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CONTRAST ENHANCEMENT FOR PCA FUSION OF MEDICAL IMAGES

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Abstract: Image Fusion is one of the major research fields in image processing. Image fusion process can be defined as the integration of information from a number of registered images without the introduction of distortion. It is often not possible to get an image that contains all relevant objects in focus. One way to overcome this problem is image fusion, in which one can acquire a series of pictures with different focus settings and fuse them to produce an image with extended depth of field which helps in clinical diagnosis. Image fusion techniques can improve the quality and increase the application of these data. The proposed paper uses multi-image Contrast enhancement for PCA fusion of medical images. The objective of this paper is to propose a technique for fusion of human brain MRI images based on Principal Component Analysis and to improve the visibility of medical images by applying contrast enhancement existing techniques. The PCA fusion technique adopted here improve resolution of the images. The PCA algorithm builds a fused image of several input images as a weighted superposition of all input images. The resulting images contains enhanced information as compared to individual images and also apply Contrast Enhancement technique to improve visibility of medical image details without introducing unrealistic visual appearances and/or unwanted artefacts. It also gives the quality comparison study of original medical images before fusion, after applying PCA and various existing techniques for contrast enhancement for those medical images.

Keywords: Adaptive Histogram Equalization, Contrast Enhancement, Histogram Equalization, Image fusion, Principal Component Analysis.

INTRODUCTION

Image Fusion [1] is a process of combining the relevant information from a set of images of the same scene, into a single image, wherein the resultant fused image will be more informative and complete than any of the input images. Principal component analysis (PCA) is a well-known scheme for feature extraction and dimension reduction and is used for image fusion. Here input images could be multimodal. One of the goals of image fusion is to create a single enhanced image more suitable for the purpose of human visual perception, object detection and target recognition. Image fusion find application in the area of navigation guidance, object detection and recognition, medical diagnosis, satellite imaging for remote sensing, rob vision, military and civilian surveillance, etc. Many images, such as medical images, remote-sensing images, electron microscopy images and even our real life photographic pictures, suffer from poor contrast. Therefore, it is very necessary to enhance the contrast of such images before further processing or analysis can be conducted. There have already been many techniques for enhancing image contrast.

The most widely used methods include various contrast manipulations and histogram equalization. Several fusion algorithms starting from simple pixel based to sophisticated wavelets and PCA based are available. Image fusion system has several advantages over single image source and resultant fused image should have higher signal to noise ratio, increased robustness and reliability in the event of sensor failure, extended parameter coverage and rendering a more complete picture of the system. The aim behind this paper is the need of technique for fusion based on PCA which is the simplest among all the other techniques to improve resolution of the images in which two images to be fused are firstly decomposed into sub-images with different frequency and then the information fusion is performed and finally these sub-images are reconstructed into a result image with plentiful information.. Fusion is a good way to increase the system accuracy and robustness. The first main task is to propose a technique for fusion of human brain MRI images for clinical diagnosis based on Principal Component Analysis and another goal is to apply Contrast Enhancement techniques. This paper also presents assessment of image fusion by measuring the quantity of enhanced information in fused images. The quality measures evaluation of various techniques of fusion will help to make proper selection of fusion technique. This will positively decrease the computational cost by a large amount and reduce the technique overhead to improve the quality of image as well as the visibility of image.

In order to study the differences between integrated PCA and various existing contrast techniques like Linear Stretch, Histogram Equalization and Adaptive Histogram Equalization comparative study is required. Section 2 describes background whereas in Section 3 we elaborate Principal Component Analysis and existing Contrast Enhancement techniques, in Section 4 presents Experiment Results of our approach and analysis of the integrated approach in Section 5 and conclusion is presented in Section 6.

BACKGROUND

During the fusion process, all the important visual information found in the input images must be transferred into the fused image without introduction of artifacts. In addition, the fusion algorithm should be reliable and robust to imperfections such as noise or mis-registration. Image fusion is a branch of data fusion where data appear in the form of arrays of numbers representing brightness, color, temperature, distance, and other scene properties. Such data can be two-dimensional (still images), three-dimensional (volumetric images or video sequences in the form of spatio-temporal volumes), or of higher dimensions. MRI images are being used from a long time to image the internal structure of human body. It is one of the most widely used diagnostic tools in the field of medicine. MRI medical imaging technique used in radiology to visualize detailed internal structures. MRI provides good contrast between the different soft tissues of the body, which make it especially useful in imaging the brain, muscles, the heart, and cancers compared with other medical imaging techniques such as computed tomography (CT). Though there are numerous advantages of MRI technology, but it generates low contrast images. One of the reasons for low contrast MRI images is presence of bulk amount of liquid in human body. One can increase the power of MRI for capturing images but it may harm human body / bones. To make the images more visual and explanatory contrast may be increased on software and hardware level. With advancement of technology some MRI machines have also been introduced which can increase the contrast at their own with the help of software and hardware.

