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# An efficient method of pan sharpening using NSCT

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**Abstract:** Non-Subsampled Contourlet Transform (NSCT) is a improvement of Contourlet Transform (CT). The important properties of the Non-Subsampled Contourlet Transforms are shift-invariance, high resolution, and high directionality. Non-Subsampled Transform represents high directional information and captures geometrical structures of the objects. In the proposed method the given numbers of decomposition levels are applied to multispectral Image and the Panchromatic Image in the relative ratio. Fine levels and coarse levels are obtained. During the Simulation process Bilinear Interpolation method is applied for fine levels of the Panchromatic Image and Multispectral Image. The coarse level of multispectral Image given to a local edge preserving filter, and later inverse NSCT is applied to get the Pan-Sharpened Image. Non-Subsampled Contourlet Transform preserves spectral and spatial information. The computation time is decreased. Considerably the detailed information can be preserved by applying Up sampling after NSCT. By this Upsampling after NSCT, the coefficients are fused by the application of Fusion Rule. After Inverse NSCT, the obtained Image is a Pan Sharpened Image. An additional Local Edge Preserving Filter (LEP) is used before NSCT to get Pan Sharpened Image with high Spatial and Spectral qualities. By Images and quality indices values, we can observe the improved Spatial and Spectral qualities.

**Keywords:** NSCT, Bilinear interpolation, Image fusion, local edge preserving filter (LEP), Pan-sharpened Image or fused image.

## I. INTRODUCTION

Nowadays, huge quantities of satellite Images are available from many earth observation platforms, such as SPOT, Landsat7, IKONOS, QuickBird and Orb view [2]. Remote sensing Images are recorded in digital form and then processed by computers to produce Image products useful for wide applications [2]. The spatial resolution of a Image sensing imaging system is expressed as the area of the ground captured by one pixel and effects the reproduction of details within the scene [2]. The instantaneous field of view (IFOV) is the ground area sensed at a given instant of time [2]. The spatial resolution is dependent on the IFOV [2].For a given number of pixels, the finer the IFOV is, the higher spatial resolution [2]. Spatial Resolution is also viewed as the clarity of the high-frequency detail information available in an Image [2]. Spatial Resolution in remote sensing is usually expressed in Meters or Feet, which represents the length of the side of the area covered by a pixel [2]. Fig.1 shows the different spatial resolutions at 5m, 10m, and 20m [2].

(a) (b) (c)

Fig.1. Images of the same area with different spatial resolution (a)5m,(b)10m,(c)20m [2].

A Multispectral Image is an Image that contains more than one spectral band [5]. A color is a very simple example of a multispectral Image that contains three bands [5]. The three bands represents Red, Green, Blue wavelength bands of the Electromagnetic Spectrum [5]. The Fig.2 shows the Electromagnetic Spectrum [5].

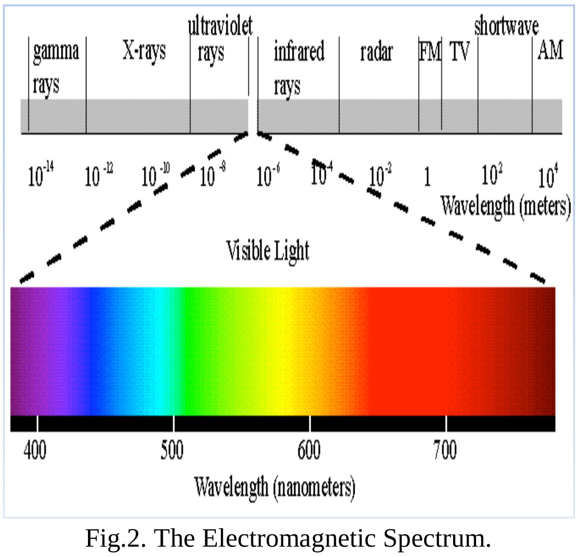


Fig.2. The Electromagnetic Spectrum.

Combining the 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-Sharpened Image or fused Image. There are

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numerous Pan sharpened methods, one of them being algorithm based Intensity-Hue-Saturation (HIS) method. Several Pan-Sharpening methods were in use based on their multiresolution approaches of the Laplacian pyramid, the Wavelet transform, and the contourlet transforms (CTs). The NSCT is the shift-invarient version of CT.

