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SATELLITE MULTISPECTRAL IMAGE ENHANCEMENT BASED ON PAN SHARPENING UNDER DUAL TRANSFORM

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Abstract*— Pansharpening for satellite Panchromatic (PAN) and Multispectral (MS) images involving Dual Transform is considered in this work. Dual Transform involves Stationary Wavelet Transform (SWT) and Non-Subsampled Contourlet Transform (NSCT). SWT is designed to overcome the lack of translation-invariance of the Discrete Wavelet Transform (DWT). NSCT approaches with different levels of decomposition and up sampling done using Gabor based fusion*. **Dual transform** *is very efficient in representing the directional information and capturing intrinsic geometrical structures of the objects. It has characteristics of high resolution, shift-invariance, and high directionality. An integration of high spatial resolution extracted from PAN images into the high spectral resolution of MS images generates both high spatial and spectral resolution pan sharpened image. By up-sampling after Dual transform, structures and detailed information of the MS images are more likely to be preserved. Hence, pan-sharpening is done by fusing it with detail information provided by the Pan image at the same fine level. The system simulated result shows that the method used here provides better resolution images than obtained in previous approaches along with the measured performance parameters such as correlation, PSNR, SSIM and standard deviation.

***Keywords*— Pansharpening, Stationary Wavelet Transform, Non-Subsampled Contourlet Transform, Gabor based fusion, Dual Transform.**

I. INTRODUCTION

Satellite image fusion has been also a popular research topic. Generally, SAT image fusion means the matching and fusion between two or more images of the same area from different Radar imaging equipment, and aims to obtain complementary information and increase the amount of information. SAR image fusion technique is to combine the information of a variety of images with computer-based image processing method. It is being used for image fusion so as to get a better image which is clearer and contains more information. In the clinical diagnosis and treatment, the use of fused images can provide more useful information. It is important for lesion location, diagnosis, making treatment and pathological study.

In the medical imaging field, we can get different images of the same part of the same patient with different imaging devices, and the information provided by a variety of imaging modes is often complementary. In the medical images, CT can clearly reflect the anatomical structure of bone tissues. Oppositely, MRI can clearly reflect the anatomical structure of soft tissues, organs and blood vessels. CT, MRI and other modes of medical images reflect the human information from various angles. In the clinical diagnosis and treatment, the problems about the comparison and synthesis between image CT and MRI were frequently encountered. With the development of new imaging sensors arises the need of a meaningful combination of all employed imaging sources. The actual fusion process can take place at different levels of information representation; a generic categorization is to consider the different levels as, sorted in ascending order of abstraction: signal, pixel, feature and symbolic level. This site focuses on the so-called pixel level fusion process, where a composite image has to be built of several input images.

The result of pixel level image fusion is considered primarily to be presented to the human observer, especially in image sequence fusion ,where the input data consists of image sequences. A possible application is the fusion of forward looking infrared (FLIR) and low light visible images (LLTV) obtained by an airborne sensor platform to aid a pilot navigates in poor weather conditions or darkness. In pixel-level image fusion, some generic requirements can be imposed on the fusion result. The fusion process should preserve all relevant information of the input imagery in the composite image pattern conservation. The fusion scheme should not introduce any artifacts or inconsistencies which would distract the human observer or following

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processing stages. The fusion process should be shift and rotational invariant, i.e. the fusion result should not depend on the location or orientation of an object the input imagery .In case of image sequence fusion arises the additional problem of temporal stability and consistency of the fused image sequence. The human visual system is primarily sensitive to moving light stimuli, so moving artifacts or time depended contrast changes introduced by the fusion process are highly distracting to the human observer. So, in case of image sequence fusion the two additional requirements apply. Temporal stability: The fused image sequence should be temporal stable, i.e. gray level changes in the fused sequence must only be caused by gray level changes in the input sequences, they must not be introduced by the fusion scheme itself; Temporal consistency: Gray level changes occurring in the input sequences must be present in the fused sequence without any delay or contrast change.

The goal has been to search for algorithms that can be used to implement for the image fusion for various applications. And another goal is to evaluate their performance of with different image quality metrics. These properties were chosen because they have the greatest impact on the detection of Image fusion algorithms.

