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A Visual Record of Medical Skin Disease Imaging Using MATLAB Tools

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Abstract - This research presents a contribution in the field of computer vision in dermatology for the follow up of skin lesions. Several known skin lesions in this country are identified. The images of these lesions are captured and stored in a computer for further image processing. Several filtering and image processing techniques available in the MATLAB tools are applied to these images to produce their histograms and color distribution particularly in the region concerned. These proposed visual records of medical skin imaging can be analyzed further and served as a visual front end for developing a knowledge-based pre-diagnostics system to aid dermatologist in their work.

1.0 INTRODUCTION

1.1 Dermatology

Dermatology is about medical study on skin diseases or lesions. The fundamental concept of learning it, is by looking at the skin lesion and tries to match its appearance to the closest appearance photo from a library text [1]. After this, experienced dermatologist will use morphological learning method and the differential diagnosis steps to identify the disease. However, both of these methods still needs conventional clinical photos or images as guidance for diagnosis. Since color, color difference as well as shape conveys important diagnostic information for a lesion, their quantitative measurements are very helpful when investigating the lesion especially when early diagnosis is crucial. At the same time, visual record for the evolution and progress growth of a suspected skin lesion is also critical

Dermatologist needs preliminary analysis of color and texture when diagnosing a skin lesion, but the human eye is not always sufficient to perform such analysis. Therefore, better true color digital imaging is required. With rapid advances in computer and video technology, low-cost medical imaging based on analysis of color and texture of skin lesions has become increasingly important and can be both medically sound and cost-effective. It enhances the dermatologist ability to communicate with patients and colleagues, use the data image more efficiently and perhaps diagnose the skin disease with better accuracy and efficiency.

Many research works have been done on capturing and improving images of skin lesions using computer vision technology and other sophisticated image processing techniques [2]. Techniques such as filtering using average or median filter, segmentation of border, clustering of colors through analysis of histograms would provide the "ABCD" quantitative information for dermatologist in diagnosing and monitoring the lesion [3]. Therefore, it is a feasible idea if these available techniques can be implemented to process skin lesion images.

The objective of this research work is to create visual records of medical skin imaging of a known skin lesion in this country. Images of this lesion are captured and stored in a computer for further image processing. Several filtering techniques available in the MATLAB tools are applied to these images to produce their histograms for analyzing color. This research will not only contribute in the field of computer vision in dermatology for the follow up of skin lesions, it can also be served as the visual front end for developing a knowledge-based pre-diagnostics system to aid dermatologist in their work.

2.0 DIGITAL IMAGE PROCESSING

Digital image processing concerns the transformation and processing of a two-dimensional image picture to a digital format by digital computers. Both the input and output of a digital image processing system are digital images, which is an array of real and complex numbers represented by a finite numbers of bits. Digital image analysis is related to the description and recognition of the digital image content. Its input is a digital image and its output is a symbolic image description.

2.1 Image Capturing

Digital image formation or capturing is the first step in any digital image processing application. The digital image capturing system consists of an optical system, the sensor and the digitizer. The optical signal is usually transformed to an electrical signal by using a sensing device (e.g. charge coupled device CCD sensor). The analog signal is then encoded to a digital one and can be stored in the storage of a computer. Each of the digital image formation subsystem will

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create a deformation or degradation to the digital image due to distortion, noise and non-linear transformation [4]. Therefore, it is necessary to implement digital image restoration and enhancement algorithms in order to reduce both deformations and degradations. These techniques concern on the improvement of the quality of the digital image involves noise reduction, contrast enhancement and digital image sharpening.

2.2 Filtering

The first task in digital image analysis especially in skin lesion is to remove any noisy signal in the image due to processing by image formation subsystem. These noisy elements can be filtered in the spatial domain through linear or non-linear convolution filtering. Convolution using low pass filter can blur the image and smoothen any edges. Median filter is therefore widely used [5]. The constraint of filtering in spatial domain is it involves many computational calculations. Preferably, filtering in frequency domain is simpler and is the more natural domain for filtering. It specifies precisely the effect that a filter has on the spatial frequencies present in the image.

