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Fusion of PET and MRI brain images and comparison of fusion methods by image quality indicators in MATLAB

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Abstract

Image fusion means merging the information of different images from one view or different views of the image into a single image to create an improved image quality while maintaining the integrity and important features of the images. The need for medical image fusion has been increasing in recent years due to the multiplicity of imaging systems. In medicine, image fusion has received a lot of attention for integrating structural information from imaging systems such as CT and MRI and metabolical information from PET and SPECT imaging systems, but achieving an optimal fusion algorithm is one of the challenges facing specialists. In this paper, 16 slides of PET and MRI images of the brain are integrated using two algorithms discrete wavelet and principal component analysis and then The performance of algorithms has been evaluated using image quality indicators such as signal to noise ratio, absolute mean error, structural similarity index and standard deviation., in which the principal component analysis algorithm has shown the best results in image quality evaluation indicators, but still, these algorithms have the potential for optimization to achieve better results.

Keywords: PET,MRI,image fusion,pca,dwt

Introduction

Imaging methods are generally divided into two categories according to the type of information: structural (such as computed tomography and magnetic resonance imaging) and metabolical (such as positron emission tomography and Single photon emission computed tomography). Clinical diagnosis is often made using images of different imaging modalities that provide complementary informatio namely metabolical and structural information. In the past, the diagnosis, locating, and treatment planning of tumors was based on Structural images such as computed tomography (CT) and magnetic resonance imaging (MRI). Structural imaging modalities canno describe tumors, dissect dead, injured, or inflamed tissue, but are highly sensitive in detecting structural changes. PET and SPECT imaging modalities are other imaging methods that provide more metabolical information from tissues than structural information, These methods are used in the evaluation of tumor metabolism, tumor elimination due to radiotherapy, diagnosis of hypoxic areas of the tumor, etc. Also, the combination of metabolical and structural information plays an important role in reducing diagnostic error. [2,1]

Materials and methods

The purpose of image fusion is to integrate the features of source images into one image. In this paper, to compare methods based on spatial and frequency transformations, two fusion methods have been studied, which are:

1-Principal Component Analysis: In mathematics and statistics, principal component analysis (PCA) converts correlated variables into uncorrelated ones.

In fusion, this algorithm converts images into columnar vectors and then merges the images by applying weight coefficients. [3] This method falls into the category of spatial transformations, in which image distortion is a major problem.

2-Discrete Wavelet Transform: DWT method decomposes two or more images into different high and low-frequency bands [4]. This method minimizes spectral distortion in the resulting fused images by producing a good signal-to-noise ratio with lower spatial resolution compared to the pixel-based method. Wavelet fusion is superior to the spatial domain fusion method in terms of minimizing distortion [5].

Preprocessing: For better results, after image registration, their brightness and noise were adjusted with MATLAB toolboxes.

Image quality evaluation indicators: To evaluate the performance of image processing algorithms, statistical indicators are used, which are: 1- Signal peak to noise ratio 2- Absolute mean error 3- Structural similarity index 4- Standard deviation. [6]

Results

To evaluate the efficiency of the mentioned algorithms using PET and MRI images of Alzheimer's patient's brain in 16 slices taken from the reference [7]with image matrix dimension 256×256, the two image fusion algorithms were implemented in MATLAB and then the efficiency of the algorithms was evaluated by image quality evaluation indicators.

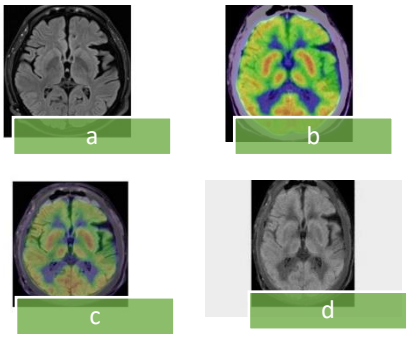

Figure1. Comparison of images of different fusion algorithms(a) MRI reference image(b)PET Reference image(c)fused image by PCA method(d)fused image by DWT method

The average results of image quality evaluation of two image fusion methods are reported in Tables 1 and 2. It is important to note that since some of the parameters used to evaluate image quality are in the category of evaluation parameters with reference, the reference image is considered once MRI and then PET.

