Various Image Enhancement Techniques for Skin Cancer Detection Using Mobile App

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***Abstract*—This paper aims to identify efficient image enhancement techniques in order to detect the preliminary effect of skin cancer. The protruding regions present on images of the skin need to be identified for further diagnosis by oncologists. We consider well established image enhancement techniques to increase or decrease image brightness and contrast levels. Specifically, we consider adaptive unsharp masking, adaptive histogram equalization, adaptive neighborhood contrast enhancement and local and global contrast stretching. We present results using these techniques on color and grey scale images in order to develop mobile application which patients can use to send such images to a medical practitioner. The application is linked to an electronic Health Information System, whose functionality is augmented by the use of this simple and efficient mobile image enhancement application. Here, the results that showed up have been discussed below.**

Keywords—**Image Enhancement, Spatial Domain, Frequency Domain, Cancer Detection, Unsharp Masking, Histogram Equalization, Adaptive Neighborhood Contrast Enhancement, Local and Global contrast stretching, Mobile health applications, Health Information System**

I. INTRODUCTION

Image enhancement is the processing of digital images to obtain the required quality through various methods which involve processing in the spatial domain and frequency domain. The image enhancement techniques provide a way to improve the object detection and identification under low illumination conditions. It can be used to make an image lighter or darker, or to increase or decrease contrast. Various methods have been designed by the researchers for improving the image quality. The most common method of enhancing the image quality is to enhance its contrast. The image contrast is defined as the perceived difference in colors which are in close proximity to each other. Using contrast effectively not only differentiates our image from others, but also it is the essential tool that makes content looks pleasant to other viewer. The objective of image enhancement is to improve visual quality of image depending on the circumstances of petition. [10]

Cancer Detection is the process of recognizing possible warning signs of cancer and taking prompt action leading to an early diagnosis. It increases awareness of possible warning signs of cancer among physicians, nurses and other health care can have a great impact on the disease. The sooner cancer is detected more chances for better recovery.

A mobile app is a computer program used for general productivity and information retrieval. The UI design in mobile apps considers constraint and context, screen, input and mobility as outlines for design.

II. SPATIAL AND FREQUENCY DOMAIN

Contrast can be defined as the ratio of the maximum intensity to the minimum intensity over an image. Contrast ratio has a strong bearing on power resolving and detects ability of an image. Larger this ratio, more easy it is to interpret the image. [1]

The contrast enhancement of image refers to the amount of color or gray differentiation that exists between various features in digital images. It's a range of the brightness present in the image. There are several methods of spatial domain and frequency domain that have been proposed to achieve contrast enhancement invariant to illumination variations. These are known as grey scale manipulation, Image Smoothing, Image Sharpening, High Boost Filtering and Homomorphic Filtering. [5]

The term spatial domain refers to the image itself plane, and approaches in this category are based on direct manipulation of pixels in an image. In Frequency domain processing, all techniques are usually based on modifying the Fourier transformation of an image.

Image Enhancement techniques that have been used in the paper based on these methods [9]

1. Adaptive Unsharp Masking
2. Adaptive Histogram Equalization
3. Adaptive Neighborhood Contrast Enhancement
4. Local and Global Contrast Stretching

1. ADAPTIVE UNSHARP MASKING

Adaptive Unsharp Masking includes the sharpening action controlled by an adaptive filter based on the input contrast, and low-contrast details are more enhanced than high-contrast details. This technique uses a blurred, or "unsharp", positive image to create a mask of the original image. The use of adaptive unsharp masking on a sample image is shown in Fig. 1.

