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Biomedical Image Fusion Using Wavelet & Curvelet Transform

Rahul Keru Patil [*1], Mrs. M. R Dixit[2]

[*1,3]Assistant Professor, College of Engineering Malegaon (Bk), India

[2]Associate Professor, KIT's College Of Engineering, Kolhapur, India

rkpatil.svpm@gmail.com

Abstract

Image fusion is the process of merging two images of the same scene to form a single image with as much information as possible. Image fusion is important in many different image processing fields such as satellite imaging, remote sensing and medical imaging. The study in the field of image fusion has evolved to serve the advance in satellite imaging and then, it has been extended to the field of medical imaging. Several fusion algorithms have been proposed extending from the simple averaging to the curvelet transform. Algorithms such as the intensity, hue and saturation (IHS) algorithm and the wavelet fusion algorithm have proved to be successful in satellite image fusion. The IHS algorithm belongs to the family of color image fusion algorithms. The wavelet fusion algorithm has also succeeded in both satellite and medical image fusion applications. The basic limitation of the wavelet fusion algorithm is in the fusion of curved shapes. Thus, there is a need for another algorithm that can handle curved shapes efficiently. So, the application of the curvelet transform for curved object image fusion would result in a better fusion efficiency. A few attempts of curvelet fusion have been made in the fusion of satellite images but no attempts have been made in the fusion of medical images.

The main objective of medical imaging is to obtain a high resolution image with as much details as possible for the sake of diagnosis. There are several medical imaging techniques such as the MR and the CT techniques. Both techniques give special sophisticated characteristics of the organ to be imaged. So, it is expected that the fusion of the MR and the CT images of the same organ would result in an integrated image of much more details. Researchers have made few attempts for the fusion of the MR and the CT images. Most of these attempts are directed towards the application of the wavelet transform for this purpose. Due to the limited ability of the wavelet transform to deal with images having curved shapes, the application of the curvelet transform for MR and CT image fusion is presented in this work.

Keywords: Wavelet transform, Curvelet transformed, Ridgelet transform,CT & MRI images & its analysis.

Introduction

- **Present Theories & Practices:**

DWT Based Image Fusion:

- Firstly, the image is decomposed into high-frequency images and low frequency Images with wavelet transform.
- Then the spatial frequency and the contrast of the low-frequency image are measured to determine the fused low frequency image.
- To the high- frequency image, we select the high- frequency coefficient based on the absolute value maximum principal and verify the consistency of these coefficients

Contrast Based Image Fusion:

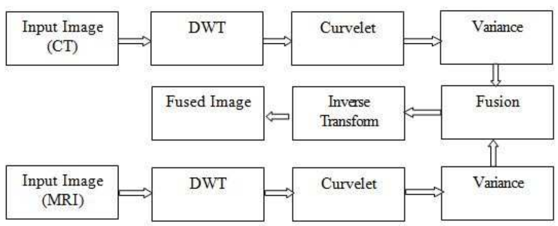
- First Pyramid Structural Transform
- The mean value of the local window of the approximate coefficient be the background of the central pixel of the corresponding local window of the detail component.
- And the maximum coefficients of detail components are respectively taken as the most salient features with the corresponding local window along horizontal, vertical, and diagonal directions.
- Then the new contrast is defined

Drawback of Existing Methods

- DWT is not a suitable transform for edge information
- For all medical images the contrast will be same so we can•t take contrast feature for Fusion

- **Proposed Method:**
  - Using Wavelet Transform to decompose original images into proper levels. One low-frequency approximate component and three high-frequency detail components will be acquired in each level.
  - Curvelet Transform of individual acquired low frequency approximate component and high frequency detail components from both of images, neighborhood interpolation method is used and the details of gray can·t be changed.
  - According to definite standard to fuse images, local area variance is chose to measure definition for low frequency component.
  - Inverse Transformation is taken to get original image

Block Diagram:



- **Scope of the work:**

Using curvlet transform, we will get a good fusion image of CT and MRI compared to the single CT or MRI images, we precisely discover and locate the diseased region in human body. It leads to accuracy which is far more improved and leads to extraction of maximum information as compared to other methods.

