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Satellite Multispectral Image Enhancement based on Pan-sharpening using NSC-Transform

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Abstract: In remote sensing, images acquired by various earth observation satellites tend to have either a high spatial and low spectral resolution or vice versa. Pan-sharpening is a technique which aims to improve spatial resolution of multispectral image. The challenges involve in the pan-sharpening are not only to improve the spatial resolution but also to preserve spectral quality of the multispectral image. Pan-sharpening for satellite Panchromatic (PAN) and Multispectral (MS) images involving Non-sub sampled Contourlet Transform is considered in this work. NSCT approaches with different levels of decomposition and up sampling done using Gabor based fusion. NSC-Transform is very efficient in representing the directional information and capturing intrinsic geometrical structures of the objects.In the propose method, a given number of decomposition levels are used for multispectral (MS) images and higher number of decomposition levels are used for Pan images. This decreases computation time and preserves both spectral and spatial qualities. Up sampling of MS images is performed after NSCT and not before. By applying upsampling after NSCT, structures and detail information of the MS images are more given be preserved and thus stay more distinguishable. Hence, we propose to exploit this property in pan-sharpening by fusing it with detail information provided every Pan image at the same fine level. The proposed method is tested on WorldView-2 datasets. Both spectral and spatial qualities have been improved.

Keywords: Pan-sharpening, Non-sub sampled Contourlet Transform, Quality Assessment etc.

I. INTRODUCTION

The quality of images provided by earth observation satellites systems is directly linked to their spatial and spectral resolutions. Due to physical and technological constraints, satellite sensors cannot provide images with both high spatial and high spectral resolutions; the spectral and spatial resolutions have inverse relationship. Consequently these systems produce on the one hand, panchromatic images (Pan) with high spatial resolution and low spectral resolution. On the other hand, they produce multispectral (MS) images with high spectral resolution and low spatial resolution. The integration of spatial information extracted from the Pan image into the MS image provides an image with both high spatial resolution and high spectral resolution. This is known as pan-sharpening.

Nowadays, the application of MS image pan-sharpening algorithms in remote sensing has become numerous due mainly to the growing number of satellite sensors. Up to now, a large collection of pan-sharpening methods have been proposed to improve MS images to higher resolutions using spatial information of the Pan images.

A. Pan-Sharpening

Pan sharpening is a process of merging high-resolution panchromatic and lower resolution multispectral imagery to create a single high-resolution color image. Google Maps and nearly every map creating company use this technique to increase image quality.

Pan sharpening produces a high-resolution color image from three, four or more low-resolution multispectral satellite bands plus a corresponding high-resolution panchromatic band:

Low-res color bands   High-res grayscale band = Hi-res color image.

Such band combinations are commonly bundled in satellite data sets. One of the principal reasons for configuring satellite sensors this way is to keep satellite weight, cost, bandwidth and complexity down. Pan sharpening uses spatial information in the high-resolution grayscale band and color information in the multispectral bands to create a high-resolution color image.

Pan-sharpening techniques can bring about spectral distortions when pan sharpening satellite images for the nature of the panchromatic band. The Land sat panchromatic band such as is not watchful blue light. As a result, the spectral characteristics of the raw pan sharpened color image may not exactly match those of the corresponding low-resolution RGB image, bring about altered color tones. This has engender the development of many algorithms that attempt to reduce this spectral distortion and to produce visually pleasing images.

"Pan Sharpening" is shorthand for "Panchromatic sharpening". It means using a panchromatic (single band) image to "sharpen" a multispectral image. In this sense, to "sharpen" means to increase the spatial resolution of a multispectral image. A multispectral image contains a higher degree of spectral resolution than a panchromatic image, while often a panchromatic image will have a higher spatial resolution than a multispectral image. A pan sharpened image represents a sensor fusion between the multispectral and panchromatic images which gives outstanding of both image types, high spectral resolution and high spatial resolution. This is the simple why of pan sharpening. Most about paper is absorbing the how of pan sharpening.

In contrast to the multispectral image, a panchromatic image contains remaining wide band of reflectance data. The data is usually representative of a range of bands and wavelengths, for example visible or thermal infrared, specially, it combines many colors so it is“pan” chromatic. A panchromatic copy the visible bands is an amount a combination of red, green and blue data into a single measure of reflectance. Modern multispectral scanners also generally include some radiation at slightly longer wavelengths than delicate subject, called “near infrared” radiation. Panchromatic images can generally be collected with higher spatial resolution than a multispectral image because the broad spectral range allows smaller detectors impending used while maintaining a high signal to noise ratio.

