Contrast Improvement of Radiographic Images in Spatial Domain by Edge Preserving Filters

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Summary
Digital Image enhancement provides a multitude of choices for improving the visual quality of radiographic images. When the details of radiographic image are lost due to various reasons, image enhancement has been applied. Many algorithms have been proposed for image enhancement in the past decade. Contrast improvement algorithms are used to enhance image contrast and some algorithms come with undesired drawbacks like the loss of tiny details, enhancement of image noise, occasional over enhancement and unnatural look of the processed images. This paper proposes new algorithms for contrast enhancement of radiographic images in spatial domain based on edge operators. Experimental results show that the proposed algorithms provide a flexible and reliable way for contrast enhancement over the traditional high pass filter.

Key words:
Digital Image Enhancement, Contrast Improvement, Radiographic images, Spatial Domain, Edge Preserving Filters

1. Introduction

The rapid introduction of direct and indirect digital imaging systems in various fields has created a wide selection of computer-based methods for the analysis of an image. Utilizing the computational power of new computers, along with the application of digital imaging algorithms, has a significant impact on analysis of an image. The adoption and innovation of these processes constantly offer researchers the new approaches to analysis an image. It is crucial to understand the mechanisms by which a given imaging algorithm modifies an image so as to be able to assess its impact on analysis of an image. Digital computers can handle well-defined, finite and countable data. Although technological enhancement in (digital) computer hardware and software has led to a significant increase in the size of data being handled by computers this limitation will remain as basic characteristic of digital computers. Assuming an object is composed of a continuum of elements, its (analog) image will contain the same data continuity requiring countless and infinite number of elements to represent it. To process such an image by digital computer, it must be converted to a digital form with a discrete representation. The discreteness applies to all attributes of the image, such as geometry, intensity and time intervals. The conversion process known as digitization is defined by

$$f(x, y, z, t) \rightarrow f(m, n, l, k) \qquad (1)$$

where f(x, y, z, t) represents a spatiotemporal continuous image and f(m, n, l, k) is its discrete representation. Image digitization involves two distinct processes, (1) sampling and (2) quantization. In direct digital imaging, both processes occur within the image receptor and electronic circuitry for image acquisition, while in indirect imaging the image is acquired through an analog medium, such as radiographic film, and then converted into a digital form through scanning. The digital image can be represented in several forms and domains. Each domain describes the image from a specific perspective, making it more suitable for certain tasks and operations. Spatial and transform domains are among the most common methods for image data representation. The digital image in the spatial domain can be represented by a 2D collection of discrete intensity levels,

$$f(m,n) : m \,\varepsilon\, [1,M],\ n \,\varepsilon\, [1,N],\ f \,\varepsilon\, [1,K] \qquad (2)$$

composed of an MxN array of picture elements (pixels), with each pixel taking one of K different intensity levels. This image representation preserves geometric pixel adjacency of the image. Image processing in general, refers to a broad class of algorithms for modification and analysis of an image. Image Processing refer to the initial image manipulation during acquisition, post-processing, or rendering/visualization. Image processing classification also may depend on the objectives in dealing with images. Examples of image processing classes include:

(a) Image enhancement,
(b) Image analysis and understanding,
(c) Quantitative imaging,
(d) Image reconstruction and restoration,

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(e) Modeling and visualization,

(f) Time-varying and functional imaging,

(g) Perceptual and cognitive imaging,

(h) Color and multi-spectral imaging. In this paper, new algorithms for contrast enhancement of radiographic images in spatial domain based on edges are proposed and their performance is measured in terms of Peak Signal to Noise Ratio (PSNR), Correlation Coefficient (CC) and Structural Similarity (SS).

