as

$$H_\sigma = L \Sigma L^T = [l_1 \quad l_2] \begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix} \begin{bmatrix} l_1^T \\ l_2^T \end{bmatrix} \quad (3)$$

Where l_1, l_2, here indicates the eigenvectors corresponding to eigen-values λ_1 and λ_2 , respectively, and $\lambda_2 \leq \lambda_1$. To provide information about local structures in the image intensity [2] eigenvalues and eigenvectors of $H\sigma$ is being utilized. For homogeneous regions, $\lambda_1 = \lambda_2 = 0$. If $\lambda_1=0$ and $\lambda_2 > 0$, it means the presence of an edge intensity. The eigen-vector l1 corresponds to the direction of the edge. Weickert [14, 15] proposed a generalization of the equation based on the divergence given by (1), where D_f is a diffusion tensor field. At each pixel, D_f (x, y) is a 2 × 2 symmetric matrix, positive definite. Weickert proposed the design of the diffusion tensor D_f for the selection of its eigen-vectors m1, m2 and eigen values of μ1, μ2 on the basis of eigen-values and eigen vectors of Gσ. D_f is then obtained as

$$D_f = \begin{bmatrix} D_{f11} & D_{f12} \\ D_{f21} & D_{f22} \end{bmatrix} = \begin{bmatrix} m_1 & m_2 \end{bmatrix} \begin{bmatrix} \mu_1 & 0 \\ 0 & \mu_2 \end{bmatrix} \begin{bmatrix} m_1^T \\ m_2^T \end{bmatrix}$$

For the coherence enhancing diffusion [2, 15] several designs for production of D have been projected the edge enhancing diffusion [2], the restoration of the color image, in-painting, and magnification [13]. Usually, Df is obtained from the given image F. These approaches modify the image intensities using the diffusion equation (1). This article shows how to get the projection tensor and discuss the properties and applications of affine transformation of the field gradient ∇ F of the image with them.

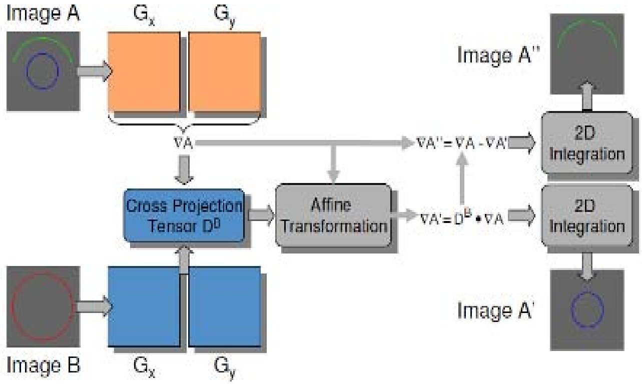


Figure 1: In image A suppressing edge is using image B by affine transformation of gradient field using cross projection tensors. DB which is the cross projection tensor is obtained using images. The gradient field A is transformed using DB to give, removing those edges from A which are present in B. Reconstruction from gives image D, with corresponding edges suppressed. Reconstruction from the difference gradient field (A−) gives image C, which preserves those edges in A which are also present in B

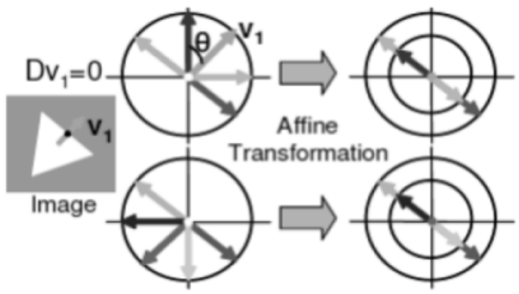


Figure 2: Envisaging affine transformation on gradient vectors. l_1. corresponds to the direction of the dominant edge at each pixel in an image,. After affine transformation using D_f^{self}, any vector gets projected to the direction orthogonal to the local gradient vector l_1

3.1 Gradient Projection

The procedure of gradient projection (GP) to remove artifact from the flash image using an image without flash environment. They project the flash image gradient in the direction of the ambient image gradient to remove specious edges from flash image due to reflections from glass. Using the idea that the direction of the gradient image is stable to change in illumination [4]. First, show that taking a projection may also be defined by an affine transformation of the gradient field. The eigen-vector l_1 of the structure tensor matrix G_σ corresponding to the edge direction. Suppose we define the self-projection D_f^{self} tensor as It is

