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Removal of Hair Particles from Skin Disease Images Using Pixel Based Approach

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Abstract— A methodology for digital hair removal from clinical dermoscopic images, based on mathematical operations is proposed in this paper. The approach used in case of grayscale images, is based on edge property of the images, where a circular mask is used for removal of non-skin element and reconstructing the image by normalized pixel values. In case of RGB images, based on histogram values, frequency of occurrence is measured through individual components. A list is deduced from this measurement that best defines the image. Neighborhood operation based on minimum distance approach between each pel component is the key strategy. It preserves the border properties. This method is applied on enormous number of image data and is observed to be produced suitable results.

***Keywords*—Dermoscopy, image enhancement, skin disease, Hair removal**

I. Introduction

Computer aided analysis of disease affected skin lesions occluded by hair is an exigent job. More than a few digital hair removal methods deal with this by tracking and replacing such hair by probable colors based on adjacent skin pixels. Regardless of several work in this part [4, 11, 20, 10, 6, 8], these strategies are challenged by hairs which are lean, entwined of analogous color properties and are of same contrast to original skin. Due to these particles, the disease affected region-of-interest is corrupted at times.

We propose a new approach for removal of hair particles from digital skin images, that overcomes by and large all of the above discussed problems.

For gray scale operation, main strategy is the averaging of the two pixel values into the circular mask, whereas the pixel sets are preferred based on fulfilling the threshold constraint relation of the logically coherent and median value of the categorized list. This method is appropriate in case of gray scale images, and it does not produce any blur effect if the threshold pixel is singled out properly.

In RGB images, the process applied is changed from averaging method to evade partial dislocation of high density pixels in three different component spaces, i.e. in each of the R, G, B component spaces. Initially, the pixels in each of the individual components, i.e. red components are selected by arranging them into a sequence that represents the high coherency to low coherency set. Then replacing the lowest frequency measures by their nearby value pixels and this improved set for each colour component is taken for calculating Euclidian distance among the pixels of each colour component individually. Then ultimately the outcome is achieved by replacement method of closest distanced pixels having values outside a predefined threshold value that resides in the hair particle area. The result is suitable.

II. Previous Work

Several hair removal methods have been proposed earlier. Using several morphological operators, hair particles are removed used in the strategies used in [1,2].

Alexandra Nasonova uses convolution based Gabor filtering approach to detect hairy pixels, and additionally extended to morphological closing operation, finally PDE-based approach was implemented to remove hair pixels.[3]

DullRazor, the robust and arguably best known method, finds dark hairs on light skin by a generalized morphological closing using three structuring elements that model three line orientations [4]. It frees the images from hairs by fundamental image bilinear color interpolation, additionally extended to partial differential equation based approach [5]. However, DullRazor cannot discover and get rid of low-contrast thin hairs or highly warped hairs.

Abbas et al. imply to locate hairs by a filtering approach called derivatives-of-Gaussian filter [6,7]. Although this technique shows good quality outcome on a few chosen images, it has a lot of procedure factors which produces high complexity.

Huang et al. uses a multiscale matched filtering approach and thresholding to detect hairy regions and thus eliminate these by region growing with partial differential equation based inpainting [8]. On the other hand, this technique is relatively takes long time.

Locating some stretched out objects such as arterial vessels is approached by path opening methods [9]

VirtualShave finds hairs by using an approach that uses top-hat filtering, similar to [10], it also uses three compactness, convex-hull based sphericity metrics to detach lean stretched out hairy structures from other compact location[11]. The grayscale skeletons [12] method fills lean gaps alike to hairy pels .

III. PROPOSED WORK

The proposed methodology has been divided into the under explained following stages:-

3.1 Database Creation and Image Preparation:-

The skin disease affected images are captured with a powerful digital camera, with the following specifications to be maintained/kept for the image:

(a)The image size must be 100 X 100
(b)The images are of .bmp, .jpeg, .tiff file formats.
(c)The bit depth: 24 bit
There are 20 types of skin disease images with hairy lesion, which are stored in the database.