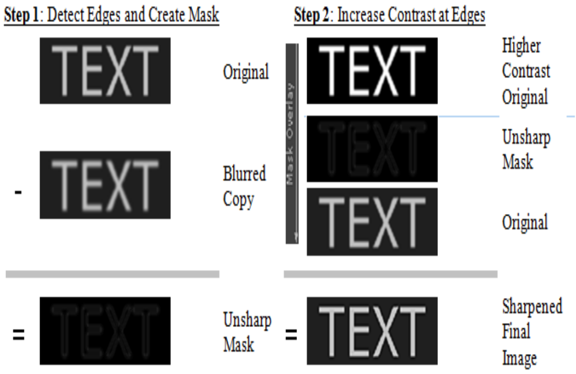


Fig 1: Steps to formulate adaptive unsharp masking

The "mask overlay" is when image information from the layer above the unsharp mask passes through and replaces the layer below in a way which is proportional to the brightness in that region of the mask. The above image does not contribute to the final for regions where the mask is black, while it replaces completely the layer below in regions where the unsharp mask is white.

If the resolution in the above image is not increasing, then final text becomes much sharper. Now we can better see how it works if we magnify and examine the edge of one of these letters as shown in Fig 2:

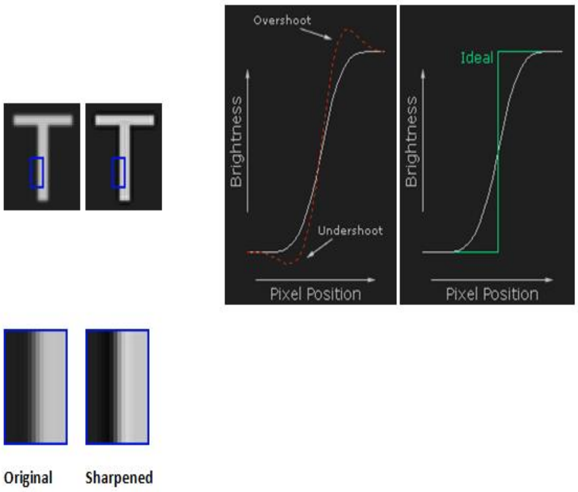


Fig 2: Graphical Representation of particular pixel of image

It may be noted that image does not transform the edges of the letter into an ideal "step," but instead exaggerates the light and dark edges of transition. An unsharp mask improves sharpness by the increasing acutance, albeit resolution remains the same. Unsharp masks are not new for photography. Traditionally, they were performed with film by utilizing a softer slightly out of focus image (which would act as the unsharp mask). The positive side of the unsharp mask was then sandwiched with the negative of the original image and made into a print. This was used more to enhance the local contrast than small-scale detail. This was used more to enhance the local contrast than small-scale detail.

Typically three settings control digital unsharp masking: [3]

•Amount is listed as a percentage, and controls magnitude of each overshoot (how much darker and how much lighter the edge borders become). This can be thought of as how much contrast is added at the edges. It doesn't affect the width of the edge rims.

•Radius affects the size of the edges to be enhanced or how wide the edge rims become, so a smaller radius enhances the details of smaller-scale. Higher radius values can be a reason of halos at the edges, a detectable tenuous light rim around objects. Fine detail needs smaller radius. Radius and amount reduction allows more of the other.

•Threshold controls the minimum brightness change that will be sharpened or how far apart adjacent tonal values have to be before the filter does anything. This reduction of action is important to prevent smooth areas from becoming speckled. The threshold setting can be used to strop more-pronounced edges, while leaving subtler edges unimpaired. Low values should strop more because fewer areas are excluded. Higher threshold value excludes areas of lower contrast.

2. ADAPTIVE HISTOGRAM EQUALIZATION

The histogram in the context of image processing is the representation of which the occurrences of each intensity value in the image. Normally, the histogram is a graph that shows the number of pixels in an image at each different intensity value found in that image.