2. Literature Survey

Image Enhancement has contributed to research advancement in a variety of fields. Some of the areas in which Image Enhancement has wide application are noted below. In forensics [1], [2], [3], Image Enhancement is used for identification, evidence gathering and surveillance. Images obtained from fingerprint detection, security videos analysis and crime scene investigations are enhanced to help in identification of culprits and protection of victims. In atmospheric sciences [4], [5], [6], Image Enhancement is used to reduce the effects of haze, fog, mist and turbulent weather for meteorological observations. It helps in detecting shape and structure of remote objects in environment sensing [7]. Satellite images undergo image restoration and enhancement to remove noise. Astrophotography faces challenges due to light and noise pollution that can be minimized by Image Enhancement [8]. For real time sharpening and contrast enhancement several cameras have in-built Image Enhancement functions. Moreover, numerous softwares allow editing such images to provide better and vivid results. In oceanography the study of images reveals interesting features of water flow, sediment concentration, geomorphology and bathymetric patterns to name a few. These features are more clearly observable in images that are digitally enhanced to overcome the problem of moving targets, deficiency of light and obscure surroundings. Image Enhancement techniques when applied to pictures and videos help the visually impaired in reading small print, using computers, television and face recognition [9]. Several studies have been conducted [10], [11], [12] that highlight the need and value of using Image Enhancement for the visually impaired. Virtual restoration of historic paintings and artifacts [13] often employs the techniques of Image Enhancement in order to reduce stains and crevices. Color contrast enhancement, sharpening and brightening are just some of the techniques used to make the images vivid. Image Enhancement is a powerful tool for restorers who can make informed decisions by viewing the results of restoring a painting beforehand. It is equally useful in discerning text from worn-out historic documents [14]. In the field of e-learning, Image Enhancement is used to clarify the contents of chalkboard as viewed on streamed video; it improves the content readability and helps students in focusing on the text [15]. Similarly, collaboration [16] through the whiteboard is facilitated by enhancing the shared data and diminishing artifacts like shadows and blemishes. Medical imaging [17], [18], [19], uses Image Enhancement techniques for reducing noise and sharpening details to improve the visual representation of the image. Since minute details play a critical role in diagnosis and treatment of disease, it is essential to highlight important features while displaying medical images. This makes Image Enhancement a necessary aiding tool for viewing anatomic areas in MRI, ultrasound and x-rays to name a few. Numerous other fields including law enforcement, microbiology, biomedicine, bacteriology, climatology, meteorology, etc., benefit from various Image Enhancement techniques. These benefits are not limited to professional studies and businesses but extend to the common users who employ Image Enhancement to cosmetically enhance and correct their images.

3. Image Enhancement

Image enhancement process consists of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine [24]. Meanwhile the term image enhancement means the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image [25]. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover observer-specific factors such as the human visual system and the observer's experience will introduce a great deal of subjectivity into the choice of image enhancement methods. Based on the image data representation space image enhancement techniques can be divided into two main categories: (1) Spatial domain (2) Transformed domain techniques. Spatial domain methods directly manipulate the image data array either by point processing or area processing. In Transform domain method the image is first transformed into the Specified domain, processed and then transformed back to the spatial domain. To provide a unified approach it is assumed that image f is normalized such that

$$f(m,n) \varepsilon [0,1] \qquad (3)$$

where 0 and 1 represent black and white, respectively. This assumption allows to express the imaging operator independent of the actual pixel-depth of the imaging system. Pixel-depth commonly expressed in terms of bits/pixel defines number of unique gray levels that imaging system can provide. Image processing in the spatial domain can be expressed by

$$g(m,n) = T\,(f(m,n)) \qquad (4)$$

where f(m,n) is the input image, g(m,n) is the processed image, and T is the operator defining the modification process. The operator `T' is typically a single-valued and monotone function that can operate on individual pixels or on selective regions of the image. In point-processing a single pixel value of the input image is used to compute the corresponding pixel value for the output image. In regional or area processing several pixel values in a neighborhood within the input image are used to compute the modified image at any given point. One can consider point processing as a special case of region processing where the region is composed of a single pixel. The point-processing operator can also be expressed by

$$s = T(r) \qquad (5)$$

where r and s are variables denoting the intensity level of f(m,n) and g(m,n) at any point (m,n). There are three approaches in spatial domain image enhancement techniques which are discussed below.