2.3 Edge Detection

The next task is about the detection of skin lesions boundaries. This is performed by using edge and line detection techniques available such as Sobel, Prewitt, Laplacian [5] and Canny [6]. An edge is typically defined at the maximum differential or zero crossing of the Laplacian respectively known as first (e.g. Sobel and Canny) and second (e.g. Laplacian) order derivatively. The lines and edges detected are followed subsequently and a list of the boundary coordinates is created. Edge-following algorithms can be constructed in such a way that they are robust to noise and can follow broken edges. Special algorithms can be written to follow lines or edges having a particular shape e.g. straight line segments or circles.

2.4 Segmentation

Region segmentation and segmentation algorithms identify homogeneous image regions. Each of them corresponds to either image objects or image background. There are many region segmentation techniques available and they can be classified into three classes [7]. Local techniques employ the local properties within the image neighborhood. Global techniques segment the image based on global information. Finally, the split and merge techniques employ both pixel proximity and region homogeneity in order to obtain good segmentation results.

2.5 Histograms

Image histogram provides useful information of the intensities of the image content [8]. It represents the relative frequency of occurrence of the various gray levels in the image. For example, if the probability density function of the pixel values is concentrated in the low image intensities, then the image is 'dark'. A 'bright' image has a histogram that is concentrated in the high image intensities. Merely by analyzing such phenomena, it is possible to determine optimal illumination conditions for capturing an image, gray-scale transformation and image segmentation to objects and background. Brightness or contrast enhancement for gray-scale transformation can be done through histogram equalization technique.

3.0 METHODOLOGY

The following simple procedures are taken to develop the visual record system:-

- Selected skin disease images from patients at HUKM are captured using a digital camera
- These images are then recorded and stored in a personal computer
- Each image will be filtered using linear and non-linear filter to remove noisy elements
- The filtered image is then enhanced by adjusting its contrast, intensity or sharpening.
- The enhanced image is segmented to clearly distinguish its edge and homogeneous region
- Finally, histograms of the final image will be displayed and can be analyzed.

The flowchart of the proposed visual system is shown in Fig. 1 below.

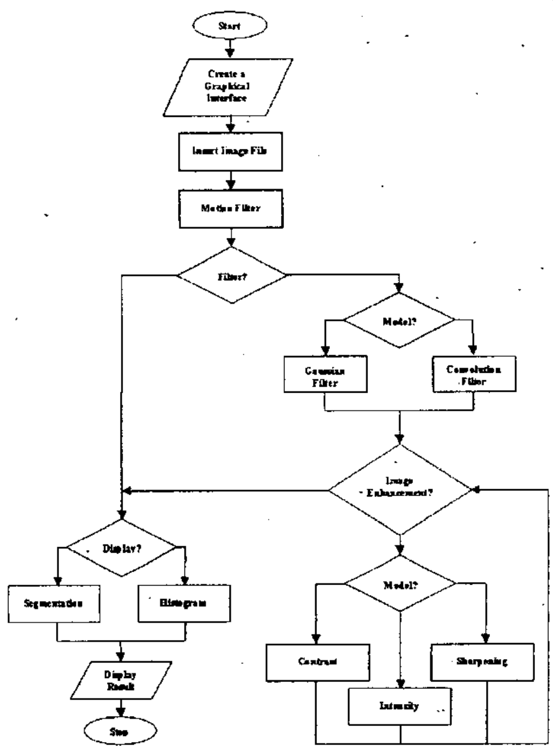

Fig. 1: Flowchart of the Visual Medical Skin Disease Imaging System.

3.1 Hardware

This project uses a digital camera, FinePix 6900Zoom from FUJIFILM, to capture an image from a selected skin disease. Images from the camera are then interfaced through USB port and stored as JPEG compression format in a laptop computer using interface software. The computer should have large capacity storage for storing these images.

