Compensation for Specular Illumination in Acne Patients Images Using Median Filter

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Abstract—Specular illumination in digital images is one of the main causes, affecting the performance of image analysis techniques. The causes of this artifact include shiny nature of the surface on which the light is falling and the intensity and distribution of light. In this paper, it is explained that how specularly illuminated spots in the color images of acne patients can be detected and compensated for that. For detecting the specular illumination spots, a fixed threshold value were used in each of the three channels of the RGB color space and after that median filtering was performed in G and B channels only. Experimentation was carried out on twenty images of acne patients and subjectively satisfactory results were obtained. The effect of filter size on processing time was also examined and it was found that with increasing filter size, the time complexity of image processing also increases.

Keywords—**Acne lesion, median filter, specular illumination, filter size.**

I. Introduction

In digital photography, the specular illumination phenomenon occurs due to the shiny nature of the surface on which the light is falling [1]. In our case, specularly illuminated spots were observed in color images of acne patients due to either pus inside the acne lesions [2] or the due to oily material applied to faces. This specular illumination wash away the original color of the image and thus it makes high level image processing techniques such as segmentation and classification of acne lesion very challenging and difficult. In order to obtain reasonably high accuracy in high level image processing such segmentation, feature extraction and classification results, the color images need to be preprocessed as color is considered a useful feature in the segmentation of color images[3, 4]. Digital cameras usually use RGB color space to represent and store color images. However RGB color space is highly vulnerable to the intensity and distribution of light sources [5].Variations in lighting conditions causes changes in the appearance of color images [6]. In order to get rid of these issues, usually images from RGB color space is converted into other color space using either linear or non-linear transformation [7]. In some color spaces the luminance and chrominance are apart, for example, perceptually uniform color spaces like L *a*b in which L represents the luminance part and the other two components (*a,*b) carry the color information.

Other color spaces can be found in [8], [9] and [10]. Besides this, ratio color spaces and difference color spaces are also mentioned in literature [11]. The usability of color spaces depends on the type of color images. No color space is fit for all scenarios.

Median filter has been used in digital image processing. It is very useful in removing salt and pepper noise from images [12]. In case of salt and pepper noise, the pixel value is either very high or very low, so it is very rationale to use median filter for this kind of noise. The conventional or non-weighted median filter first sorts the values in the window of filter and then assigns the mid value to the center pixel of the window. Unlike other linear filters, median filter has edge preserving property. Since in conventional median filtering, every pixel of the image is processed whether or not it is contaminated with salt-and-pepper noise. In order to be applied to only noise corrupted pixels, progressive switching median filter was proposed [13]. Actually this technique consists of two steps; detection of pixels with salt-and-pepper noise and removal of noise using median filter several times. Other modified median filtering approaches like Laplacian switching median filter and fuzzy switching median filter are proposed in [14] and [15]. Fuzzy switching median filter has been proved very efficient in removing salt-and-pepper noise while retaining image details and textural properties intact. It makes use of fuzzy logic concept to detect noisy pixels in image and after that; median filter is applied to the noisy pixels only.

From color image analysis perspective, specular illumination can be considered a kind of salt noise as it degrades the color information of the digital images. So it is quite reasonable to use median filter of suitable size. Median filter can be used to color images in two ways; apply it to each of the three channels of RGB color space or convert the color image to some other color space where luminance and chrominance components are apart and apply median filter to the luminance component only. Applying median filter to color images is very tricky as changes in individual color channels values cause

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changes in the color of digital images. According to the application demands, median filter is applied to color image in modified and different ways and reasonably acceptable result can be generated.