3.1. Linear point processing

Linear point processing is defined by,

$$s= ar+b \qquad (6)$$

where a and b are two parameters defining the transformation function. As a result of this operation the variable s can take on any positive or negative value. Following the common approach that the pixel value should fall in the range of 0 and 1, the resultant of the operator should be limited to this range. This can be achieved through either re-mapping s to [0,1] or discarding all out-of-range values by clipping them back to one of the boundary values. By setting a=1 and varying b one can adjust the image brightness. When the brightness of the image is changed the relative difference between pixel values is preserved. This is an important property when utilizing the quantitative property of an enhanced image.

3.2Non-linear point processing

There are infinite ways in which gray levels can be modified in a nonlinear fashion. Exponential and logarithmic intensity modifications are among closed-form functions used for this type of image enhancement. The exponential gray level image mapping can be expressed by,

$$S=r^{\gamma} \qquad (7)$$

where γ defines the exponent which can be selected according to image content and viewing setting. Another application of the exponential processing function is the compensation for the non-linear response of phosphor being used in the computer display device. This is a built-in contrast manipulation in CRT-based display devices that can be either compensated through hardware or by post-processing of the images. By measuring the gamma of a given display device it is able to modify the image so that the displayed image is rendered in a linear fashion. Gray level slicing is another type of nonlinear processing method frequently used to highlight a range of desired gray levels or to mask out unwanted gray levels. The threshold for each segment can be set manually or automatically. Morphological filtering also represents a broad class of non-linear operation and has been shown to be effective for image enhancement.

3.3 Lookup table approach

Another approach to point-based image enhancement is through the use of lookup tables. The lookup table defines how each input value is mapped to the output value and can approximate a single or multi-valued function. For intensity images the lookup table is a linear array of indices while for color images there is one array for each color. To speed up image rendering it is common to pre-compute such a table (for linear and nonlinear operators) and use it when needed.

4. Contrast Enhancement

The problem of enhancing contrast of images or edge of an image enjoys much attention and spans a wide gamut of applications, ranging from improving visual quality of photographs acquired with poor illumination. Taking a picture in an excessively bright or dark environment makes the captured image less contrasted. To enhance image contrast, Histogram Modification (HM) is a widely used approach and has been recognized as the ancestor of plentiful contrast enhancement algorithms. This HM approach analyzes the histogram of the given image and assigns a broader range of gray values to these gray levels with larger counts. The histogram modification problem can be formulated as follows, to compute a transformation function T, if PDF of the input image $p_r(r)$ and PDF of the desired image $p_s(s)$ are given, to modify gray values of the input image to achieve the desired PDF. The first step in this process is to select the desired PDF for a given image. Such a selection is typically both a function of image content and the task at hand. For example, the most common histogram modification technique, histogram equalization, tends to re-distribute the gray levels in such a way that there is a uniform distribution of gray levels in the output range. Note that although the modified histogram is less skewed toward the low gray values, it is not uniformly distributed. This is due to the small number of gray levels (256 levels) available in this image. As the number of possible gray levels, i.e. pixel depth, increases, the modified histogram tends more toward flat shape. The following list shows some of typical histogram models used for histogram modification. For uniform Equalization,

$$p_s(s) = \frac{1}{r_{\max} - r_{\min}} \quad if\ r_{\min} < s < r_{\max} \tag{8}$$

For exponential histogram modification,

$$p_s(s) = \alpha e^{-\alpha(s - r_{\min})} \quad if\ s \geq r_{\min} \tag{9}$$

For Rayleigh histogram modification,

$$p_s(s) = \frac{s - r_{\min}}{\alpha^2} e - \frac{(s - r_{\min})}{2\alpha^2} \quad if\ s \geq r_{\min} \tag{10}$$

For hyberbolic cubic root histogram modification,

$$p_s(s) = \frac{1}{3} \frac{s^{-2/3}}{r_{\max}^{1/3} - r_{\min}^{1/3}} \tag{11}$$