After that the following steps are followed:-
Step1: Start
Step2: Set a variable NUMRGB to the value of total no of files that is counted for RGB color images count.
Step3: Set a variable NUMGRAY to the value of total no of image files.
Step4: Set a variable TOTAL to the value of total no of image files irrespective of color map.
Step 5: Store the files from their respective folders into an array for future processing.
Step6: Convert the RGB image into its equivalent grayscale image using the luminosity method:

$$G=0.21R+0.72G+0.07B \qquad (1)$$

Save this grayscale images into another folder.
Step7: Store the files from the grayscale images folder into an array for future reference.
Step8: Convert the RGB format image files into binary mode and save as a 1-D array.
So, output of this phase is 8-bit grayscale image and binary image having its corresponding values.
Step9: Go to the next phase.

3.2 Hair Particle Detection in Grayscale Images:-

Step1: Start
Step2: Load the 8-bit intensity image (range of pixel values: 0-255) and store the pixel values in a one-dimensional (1-D) user defined array. The array class can be declared as of double, uint8, or uint16.
Step3: Identify the edge pixels of the intensity image using Sobel's edge detector.
Step4: Store the edge values into a n-dimensional array Q as a property.
Step5: Select the subset Q1 from Q that constitutes the darker region, i.e. values near 0 values.
Step6: Apply Hough Transform technique to detect the valid hair lines depending upon set Q1:
(i)Quantize the Parameter space. If the current pixel lies in Q1 space, then
(ii) Calculate ρ for the pixel at (x,y) and θ.

$$\rho=x\cos(\theta)+y\sin(\theta) \qquad (2)$$

(iii)Go to the next position of (ρ, θ) in the accumulator array P.
(iv)Display the Hough Space.
(v)Draw the valid line segments connecting the local maxima values.
(vi)Store the pixel values residing on the valid line segments into a static array for further processing. This becomes the determinant set for setting the threshold limit in choosing pel values in the next phase.
Step7:Go to next phase.

3.3 Hair Particles Removal:-

3.3.1 Hair Particles Removal in Grayscale Images:-

Step1: Start
Step2: Create a kernel of circular shape having radius R.
Step3: Pick the pixel value from the circular kernel that is marked as coherent pel(p_x) and has a value p_x>20.
Step4: Pick the median value (p_y) >20 from the mask.
Step5: Then calculate average of p_x and p_y, i.e. $s= (p_x+ p_y)/2$
Step5: Substitute this's' value into the central position of the kernel.
Step6: Continue this process until the all pixels from that image are visited.
Step7: Save the final image into Test folder.
Step8: Go to next stage.

3.3.2 Hair Particles Removal in RGB Images:-

Step1: Start
Step 2: Read a standard RGB image.
Step3: Get the dimensions of the image and store into variables m, n, p.
Step4: Extract individual red, green and blue components of that image and store each of these components separately into three different arrays.
Step5: Calculate the image histogram for color vectors C= (c1, c2,….., cn) for each set of R, G,B values separately. C denotes the pixel set values.
Step6: Measure the frequency of occurrence of each pixel value in each of the three channels: R, G and B. Store the pixels from each channel based on frequencies into three distinguished arrays : namely f1, f2 and f3.
Step7: Choose N- no of values from each of the sorted list f1, f2, f3 those have the highest probability of occurrence. So this set of coherent pixels from each channel becomes $\{f1^h, f2^h, f3^h\}$.
Set $f1^h \in$ RedComponent; Set $f2^h \in$ GreenComponent; Set $f3^h \in$ BlueComponent
Step8: Choose another N-no of values from each of the sorted list f1,f2, f3, those have lowest occurrence probabilities, i.e. incoherent pixels: name this set as $f1^l, f2^l, f3^l$.
Set $f1^l \in$ RedComponent, Set $f2^l \in$GreenComponent , Set $f3^l \in$ BlueComponent

Step9: Calculate normalized Euclidian distance between each color pixel for every individual color component.