II. METHODOLOGY

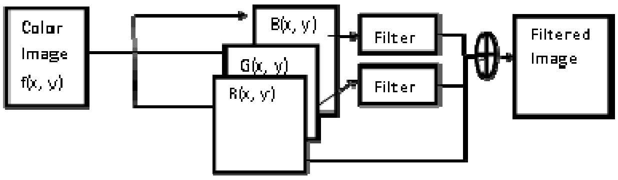


Figure 1 Flow chart for Processing specularly Illuminated region

Our proposed method consists of the following steps:

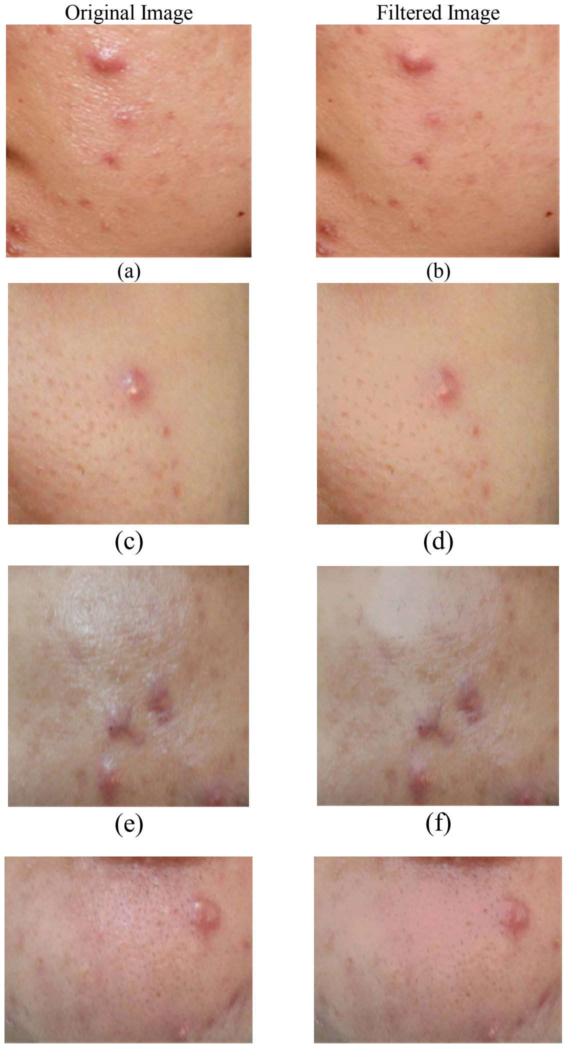
1. The input color image, say f(x, y) is split into corresponding R (x, y), G (x, y) and B (x, y) channels.
2. If pixel values in all the three channels at location (x, y) is greater than 170, then it is specularly illuminated otherwise it is not.
3. A window of some size say, w is drawn around that pixel only in green and blue channel.
4. All pixels in that window are sorted in descending order and the middle value is assigned to the pixel in the corresponding channels.
5. In the last the step, the three channels are concatenated together into color image.

Our proposed method comprises two main steps; detection of pixels contaminated with specular illumination and restoration from the illumination. To determine whether a pixel is contaminated, values for that pixel in each of the three channels (red, green and blue) is checked against a fixed threshold value (170). This threshold value is determined empirically. Now if values in all the three channels for a pixel are greater than the threshold, then it is declared to be contaminated pixel and need to be processed. The restoration process is explained in the form of block diagram as shown in Fig.1. The blocks labeled as filter are actually median filters and plus symbol block is for representing concatenation of the three channels into a single color image after the filtering process. The median filters are applied to the two channels; green (G(x, y)) and blue (B(x, y)) and the red channel (R(x, y)) is left as it is.

III. RESULTS AND DISCUSSION

In this section, the results of our proposed methods are shown. Results are generated with median filters of three different sizes. The effect of filter size on processing is also examined. We conducted experiment with twenty images of acne patients acquired at the Hospital Kuala Lumpur. These images are cropped from original images. These images were taken from five parts of the faces. The five parts include forehead, Nose, chin, left cheek and right cheek. For the sake of space, results only for few images are presented in this paper.