3.2 Software

For this system, image processing, analysis, and algorithm development of the captured image is carried out using the available image processing toolbox provide by MATLAB. These algorithms include non-linear filtering, edge-detection, image segmentation and image analysis of feature statistic and measurement. Output of the system is represented by the visual display of the enhanced and segmented image together with its gray level distribution in terms of histogram spectrum. A graphical user interface (GUI) is also being implemented so that the system is user friendly and easier to use by the end user i.e. the dermatologist.

4.0 RESULTS

A sample of skin lesion image identified as Histoplamosis is captured and shown together with its histogram in Fig. 2. As it can be seen, the original image has noise in it portrayed by streams of white lines caused by the linear motion of the digital camera and presented by the existence white levels of the histogram. The noise is being removed after applying the motion filter, shown in Fig. 3 characterized by the missing black and white levels at both ends of the histogram. Applying low pass Gaussian filter would remove high frequencies which are represented by drastic changes of color but smoothened any edges of the image. It can be seen features are not clearly defined in Fig. 4. This can be improved if using convolution filter where edges are enhanced and features in the middle of the image are brighter as shown in Fig. 5. The histogram levels are equally distributed and covers the white intensity region. Fig. 6, 7 and 8 shows enhancement being applied for the Gaussian filtered image. There's not much difference in the histograms levels except more white intensity exists for intensity enhancement and black intensity for contrast enhancement. As for these enhanced images, contrast produced better visible features in the middle of the lesion. Sharpening enhancement only sharpened any edges available. Same analysis can be said for Fig. 9, 10 and 11 which enhancement being applied for convolution filtered image. Again, contrast gives better feature information as clearly shown in Fig. 9. The segmentation border of each feature found in the lesion image is presented in Fig. 12. The outlined border is superimposed to the actual image on the right. Morphological opening and closing algorithms are applied during segmentation of this image where this method would remove small texture and hair like structures while preserving the shape and size of the features in the lesion. Only segmentation of filtered and enhanced image in Fig. 11 is shown here because other images produced about the same border segmentation.

5.0 CONCLUSIONS

A front end system has been successful developed using MATLAB incorporating image processing toolbox. The comparison can be made after the results are obtained. There are varieties of filter design but in this program linear filtering and further enhancement are applied. The digitizing parameter in the histogram gives a simple visual indication as to whether or not an image make use of all or almost all of the available gray levels. Once the image has been digitized to fewer than 256 gray levels, the lost information could not be restored without redigitizing or recapturing. It is suggested that other non-linear filtering or filtering using the frequency domain be applied as well as other edge detection techniques. Lastly, it is hoped that the proposed visual record system presented in this paper will assist and aid dermatologist in their work to easily diagnose, identify and analyze skin lesion.

6.0 ACKNOWLEDGEMENTS

The authors acknowledge with gratitude the great support by the management of Hospital Universiti Kebangsaan Malaysia (HUKM) especially Dr. Saadiah Sulaiman from the Dermatology department. Without their generosity, the capturing of skin lesion images from available patients would not be possible.

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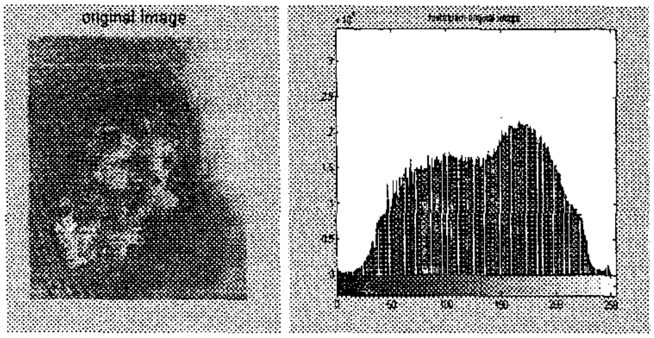

