Fusion Based Image Enhancement of Satellite Data

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Abstract- Two pan-sharpening methods based on the non-subsampled contourlet transform (NSCT) are proposed. NSCT is very efficient in representing the directional information and capturing intrinsic geometrical structures of the objects. By applying upsampling after NSCT, structures and detail information of the MS images are more likely to be preserved and thus stay more distinguishable. Hence, we propose to exploit this property in pan-sharpening by fusing it with detail information provided by the Pan image at the same fine level. Visual and quantitative results demonstrate the efficiency of the proposed methods. Both spectral and spatial qualities have been improved.

Key Words - Fusion , Satellite, Non-subsampled Contourlet Transform, PSNR, Sampling.

I.   INTRODUCTION

The image fusion between low resolution input raw multispectral (MS) and high resolution panchromatic image is important for a variety of remote sensing applications. In research publications the widely used image fusion quality evolution approaches can be included into two main categories. The demand for high spatial and spectral resolutions imagery in applications like change analysis, environmental monitoring, cartography, and geology is increasing rapidly. A number of different pan-sharpening algorithms are used to produce images with both high spatial and spectral resolutions. 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. In this paper, we will briefly describe the NSCT-based pan-sharpening algorithms in the standard form and then propose more efficient schemes improving the former. The first proposed method is similar to the standard method; however, the number of decomposition levels used for MS bands is lower than the number of decomposition levels for the Pan image. The second proposed method represents an improvement of the first one by using a more efficient upsampling algorithm and applying some rules to fuse the NSCT coefficients. It is shown that upsampling is very important in preserving edges in the pan-sharpened images. The upsampling step is accomplished using an interpolation algorithm based on NSCT. The second proposed method uses NSCT with an optimized number of decomposition levels and an efficient interpolation method. Generally, the different image quality matrices like entropy, mean, standard deviation, correlation coefficient between a raw multispectral image and pan-sharpened image, correlation coefficient between a pan image and pan-sharpened image, peak signal to noise ratio, normalized root mean square error, mean gradient, relative average spectral error (RASE) are employed.

In this paper, we have selected the following widely used parameters for assessing the quality of the obtained results.

1) The correlation coefficient (CC) : it is the most popular. It measures the similarity between the fused and original images. A CC value of indicates that the two images are highly correlated or similar.

$$C_{x,\hat{x}} = E[(x-\mu_x) (\hat{x}-\mu_{\hat{x}})] / \sigma_x. \sigma_{\hat{x}}$$

2) Mean Square Error (MSE): The Mean squared error (MSE) measures the average absolute difference between two images. Smaller the MSE value, the closer the fit is to the data.

$$MSE =1/MN * \sum_{j=1}^{M} \sum_{k=1}^{N}(x - \mathfrak{x})^2$$

If this value is low, the PSNR value will be high and vice versa. Its value must be minimum as much as possible.

3) Peak Signal To Noise Ratio (PSNR): PSNR is the ratio between possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Higher PSNR value provides higher image quality. It is given by,

$$PSNR=10\log 10 * (2^n-1) / MSE$$

II.   PROPOSED PROCEDURE

Fusion process is conducted as described by the following steps.

1) Each original band is decomposed, using NSCT, in one coarse level and one fine level, whereas the Pan image is decomposed into one coarse level and three fine levels.

2) The obtained coefficients are then upsampled using the bi-linear interpolation algorithm.

3) The coarse level of the fused image is the upsampled coarse level of the band.

4) Fine levels 2 and 3 of the fused image are set to fine levels 2 and 3 of the Pan image.

5) Fine level 1 of the fused image is obtained by fusing the coefficients of the same level obtained from both the band and the Pan image. The fusion rule uses the local energy (LE) of each coefficient calculated within a window to generate a decision map.

6) The obtained image after inverse NSCT is the final fused image.

7) Measure the quality parameters for output image.

III. RESULTS AND CONCLUSION

In the present paper the previous methods of NSCT and proposed method have been tested on calculated the quality parameters like CC, MSE and PSNR. Figure 1 has given clear idea about the proposed process to fuse panchromatic image or PAN image or Synthetic RADAR image or SAR image and optical image. Table 1 has given the quality parameters of fused images of different techniques. The images that considered for this process are from sensors like WORLD VIEW -2 and RISAT-1 images.

The proposed method has produced the highest CC value , the lowest MSE value and the highest PSNR values. The images that we considered are having different sizes, because after upsampling process they need to have same pixel size. The size of the images depends on the level of decomposition used in the process. The original transform use up and down sampling of the data. Due to these process the information may be lost. This disadvantage is avoided in non sub sampled contourlet transform.

The parameters like edge saving index, standard deviation, relative variance, relative bias, structural similarity, QNR index, accuracy measurement, confusion matrix , etc can also be calculated using these method.
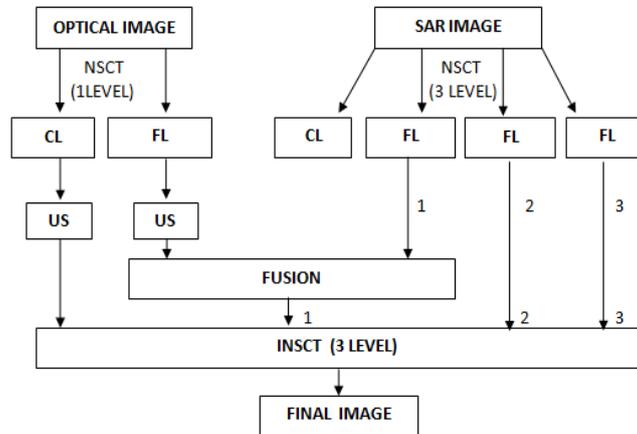

Figure 1: Proposed Method

Table 1: Comparison of Quality Parameters

IMAGES	METHOD	Correlation Similarity	Error (MSE)	PSNR
SET-1	Method-1	0.9837	9.4144	38.3929
	Method-2	0.9844	9.3667	38.4149
	Proposed	**0.9845**	**9.3318**	**38.4312**
SET-2	Method-1	0.2785	10.2915	38.0060
	Method-2	0.3403	10.2473	38.0247
	Proposed	**0.3700**	**10.1541**	**38.0644**
SET-3	Method-1	0.3998	10.6126	37.8726
	Method-2	0.4915	10.5913	37.8813
	Proposed	**0.5128**	**10.5163**	**37.9122**
Average	Method-1	0.554	10.1061	38.0905
	Method-2	0.6125	10.0684	38.1069
	Proposed	**0.6224**	**10.0007**	**38.1359**

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