Histogram equalization is a technique for adjusting image intensities to enhance contrast. This method usually increases the global contrast of many images, especially when the useful data of the image is represented by close contrast values. Via this adjustment, the intensities can be better distributed on the histogram. This allows for the areas of lower local contrast to gain a higher contrast. Histogram equalization possess this by effectively spreading out the most frequent intensity values. [7]

The equation transforms the gray levels of the image so that the histogram of the resulting image is equalized to become a constant by equation (1):

$$h[i] = constant, \quad 0 \leq i < L \ldots (1)$$

Where, h[i] is the histogram equalization and L is the number of possible intensity values usually 256.

The purposes:

- To equally make use of all the gray levels available in the dynamic range;
- For further histogram specification.

The goal of histogram equalization is to reshape the image histogram to make it flat and wide.
In order to equalize the histogram a cumulative histogram as the integral of intensity mapping function has been used.
A cumulative histogram counts cumulative cases over the range of cases. The main drawback of histogram equalization due to which adaptive histogram equalization came into existence is the grey values of an image is physically far apart from each other. The histogram could not be flattened due to which loss of information takes place.
Adaptive Histogram Equalization (AHE) is a technique used to improve contrast in images. The adaptive method computes several histograms, each corresponding to distinct section of the image, and use them to redistribute the lightness values of the image. It is suitable for improving the local contrast. This technique transforms each pixel with the transformation function derived from a neighborhood region.

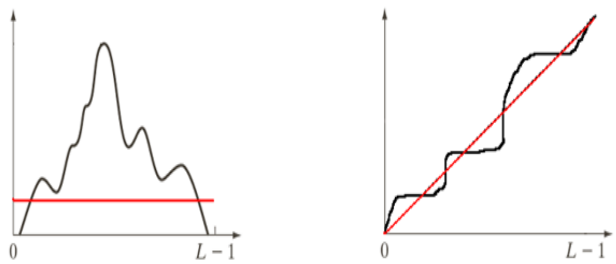


Fig 3: Cumulative histogram as intensity mapping function

Adaptive Histogram equalization can be done in three steps:-

1. Compute the histogram of the image
2. Calculate the normalized sum of histogram
3. Transform the input image to an output image

An example of histogram equalization is shown in Fig 4.

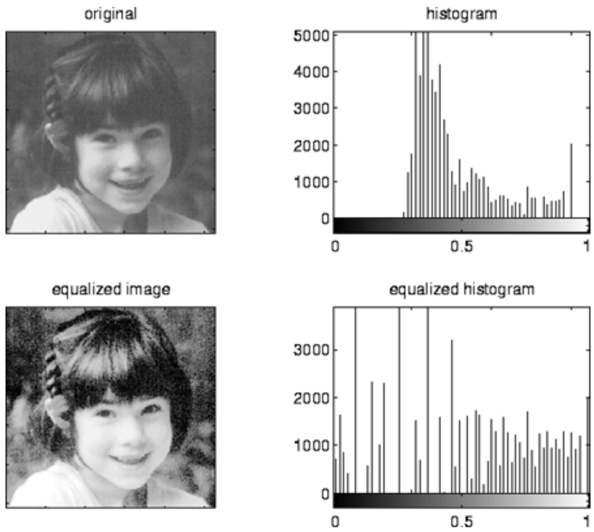
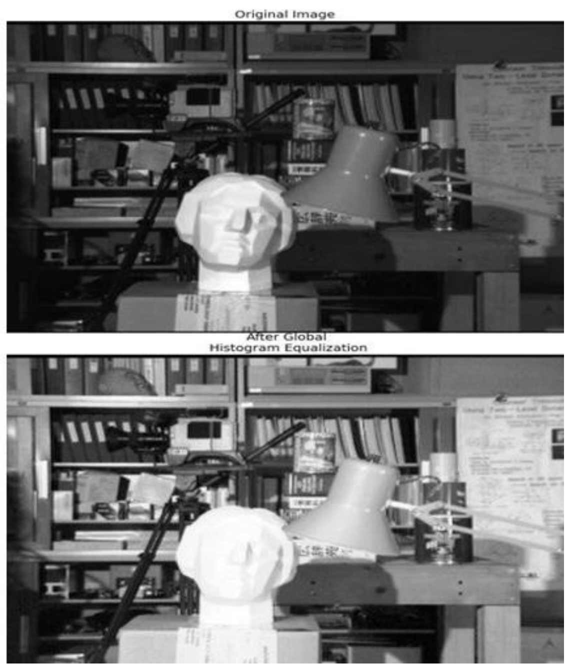