## II.NON-SUBSAMPLED CONTOURLET TRANSFORM

Pan-Sharpening is conducted using a multilevel decomposition to separate high and low frequencies. Pan-Sharpening techniques based on multiresolution analysis use multilevel decomposition methods to decompose MS and respectively. A large number of methods have been proposed based on the Wavelet Transform. CT is a better approach than the Wavelet one for Pan-Sharpening. Contourlet Transforms is able to capture and link the points of discontinuities to form a linear structure (contours). The local Directional Filter Bank (DFB) is used to group these Wavelet-like coefficients to obtain a smooth contour. NSCT is a shift-invariant version of CT and has some excellent properties including multilevel and multidirectional properties. NSCT provides a better representation of the contours. CT employs the Laplacian pyramid for multiscale decomposition and the DFB for directional decomposition. To reduce the frequency aliasing of CT and to reach the shift invariance, NSCT eliminates the downsamplers and the upsamplers during the decomposition and the reconstruction of the Image; it is built upon the Non-Subsampled Pyramid Filter Banks (NSPFBs) and the non-subsampled DFBs (NSDFBs). DFB is constructed by combining critically sampled two-channel fan filter banks and resampling operations, which results in a tree-structured filter bank that splits the 2-D frequency plane into directional wedges [1].

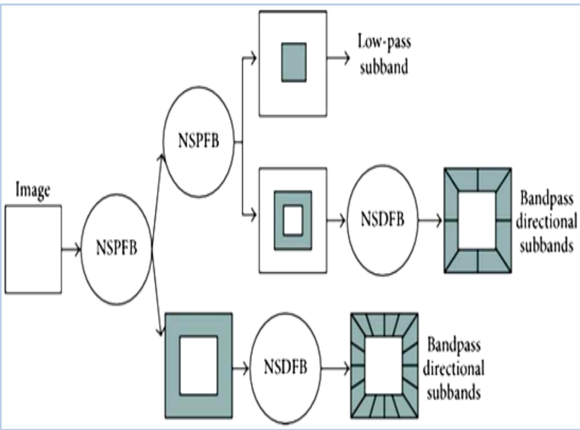


Fig.3. NSFB structure that implements NSCT.

## III QUALITY ASSESMENT

The quality assessment of the Pan-Sharpened MS Images presents a problem since no reference Image exists at the Pan sharpened resolution. The following widely used indices for assessing the quality of the obtained results.

1) **The Correlation Coefficient** (CC): This measures the similarity between the fused and original Images. A CC value of indicates that the two Images are highly correlated or similar.

2) **The correlation between high frequencies** (sCCz) based on: a high-pass filter is applied to the fused bands and the Pan Image. Then, the CC coefficient between the resulting Images is computed.

3) **The correlation between high frequencies (sCCo)** based on: high-pass filtered versions of the Pan-sharpened bands are compared with the high-pass filtered versions of the original MS bands.

4) **The relative bias (BIAS):** This is the difference between the mean of the original Image and that of the fused one, divided by the mean of the original Image.
5) **The relative variance (VAR):** This represents the difference in variance between the original and fused Images, divided by the variance of the original Image.
6) **The Standard Deviation (SD)** of the difference Image in relation with the mean of the original Image: it indicates the level of the error at any pixel.
7) **The Structural Similarity (SSIM) index:** It measures the similarity between two Images. The SSIM index can be viewed as a quality measure of one of the Images being compared provided the other Image is regarded as of perfect quality.
8) **The Universal Objective Image Quality Index (Q):** it models distortion as a combination of three different factors: loss of correlation, luminance distortion, and contrast distortion.
9) **The Relative Average Spectral Error (RASE):** It is used to characterize the average performance of the Pan-Sharpening method in spectral bands.

10) **The Root-Mean-Square Error (RMSE).**

11) **The average Spectral Angle Mapper (SAM):** It computes the change in angle of spectral vectors.
12) **The Relative Dimensionless Global Error in Synthesis (ERGAS):** It provides a single quantity synthesizing the quality of the fused dataset.
13) **The QNR Index:** It is used to assess fusion quality without requiring reference Images.
Pan-Sharpening method is conducted as described by the following algorithmic steps given in Table 1.

| |
|---|
| ***1. Each original MS band is decomposed, using NSCT, in coarse level and one fine level, whereas the Pan Image is decomposed into one coarse level and three fine levels.*** |
| ***2. The obtained MS coefficients are then up sampled using the bi-linear interpolation algorithm.*** |
| ***3. The coarse level of the Pan-sharpened MS band is the up sampled coarse level of the MS band.*** |
| ***4. Fine levels 2 and 3 of the Pan-sharpened MS band are set to fine levels 2 and 3 of the Pan Image.*** |
| ***5. Fine level 1 of the Pan-sharpened MS band is obtained by fusing the coefficients of the same level obtained from both the MS band and the Pan Image. The Fusion rule uses the local energy (LE) of each coefficients are calculated.*** |

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|---|
| ***6. After the up sampling method a local edge preserving filter (LEP) is used to get high spatial and spectral qualities.*** |
| ***7. Finally inverse NSCT is obtained Pan-sharpened Image.*** |

Table.1. Algorithm for Pan Sharpening method using NSCT.