Fig. 2: Original Image

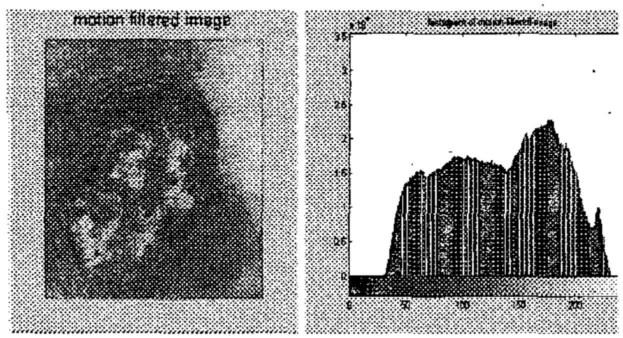

Fig. 3: Motion Filter Image

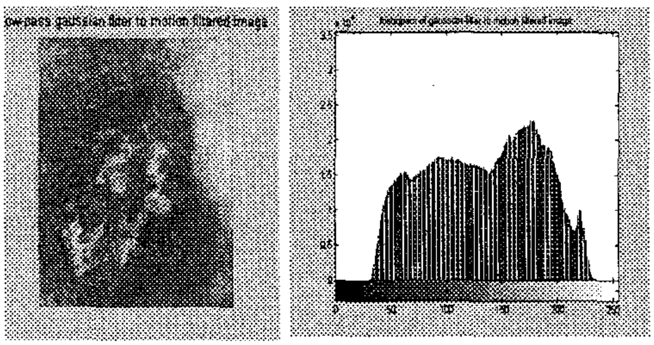

Fig. 4: Low Pass Gaussian Filter

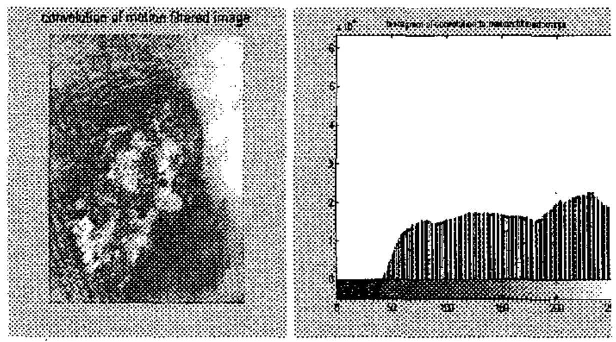

Fig. 5: Convolution Filter

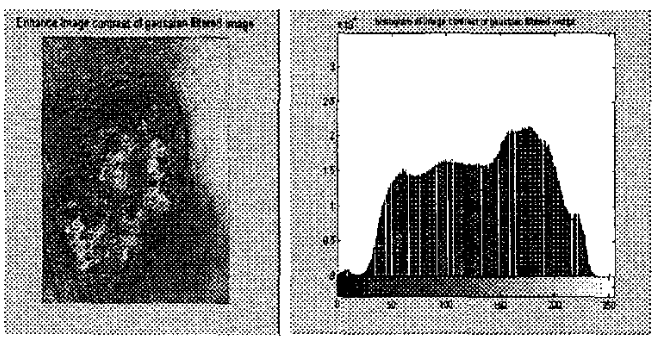

Fig. 6: Gaussian Filter + Contrast

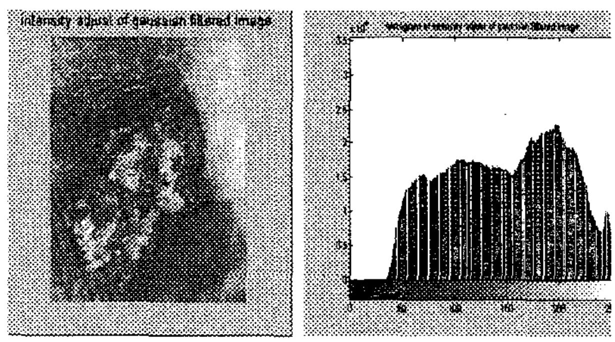

Fig. 7: Gaussian Filter + Intensity