As the MRI images are being used for diagnostic purposes, some software may also be designed to perform auto diagnosis. In general, the elucidation of MRI is being done manually by experienced interpreters of the medicine field. It is time and manpower consuming work. Additionally, human elucidation of MRI images is very subjective, inconsistent and sometime predisposed. Image enhancement is also a significant part for automated MRI inspection systems. For making the MRI images more visual and explanatory some contrast enhancement techniques may be implemented in manual or auto-diagnose system.

In recent years, multivariate imaging techniques have become an important source of information to aid diagnosis in many medical fields. Mallat and Zhong proposed that if the wavelet coefficients undergo a modification like coefficient merging, quantization etc. then the inverse transform preserves this modification because the transform is non redundant [2]. Sveinsson proposed cluster based feature extraction and data fusion in the wavelet domain [3].P.A. Vanden Elsen proposed that a single composite image from different modality images of the same subject and provide a complete information for diagnosis [4]. H. Li, B.S. Manjunath and S. K. Mitra adopted wavelet transform for multisensor image fusion [5]. David A.Y. proposed method for image merging by means of discrete two dimensional wavelet transform [6]. Gorzelli explained possibilities and limitations to use wavelets in image fusion [7]. Lau Wai Leung compared image fusion techniques using entropy and image noise index (INI) [8]. Chavez proposed three different methods to merge multiresolution and multispectral data [9]. Rockinger, O., proposed new merger based on shift invariant discrete wavelet transform(SIDWT) theory using maximum value selection rule of approximation coefficents for landslide characteristic enhancement [10]. Ramac, L. C., Uner, M. K., Varshney, P.K., presented Morphological filters and wavelet based image fusion [11].

PROPOSED WORK

The paper presents PCA based image fusion to improve resolution of the images in which two images to be fused are firstly decomposed into sub-images with different frequency and then the information fusion is performed and finally these sub-images are reconstructed into a result image with plentiful information and apply various contrast enhancement techniques on the fused image. We also carry out the quality analysis of original images with fused image.

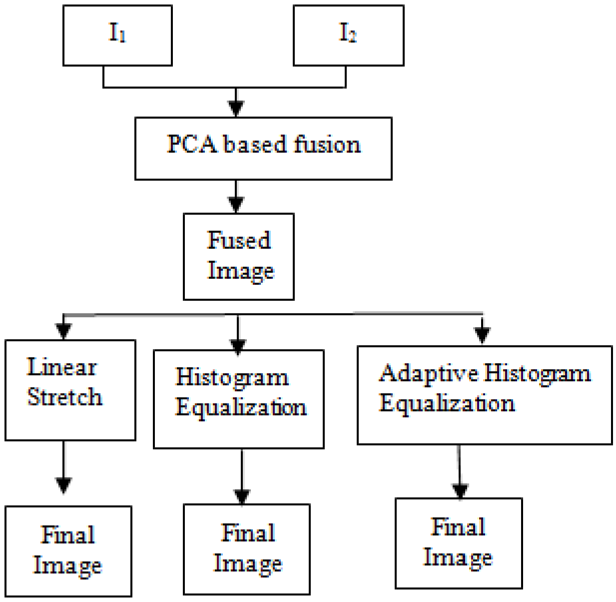

Figure 1.1 Proposed Work processing Steps

PCA is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. PCA is theoretically the optimum transform for a given data in least square terms PCA is theoretically the optimum transform for a given data in least square terms.