Original Image — Filtered Image



(a) (b) (c) (d) (e) (f) (g) (h)

Figure 2 Results of Median filter with size 51×51 pixels

Fig.2 represents the restoration results of median filter with window size of 51×51 pixels. The first column contains the original images with specular illumination while the second column contains filtered, that is illumination compensated images. From image Fig.2 (b) and Fig.2 (d), it is clear that our proposed technique performs well and produces best results. Our technique produces good results as long as the window size of the filter is larger than area of skin contaminated with illumination. One very interesting aspect of our technique is that it automatically assigns the color of lesions to illumination-affected pixels. The reason behind this is that the red channel is left unfiltered while the other two channels; green and blue are altered according to the median filter evaluation. Also the pixel is processed only if it affected with illumination. So in the filtered image, the red channel component is dominant and it gives the image reddish appearance on the more illuminated pixels. Fig.2 (f) shows that it does not produce good results when illumination contaminated area is quite large. In that case, this technique gives grayish look to the area affected. Even in this case, good results can be generated but for that we have to increase the filter size. But filters with very large size takes very long to be executed and cannot be used for real time application.

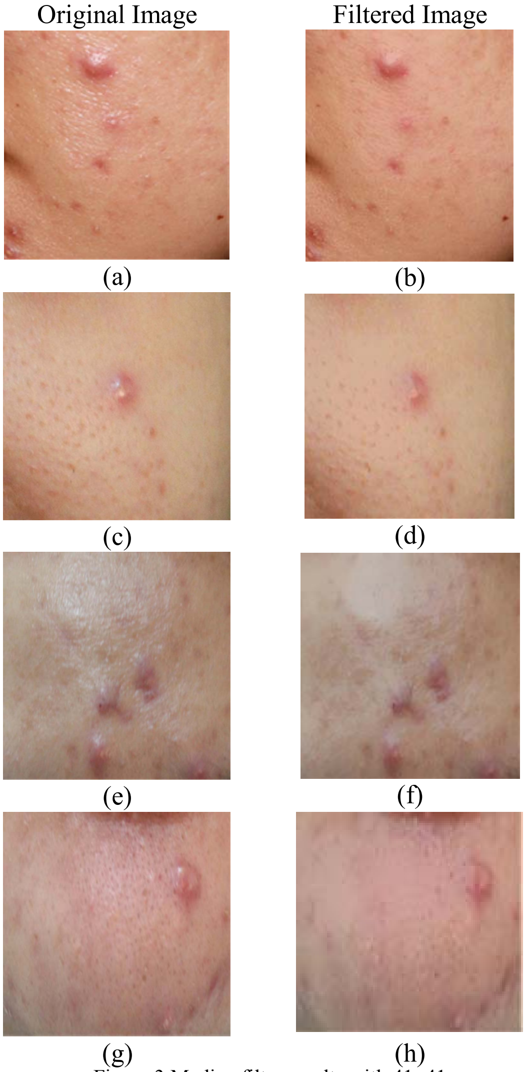


Figure 3 Median filter results with 41×41

Here in Fig.3, the results of applying median filter with size 41×41 are shown. The results are somehow similar to results in Fig.2. However the difference in the results can be observed from image Fig.3 (f) and Fig.2 (f). Similarly, results for median filter of size 31×31 pixels are in Fig.4. Even the results in Fig.4 suggest that as long as the filter size large enough for area affected with specular illumination, our techniques performs well. On the other hand, for larger affected area, the filter size can be increased at expense of increased processing time. In order to measure the time complexity of our technique, we experimented with twenty images of different sizes. We are presenting time elapsed in processing images of different sizes only for eight images.