For hyberbolic logarithmic histogram modification,

$$p_s(s) = \frac{1}{s[\ln(r_{\max}) - \ln(r_{\min})]} \tag{12}$$

Since this approach only takes global information into account, some portions of the image may get over-enhanced and the processed image may look unnatural. Moreover, because the pixel counts of tiny regions only contribute small portions of the histogram, in some situations the contrast of tiny regions may get compressed after contrast enhancement. The over-enhancement problem in HM may be properly avoided by preserving the intensity mean of the image data. However, with the preservation of intensity mean, the enhanced images may still look unnatural since some other factors, like color and object shape, may also get affected during the contrast enhancement process. Another popular approach for contrast enhancement is adaptive histogram equalization (AHE). The operation of AHE is similar to HE, except that the histogram is now based on localized data. AHE usually provides significant contrast enhancement and may well preserve fine details. However, from time to time, over-enhancement may happen and the enhanced images may look unnatural.

5. Spatial Filters for Contrast Enhancement

Filtering is an essential part of image contrast enhancement. Several filtering techniques have been reported over the years for various applications. In image processing problems, nonlinear filtering techniques are preferred as they can cope with the nonlinearities of the image formation model and also take into account the nonlinear nature of the human visual system. Thus, the filters having good edge and image detail preservation properties are highly desirable for image filtering.

5.1 Mean filter

The output or response of the averaging filter is simply the averaging of the pixels contained in the neighborhood of the filter mask. They are also referred to as low pass filters. The value of every pixel is replaced by the average of the gray levels in the neighborhood defined by the filter mask. Mean filtering is a simple, intuitive and easy to implement. In mean filters a single pixel with a very unrepresentative value can significantly affect the mean value of all the pixels in its neighborhood. When the filter neighborhood straddles an edge, the filter will interpolate new values for pixels on the edge and so will blur that edge. This may be a problem if sharp edges are required in the output. The Mean Filter is a simple one and does not remove the speckles but averages it into the data. Generally speaking, this is the least satisfactory method of speckle noise reduction as it results in loss of detail and resolution. However, it can be used for reducing Gaussian noise.

5.2 Median Filter

Median filtering is a non-linear method used for the removal of impulsive noise. It is implemented to an image using a mask of odd length, the mask moves over the image and at each center pixel the median value of the data within the window is taken as the output. The non-linear median filter provides the most robust restoration from the noisy image than linear filtering algorithms by moving over it uniformly and having every pixels of the image replaced by the median of the pixels chosen from among their neighborhood. The median filter response is based on ordering the pixels contained in the image area encompassed by the filter and then replacing the value of the center pixel with the value determined by the ranking result. As the name implies this replaces the value of the pixel by the median of the gray levels in the neighborhood of the pixel. The original value of the pixel is also included in the computation of the median. Median filter belong to the class of edge preserving smoothing filters. Median filtering is comparatively better that mean filter since it preserves some useful details in an image. It helps in reducing mainly speckle and salt and pepper noise. Median filtering is also called rank filtering.

5.3 Relaxed Median Filter

The median filter is far from being a perfect filtering method as it removes fine details, sharp corners and thin lines. The main reason is that the ordering process destroys any structural and spatial neighborhood information. As an alternative to median filter, a version of median filter, the relaxed median filter is used. This filter is obtained by relaxing the order statistic for pixel substitution. By using a relaxed median filter, more image details can be preserved than the standard median filter. This method will not introduce any blocky effects in images and also preserve fine details, sharp corners and thin lines and curved structures better than median filter.

5.4 Midpoint Filter
Midpoint filters are those that replace the value of the pixel by the midpoint of the maximum and the minimum value of the pixels that are in a sorted order.