B. System Architecture

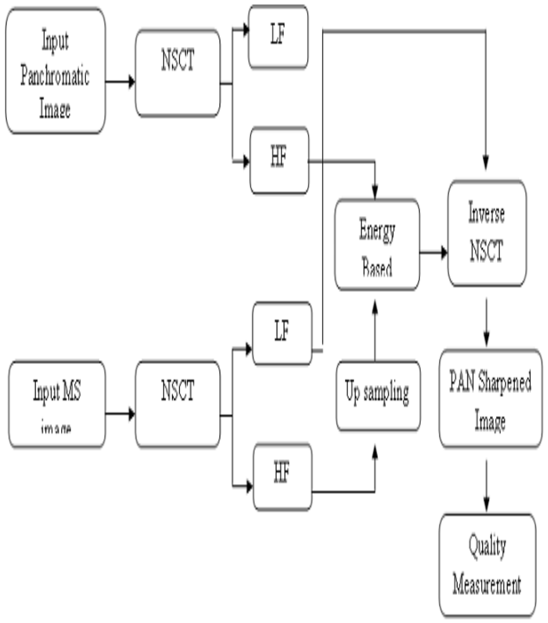

Figure 1: Block Diagram of the Proposed System

II. NSCT DECOMPOSITION

A number of image processing tasks are efficiently carried out in a domain aside from the pixel domain, often according to what an invertible linear transformation. For example, image compression and de-noising are efficiently done for the wavelet transform domain. A good transform or representation would capture the essence of a given signal or class of signals with few basis elements. The set of basic functions completely characterizes the transform and this set perhaps redundant instead, depending on whether the basic functions are linear dependent. By allowing redundancy, it is possible to enrich the set of basic functions in case the representation is more efficient in capturing some signal behavior. Applications for example edge detection, contour detection, de-noising, and image restoration can greatly benefit from redundant representations.

The contour let transform is a multi-directional and multi-scale transform especially constructed by combining the Laplacian pyramid and the directional filter bank (DFB). Due to down samplers and up samplers present in both the Laplacian pyramid and the DFB, the contour let transform is not shift-invariant. The NSCT is a fully shift-invariant, multi-scale, and multi-direction expansion that has better directional frequency localization and a fast implementation. In essence, the proposed structure achieves a similar sub band decomposition as that of contour lets.

The structure consists in a bank of filters that splits the 2-D frequency plane in the subbands illustrated in Figure 2. Our proposed transform can thus be divided into two parts that are both shift-invariant

- A nonsubsampled pyramid structure that ensures the multi-scale property
- A nonsubsampled DFB structure that gives directionality.

A. The Nonsubsampled Pyramid (NSP)

The multi-scale property of the NSCT is a shiftinvariant filtering structure that achieves a subband decomposition similar to that of the Laplacian pyramid. Our solution is obtained by using two-channel nonsubsampled 2-D filter banks. The proposed nonsubsampled pyramid (NSP) decomposition with $J = 3$ stages. Such expansion is conceptually similar to the 1-D nonsubsampled wavelet transform computed with the a trous algorithm.

The filters for subsequent stages are obtained by upsampling the filters of the first stage. This gives the multi-scale property without the need for additional filter design. The proposed structure is thus different from the separable nonsubsampled wavelet transform (NSWT). In particular, one bandpass image is produced at each stage bring about J 1 redundancy. By contrast, the separable NSWT produces three directional images at each stage get 3J 1 redundancy.

The NSFB is built from a given lowpass filter $H0(z)$. One then sets $H1(z) = 1 - H0(z)$, and $G0(z) = G1(z) = 1$. This perfect reconstruction system can be seen as a particular case of our more general structure. The advantage of our construction is full is less restrictive and properly, better filters can be obtained.

B. Nonsubsampled Directional Filter Bank (NSDFB)

The directional filter bank of Bamberger and Smith is constructed by combining critically-sampled two-channel fan filter banks and resampling operations. The result is a

tree-structured filter bank that splits the frequency plane in the directional wedges.
The number of channels is L = 2l, where l is the number of stages in the tree structure. Using multirate identities, the tree-structured DFB can be put into the equivalent form. It is clear from the above that the DFB is not shift-invariant. A shift-invariant directional expansion is obtained with a nonsubsampled DFB (NSDFB).
The NSDFB is constructed by eliminating the downsamplers and upsamplers.This is equivalent to switching off the downsamplers in each two-channel filter bank in the DFB tree structure and upsampling the filters accordingly. This bring about a tree composed of two-channel nonsubsampled filter banks.

C. Combining The Nsp And Nsdfb In The NSCT

The NSCT is constructed by combining the NSP and the NSDFB. In constructing the nonsubsampled contourlet transform, care must be taken when applying the directional filters to the coarser scales of the pyramid. Due to the tree-structure nature of the NSDFB, the directional response at the lower and upper frequencies receive aliasing which can be a problem in the upper stages of the pyramid. The passband region of the directional filter is labelled as “Good” or “Bad”. Thus we see that for coarser scales, the highpass channel in effect is filtered with insolvent portion of the directional filter passband. This get severe aliasing and in some observed cases a considerable loss of directional resolution.