$m_1 = l_1$, $m_2 = l_2$, $\mu_1 = 0$, $\mu_2 = 1$

$$D_f^{self} = \begin{bmatrix} l_1 & l_2 \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} l_1^T \\ l_2^T \end{bmatrix} \quad (4)$$

It is unproblematic to see that an affine transformation of the image gradient using D_f^{self} will remove the local edge.

$$D_f^{self} = \begin{bmatrix} l_1 & l_2 \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} l_1^T \\ l_2^T \end{bmatrix} l_1 \quad (5)$$

$$= \begin{bmatrix} l_1 & l_2 \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Fig.2 shows the effect of the gradient vector transformation using D_f^{self} other. All vectors are projected to the direction orthogonal to the local gradient vector *l1*. Thus, we can establish the following relationship. The transformation of a vector with D_f^{self} is equivalent to the projection in the orthogonal direction of the local gradient vector

The gradient projection approach as described in [1] cannot handle homogeneous regions and introduces color artifacts. This is because it does not include support for the estimation of gradient direction neighborhood, which is unstable in the presence of noise and low frequency regions. Furthermore, the projection is done for each channel separately which leads to color artifacts. Our approach combines spatial data (with σ> 0) and in all channels to handle the noise and have no color artifacts.

3.2 Cross-Projection Tensors

We now illustrate how to remove the scene texture edges of an image by transforming the gradient field using cross-projection tensors obtained from a second image of the same scene (see Fig. 1). The final image is obtained by a 2D integration of the modified gradient field.

Let A and B represent the two images. That H_σ^A and H_σ^B denote the smoothed structure tensors for image of A and B, respectively. The eigen values and eigen-vectors of the H_σ^A and H_σ^B is denoted by superscripts A and B, respectively. The technique for obtaining the cross projection tensor D_f^B is now explained. Note that by transforming ∇A with D_f^B , we (a) removing all edges of the A that are present in B, and (b) retain all edges in A which are not in B. For D_f^B , we propose the following rules:

(a) $m_1 = \lambda_1^B$, $m_2 = \lambda_2^B$

(b) If B is homogeneous ($\lambda_1^B = 0$)

(i) If A is also homogeneous ($\lambda_1^A = 0$), set $\mu_1 = \mu_2 = 0$. This results in $D_f(x,y) = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$ for that pixel

(ii) If A is not homogeneous ($\lambda_1^A > 0$), set $\mu_1 = \mu_2 = 1$ This results in $D_f(x,y) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

©Edges which are in A but not in B can be retained. Else, if there is an edge in B ($\lambda_1^B > 0$), remove that edge by setting $\mu_1 = 0$, $\mu_2 = 1$