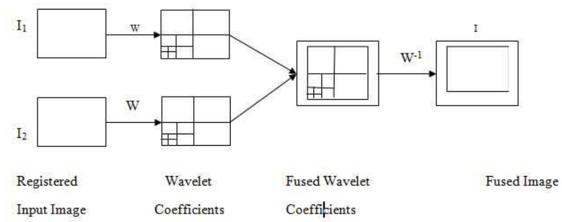
- **Theoretical Analysis:**

Need of Image Fusion:
  - Several situations in image processing require high spatial and high spectral resolution in a single image.
  - Most of the available equipment is not capable of providing such data convincingly.
  - The image fusion techniques allow the integration of different information sources.
  - The fused image can have complementary spatial and spectral resolution characteristics.

- Magnetic resonance imaging (MRI) is primarily a medical imaging technique most commonly used in radiology to visualize the structure and function of the body.
- MRI provides much greater contrast between the different soft tissues of the body than computed tomography (CT) does, making it especially useful in neurological (brain).
- Unlike CT, it uses no ionizing radiation, but uses a powerful magnetic field to align the nuclear magnetization of (usually) hydrogen atoms in water in the body.
- Radio frequency fields are used to systematically alter the alignment of this magnetization, causing the hydrogen nuclei to produce a rotating magnetic field detectable by the scanner
- This signal can be manipulated by additional magnetic fields to build up enough information to construct an image of the body.
- The body is mainly composed of water molecules which each contain two hydrogen nuclei or protons.
- When a person goes inside the powerful magnetic field of the scanner these protons align with the direction of the field.
- A second radiofrequency electromagnetic field is then briefly turned on causing the protons to absorb some of its energy.
- When this field is turned off the protons release this energy at a radiofrequency which can be detected by the scanner.
- Computed tomography (CT) is a medical imaging method employing tomography.
- Tomography is imaging by sections or sectioning.
- Digital geometry processing is used to generate a three- dimensional image of the inside of an object from a large series of two-dimensional X-ray images taken around a single axis of rotation.
- CT is a sensitive method for diagnosis of abdominal diseases. It is used frequently to determine stage of cancer.

Wavelet Transform Fusion

The most common form of transform image fusion is wavelet transform fusion. In common with all transform domain fusion techniques the transformed images are combined in the transform domain using a defined fusion rule then transformed back to the spatial domain to give the resulting fused image. Wavelet transform fusion is more formally defined by considering the wavelet transforms ω of the two registered input images $I_1(x,y)$ and $I_2(x,y)$ together with the fusion rule ϕ. Then, the inverse wavelet transform ω^{-1} is computed, and the fused image $I(x,y)$is reconstructed



The wavelet transform concentrates on representing the image in multiscales and it's appropriate to represent linear edges. For curved edges, the accuracy of edge localization in the wavelet transform is low. So, there is a need for an alternative approach which has a high accuracy of curve localization such as the curvelet transform.

Curvelet Transform Fusion

The curvelet transform has evolved as a tool for the representation of curved shapes in graphical applications. Then, it was extended to the fields of edge detection and image denoising. Recently, some authors have proposed the application of the curvelet transform in image fusion

Conceptually, the curvelet transform is a multiscale pyramid with many directions and positions at each scale. Although it is originally a continuous transform, it has several digital implementations. One implementation is based on unequally-spaced fast Fourier transforms (USFFT), while the other one is based on the wrapping of specially selected Fourier samples. The use of the USFFT based digital curvelet transform would lead us to similar results and conclusions.