5.4 Weiner Filter
A Wiener filter is a minimum mean square error filter. It has capabilities of handling both the degradation function as well as the noise, unlike the inverse filter. In Global Wiener filtering, the Wiener filter is applied over the whole image. This method does a good job at deblurring. The filter is designed by minimizing the MSE between the restored image and the true image. It should be noted that the Wiener filter is derived under the assumption that the noise n is not correlated to the true image. Blur and speckles are also removed efficiently by using Weiner filter. Wiener filtering as a linear is often assumed to be unsuitable for images containing edges. The restored image generally exhibits artifacts due to the attenuation of high frequency components.

5.5 Gaussian Filter
Gaussian filter is a filter whose impulse response is a Gaussian function. A Gaussian filter modifies the input signal by convolution with a Gaussian function.

5.6 Kuan filter
The Kuan filter is used primarily to filter speckled radar data. It is designed to smooth out noise while retaining edges or shape features in the image. Kuan filter also smoothes the image without removing edges or sharp features in the images. It is only applicable for radar intensity image. Kuan filter first transforms the multiplicative noise model into a signal-dependent additive noise model. Then the minimum mean square error criterion is applied to the model. The resulting filter has the same form as the Lee filter but with a different weighting function. Because Kuan filter made no approximation to the original model, it can be considered to be superior to the Lee filter.

5.7 DBAIN Filter
The decision-based algorithm for the restoration of images that are highly corrupted by Salt-and-Pepper noise is fast and efficient. The algorithm utilizes previously processed neighboring pixel values to get better image quality than the one utilizing only the just previously processed pixel value. This algorithm is faster and also produces better result than a Standard Median Filter (SMF), Adaptive Median Filters (AMF), Cascade and Recursive non-linear filters. This method removes only the noisy pixel either by the median value or by the mean of the previously processed neighboring pixel values. This method found to produce better PSNR value for salt and pepper noise.

6. Proposed Algorithms

This paper proposes three numbers of new algorithms to enhance the contrast of a given image.

6.1. Adaptive Weighted Mean Filter (AWMF)
Filtering is a mathematical operation in which the intensity of one pixel is combined with the intensity of neighboring pixels. This neighborhood is defined by a box that has at least three pixels on a side. Perhaps the simplest filter is the mean filter, which sums the intensity of pixels in the box and determines the mean. The averaging of neighboring pixels will result the blurred image due to the random nature of pixels at the neighboring position. To avoid this blurring, this paper introduces Adaptive Weighted combination of pixel values I(i,j), I(i,j-1), I(i-1,j-1), I(i-1,j), I(i-1,j+1), I(i+1,j+1), I(i+1,j-1), I(i,j+1) and I(i,j+1) is used to estimate the value for pixel I(i,j). This scheme has been considered as the four neighboring pixels of the current pixel which are most likely to be involved in the generation of the back reflection value in pixel position (i, j).The mask for this filter is shown in figure1. The given image is passed through an edge detector and converted into a binary image. If the pixel of interest I (i,j) is an edge, the particular pixel is omitted. If the pixel of interest I(i,j) is not an edge, adaptive weighted mean filter omitting the edge pixel is applied.

1	2	1
2	4	2
1	2	1

Fig 1: Mask for Adaptive Weighted Mean Filter

6.2 Edge Adaptive Sigma Filter (EASF)
The sigma filter averages only those pixels within a box of predetermined size that do not deviate too much from the pixel that the box is centered on. To set the threshold value for a sigma filter, one must know the type of noise affecting the image and its standard deviation. To avoid this, this paper introduces another filter, namely edge adaptive sigma filter to enhance the contrast of a given image. The given image is passed through an edge detector and converted into a binary image. If the pixel of interest I(i,j) is an edge, a high pass filter mask is applied to sharpen the edge. If the pixel of interest I(i,j) is not an edge, an low pass mean filter omitting the edge pixel is applied.

6.3 Edge Adaptive Hybrid Filter (EAHF)
To improve the edges and fine details present in the given image, this paper proposes a new filter namely Edge

Adaptive Hybrid filter which a combination of low pass and high pass filter. In this algorithm also, an edge detector is applied to the given image and converted into binary image. If the pixel of interest I(i,j) is an edge, a high pass filter mask is applied to sharpen the edge. If the pixel of interest I(i,j) is not an edge, an low pass mean filter is applied to improve the fine details.