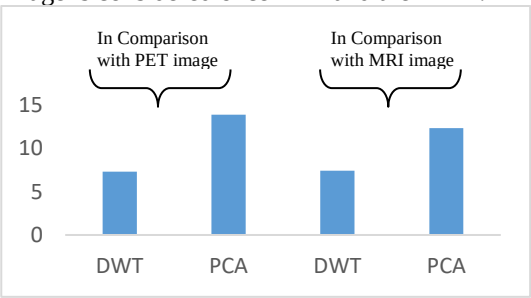

Figure2. PSNR chart. left comparison of fused image and PET image.right comparison of fused image and MRI image

Table 1. Results of image quality evaluation between fused image and MRI image as a reference

Qa Metric / Fusion method	SSIM	MAE	PSNR	STD
PCA	0.61	99.86	12.32	95.87
DWT	0.52	182.15	7.41	92.28

Table 2. Results of image quality evaluation between fused image and PET image as a reference

Qa Metric / Fusion method	SSIM	MAE	PSNR	STD
PCA	0.59	75.08	13.86	95.87
DWT	0.42	201.64	7.30	92.28

In the structural similarity index, the PCA algorithm shows the most similarity to the reference images, which indicates the ability of this algorithm to maintain the structure of the reference images. The wavelet method is discrete because frequency transformations do not avoid noise.

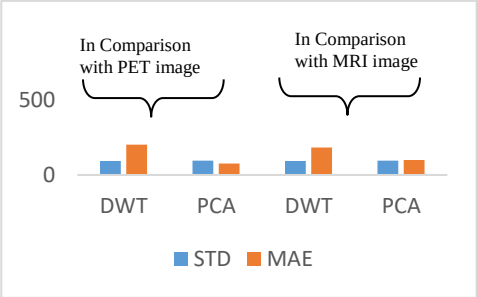

Figure3. Standard deviation(blue) and absolute mean error(orange) chart.left comparison of fused image and PET image.right comparison of fused image and MRI image

Conclusion

According to the results of this study, the PCA method has shown better results than the discrete wavelet metode in various parts of image quality assessment such as structural similarity index and absolute mean error As can be seen in Figure 3. PCA also offers higher contrast compared to the DWT method due to higher standard deviation. The intense difference between the two methods in the signal-to-noise ratio index As can be seen in Figure 2 is due to the inability of frequency-based methods to eliminate noise. However, distortion is still a major problem in spatial transformation methods, such as principal component analysis. It seems that the combination of these two algorithms, PCA-DWT, can lead to optimal results.

References

[1] Antoch, G. and Bockisch, A., *Combined PET/MRI: a new dimension in whole-body oncology imaging?*. Eur. J. Nucl. Med., 36(1), pp.113-120 (2009)

[2] Schlemmer, H.P.W., Pichler, B.J., et al., *Simultaneous MR/PET imaging of the human brain: feasibility study*. Radiology, 248(3), pp.1028-1035 (2008)

[3] Naidu, V.P.S. and Raol, J.R., *Pixel-level image fusion using wavelets and principal component analysis*. Def. Sci. J., 58(3), p.338(2008)

[4] Chandrasekhar, C., Viswanath, A. and NarayanaReddy, S., *FPGA Implementation of Image Fusion Technique Using DWT for Micro Air Vehicle Applications*. 4(8): 307–315(2013)

[5] Jiang, D., Zhuang, D., Huang, Y. and Fu, J., *Survey of multispectral image fusion techniques in remote sensing applications*. Image fusion and its applications, pp.1-23(2011)

[6 Ma, J., Ma, ,Y. and Li, C., 2019. *Infrared and visible image fusion methods and applications: A survey*. Inf Fusion, 45, pp.153-178 (2019)

[7] radiopaedia.org