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Review On: Image Fusion Using Wavelet and Curvelet Transform

Navneet kaur[#1], Madhu Bahl[*2],Harsimran Kaur[#3]

[#]Computer Science Departmaent, Punjab Technical University
Landran,Distt.Mohali,Punjab,India

[*]Computer Science Department
Landran,Distt.Mohali

***Abstract* - Image fusion refers to the process of combining the information from two or more images into a single highly informative image. The resulting fused image contains more information than the input images. In this paper, two medical images are fused based on the Wavelet Transform (WT) and Curvelet transform using different fusion techniques. The objective of the fusion of an MR image and CT image of the same organ is to obtain a single image containing as much information as possible about that organ for diagnosis .In this paper ,the input CT and MR images are registered and wavelet and curvelet transforms are applied on it. Finally, the results are evaluated using fusion techniques. The parameters like PSNR, CCR and MSE are evaluated. In our proposed work results are better showed by using ANFIS tool in Wavelet and Curvelet transform.**

***Keywords*— Curvelet Transform, Wavelet Transform, Image Fusion, Peak Signal to Noise Ratio(PSNR), Root Mean Square Error(R MSE), ANFIS Tool**

I. INTRODUCTION

With the continuous development of sensor technology, people have more and more ways to obtain images, and the image fusion types are also increasingly rich, such as the Image fusion of same sensor, the multi-spectral image fusion of single-sensor, the image fusion of the sensors with different types, and the fusion of image and non-image. Traditional data fusion can be divided into three levels, which are pixel-level fusion, feature-level fusion and decision level fusion. The different fusion levels use different fusion algorithms and have different applications, generally, we all research the pixel-level fusion. Classical fusion algorithms include computing the average pixel-pixel gray level value of the source images, Laplacian pyramid, Contrast pyramid, Ratio pyramid and Discrete Wavelet Transform (DWT). However, computing the average pixel-pixel gray level value of the source images method leads to undesirable side effects such as contrast reduction. Wavelet-based image fusion method provides high spectral quality of the fused satellite images. However, the fused image by Wavelets has much less spatial information than those by the Brovey, IHS, and PCA methods. The spatial information of fused image is an important factor as much as the spectral information in many remote sensing applications. In particular, this improves the efficiency of the image fusion application, such as unsupervised image classification. In other words, it is necessary to develop advanced image fusion method so that the fused images have the same spectral resolution as the multispectral images and the same spatial resolution as the panchromatic image with minimum artifacts. The basic idea of DWT based methods is to perform decompositions on each source image, and then combine all these decompositions to obtain composite representation, from which the fused image can be recovered by finding inverse transform. This method is shown to be effective. However, wavelets transform can only reflect "through" edge characteristics, but cannot express "along" edge characteristics. At the same time, the wavelet transform cannot precisely show the edge direction since it adopts isotropy. According to the limitation of the wavelet transform, Donoho et al. was proposed the concept of Curvelet transform, which uses edges as basic elements, possesses maturity, and can adapt well to the image characteristics. Moreover, Curvelet Transform has anisotropy and has better direction, can provide more information to image processing. Through the principle of Curvelet transform we know that: Curvelet transform has direction characteristic, and its base supporting session satisfies content anisotropy relation, except have multi scale wavelet transform and local characteristics. Curvelet transform can represent appropriately the edge of image and smoothness area in the same precision of inverse transform. The low-bands coefficient adopts NGMS method and different direction high-bands coefficient adopts LREMS method was proposed after researching on fusion algorithms of the low-bands coefficient and high-bands coefficient in Curvelet Transform. Image fusion is a useful technique for merging similar sensor and multi-sensor images to enhance the information content present in the images. Image fusion has several applications in various areas such as Medical Imaging, Satellite Imaging, Remote sensing, Robotics, Military applications and so on [1-4]. Computer Tomography (CT) and Magnetic Resonance (MR) are the most important modalities in Medical Imaging, used for clinical diagnosis . CT provides more information about Bone structures and less information about soft tissues. Magnetic Resonance (MR) imaging provides more information about the Soft tissues and less information about the bone structures .Image fusion has the following advantages:-

1. It improves the reliability by taking care of the redundant information.
2. It improves the capability as it keeps complementary information.