In the following chapters, the topics discussed are as follows: Chapter II briefly explains about the NSCT, Chapter III explains SWT, Chapter IV describes the system model, Chapter V discusses simulation results and Paper concluded in Chapter VI.

II. NON-SUBSAMPLED CONTOURLET TRANSFORM

NSCT decomposition is to compute the multi scale and different direction components of the discrete images. It involves the two stages such as non sub sampled pyramid(NSP) and non sub sampled directional filter bank(NSDFB) to extract the texture, contours and detailed coefficients. NSP decomposes the image into low and high frequency subbands at each decomposition level and it produces n+1 sub images if decomposition level is n. NSDFB extracts the detailed coefficients from direction decomposition of high frequency subbands obtained from NSP. It generates m power of 2 direction sub images if number of stages be m.

Fig.1 shows the decomposition flow of Non-Subsampled Countourlet Transform.

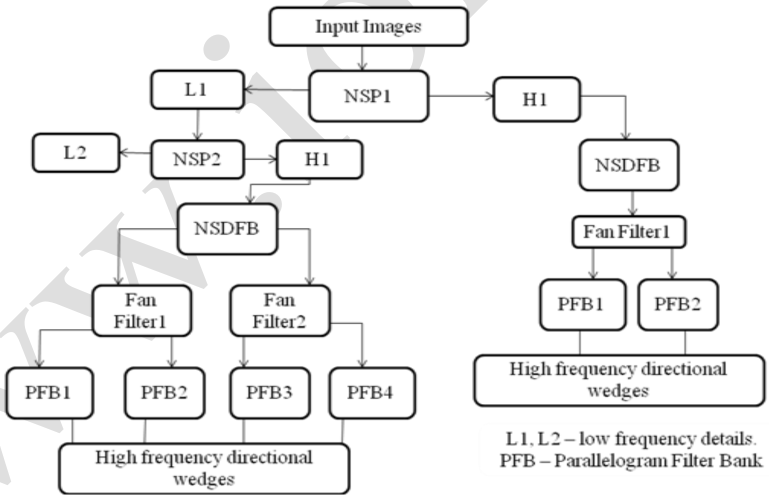

Fig.1 Block diagram of NSCT decomposition

III. STATIONARY WAVELET TRANSFORM

The Stationary wavelet transform (SWT) is a algorithm designed to overcome the lack of translation-invariance of Discrete Wavelet Transform (DWT). Translation-invariance is achieved by removing the downsamplers and upsamplers in the DWT and upsampling the filter coefficients by a factor of $2^{(j-1)}$ in the j^{th} level of the algorithm. The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input. So for a decomposition of N levels there are a redundancy of N in the wavelet coefficients.

Wavelets are mathematical functions defined over a finite interval and having an average value of zero that transform data into different frequency components, representing each component with a resolution matched to its scale. The basic idea of the wavelet transform is to represent any arbitrary function as a superposition of a set of such wavelets or basis functions. These basis functions or baby wavelets are obtained from a single prototype wavelet called the mother wavelet, by dilations or contractions (scaling) and translations (shifts). They have advantages over traditional Fourier methods in analyzing physical situations where the signal contains discontinuities and sharp spikes. Many new wavelet applications such as image compression, turbulence, human vision, radar, and earthquake prediction are developed in recent years. In wavelet transform the basis functions are wavelets. Wavelets tend to be irregular and symmetric. All wavelet functions, w (2kt - m), are derived from a single mother wavelet, w(t). This wavelet is a small wave or pulse like the one shown in Fig. 2.

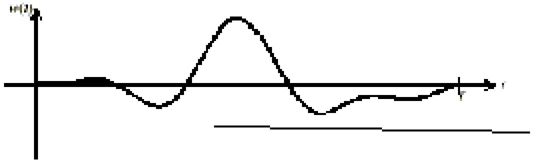

Fig.2 Mother Wavelet w (t)

Normally it starts at time t = 0 and ends at t = T. The shifted wavelet w (t - m) starts at t = m and ends at t = m + T.

Wavelet Transform is a type of signal representation that can give the frequency content of the signal at a particular instant of time or spatial location. Stationary wavelet transform decomposes the image into different subband images without down sampling and it splits component into numerous frequency bands called subbands. They are LL, LH, HL, and HH subbands. A high-frequency subband contains the edge information of input image and LL subband contains the clear information about the image. The high frequency bands of two input samples are utilized to decompose at different orientation edges using NSCT to get relevant details about textural components of an image.