7. Experimental Work

Three Medical images are taken and applied with additive white Gaussian noise. The images are passed through the three filters mentioned above. IDL software package is used to write the codes for testing the validity of the above filters. Image enhancement is the one of the simplest categories of image processing, attempts to make the analysis of an image more obvious. A wealth of techniques exists for reducing the image noise and highlighting edges. It is difficult to judge the effectiveness of these techniques for three reasons

1. The outcome depends on the exact application
2. A different outcome might be desired for different persons.
3. Image enhancement does not attempt to suppress artifacts or make images more accurate – just easier to interpret. Anyway these three filters are evaluated and compared with traditional high pass filter (HPF) using three performance measures like PSNR, CC and SS and tabulated in Table I. The outputs from the above three filters are shown in figure 2.

Table I: Results of Edge Preserving Contrast Enhancement Filters

	Filter	PSNR	CC	SS
Image1	HPF	17.459993	0.123383	0.462605
	AWMF	21.208031	0.945692	0.339348
	EASF	24.446018	0.973322	0.510785
	EAHF	24.596769	0.974237	0.519020
Image2	HPF	18.615047	0.073046	0.401759
	AWMF	21.600517	0.965229	0.243731
	EASF	25.512057	0.985542	0.568655
	EAHF	25.921262	0.986839	0.574605
Image2	HPF	17.034144	0.216205	0.534502
	AWMF	21.351333	0.943476	0.449520
	EASF	23.94478	0.967846	0.566640
	EAHF	24.186566	0.969577	0.577373

