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A Comparison of the Vein Patterns in Hand Images with other image enhancement techniques

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ABSTRACT
This research work presents an overview of image enhancement processing techniques in spatial domain and frequency domain to enhance the vein patterns in hand image and a comparative study is made between these techniques. Captured hand image needs better enhancement technique to detect the vein patterns due to existence of indistinct state and unwanted noise in hand image which result in false detection of veins. The image preprocessing such as image enhancement techniques are necessary to improve the image for visual perception of humans and making further easy processing steps on the resultant images by machines. This research work explains various enhancement techniques such as image negative, gray level slicing, contrast limited adaptive histogram equalization, Laplacian filtering, unsharp masking, sharpening and high boost filtering. **Homomorphic filter** ***characteristic is used for nonlinearities (mainly the logarithm) to transform convolved or nonlinearly related signals to additive signals and then to process them by linear filters. A comparative study on all these enhancement techniques is carried out to find the best technique to enhance hand vein pattern. The various contrast enhancement techniques are effectively applied on the captured hand image. From these techniques, homomorphic filtered image gives the best result and could give exact information about the vein pattern in the captured image. As a result, vein can be detected using this technique appears to be clearer and would provide ease further analysis in vein applications. Image quality measures (IQMs) are also evaluated and tabulated.***

Keywords: Hand Vein Image Enhancement, Contrast Limited Adaptive Histogram Equalization, Homomorphic Filtering Filtering, Image Quality Measures.

1. INTRODUCTION

In circulatory system, veins are the blood vessels that carry deoxygenated blood from the tissues back to the heart. Veins are available close to the surface of the skin as well as away from it, the closer ones are called superficial veins and the other ones away from the skin are called deep veins. Even though superficial veins are closer to the skin they are not completely visible for our naked eyes, only a part of it is visible [1]. By making the vein pattern visible or detecting, it could be applied in the fields of biometrics and biomedical. For both the application, the vein detection is considered on the upper limb superficial vein especially on the back of the hand above the wrist region [2][3]. To detect the vein on the superficial part, certain acquisition steps of hand image is needed.

In recent years, hand vein pattern has attracted biometrics increasing interest from both research communities and industries [4]. In biometrics, veins are unique patterns for every individual and can be used for accessing, identifying, authenticating purposes. From the detected vein, certain features are extracted out and matched with already stored features by using classifier for the above mentioned purposes. In biomedical, catheterizations on vein are performed by trained professionals, even they also find difficulties in finding veins in emergency cases. Thus the aiding system pointing on a hand region recognizes the vein patterns in that region and projects it back on the same region makes the vein visible for catheterization purpose [5][6].

In this paper, a comparative study on enhancement of vein patterns in hand images is proposed. The rest of the paper is organized as follows: Section 2 discusses various enhancement operations are carried out on the captured image such as image negative, gray level slicing, contrast limited adaptive histogram equalization, unsharp masking, high boost filtering, sharpening. Section 3 gives the proposed methodology. Section 4 describes the image quality measures on all these enhancement techniques of hand vein image and the result shows the proposed system provides better image and better image quality measures. Finally conclusion is presented in section 5 of the paper.

2. EXISTING METHODOLOGY

2.1 Spatial Domain Methods

Spatial domain techniques directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. Spatial domain techniques like the logarithmic transforms, power law transforms, histogram equalization, are based on the direct manipulation of the pixels in the image.

Spatial techniques are particularly useful for directly altering the gray level values of individual pixels and hence the overall contrast of the entire image. But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results. It is not possible to selectively enhance edges or other required information effectively. Techniques like histogram equalization are effective in many images. The term spatial domain refers to the aggregate of pixels composing an image. Spatial domain methods are procedures that operate directly on these pixels. Spatial Domain processes will be denoted by the expression

$$g(x, y)= T[f(x, y)] \qquad \dots (1)$$

where g(x, y) is an output image, f(x, y) is an input image and T is an operator on f (or a set of input images), defined over neighborhood of (x, y) that shown in equation (1).

2.2. Frequency Domain Methods

Frequency domain methods are based on the manipulation of the orthogonal transform of the image rather than the image itself. Frequency domain techniques are suited for processing the image according to the frequency content. The principle behind the frequency domain methods of image enhancement consists of computing a 2-D discrete unitary transform of the image, for instance the 2-D DFT, manipulating the transform coefficients by an operator M, and then performing the inverse transform.

The orthogonal transform of the image has two components magnitude and phase. The magnitude consists of the frequency content of the image. The phase is used to restore the image back to the spatial domain. The usual orthogonal transforms are discrete cosine transform, discrete Fourier transform, Hartley Transform etc. The transform domain enables operation on the frequency content of the image, and therefore high frequency content such as edges and other subtle information can easily be enhanced

2.3 Image Negative

It is used to enhance the gray or white detail embedded in dark region of an image. Original image pixel values are inverted using image negative operation by point operation. Each and every pixel value in the original value is modified by some new pixel values [9].