Image fusion is a sequel to data fusion. The basic limitation of the wavelet fusion algorithm is in fusion of curved shapes and this can be accurated by the application of the Curvelet transform, would result in the better fusion efficiency. Curvelet transform involves the segmentation of the whole image into small overlapping tiles.Then the ridgelet transform is itself a 1-D wavelet transform applied on the Radon transform of each tile, which itself is a shape detection tool. The purpose of the segmentation process is to approximate curved lines by small straight lines. The overlapping of tiles aims at avoiding edge effects. Initially, Curvelet transform was proposed for image denoising [5,6]. It is expected that the Curvelet transform would produce better fusion results than those obtained using the Wavelet transform. In this paper, we propose the effective and better results by using the medical CT images and MR images by Artificial Neuro-Fuzzy Inference System (ANFIS) than the previous results. We have selected wavelet here, because it surpasses single wavelets by its features such as orthogonality, short support, symmetry, and high degree of vanishing moments and another curvelet, which deals with the curved shapes. The proposed technique is comprised of training and testing phase.

This paper is organized as follows. Section II gives detail about discrete wavelet transform. In section III, Curvelet wavelet are presented. Fuzzy logic is discussed in Section IV. The conclusion used is described in Section V.

II. DISCRETE WAVELET TRANSFORM

The most common form of transform type image fusion algorithms is the wavelet fusion algorithm due to its simplicity and its ability to preserve the time and frequency details of the images to be fused.

Wavelet transfer of the wavelet fusion algorithm of two registered images P1 ($x1, x2$) and P2 ($x1, x2$) .It can be represented by the following equation:

$I(x1, x2) = W-1(\psi(W(P1 (x1, x2)),W(P2 (x1, x2))))$

Where W, $W-1$and ψ are the wavelet transform operator, the inverse wavelet transform operator and the fusion rule, respectively. There are several wavelet fusion rules that can be used for the selection of wavelet coefficients from the wavelet transforms of the images to be fused. The most frequently used rule is the maximum frequency rule which selects the coefficients that have the maximum absolute values.The wavelet transform concentrates on representing the image in multi-scale and it is 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.Algorithm for wavelet transform is:

1. The two input images are registered initially.
2. The wavelet transform steps are performed for both images (each input image is analysed and a set of wavelet Coefficients are generated).
3. The maximum frequency fusion rule or any other rule is used for the fusion of the wavelet coefficients.
4. The inverse wavelet transform step is performed (The fused coefficients are subjected to the inverse wavelet transform) to obtain the fused image

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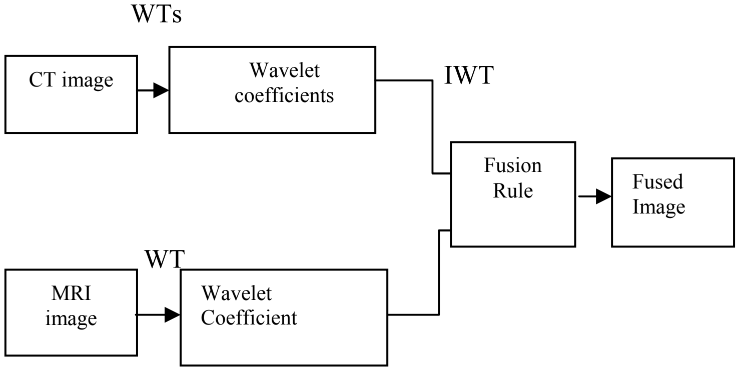

Figure.1.Wavelet Transform based image fusion

III CURVELET TRANSFORM

The Curvelet transform (CVT) is a multi-scale transform proposed by Candes and Donoho and is derived from the Ridgelet transform. The Curvelet transform is suited for objects which are smooth away from discontinuities across curves. Fourier Transform does not handle point's discontinuities well because a discontinuity point affects all the Fourier Coefficients in the domain. Moreover, Wavelet transform handles point discontinuities well and doesn't handle curve discontinuities well. Curvelet transform handles curve discontinuities well as they are designed to handle curves using only a small number of coefficients. Curvelet transform has several applications in various areas such as image denoising, image fusion, Seismic exploration,Turbulence analysis in fluid mechanics and so on [14-16].