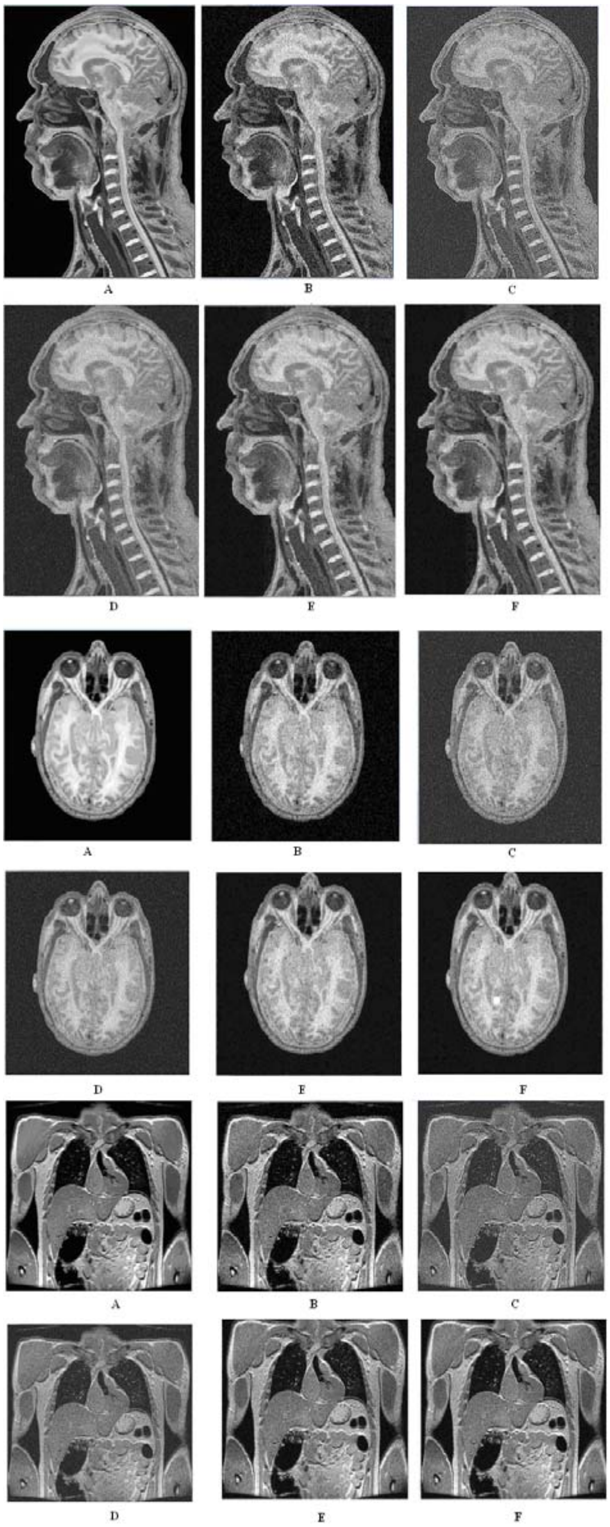

Fig 2: Results of Edge Preserving Contrast Enhancement Filters
A. Original Image B. Noisy Image C. Output from HPF
D. Output from AWMF E. Output from EASF
F. Output from EAHF

8. Conclusions

In this paper, three filters are proposed for contrast enhancement based on edge operators. After distinguishing edge regions from flat regions, separate filters are applied accordingly. In future, to provide a natural looking processing result, it is planned to apply histogram equalization to the outputs from these filters. Experimental results do demonstrate the superiority of the proposed approaches over the traditional high pass filter.

References

[1] K. Teddy, "Fingerprint Enhancement by Spectral Analysis Techniques," *in 31stApplied Imagery Pattern Recognition Workshop,* Washington DC, WA, Oct 2002, pp. 16-18.

[2] S. Greenberg, M. Aladjem, and D. Kogan, "Fingerprint Image Enhancement using Filtering Techniques," *Real-Time Imaging,* vol. 8, no. 3, pp. 227-236, June 2002.

[3] Z. Abu-Faraj, A. Abdallah, K. Chebaklo, and E. Khoukaz, "Fingerprint Identification Software for Forensic Applications," *in 7th IEEE Int. Conf.Electronics, Circuits and Systems,* Jounieh, Lebanon, Dec 2000, pp. 299-302.

[4] D. W. Armitage, and J. P. Oakley, "Noise Levels in Colour Image Enhancement," *in Visual Inform. Eng.,* London, UK, July 2003, pp. 105-108.

[5] J. M. Buckingham, and J. Bailey, "Imagery Enhancement to Meteorological Collection Platform," *in Proc. Syst. and Inform. Eng. Design Symp* Charlottesville, VA, April 2003, pp. 275-281.

[6] G. Woodell, D. Jobson, Z. u. Rahman, and G. Hines, "Advanced Image Processing of Aerial Imagery," *in Proc. SPIE Visual Inform. Process. XIV,* Kissimmee, FL, May 2006, p. 62460E.

[7] R. Vorobel, "Contrast Enhancement of Remotely-Sensed Images," *in 6th Int. Conf. Math. Methods in Electromagnetic Theory,* Lviv, Ukraine, Sept 1996, pp. 472-475.

[8] P. Fridman, "Radio Astronomy Image Enhancement in the Presence of Phase Errors using Genetic Algorithms," *in Int. Conf. on Image Process.,* Thessaloniki, Greece, Oct 2001, pp. 612-615.

[9] T. Jinshan, K. Jeonghoon, and E. Peli, "Image Enhancement in the JPEG Domain for People with Vision Impairment," *IEEE Trans. Biomed. Eng.,* vol. 51, no. 11, pp. 2013-2023, Nov 2004.

[10] E. Peli, R. B. Goldstein, G. M. Young, C. L. Trempe, and S. M. Buzney, "Image Enhancement for the Visually Impaired. Simulations and Experimental Results," *Investigative Ophthalmology & Visual Sci.,* vol. 32, no. 8, pp. 2337-2350, July 1991.