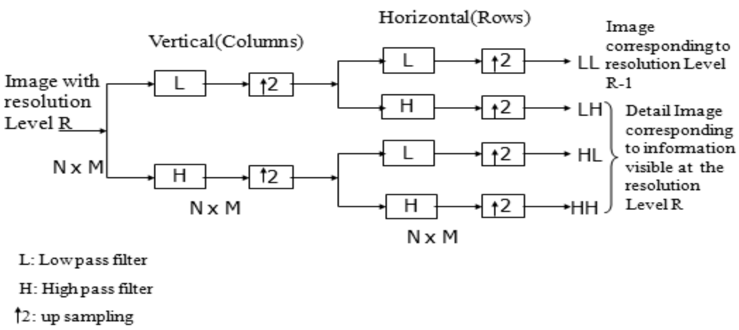

Fig.3 Block diagram of SWT decomposition flow.

IV. SYSTEM MODEL

In general, all the multiresolution-based pan-sharpening methods adopt the following process:

- Forward transforming of the Pan and MS images using a sub-band and a directional decomposition such as the subsampled or non-subsampled wavelet or contourlet transform.
- Applying a fusion rule onto the transform coefficients.
- Generating the pan-sharpened image by performing the inverse transform.

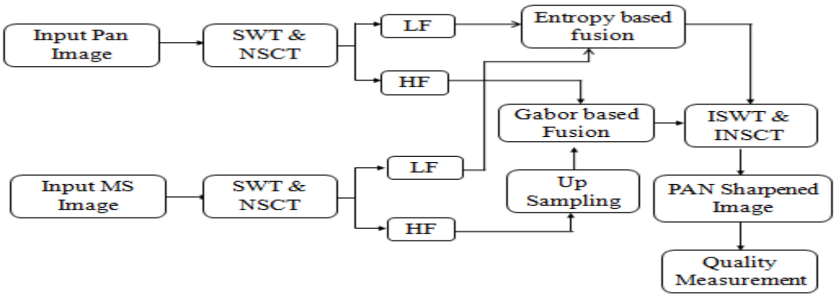

Fig.4 System Model

The model given in Fig. 4 shows the architecture of the system which involves the blocks such as input images, NSCT&SWT, Gabor and entropy based image fusion, inverse NSCT&SWT, and its quality measurement.

V. EXPERIMENTAL RESULTS

In this section, the proposed method has been evaluated and compared with the standard NSCT method. The quality measurement is based on the following parameters. Fig. 5 shows the selected input PAN image and MS image and Fig. 6 shows the resulting image of the dual transform. Visually the images may be looks similar and no major differences visually noticeable to the eye. The quality metrics shows the performance and improvement introduced by the proposed dual transform method compared with the standard one.

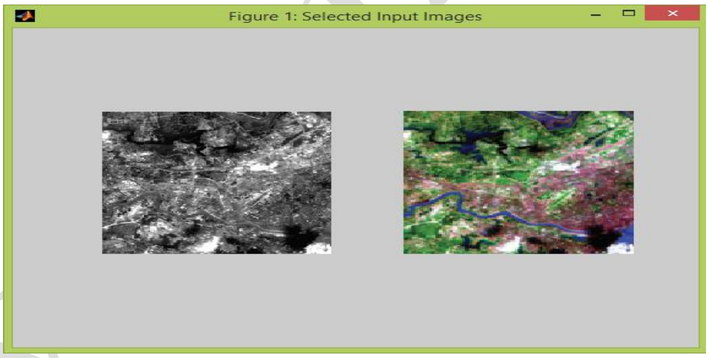

Fig. 5 Selected input PAN and MS image.