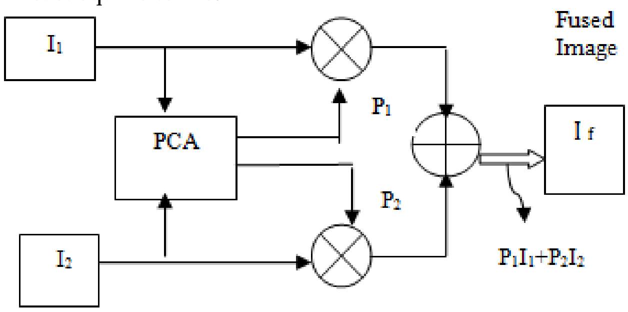

Figure 1.2 PCA Operation

The weights for each source image are obtained from the eigenvector corresponding to the largest eigen value of the covariance matrices of each source. Arrange source images in two-column vector.

a. Organize the data into column vector. Let S be the resulting column vector of dimension $2 \times n$.
b. Compute empirical mean along each column. The empirical mean vector M_e has a dimension 1×2.
c. Subtract Me from each column of S. The resulting matrix X is of dimension $2 \times n$.
d. Find the covariance matrix C of matrix X i.e. $C=XX_T$ mean of expectation = cov(X).
e. Compute the eigenvectors V and eigen value D of C and sort them by decreasing eigenvalue. Both V and D are of dimension 2×2.
f. Consider first column of V which correspond to larger eigen value to compute normalized component P1 and P2.
$P_1 = V(1) / \sum V$ and $P_2 = V(2) / \sum V$ (1)
g. The fused image $I_f(x, y)$ is computed as below if the input images are $I_1(x, y)$ and $I_2(x, y)$.
$I_f(x, y) = P_1I_1(x, y) + P_2I_2(x, y)$ (2)

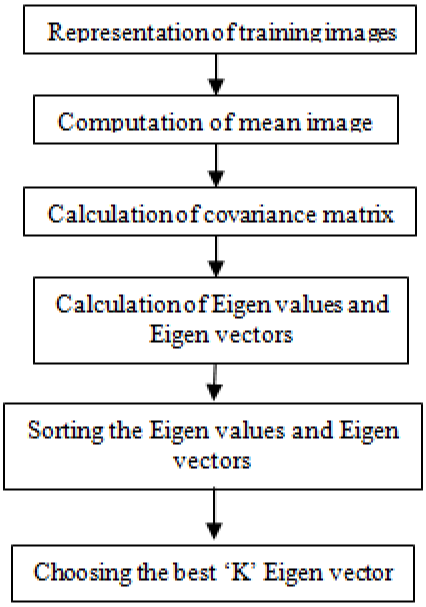

Figure1. 3 Steps involved in PCA

A lot of techniques are already available for contrast enhancement of medical images. Commonly used techniques are: 1. Linear Stretch: This is the simplest technique which enhances the contrast of an image. In this technique the intensity is increased uniformly for all the pixel values. 2. Histogram-Equalized: Histogram equalization is a technique by which the dynamic range of the histogram of an image is increased. It flattens and stretches the dynamic range of the image's histogram and resulting in overall contrast improvement. Histogram equalization assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. It improves contrast by obtaining a uniform histogram. This technique can be used on a whole image or just on a part of an image. 3. Adaptive Histogram Equalization: In this method, the contrast of the image is enhanced by transforming the values in the intensity image.

EXPERIMENTS / RESULTS

We demonstrate PCA fusion and Contrast enhancement results using multimodal images like human brain MRI images. Initially the source images of the human brain MRI images are given as input and we will get fused image after PCA fusion and Contrast enhancement techniques as their output in fig 1.4, 1.5 respectively.

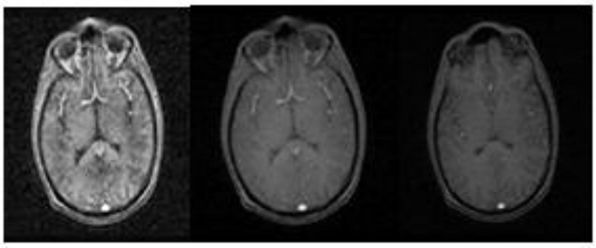

Figure 1.4 Input Images for PCA fusion and output human brain MRI image after PCA fusion

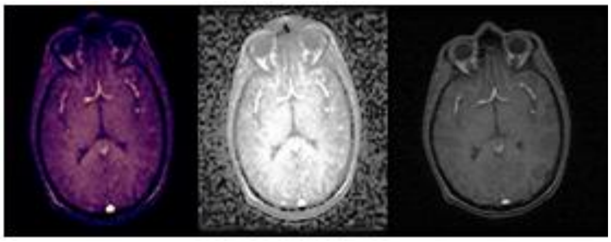

Figure 1.5 Results after applying Linear Stretch, Histogram Equalization and Adaptive Histogram Equalization Contrast Enhancement on Fused human brain MRI images.