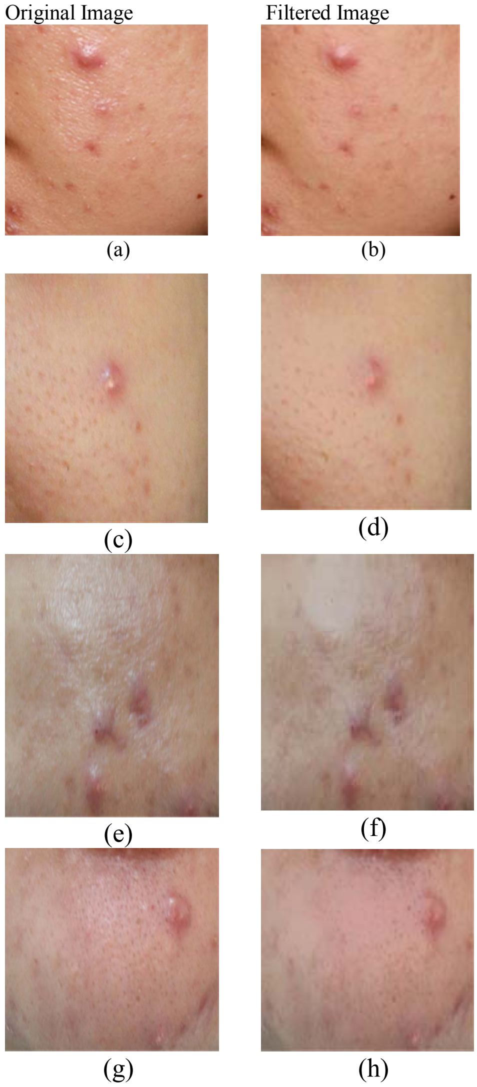


Figure 4 Median filter with size 31×31

Table 1 shows that how image-processing time decreases with decreasing size of median filter. In this case w represents the filter size or window size. We have tabulated processing time for eight images and three filters with different sizes and time is measured in seconds.

Table 1 Time (sec) complexity median filter with three sizes

k	w=51×51	w=41×41	w=31×31
1	50.17872	20.63754	11.17919
2	0.221214	0.130102	0.09914
3	1383.643	567.5474	313.3026
4	244.5866	100.1822	55.3177
5	136.2866	56.64974	31.18729
6	4.418667	1.826177	0.946086
7	397.4227	162.0166	87.54399
8	13.80575	5.484859	2.944167

In table 1, variation can be observed in two ways; across the columns and across the rows. Variation across the columns is due to different sizes of images while variation across the rows is due to increasing sizes of median filters. Second row in table 1 shows processing times for the first image and measured values for the three filter sizes (51, 41 and 31) are 50.1782, 20.63754 and 11.17919 respectively. Similar trends can be seen in processing time for other images. It proves that filter size and image processing time are proportional.

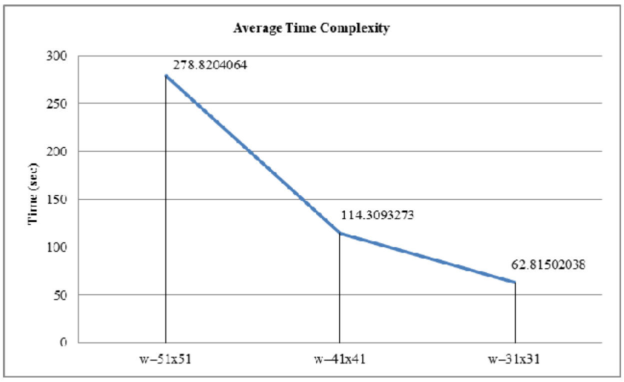


Figure 5 Time complexity for median filters

Figure 5 is the visual representation of data presented in table 1. In the graph, average time elapsed using median filter of specific size is plotted. The filters of different sizes are plotted along the horizontal line and the average elapsed time is plotted along vertical line. From this figure, it can be observed that peak corresponding to median filter of size w=51×51 is above the other two curves for all images. The peak corresponding to the filter of size 31 is the lowest for all images. So this graph also confirm presented in tabular form that processing time and filter size are proportional to each other.

IV. CONCLUSION

It can be deduced that if specular illumination is prevailing on skin area less than the filter size then it can be detected and compensated easily using median filter. This method can be very useful when the specular illumination is due to oily nature of pus inside acne lesion (pustule). We are expecting, our technique can be helpful in producing accurate in segmentation. However if the affected skin area is larger than filter size, in that case this method does not produce promising ,however the window size of the filter size of the filter can be increased. On the other hand, the window size of the filter and time complexity of filtering is proportional. As the window size increases, so does the time complexity of the algorithm.

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