Fig 4: Histogram formulation of original and equalized image

The histogram equalization, considers the global contrast. In many cases, this is not a good idea. For example, above image shows an input image and its result after global histogram equalization.

3. ADAPTIVE NEIGHBORHOOD CONTRAST ENHANCEMENT

In the algorithms already discussed, the local neighborhood at every pixel is a rectangular region, which may not adequately represent the local characteristics of a pixel. Thus, at every pixel it is important to define a contextual region, appropriate to that particular pixel that defines the local neighborhood of that pixel. This is done with adaptive-neighborhood or region-based image processing.



After neighborhood contrast enhancement

Fig 5 : Shows an input image and its result after global histogram equalization and neighborhood contrast enhancement.

Consider an example shown in FigV. It is true that the background contrast has improved after histogram equalization. Comparing the face of statue in both images we lost most of the information due to over-brightness. This is because its histogram is not confined to a particular region as in previous cases so to solve this problem, adaptive histogram equation is used. In this, image is splitted into small blocks called "tiles" (tile size is 8x8 by default in OpenCV [11]). Then each of these blocks are histogram equalized as usual. So in a small area, histogram would confine to a small region (unless there is noise). If noise is there, it will be amplified. To avoid this, contrast limiting is applied. If any histogram bin is above the specified contrast limit (by default 40 in OpenCV), those pixels are clipped and distributed uniformly to other bins before applying histogram equalization. After equalization, to remove artifacts in tile borders, bilinear interpolation is applied.

The basic idea of this method is to increase the contrast of only those regions whose contrast is lower than minimum contrast and to retain other regions with no change. The method consists of computing a local contrast around each pixel using a variable neighborhood whose size and shape depend on the statistical properties around the given pixel.

4. LOCAL AND GLOBAL CONTRAST STRETCHING

Local contrast stretching equalizes contrast throughout the image and makes it easier to see image detail in regions that were originally very light or very dark. Local contrast stretching is an enhancement method performed on an image for locally adjusting each picture element value to improve the visualization of structures in both dark and lightest portion of the image at the same time. Here, the kernel has been used. [5]

Local Contrast Stretching (LCS) is performed by sliding windows (called the KERNEL) across the image and adjusting the centre element using the equation (2):

$$Ip(x, y) = 255. [Io(x, y) – min] / (max - min) \ldots (2)$$

Where, Ip(x, y) is the color level for the output pixel (x, y) after the contrast stretching process. Io(x, y) is the color level input for data the pixel(x, y).

Max- is the maximum value for color level in the input image.
Min- is the minimum value for color level in the input image.

Global contrast stretching considers the entire color palate range at once to determine the maximum and minimum for all RGB color image. The combination of RGB color will give only one value for maximum and minimum for RGB color. This maximum and minimum value will be used for contrast stretching process. This technique enhances the image from the luminance information of an entire image. Image with a high global contrast will present a detailed and variation-rich image. On the other hand, image with a lower global contrast contain less information, less details and appears to be more uniform.
The formula for global contrast stretching is governed by equation (3):-

$$out_{RGB}(x,y) = 255 * \left[\frac{in_{RGB}(x,y) - min_{RGB}}{max_{RGB} - min_{RGB}}\right] .... (3)$$

Where, $\mathrm{in_{RGB}}(x,y)$ is the original value of the pixel, $\mathrm{out_{RGB}}(x,y)$is the new RGB value of the pixel, $min_{RGB}$is minimum value between the RGB components, and is $max_{RGB}$is maximum value between the RGB components.