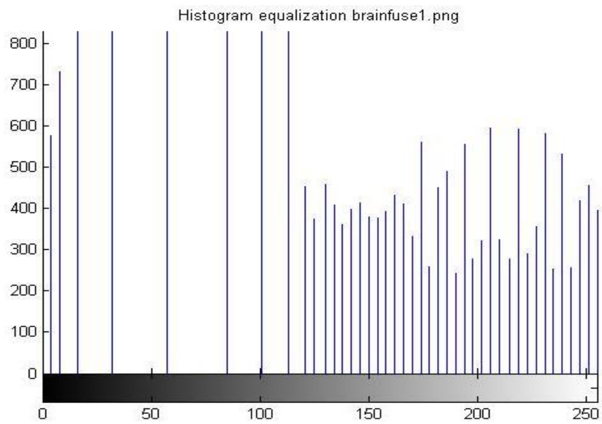

Figure 1.6 Histogram after applying Histogram Equalization Technique.

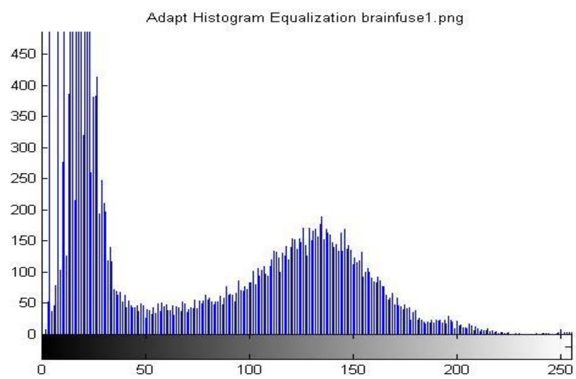

Figure 1.7 Histogram after applying Adaptive Histogram Equalization Technique.

ANALYSIS

There is an increasing need for performance or quality assessment tools in order to compare the results obtained with different contrast enhancement techniques applied on PCA fused image. This analysis can be used to select a specific contrast enhancement technique that can be used to reduce, compress or simplify a data set. PCA is the simplest among all the available fusion techniques. PCA and different contrast enhancement techniques are compared, in terms of accuracy to other enhancement methods such as Linear stretch, Histogram Equalization and Adaptive histogram equalization.

a. ***Quantitative quality Analysis:*** We carry out the quantitative quality analysis of Contrast enhancement techniques for PCA fused images using Peak Signal Noise ratio (PSNR), Mean Square error (MSE),Normalized Cross Correlation. The quality analysis of Contrast enhancement techniques for PCA fused images is shown in Table- 1. We can see from the table 1 quality parameters like PSNR value is high, MSE is low as it is directly proportional to PSNR, NCC lies between 0 and 1 which shows that result image is good in case of PCA and Linear Stretch contrast enhancement that's why PCA and Linear Stretch technique is best among all the other applied contrast enhancement technique.

b. ***Subjective quality Analysis:*** We carry out the subjective analysis of Contrast enhancement techniques for PCA fusion algorithms. The results of various contrast enhancement techniques and PCA fusion algorithms for two human brain MRI images are shown in figure1.4 and fig 1.5.

CONCLUSION

Human brain MRI images fusion is one of the most modern, accurate and useful diagnostic techniques in diagnosis brain tumours in medical imaging today. In this paper the integration of PCA for the fusion of magnetic resonance human brain MRI images and existing contrast enhancement techniques has been proposed. PCA fusion is used to fuse human brain MRI images and various contrast enhancement techniques are applied on the fused image. The quality comparison of obtained resultant image with original images is done on the basis of different parameters which are shown in table. From the statistical analysis, it is proved that the PCA and Linear Stretch is more suitable for human brain MRI image fusion, since it provides high PSNR value means less noise than PCA and Histogram Equalization and PCA and Adaptive Histogram Equalization. From the simulation results it is obvious that the resultant fused image and contrast enhanced image consists of information free from unwanted artefacts or distortion which helps in clinical diagnosis. Finally this paper concludes that image fusion algorithm based on combination of DWT and PCA with morphological processing may be the future trend of research regarding image fusion.

Table 1. Quantitative Analysis for Input image (Brain1) and resultant Image after applying different PCA and Contrast Enhancement techniques.