$$CD= (\Sigma^{m}_{i=0} \Sigma^{n}_{j=0} ||\Delta E_{RGB}||)/ (\Sigma^{m}_{i=0} \Sigma^{n}_{j=0} ||E^*_{RGB}||) \quad (3)$$

$$\Delta E_{RGB}= [(\Delta R^*)^2 +(\Delta G^*)^2+(\Delta B^*)^2]^{1/2} \quad (4)$$

$$E^*_{RGB}=[(R^*)^2 +(G^*)^2+(B^*)^2]^{1/2} \quad (5)$$

Where, ΔR^*, ΔG^*, ΔB^* are the difference in the R*, G* and B* components respectively, between two color vectors considerably. ΔE_{RGB} is the color error which is calculated for each pixel.

```
for(x=0;x<=RGBMaskImage.rows-1;x++) {

for (y=0;y<=RGBMaskImage.cols-1;y++) {

    for (i=0;i<n1;i++) {

      for (j=0;j<n2;j++) {

        for(k=0;k<n3;k++){


          R1=extractedColor.value;
          //Delta (R1) =Mean (R1i,j,k)-R1i,j,k

  DeltaE_color_class1=sqrt[Delta(R1)^2+Delta(G1)^2+Delta(B1)^2]
        }
        }
      }
    }
  }
}
```

Step10: Calculate a suitable threshold value (Here T=128) based on the hair region pixels.

Step11: Pick those pixels from the entire set $F=\{f1,f2,f3\}=\{ f1^h\ f2^h,\ f3^h\ ,f1^l,f2^l,f3^l \}$ those have values lying in the outer range than T to create threshold mask.

Step12: Create a mask region for each color component, where selected_Component_pixel ∈F;

```
    %Image_component1=selected_Component_pixel<T

  Image_component1=redComponent_pixel<T;
```

Step 13: Replace those pixels that have values in the T plane, with its nearest minimum distanced (having minimum Euclidian distance), pixel value which satisfies the condition.

```
  If( r=(new_redComponent!=T))

    Image_Component_Nohair=r;
```

Step14: Do step 11, for each channel, i.e. (R, G, B) individually.

Step 15: Combine the separate normalized color channels: R, G, and B in order to reconstruct the image based on the normalized pixel values, which is free of hair pixels.

Step 16: Stop

IV. Result And Analysis

The proposed algorithm was tested for a set of skin disease images and showed efficiency. Various test results with discussions are displayed in figure 1(a) and figure 1(b), (c), (d), (e), (f), (g), (h) and in figure 2(a),2(b),2(c).

The algorithm serves sensitivity of 86.56%.

The proposed methodology was implemented and tested among some clinical images corrupted with hair pixels. It is to be mentioned that in this paper, the black hair pixels are removed using two different strategies in case of grayscale image and of color images. For grayscale image, an edge detector algorithm such as Sobel operator is applied on the whole image in order to detect the edge pixels in them. The binarized output of edge detection is shown in figure 1(d). Then, from the edge pixels, those are chosen that lies into the domain of black pixel region, i.e. representing hair pixels. These pixels form another sub image area, upon which Hough transformation is done to detect the hair ruling lines, the result of Hough transform is shown in fig1(b) and the accumulator array is shown in fig1(c). So, this gray image is further processed to remove the hair pels by using a pixel-based approach, whereas a circular mask is used and the value chosen for substituting the kernel becomes by averaging the coherent and median value from the mask. After this substitution all over the image area, the final output is shown in fig1 (e), which is no-hair grayscale image from which region-of-interest can be extracted easily. In case of RGB images, we apply different approach, whereas the pixels are ordered into two sets: first one containing the pixels with highest frequency of occurrence and second set contains lowest frequency of occurrence. Then we deduct the mostly lowest frequency pixels and the new pixels forming the new image are parameter to next calculation. A set of values are taken as threshold for each of the color channel, that denotes the hair area, and these are substituted by that minimum distanced pixel that does not lie into the threshold space. Fig1(g) shows if we choose large sized window and at the same time minimum distanced pixel that does hold the brighter value, the result can affect region-of-interest in case of RGB images. But, if smaller size window is used, here 3 X 3, then if the threshold chosen is appropriate, then applying Gaussian filter gives the result which is more suitable.Fig2(a),2(b),2(c) shows the outcome of the methodology on another image.

This implementation is done using MATLAB language.