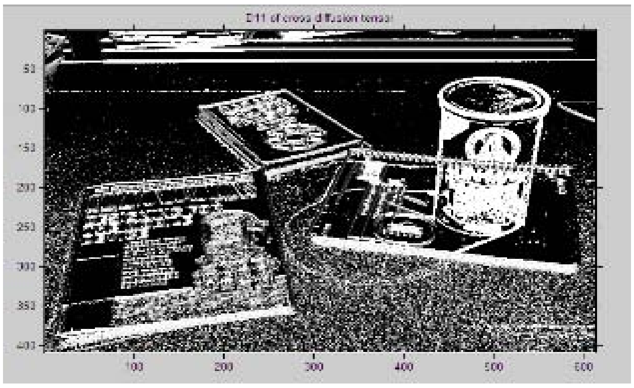
4. Results

4.1 Under varying illumination recovering the foreground layer

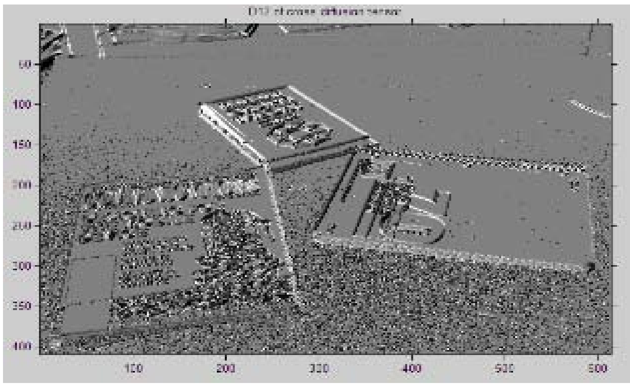
In this paper to design edge-suppressing operations on images is our goal. Shape and reflectance of the objects in the scene and the scene illumination are the factors on which the image formation depends. For example, the analysis of Scene involves factoring the image to recover the reflectance or illumination map. One of the common method to preserve (or suppress) image gradients at known locations so that in the recovered map, corresponding edges and textures are conserved (or suppressed) in techniques that use local per-pixel operations.

(a) Image A

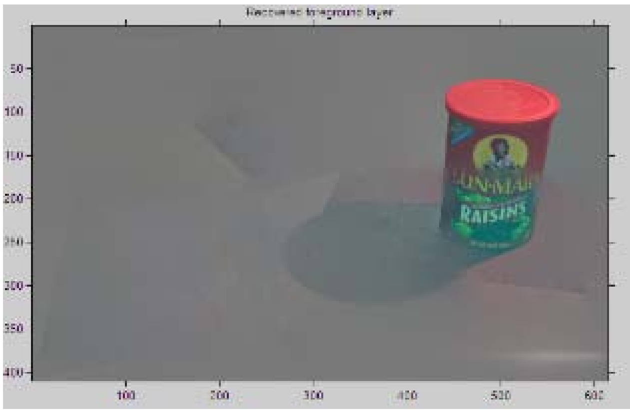
(b) Image B



(c) D11 cross diffusion tensor



(d) D12 cross diffusion tensor

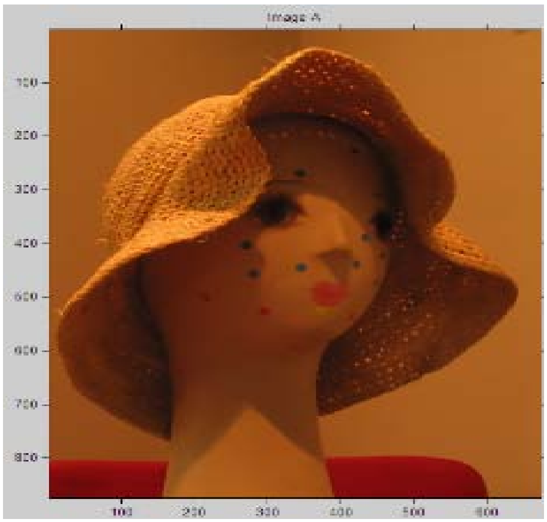


(e) Recovered foreground layer

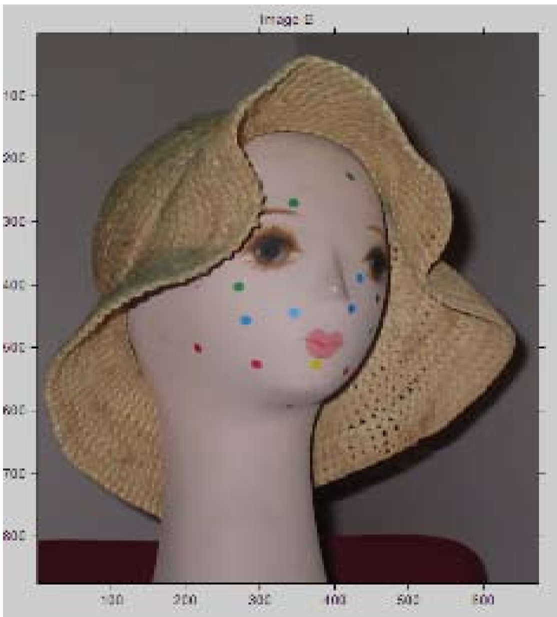
Figure 3: Suppression of the edges under varying illumination using affine transformation of gradient fields. Two images, Image (a) & Image (b) of a scene captured under different illumination, but with one having a foreground object. Image (c) & Image (d) represents D11 and D12 cross diffusion tensor technique. By removing edges in ∇ A which are present in ∇ B, we recover the foreground layer in image (e). Observe that image (e) is free of all scene texture edges apart from those due to the box even inside the box shadow