2.4 Gray Level Slicing

Gray level slicing is a point operation enhancement technique in which the slicing of specific gray values from the rest of the gray values is used for enhancement. The method has two approaches**,** in first approach a specific gray values alone enhanced to a brighter gray values and unspecified gray value are left unchanged. In second approach a specific gray values are enhanced and the remaining gray values are set to zero. It is also said as gray level slicing without background which yields a binary image.

2.5 Unsharp Masking

Unsharp masking is a technique where amplification factor is equal to one, it works like high pass filter but when amplification factor is greater than one. Then part of the original image is added back to the high pass filtered image.

2.6 Sharpening

Highlights fine details or enhance detail that has been blurred. The elements of the mask contain both positive and negative weight. Sum of the mask weights is zero. Note that the result of high pass filter might be negative. Values must be remapped to [0,255].Obtain a sharp image by subtracting a low pass filtered image from the original image [9]. Image sharpening emphasizes edges but details must be lost. High boost filter amplify input image then subtract a low pass image.

2.7 Laplacian

Laplacian sharpening is a second order derivative method of enhancement which finds fine details in an image and it restores the fine details to an image. First order derivatives such as sobel, prewitt are used to find edges, and here the derivative operator is used to sharpen the details of the image. The second order derivative operator which can also be implemented by the mask. After applying the laplacian mask laplacian filtered image is obtained. The laplacian filtered image may contain positive and negative values so scaling has to be performed on the laplacian filtered image. Then the scaled laplacian image is subtracted from the original image to provide the laplacian sharpened image.

2.8 High Boost Filtering

A high boost filter is also known as frequency emphasis filter. A high boost filter is used to retain some of the low frequency components to and in the interpretation of an image.

2.9 Contrast Limited Adaptive Histogram Equalization

Contrast limited adaptive histogram equalization differs from ordinary histogram equalization in its contrast limiting. In the case of CLAHE the contrast limiting procedure has to be applied for each neighbourd from which a transformation function is derived. CLAHE was

developed to prevent the over amplification of noise that adaptive histogram equalization can give rise to.
This is achieved by limiting the contrast enhancement of adaptive histogram equalization. The contrast amplification in the vicinity of a given pixel value is given by the slope of the transformation function. This is proportional to the slope of the neighborhood cumulative distribution function and therefore to the value of the histogram at that pixel value CLAHE limits the amplification by clipping the histogram at a predefined value before computing the CDF[10]. This limits the slope of the CDF and the transformation function. CLAHE can be performed by the following steps,

3. PROPOSED METHODOLOGY

A special class of filters has been developed for the processing of convolved and nonlinearly related signals. They are called homomorphic filters. Their basic characteristic is that they use nonlinearities (mainly the logarithm) to transform convolved or nonlinearly related signals to additive signals and then to process them by linear filters. The output of the linear filter is transformed afterwards by the inverse nonlinearity. The illuminance-reflectance model can be used to develop a frequency domain procedure for improving the appearance of an image by simultaneous gray level range compression and contrast enhancement based on Homomorphic filtering has found many applications in digital image processing.
It is recognized as one of the oldest nonlinear filtering techniques applied in this area. The main reason for its application is the need to filler multiplicative and signal-dependent noise. Linear filters fail to remove such types of noise effectively. Furthermore, the nonlinearity (logarithm) in the human vision system suggests the use of classical homomorphic filters. Homomorphic filtering can also be used in image enhancement. Object reflectance and source illumination contribute to the image formation in a multiplicative way.

3.1 Algorithm

Step1. Read the original image.
Step2.Apply Natural Logarithm on the original image.
Step3.ApplyDiscrete Fourier Transform on the output of the above resultant Image.
Step4.Apply Gaussian filter function on the Discrete Fourier Transformed Image.
Step5.Apply Inverse Fourier Transform on the Gaussian Filtered Image.
Step6.Apply Exponential Function on the Inverse Fourier Transformed Image.
Step7. Apply Homomorphic filtering.
Step 8.Get the Enhanced Image.