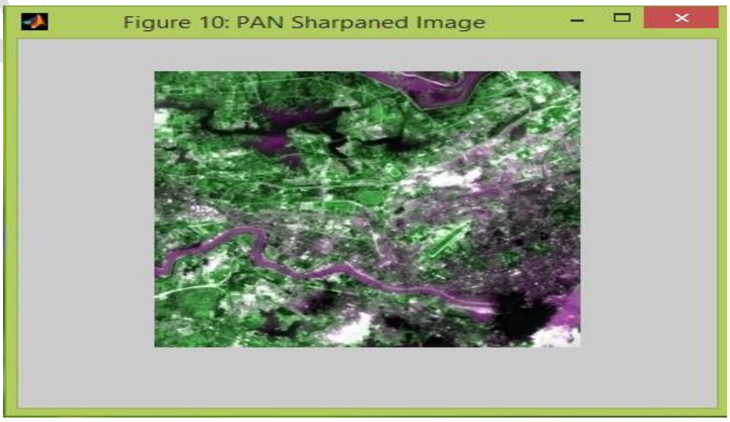

Fig.6 Resulting Pan sharpened image.

Fig. 7 shows the performance of parameters such as root mean square error, correlation and Standard deviation for the resulting pan sharpened image.

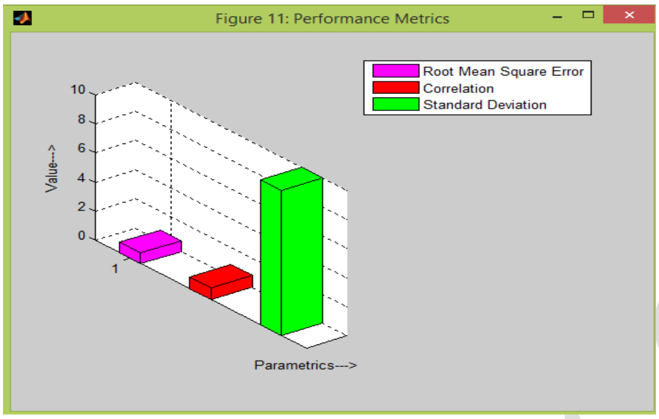

Fig.7 Performance of pan sharpened image.

The comparison of the standard NSCT method and the resulted pan sharpening using the dual transform in shown in Fig. 8. Here the existing indicates the standard NSCT method and the proposed indicates pan sharpening under dual transform. Here the Parameter Peak signal to noise(PSNR) ratio is compared.

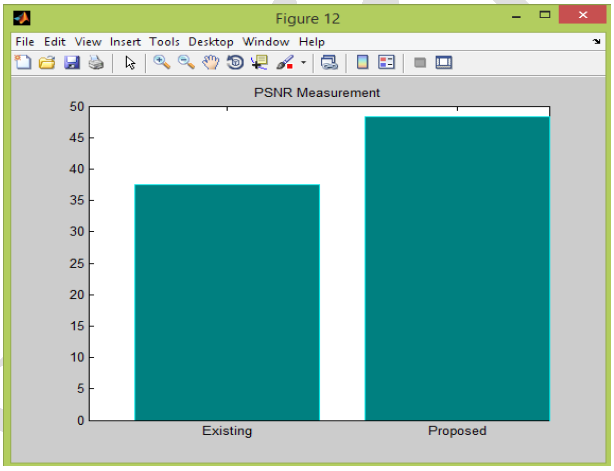

Fig. 8 comparison of standard NSCT and Dual Transform

The following values of parameters are obtained from the output pan sharpened image, Correlation Coefficient: 0.8363, Relative Bias: 0.7083, Relative Variance: 0.4187, Standard Deviation: 9.9522, Root Mean Square Error: 0.7361, Percentage Residual Difference: 0.0066, Peak Signal to Noise Ratio: 49.4616.

VI. CONCLUSION

The performance of Pansharpening based on dual transform has been compared with the performance of standard NSCT transform and the simulations have been carried out using MATLAB. Earlier the improvement of the NSCT based image pan-sharpening is assured by using a low number of decomposition levels for MS images and a higher number of decomposition levels for the Pan image. This strategy allows getting simultaneously satisfying results and increases the computation time and providing pan-sharpened images with a good spectral quality. Moreover, in dual transform the process is considered after applying NSCT and SWT in order to preserve the detail information existing in the MS images.

The performances of the proposed pansharpening under dual transform are tested on the WorldView-2 dataset. The obtained results confirm the added-value of upsampling and by using a Gabor and entropy based fusion. Both visual and quantitative qualities achieved by the proposed methods are satisfactory and the quality is improved.

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