4.2 Removal of the Shadow

We use a flash image B of the scene to confiscate shadows from the ambient (no-flash) image A. By using the sobel gradient operator the edges of the image had also been attained. The flash and ambient images were captured in rapid progression with the effectiveness of remote capture with the camera on a tripod. We achieve the cross projection tensor using B and transform the gradient field A using it. The recovered shadow free image C has no color artifacts and the recovered illumination map D is free of strong texture edges. Fig. 4 shows a challenging scenario where the hat on the mannequin casts shadows on the mannequin’s face and neck. Generally, the ambient and flash images have a different color tone due to the ambient light is yellow-red and flash illumination is blue. Our algorithm not calibration requires pre-processing or color calibration and no color artifacts compared with the result using gradient projection. One might think that the ratio image A/B could give the illumination map of the scene. However, the ratio image does not represent the illumination map due to the effects of flash shadows and variations in illumination due to the flash. The illumination map obtained by our approach better represents the diffuse ambient illumination.



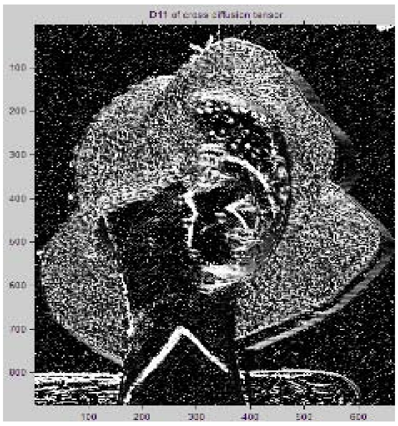
(a) Ambient Image



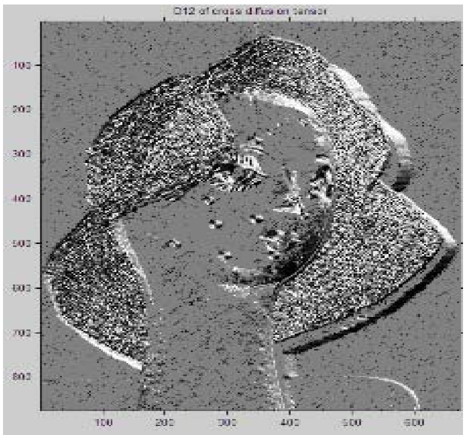
(b) Flash image

(c) Sobel gradient image

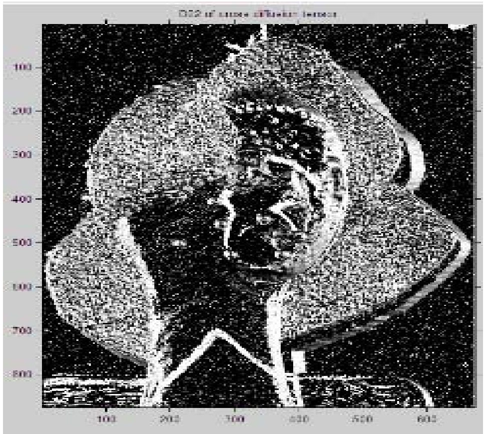
(d) Edge detected image



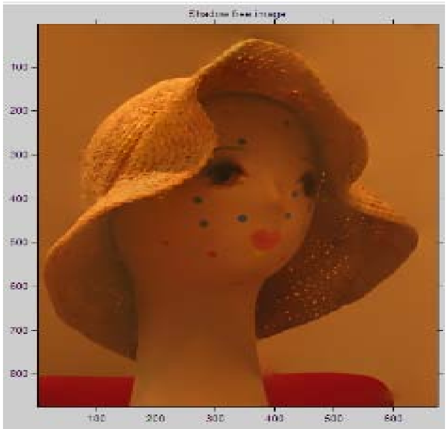
(e) D11 cross diffusion tensor



(f) D12 cross diffusion tensor



(g) D22 cross diffusion tensor



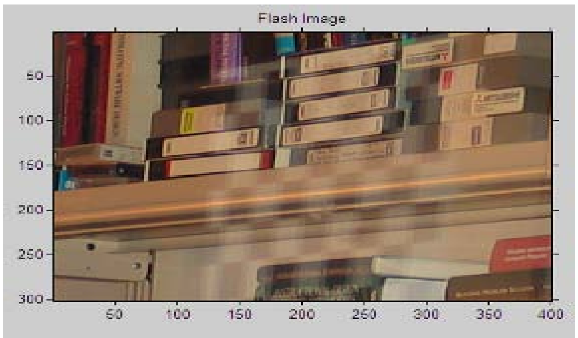
(h) Shadow free image