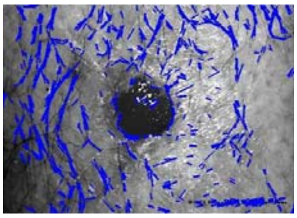

Fig. 1(a): Original Image Fig. 1(b):Hair particle Detection

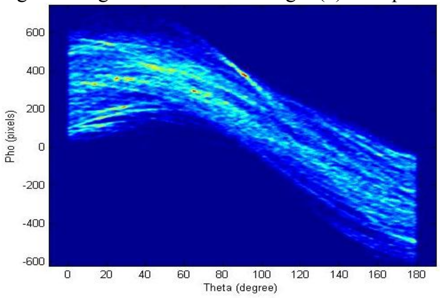

Fig. 2(c):Accumulator array

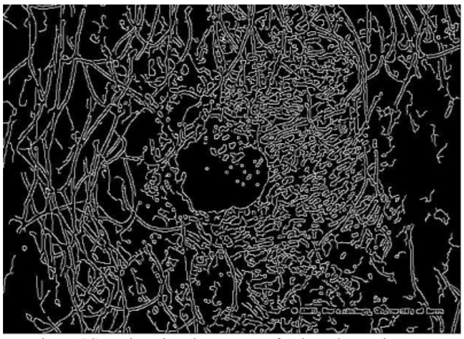

Fig 1(d) :Binarized output of edge detection

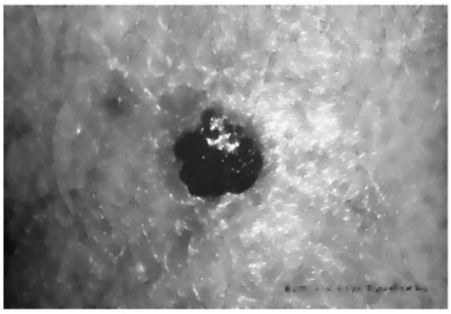

Fig 1(e):Final output image

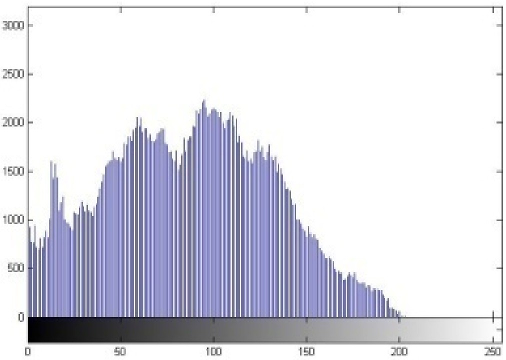

Fig 1(f):Histogram representation

Fig 1(g):Case 1 output RGB image

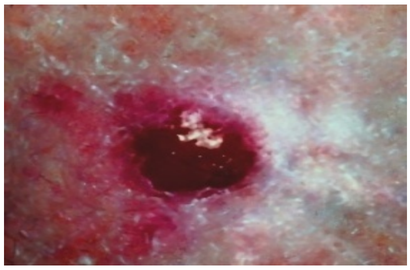

Fig1(h):Case 2 output RGB Image

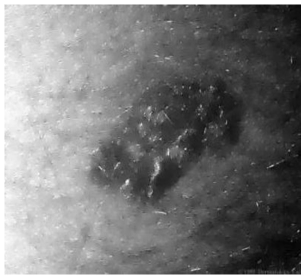

Fig 2(a):Original Image Fig 2(b):Non-hairy Output image

Fig 2(c):Final RGB output image

V. CONCLUSION

A large number of image data has been tested. Only one such instance is shown in this paper. In case of gray scale operation, the averaging of the two pixel values into the circular mask, whereas the pixel sets are chosen based on satisfying the threshold constraint relation of the coherent and median value of the labelled list. This method is applicable in case of gray scale images, and it does not produce any blur effect if the threshold pixel is picked appropriately. In RGB images, the method applied is different from averaging method to avoid partial displacement of high density pixels in three different component spaces, i.e. in each of the R, G, B component spaces. Firstly, the pixels in each of the individual components, i.e. red components are chosen by arranging them into a series that represents the high coherency to low coherency set. Then replacing the lowest frequency particles by their closest value pixels and this renewed set for each colour component is taken for calculating Euclidian distance between the pixels of each colour component individually. Then finally the result is achieved by substitution method of nearest distanced pixels having values outside a predefined threshold value that resides in the hair particle domain. The result is satisfactory. But the pitfall in case of RGB operations is that when an image has one side much brighter, and if it has hair particles affecting the region-of-interest, then sometimes, the brighter portion effects the region-of-interest by blurring the area(as shown in fig1(g)). In order to remove this effect, use of a Gaussian mask filter at the time of substitution is the solution which produces the result as shown in Fig1 (h).

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