Type / Parameter	PCA and Linear Stretch	PCA and Histogram Equalization	PCA and Adaptive Histogram Equalization
Mean Square Error	791.4574	1.1173e+004	2.7146e+003
Peak Signal Noise Ratio	19.1465	7.6490	13.7938
Normalized Cross Correlation	0.5319	2.6935	1.6646
Average Difference	14.9871	-93.7491	-36.5842
Structural Content	2.5674	0.113	0.2902
Maximum Difference	177	114	110
Normalized Absolute Error	0.5446	2.7938	1.1362

Table 2. Quantitative Analysis for Input image (Brain2) and resultant Image after applying different PCA and Contrast Enhancement techniques.

Type / Parameter	PCA and Linear Stretch	PCA and Histogram Equalization	PCA and Adaptive Histogram Equalization
Mean Square Error	550.9719	1.2229e+004	3.1530e+003
Peak Signal Noise Ratio	20.7195	7.2569	13.1435
Normalized Cross Correlation	0.6079	3.1068	1.9172
Average Difference	10.8460	-97.8402	-40.6753
Structural Content	1.9464	0.0844	0.2200
Maximum Difference	195	75	89
Normalized Absolute Error	0.5052	3.3166	1.4090

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REFERENCES

[1]. Y. Zheng, X. Hou, T. Bian, Z. Qin - Effective Image Fusion Rules Of Multi-scale Image Decomposition , Proceedings of the 5th International Symposium on image and signal Processing and Analysis(2007) pp362-366.

[2]. JIA Yong-hong, Li de-ren, SUN Jia-bing “Multidimentional Remote Sensing Imagery Data Fusion” Remote Sensing Technology and Application 2005,15 (1) : 41-44.

[3]. S. Mallat, “A Wavelet Tour of Signal Processing” Academic Press, Second Edition, 1998.

[4]. Svensson, J. R..,M. O.Ulfarsson & J. A. Benediktsson, “Cluster Based Feature Extraction and Data Fusion in the Wavelet Domain” In:Pro. IEEE International Geoscience and Remote Sensing Symposium, pp. 867-869.

[5]. Garzelli, A” Possibilities and Limitations of the Use of Wavelets in Image Fusion.” In: Pro.IEEE International Geoscience and Remote Sensing Symposium, 2002.

[6]. Lau Wai Leung, Bruce King and Vijay Vohora,” Comparison of Image Fusion Techniques using Entropy and INI”, In: Pro. 22nd Asian Conference on Remote Sensing,5-9 Nov 2001.

[7]. Chavez, P.S., Sides, S. C. Anderson, J.A., “Comparison of Three Different Methods to Merge Multiresolution and Multispectral Data: Landsat TM and SPOT Panchromatic”, Photogrametric Engineering and Remote Sensing, 57,295-303.

[8]. Jiangsheng You,Weiguo Lu, Jian Li et. al. “Image Matching for Translation Rotation and Uniform Scaling by Radon Transform” 0-8186-8821-1/98, 1998 IEEE.

[9]. Lau Wai Leung, Bruce King and Vijay Vohora,” Comparison of Image Fusion Techniques using Entropy and INI”, In: Pro. 22nd Asian Conference on Remote Sensing, 5-9 Nov 2001.

[10]. Li, Z. Li, J. Gong – “Multivariate statistical analysis of measures for assessing the quality of image fusion . International Journal of Image and Data Fusion”, Volume 1, Issue 1 March 2010 , pp 47 – 66

[11]. A. Soma sekhar, Dr.M.N Giri Prasad ,‖ Novel approach of image fusion on MR and CT images using wavelet transforms‖ IEEE Conferences, 2011.

[12]. S.M. Pizer a al.: Adaptive histogram equalization and its variations, Computer Vision, Graphics and Image Processing. Vol. 39, no. 3, pp 355-386.September 1987.

[13]. V. Casells, J.L Lisani,J.M. Morel and G. Sapiro: Shape preserving local histogram modification, IEEE Trans. Image processing, vol. 8, 00. 2, pp. 220-230, 1998.

[14]. J. A. Stark: Adaptive contrast enhancement using generalization of Histogram equalization, IEEE Trans. Image processing, vol. 9, no. 5, pp 889-906.2000.

[15]. H. Huttunen and O. YLI-Harja: Fasl algorithm for updating the local histogram of mullidimensional signals, Proc. 1998 IEEE International conference o n Image Processing, 1998.

[16]. OJ. Jobson, Z. Rahman and G.A Woodell: Properties and performance of a center/surround retinex, IEEE Trans. Image Processing,vol. 6, no. 3, pp. 451-462, 1997.

SHORT BIO DATA FOR THE AUTHOR

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