3.2 Flow Chart for the Proposed System

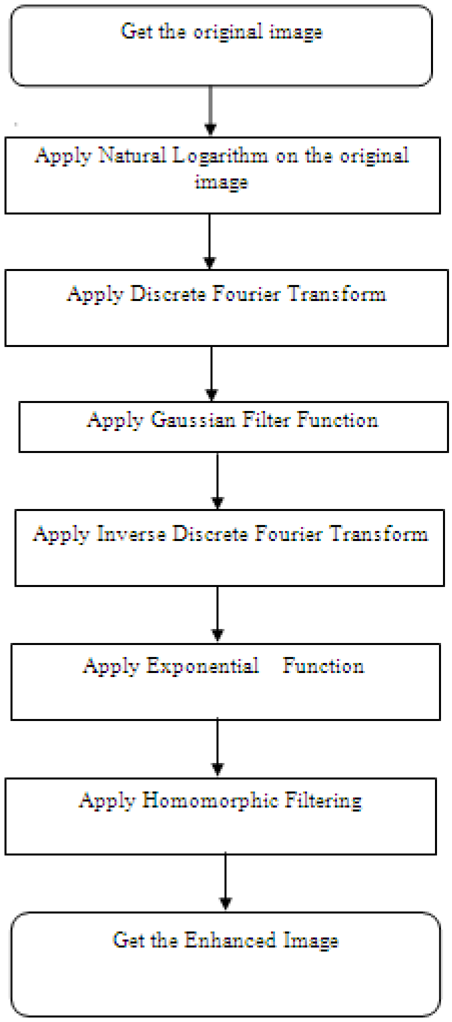


Figure.1 Proposed System

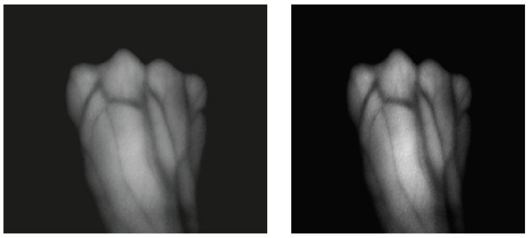
4. RESULTS AND DISCUSSION

In the image negative enhancement operation the high illumination effects are visible as image. i.e. vein in the original image are not enhanced. Hence image negative is not suitable enhancement for vein detection. It is observed that the veins are not clearly sliced in the range properly. It is to be pointed out that for this enhancement technique gray values of the vein patterns should be known ahead for slicing those patterns alone.
The enhancing value used in the original image is 1. Generally gray level slicing technique is not suitable for automation because every time the gray values have to be provided for slicing and the desired patterns vary their values due to illumination condition .Hence gray level slicing is not suitable enhancement technique for vein detection.
It is observed that the low pass filtered image provides blurred version of the original image, which means that it removes the noise, fine details and high frequency components present in the original image. The kernel

sizes of the filter have more influence on the output image. If the kernel size is large the image is more blurred i.e. the output image has less fine details and more amount of noise is reduced and vice versa. Thus sharpening is an intermediate stage in spatial enhancement technique.

Original image covers only narrow range of gray value in the histogram and makes it as a low contrast image. To increase the contrast of an image gray values in the original image are increased throughout the entire range of gray value [0 - 255] without distortion. From the figure it is observed that this technique increases the contrast of the original image but it also introduced undesirable patterns and noise. Hence this enhancement technique of vein patterns is also not sufficient.

The figure 2 shows the enhanced image of applying homomorphic filtering. The figure shows the vein clearly compared to the original image. Thus homomorphic filtering is the best enhancement technique based on homomorphic filtering for enhancing the vein patterns in the hand images and the image quality measures are shown on Table 1.



(a) (b)

Fig.2 (a) .Original image, (b) Homomorphic filtered image.

Table 1: Comparative results of the vein Image

S.No	Method	Mean square error	Peak Signal to Noise Ratio	Normalized cross correlation	Structural Content	Average Difference	Maximum Difference	Normalized Absolute Error
1.	Image negative	1.75e+004	5.69	0.44	1.92	51.05	255.00	0.70
2.	Gray level slicing	3.33e+003	12.91	0.94	1.0	14.52	117.00	0.31
3.	Sharpening	5.18e+000	40.99	1.00	1.00	36.89	85.00	0.4
4.	Laplacian	4.38e+001	31.71	1.00	0.99	43.44	47.00	0.34
5.	Unsharp masking	2.37e+001	34.438	0.99	1.03	22.39	71.00	0.22
6.	High boost filtering	5.05e+002	21.10	1.10	0.82	15.62	255.00	0.18
7.	Clahe	4.45e+002	21.65	1.21	0.66	19.78	64.00	0.23
8.	Proposed system	2.88e+005	41.47	2.59	0.01	245.04	49.46	0.11

5. CONCLUSION

The objective of our research work is to smooth and sharpen the images by using various spatial domain and frequency domain filtering techniques. Filtering techniques in spatial domain techniques and frequency domain are one of the enhancement techniques in digital image processing and thus helps the beginners of image processing to introduce to various filtering techniques. In this research work we had implemented few spatial domain filters and frequency domain filters to enhance vein patterns in hand images.

The various contrast enhancement techniques have been effectively applied on the captured hand image. From these techniques, proposed methodology gives us the best result and could give exact information about the vein pattern in the captured image. As a result, vein can be detected using homomorphic technique appears to be clearer and would provide ease further analysis in vein applications. It can be applied to other image processing applications, which is currently under study in our research.

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