The curvelet transform decomposes the image in several frequency scales. At the coarsest scale, isotropic wavelets are used as basis functions. At coarsest scales, curvelets take over this role. At the finest scale (highest frequencies), one can choose between a wavelet and a curvelet decomposition. In case of wavelet decomposition, the overall redundancy of the method is compared to others. We always choose curvelet decomposition at the finest scale in this work.

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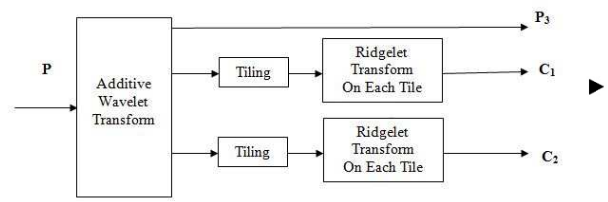
Algorithm

The algorithm of the curvelet transform of an image *P* can be summarized in the following steps:

- The image *P* is split up into three subbands Δ_1, Δ_2 and P_3 using the additive wavelet transform
- Tiling is performed on the subbands Δ_1 and Δ_2.
- The discrete ridgelet transform is performed on each tile of the subbands Δ_1 and Δ_2.

Schematic Diagram of the Curvelet Transform



Subband Filtering

The purpose of this step is to decompose the image into additive components; each of which is a subband of that image. This step isolates the different frequency components of the image into di erent planes without down sampling as in the traditional wavelet transform.

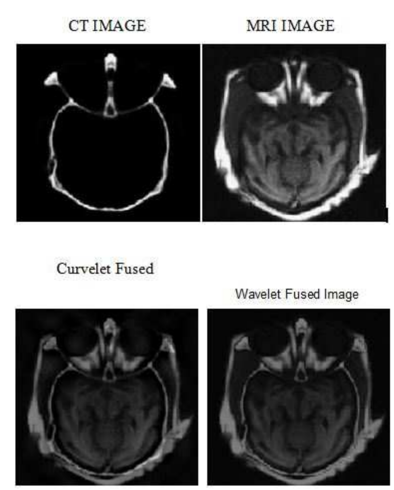
Tiling

Tiling is the process by which the image is divided into overlapping tiles. These tiles are small in dimensions to transform curved lines into small straight lines in the subbands Δ_1 and Δ_2 [11–13]. The tiling improves the ability of the curvelet transform to handle curved edges.

Ridgelet Transform

The ridgelet transform belongs to the family of discrete transforms employing basis functions. To facilitate its mathematical representation, it can be viewed as a wavelet analysis in the Radon domain. The Radon transform itself is a tool of shape detection. So, the ridgelet transform is primarily a tool of ridge detection or shape detection of the objects in an image.

Experiment Results



Results

Technique	Family	PSNR		Correlation		Erms		Entropy
		CT	MRI	CT	MRI	CT	MRI	Fused Image
Wavelet Transform	Symlets	16.67	15.67	0.41	0.85	0.22	0.23	5.84
	Coiflets	16.06	15.70	0.41	0.67	0.22	0.23	5.80
	Biorsplines	16.11	15.72	0.43	0.45	0.22	0.23	5.79
Curvelet Transform	-	16.20	15.87	0.82	0.46	0.07	0.07	6.10

Conclusion

Improved Extraction Accuracy: Curvelet will leads to accuracy which is far more improved and leads to extraction of maximum information as compared to the other methods.

Better Visualization & Interpretation: Curvelet Transform will shows better resemblance with HUMAN VISUAL SYSTEM hence resulting in improved visualization and interpretation compared to other methods.

Effective Tool in Remote Sensing : Proposed fusion method it is able to increase the spatial resolution and reduce the spectral distortion of the fused image at the same time. Also it provides better visual and quantitative results required for remote sensing. Therefore it proves to be effective tool in remote sensing.

PSNR, Entropy & Correlation of curvelet transform is higher than the wavelet transform & Erms of curvelet transform is less than the wavelet transform . So it improves the visual quality of image.

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