[11] E. Peli, E. Lee, C. Trempe, and S. Buzney, "Image Enhancement for the Visually Impaired: The Effects of Enhancement on Face Recognition," *J. Opt. Soc. Am. A,* vol. 11, no. 7, pp. 1929-1939, July 1994.

[12] E. Peli, E. Lee, C. Trempe, and S. Buzney, "Recognition Performance and Perceived Quality of Video Enhanced for the Visually Impaired " *Ophthalmic and zhysiological Optics,* vol. 25, no. 6, pp. 543–555, Nov 2005.

[13] P. Soo-Chang, Z. Yi-Chong, and C. Ching-Hua, "Virtual Restoration of Ancient Chinese Paintings Using Color Contrast Enhancement and Lacuna Texture Synthesis," *IEEE Trans. Image Process.,* vol. 13, no. 3, pp. 416-429, March 2004.

[14] Z. Shi, and V. Govindaraju, "Historical Document Image Enhancement Using Background Light Intensity Normalization," *in Proc. 17th Int.Conf. Pattern Recognition,* Cambridge, UK, Aug 2004, pp. 473-476.

[15] H. Wei Jyh, and T. Qi, "Content Enhancement for e-learning Lecture Video Using Foreground/Background Separation," *in IEEE Workshop Multimedia Signal Process.,* Singapore, Singapore, Dec 2002, pp. 436-439.

[16] Z. Zhengyou, and H. Li-Wei, "Whiteboard Scanning and Image Enhancement," *Digital Signal Process.,* vol. 17, no. 2, pp. 414-432, March 2007.

[17] D. Y. Tsai, L. Yongbum, M. Sekiya, S. Sakaguchi, and I. Yamada, "A Method of Medical Image Enhancement using Wavelet Analysis," *in 6th Int. Conf. Signal Process.,* Beijing, China, Aug 2002, pp. 723-726.

[18] C. Haiguang, A. Li, L. Kaufman, and J. Hale, "A Fast Filtering Algorithm for Image Enhancement," *IEEE Trans. Med. Imag.,* vol. 13, no. 3, pp. 557-564, Sept 1994.

[19] W. Ping, J. Li, D. Lu, and C. Gang, "A Multi-scale Enhancement Method to Medical Images Based on Fuzzy Logic," *in IEEE Region 10 Conference TENCON,* Hong Kong, China, Nov 2006, pp. 1-4.

[20] M. Nordt, J. Meisner, R. Dongaonkar, C. Quick, S. Gatson *et al.*, "eBat: A Technology-enriched Life Sciences Research Community," *Proc. American Soc.Inform. Sci. and Technology,* vol. 43, no. 1, pp. 142-142, Oct 2007.

[21] U. Karadkar, M. Nordt, R. Furuta, C. Lee, and C. Quick, "An Exploration of Space-Time Constraints on Contextual Information in Image-Based Testing Interfaces," *Proc. ECDL 2006*, Springer Berlin / Heidelberg, Sept 2006, pp. 391-402.

[22] Dimou, G. Jager, and P. Frangos, "Adaptive Edge Enhancement in SAR Images Training on the Data vs. Training on Simulated Data," *in Int. Conf.Image Process.,* Thessaloniki, Greece, Oct 2001, pp. 493-496.

[23] H. Li, J. Gao, and D. C. Liu, "Adaptive Edge Enhancement of the Ultrasound Image," *in 4th Int. Conf. Image Graph.,* Washington DC, WA, Aug 2007, pp. 86- 91.

[24] T.K. Kim, J.K. Paik and B.S. Kang, "Contrast Enhancement System Using Spatially Adaptive Histogram Equalization with Temporal Filtering," IEEE Transactions on Consumer Electronics, Vol. 44, Issue 1, pp.82-87, Feb. 1998.

[25] William K.Pratt(2007), "Digital Image Processing" , Los Altos, California.

[26] Bhabatosh Chanda and Dwijest Dutta Majumder, 2002, "Digital Image Processing and Analysis".

[27] R.C. Gonzalez and R. E. Woods, "Digital image processing", Addison-Wesley, 2002.

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