III. RESULTS

The various image enhancement techniques that have been applied on particular images can be differentiated on the basis of image size and in order to formulate a particular use of it.
In case of Adaptive unsharp masking, we have compared the different parameters on two images as:

S.No	ORIGINAL IMAGE	ENHANCED IMAGE	Image Size
1			Incremented from 281 KB to 523 KB
2			Reduced from 114 KB to 17.8 KB

Fig 6: Results of Adaptive Unsharp Masking

The original image of cancer affected region present on leg and eye as shown in Fig 6 above gets enhanced through adaptive unsharp masking thereby changing the image size
In case of Adaptive histogram equalization, we have compared the different parameters on two images as:

S.No	ORIGINAL IMAGE	ENHANCED IMAGE	Image Size
1			Reduced from 281 KB to 34.9 KB
2			Reduced from 114 KB to 51.9 KB

Fig 7: Results of Adaptive Histogram Equalization

The enhanced image from Adaptive Histogram Equalization as shown in Fig 7 gets reduced to less than minimum range of values thereby showing the protruding region more effectively.

In case of Adaptive neighborhood contrast enhancement, we have compared the different parameters on two images as:

S.No	ORIGINAL IMAGE	ENHANCED IMAGE	Image Size
1			Reduced from 281 KB to 14.6 KB
2			Reduced from 114 KB to 39.5 KB

Fig 8: Results of Adaptive Neighborhood Contrast enhancement

The images of cancer affected regions as shown in Fig 8: above only focuses on the affected part in enhanced form. It also reduces the size of image to minimum.

In case of Contrast stretching, we have compared the different parameters on two images as:

S.No	ORIGINAL IMAGE	ENHANCED IMAGE	Image Size
1			Reduced from 281 KB to 30.3 KB
2			Reduced from 114 KB to 35.9 KB

Fig 9: Results of Contrast Stretching

The enhancement of images of image from cancer affected region at particular range of values has been shown in Fig 9 above with the reduction in the size of image.
The graphical representation of the above images at certain values can be shown as in Fig 10 as:

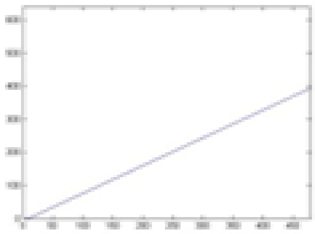
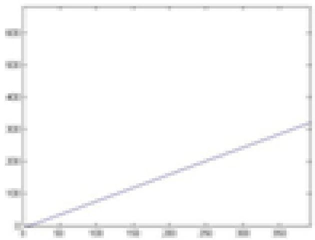
S.No	GRAPHICAL REPRESENTATION
1	
2	

Fig 10: Graphical Representation of enhanced images in contrast stretching

In the mobile app as client an image have been picked from gallery and submitted to server. Server consists of the image enhancement techniques in a well-defined form with the original image and the enhanced images independently. The medical practitioner who is involved with this app can download any of the images to analyze the affected region. The medical practitioner or doctor can send the response in the form of email or message to the registered detail of a particular patient with the original image of the patient.
Authors are indebted to all the providers whose images have been used in all above analysis.

IV CONCLUSION AND FUTURE WORK

This paper provides the basic techniques of image enhancement by providing the result of different parts of skin affected by skin cancer. The images are differentiated on the basis of different parameters by concluding the image size and RGB values with the enhanced form of the original image.

For mobile app implementation normal digital camera has been used for input image and the enhanced output has been provided, therefore initial techniques have been preferred. The main idea of this paper is to provide enhanced images through above mentioned techniques based on well defined parameters so that it can be helpful for doctors and other medical practitioners to conclude the result and use any of the techniques as per requirement.

As part of the future work, we can also apply one image enhancement technique to the enhanced image itself thereby creating a hybrid of two or more techniques.

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[1]