The fusion rule uses the local energy, to calculate LE given by the formula [1].

$$\mathrm{LE}(x,y) = \sum_{i=-M}^{M} \sum_{j=-N}^{N} (\mathrm{Fine\_level\_coeff}(x+i, y+j))^2.$$

To map ms coefficients and pan coefficients we use the formula [1].

$$\mathrm{Fused\_fine\_level\_coeff}(x,y) = \begin{cases} \mathrm{MS\_fine\_level\_coeff}(x,y), & \text{if } \mathrm{LE_{MS}}(x,y) \geq \mathrm{LE_{Pan}}(x,y) \\ \mathrm{Pan\_fine\_level\_coeff}(x,y), & \text{otherwise.} \end{cases}$$

Flowchart of the above algorithmic steps, which is shown below. Fusing the Pan Image and ms Images, by applying NSCT for Pan and MS Image. After applying NSCT decompose into fine and coarse levels. Pan Image is split into low frequency component and high frequency components. All high frequency components are compared by local energy (ms) greater than local energy (Pan).Compared by local energy of ms is greater than by local energy of Pan Image.

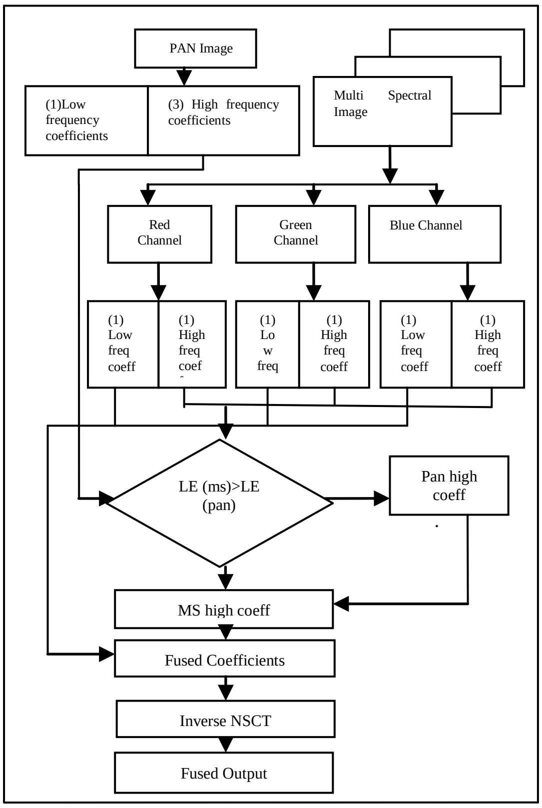


Fig.4. Flow chart of the Existing Method to get Pan sharpened Image using NSCT.

Existing method is shown in Fig.5. Pan and the ms Images are applied for NSCT.3-level for Pan Image and 1-level for MS Image. For MS Images we are applying up sampling to get the number of decomposition levels, after we are applying local energy fusion rules, for fine levels of the Pan and ms Images. At last we are applying inverse NSCT to get the fused or Pan-sharpened Image.

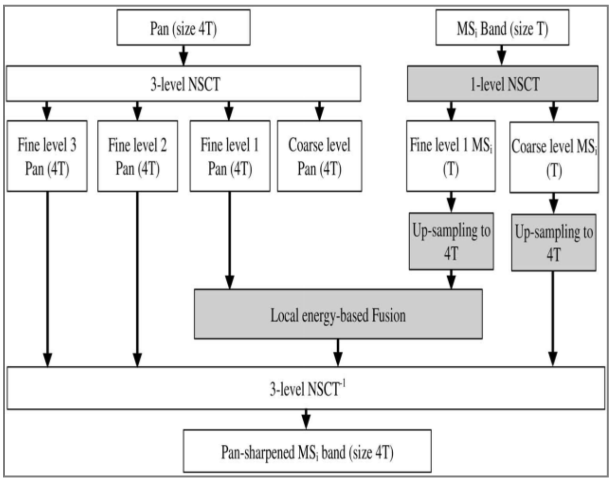


Fig.5 Existing Method based on Pan Sharpened Image.

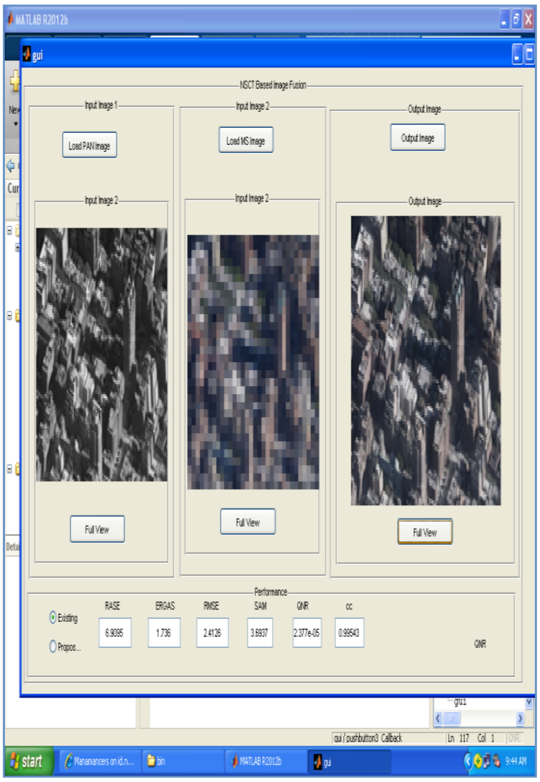

Fig.6. Pan-sharpened Image of the existing method based on NSCT.

