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A Novel Technique for Fusing Multimodal and Multiresolution Brain Images

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Abstract

Multiscale Transforms (MST) are widely used in fusing multimodal images, however these suffer from drawbacks like poor contrast, low edge detection, blurring, redundancy and high execution time. Besides, choice of decomposition levels and fusion rules is also a challenge. Sparse Representation (SR) based image fusion techniques overcome these drawbacks. This paper aims the implementation of MST and MST-SR based fusion techniques for multimodal and multiresolution brain images. A novel technique based on LP-SR is proposed. Both subjective and objective evaluation is made on multiple sets of source images. LP-SR show superior results for contrast, SSIM and UIQI.

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Keywords:Multimodal Image Fusion;DWT; LP; Sparse Representation.

1. Introduction

CT, MRI, PET and SPECT are usually the imaging techniques used to detect the brain tumors. The CT scan provides the anatomy information of the brain. The physiological information is obtained from MRI scans. The growth or spread of the cancer cells is indicated by PET scan and the 3D view can be observed using SPECT. Since a sole imaging technique is not enough to exactly detect the occurrence and size of tumor, multiple images are merged to provide complete information of the brain. This process of fusing images containing complementary

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information of the brain is called Multi modal image fusion. Several studies have shown image fusion enhances the quality of image and also reduces ambiguity. Various approaches have been proposed for image fusion, yet the Multiscale transforms (MST) are widely employed to perform Multimodal and Multifocal image fusion. Some of the well accepted MSTs are Discrete Wavelet Transform (DWT), Curvelet, Gaussian Pyramid (GP), Laplacian Pyramid (LP) Contourlet transform and Non sub Sampled Contourlet transform (NSCT) [1].

In general, the methodology of MST based image fusion can be divided into 4 stages – 1) Decomposition of source images into high pass and lowpass sub bands with the help of transforms, 2) Fusion of the transformed coefficients based on certain fusion rules, 3) Recombine the fused coefficients to reconstruct the fused image and 4) analysis and evaluation of the fused images based on performance metrics. Medical images more often contain edges and contours represent vital organs or tumors in the brain. These are vital in analysis and need to be characterized effectively. Contrast in medical images is also important in distinguishing the healthy and cancer affected cells. The main limitation with MST lies in selection of transforms and fusion rules. The right fusion rules assist in retaining the finest details and improving the contrast of the source images. The incorrect choice of fusion rules can introduce ambiguity or noise in the fused images. Hence, it is critical to consider the right fusion rules as well as the transforms and decomposition levels. The fusion rules range from simple ones like choosing the maximum value of the pixel or averaging the pixel values to more complex ones like maximum likelihood or local energy based on neighboring pixels or region. In majority of cases, fusion rules are limited to either high pass or low pass sub bands.

Amongst the MSTs, LP and DWT are simple to implement, however are not shift invariant, redundant and poor in retaining the directionality information in the source images. The shift invariance is caused due to aliasing in the process of up sampling and down sampling. These limitations of LP and DWT are addressed using Sparse Representation based Multiscale transforms. This technique deals with representing all the features of the source images with fewer samples, thereby reducing the redundancy. Unfortunately, the problem of finding the precise number of samples is a NP-hard problem. Techniques to find an approximate solution to such problems are computationally demanding. In spite of the above shortcomings, this paper aims to identify a fusion technique for based on MST and SR. The paper is organized as follows: Section 2 gives an overview of DWT, LP and SR based image fusion. A novel methodology based on Laplacian transform and Sparse Representation is presented in section 3. Section 4 consists of results and discussion and section 5 discusses the conclusion.

Nomenclature

CT	Computed Tomography
MRI	Magnetic Resonance Imaging
PET	Positron Emission Tomography
SPECT	Single Photon Emission Computed Tomography
MST	Multiscale transforms
DWT	Discrete Wavelet Transform
LP	Laplacian Transform
SR	Sparse Representation
NP	Non-deterministic Polynomial time
DWT-SR	SR based DWT
LP-SR	SR based LP

2. Related Work

This section discusses the various MSTs like DWT and LP. The implementation of MSTs for multi modal image fusion, the selection of decomposition levels and fusion rules are discussed along with their merits and demerits.

2.1 Discrete Wavelet Transform (DWT)