Figure 4 (a) Ambient image A . The hat casts shadows on the mannequin's face and neck in the ambient image A. **(b)** Image B with flash taken with a short exposure time. **(c)** image obtain using the sobel gradient operator **(d)** Edge detected image **(e)** image with component D11 of cross projection tensor. **(f)** image with component D12 of cross projection tensor. **(g)** image with component D22 of cross projection tensor. **(h)** Shadow free image C.

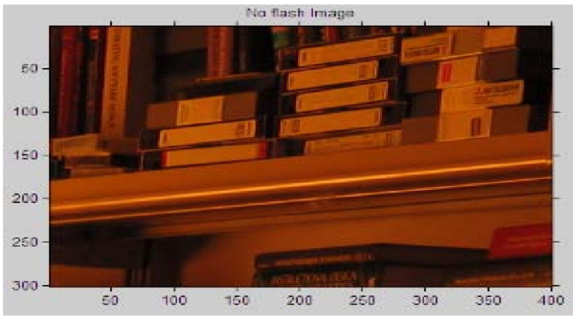
4.3 Removing the Reflections in Glasses

While photographing through glass in low light, an ambient image is usually of stumpy quality and has low contrast. Using a flash improves contrast, but can result in reflections of objects in front of the glass. Fig.5 shows an example where the camera is looking at an office scene through a glass window.

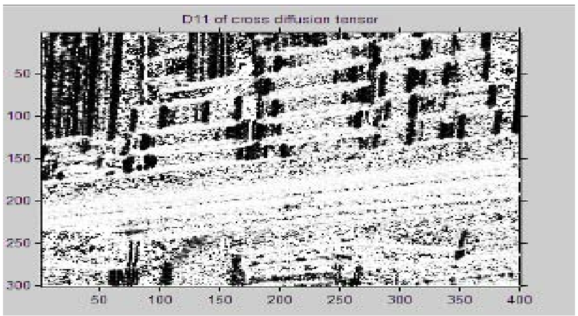
(a) Original Image



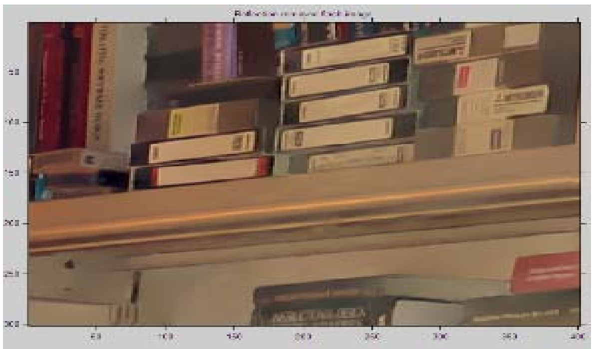
(b) Flash image



(c) No flash image



(d) D11 cross diffusion tensor



(e) Glass reflection removed

Figure 5: (a) Original Image (b) Flash Image A. (c) No flash Image without flash B. (d) D11 cross diffusion tensor (e) Glass reflection removed from flash image

5. Conclusion

We have made an approach for edge-suppressing operations on an image, based on affine transformation of gradient fields using cross projection tensor derived from another image. Here the approach is local and requires no global analysis. In recovering the illumination map, we make the usual assumption that the scene texture edges do not coincide with the illumination edges. Hence, all such illumination edges cannot be recovered. Similarly, while extracting foreground layer, edges of the foreground object which exactly align with the background edges cannot be recovered. This may be handled by incorporating additional global information in designing the cross projection tensors, which remains an area of future work.

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