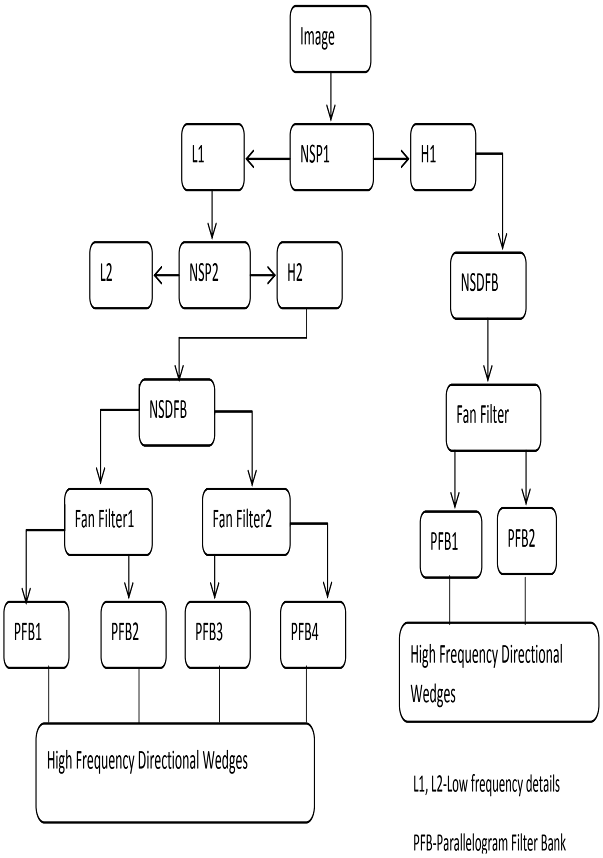

Figure 2: Decomposition Flow

(a) With no upsampling, the highpass at higher scales will be filtered individually portion of the directional filter that has “bad” response.(b) Upsampling ensures that filtering is done in the “good” region.

NSCT decomposition is to compute the multi scale and different direction components of the discrete images. It involves one and the other stages for example 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 extremely high frequency sub bands at each decomposition level and it produces n 1 sub images if decomposition level is n.

III.IMAGE FUSION

A. Pixel Level Fusion

- The sub band images of two source images obtained from NSCT are utilized for morphing process to get the enhanced information to diagnose the brain diseases.
- Here, the pixel level fusion method is approached for this process. It will be implemented based on Gabor filter bank and gradient detection for coefficient selection.
- The low frequency sub bands of two source images will be fused by Gabor coefficients selection and high frequency sub bands will be fused by gradient measurement to select desired coefficients.
- Finally, fused two different frequency sub bands are inverse transformed to reconstruct the fused image and parameters will be evaluated between input and fused image.

B. Local Energy Based Fusion

After Fourier transform into the frequency domain, there are high frequency and low frequency of sub. Most of the energy of image concentrated in low frequency coefficients. So, how to choose the low frequency coefficients is the key to improve the image quality. All kinds of beyond wavelet transforms are based on the geometric features of image analysis method, to achieve multi-scale and multi-directional image decomposition. This is suitable for the line singular analysis. But because these transforms contain down sampling, it is not translation invariance, leading to pseudo-Gibbs effects.
In other side, as the incomplete of the multi-scale decomposition, some details of the image are still remaining in the low frequency components.

This phenomenon is obviously when the decomposition levels are less. Because of this, someone suggested that use edge-based fusion method in low frequency. We use the local energy (LE) as a measurement to choose the low frequency coefficients. Select the maximum energy of two source images as output. Due to the partial human visual perception characteristics and the relationship of decomposition about local correlation coefficients, the statistical characteristics of neighbour should be

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considered. Therefore, the statistic algorithm is based on the 3×3 window. We use 3 directional filtering operators extract the edge information with spatial filters for low frequency.

IV. SIMULATED RESULTS

A. Input Images

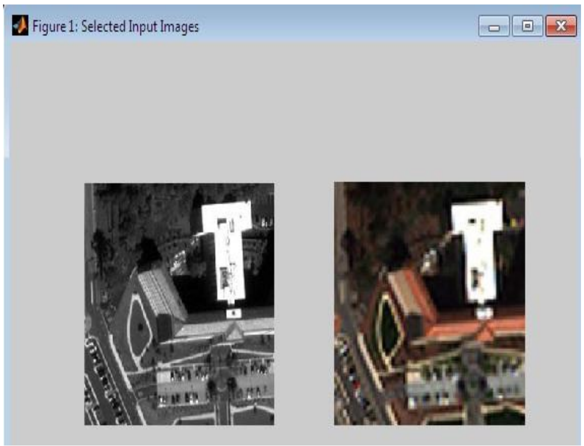

Figure 3: PAN and MS images

B. Pan-sharpened Image

Figure 4: Pan-sharpened image

C. Final Output window on GUI

Correlation 0.968836
SD 8.06501
RMSE 10.839
PRD 0.100716
PSNR 37.7809
RV 0.0106950
RB 0.121256

Figure 5: Final output window on GUI

V. CONCLUSION

The project presented the Multispectral Satellite Image Enhancement based on Pan Sharpening under Non Sub sampled Contour let Transform. It involves two different approaches that are, NSCT with different levels of decomposition and NSCT with up sampling based pixel level fusion. NSCT is very efficient in representing the directional information and capturing intrinsic geometrical structures of the objects. In this type, Local energy based fusion approach was utilized. Here, the image will be enhanced with high spectral and special resolution. The simulated results shown that generated fused image has less distortion, high shift invariant and improved contour edges.

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