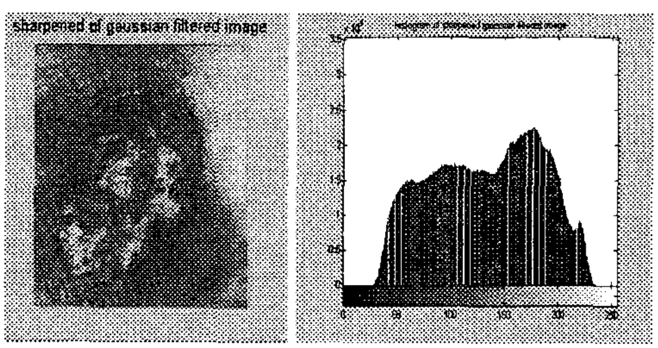

Fig. 8: Gaussian Filter + Sharpening

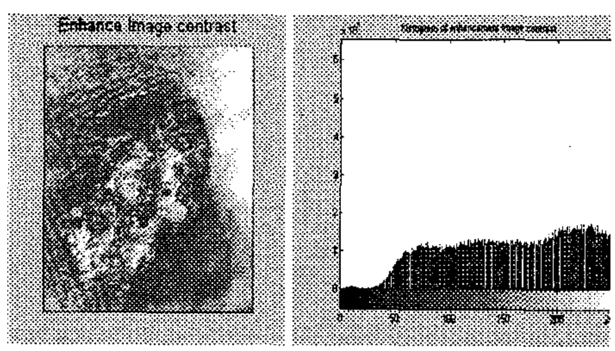

Fig. 9: Convolution Filter + Contrast

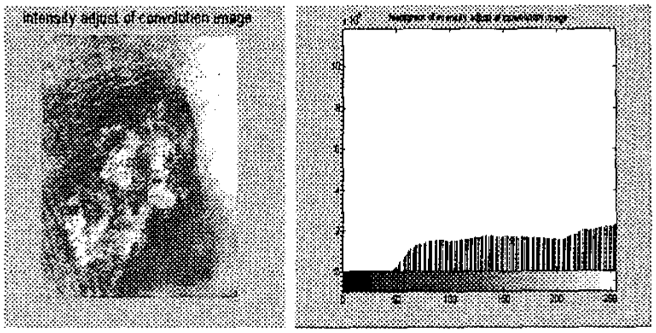

Fig. 10: Convolution Filter + Intensity

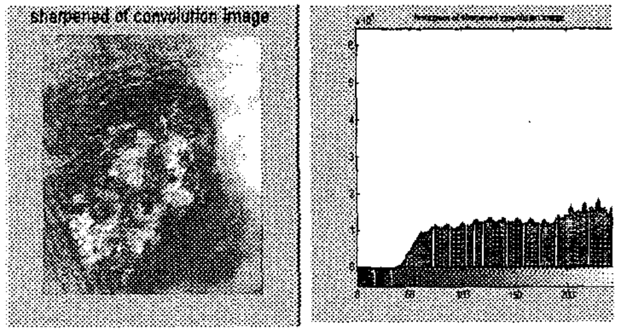

Fig. 11: Convolution Filter + Sharpening

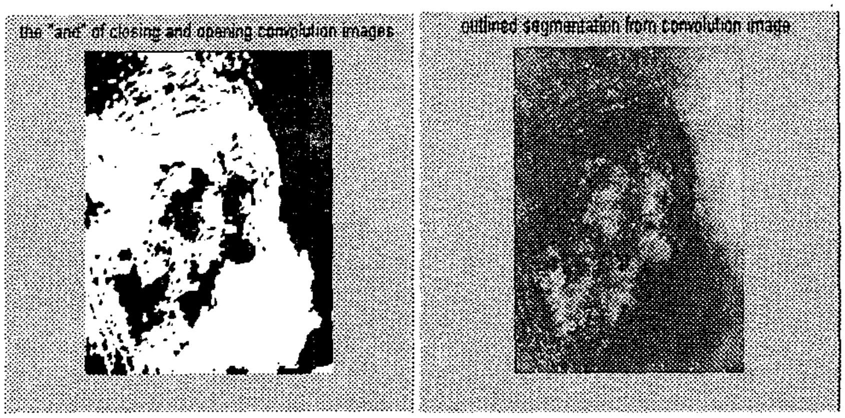

Fig. 12: Border Segmentation of Convolution Filter + Sharpening Image