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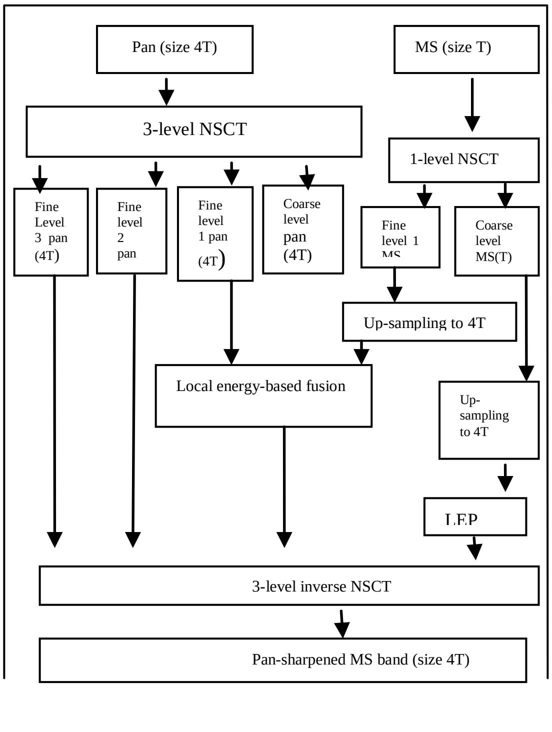


Fig.7.Proposed Method based on NSCT using LEP (local edge preserving filter).

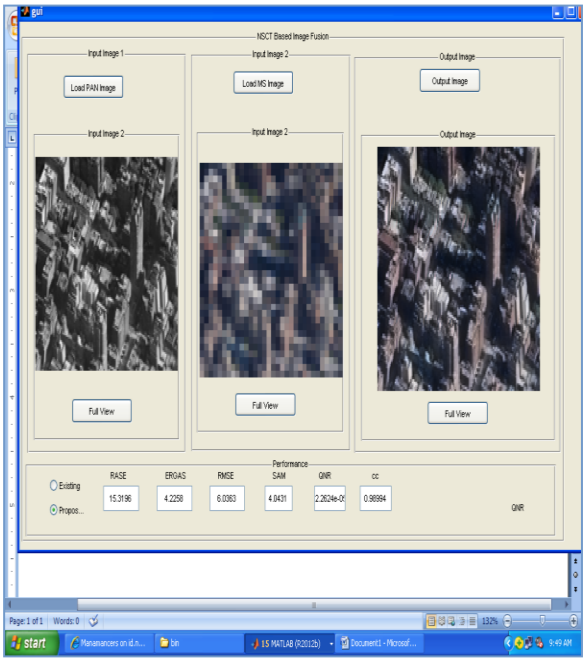


Fig.8. Pan-Sharpened Image of the proposed method based on NSCT using LEP.

| INDEX | EXISTING METHOD | PROPOSED METHOD |
|---|---|---|
| RASE | 6.9095 | 15.3196 |
| ERGAS | 1.736 | 4.2258 |
| RMSE | 2.4126 | 6.036 |
| SAM | 3.6937 | 4.0431 |
| QNR | 2.377E -05 | 2.2624E -05 |
| CC | 0.99543 | 0.98994 |

Table.2. Quality Assessment.

## IV. CONCLUSION

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. By using this method we can reduce the computation time to obtain better Pan-Sharpened Image as compared to previous method. In the first method, we can get a good spectral quality but resolution is not good. Moreover, the Upsampling process is considered. We propose to use Upsampling process after applying NSCT in order to preserve the detail information existing in the MS Images. Thus, a second method is proposed, where in addition to different numbers of decomposition levels, the Interpolation is conducted after NSCT. The obtained fine levels from MS and Pan Images are fused using the LE as the fusion rule. Performances of the proposed strategies are tested on theWorldView-2 dataset. The obtained results confirm the added-value of using an adequate number of decomposition levels and Upsampling after the NSCT decomposition. Both visual and quantitative qualities achieved by the proposed methods are satisfactory and the improvement of quality, compared to the standard NSCT-based method.

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