The algorithm is as:

A) The image P is split up into three subbands P1,P2 and P3 using the additive wavelet transform.

B) Tiling is performed on the subbands P1 and P2.

C) The discrete Ridgelet transform is performed on each tile of the subbands P1 and P2.

It has the following steps:

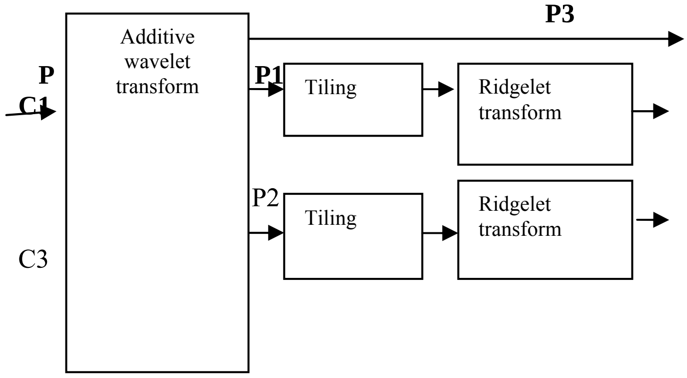

Figure 2:Curvelet Transform of an image P

A. 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 different planes without down sampling as in the traditional wavelet transform.

B. Tilting:

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 P1 and P2. The tiling improves the ability of the curvelet transform to handle curved edges.

C. Ridgelet Transform:

The ridgelet transform belongs to the family of discrete transforms employing basis functions.To sfacilitate 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.

IV FUZZY LOGIC

The concept of Fuzzy Logic (FL) was conceived by LotfiZadeh, a professor at the University of California at Berkley, and presented not as a control methodology, but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership. This approach to set theory was not applied to control systems until the 70's due to insufficient small-computer capability prior to that time. Professor Zadeh reasoned that people do not require precise, numerical information input, and yet they are capable of highly adaptive control. If feedback controllers could be programmed to accept noisy, imprecise input, they would be much more effective and perhaps easier to implement. Unfortunately, U.S. manufacturers have not been so quick to embrace this technology while the Europeans and Japanese have been aggressively building real products around it. In this context, FL is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much faster.

A. Fuzzy logic as Control Method

FL incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically. The FL model is empirically-based, relying on an operator's experience rather than their technical understanding of the system. For example, rather than dealing with temperature control in terms such as "SP =500F", "T <1000F", or "210C <TEMP <220C", terms like "IF (process is too cool) AND (process is getting colder) THEN (add heat to the process)" or "IF (process is too hot) AND (process is heating rapidly) THEN (cool the process quickly)" are used. These terms are imprecise and yet very descriptive of what must actually happen. Consider what you do in the shower if the temperature is too cold: you will make the water comfortable very quickly with little trouble. FL is capable of mimicking this type of behaviour but at very high rate. FL requires some numerical parameters in order to operate such as what is considered significant error and significant rate-of-change-of-error, but exact values of these numbers are usually not critical unless very responsive performance is required in which case empirical tuning would determine them. For example, a simple temperature control system could use a single temperature feedback sensor whose data is subtracted from the command signal to compute "error" and then time-differentiated to yield the error slope or rate-of-change-of-error, hereafter called "error-dot". Error might have units of degs F and a small error considered to be 2F while a large error is 5F. The "error-dot" might then have units of degs/min with a small error-dot being 5F/min and a large one being 15F/min. These values don't have to be symmetrical and can be "tweaked" once the system is operating in order to optimize performance. Generally, FL is so forgiving that the system will probably work the first time without any tweaking.

V CONCLUSION

We proposed image fusion by using ANFIS tool in wavelet and curvelet transform.this algothim of neuro fuzzy gives better results than the previous work done.The image used in this are CT and MR image are rectified under this new work.

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