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# **Pansharpening Based Multispectral Image Enhancement under Dual Transform**

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**ABSTRACT:** The paper presents satellite image enhancement based on SWT, NSCT with Gabor based pixel level fusion for Pansharpening. SWT decompose the image into finer and coarser details and these details will be decomposed into different orientation edges using NSCT. NSCT 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 Image fusion involves Gabor filter to fuse finest details obtained from NSCT It enhances the spatial information of multi spectral images, Gabor is useful to discriminate and characterize the texture of an image through frequency and orientation representation. All subbands are fused by pixel level fusion with maximum rule to achieve better accuracy. 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 pansharpened image. Here, a given number of decomposition levels are used for multispectral images while a higher number of decomposition levels are used for Pan Images relatively to the ratio of the Pan Pixel size to the MS pixel size. This preserves both spectral and spatial qualities while decreasing computation time. By applying upsampling after NSCT, structures and detail information of the MS images are more likely to be preserved. Hence, pansharpening is done by fusing it with detail information provided by the Pan image at the same fine level. The system simulated result shows that used method provides better resolution in these images rather than prior approaches and it also measured the performance parameters such as correlation, PSNR, PSD and standard deviation.

**KEYWORDS:** Panchromatic(pan) Imagery, Multispectral (MS) Imagery, Image Fusion, Pansharpening, NSCT, Upsampling, Quality assessment.

## **I. INTRODUCTION**

Satellite systems produced the sensed images of the earth, sensed image quality to be link with both spatial and spectral resolution. Resolution is the detail of an image, Spatial resolution means the details of the pixel arrangements in an image, highest spatial resolution sensor goeeye-1(0.41m). Spectral resolution refers the number of bands involved in spectrum, world view-2 images refer 8 band in spectrum has highest spectral resolution in world. Both the spatial and spectral resolution are inverse relationship[1] Satellite system provide the sensed image with different sensor, like panchromatic and multispectral image. Panchromatic image is the  $m \times n \times 1$  single band images have high spatial and low spectral resolution. Like MS image is  $m \times n \times 3$  multiple bands have high spectral and low spatial resolution[1]. Several situations in image processing require high spatial and high spectral resolution in a single image[2]. Solution is image fusion, process of combining relevant information from two or more images into a single image[5]. Injection of the fine spatial information from the high spatial resolution of the pan image in to the high spectral resolution of the MS image to create a both high spatial and spectral resolution of MS image is known as the Pansharpening[3]. Various Pansharpening methods are proposed to enhance the multispectral image [6].

## **II. SURVEY OF PAN SHARPENING METHODS**

Several pan sharpening methods such as averaging, brovey, principal component analysis (PCA), IHS and high pass filtering fall under spatial domain approaches. Intensity-hue-saturation (IHS) transform color distortion problem arises from the change of the saturation during the fusion process, arbitrary order are used for hyper spectral image[2,3,4,5].

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Brovey transform single image fusion preserves the relative a spectral contributions of each pixel[3]. drawback of the approaches are color distortion, limited directionality, fail to capture the smoothness along the contour. In the spatial domain approaches spectral distortion is a negative factor for the processing, so frequency domain approaches for pan sharpening process [7]. For frequency domain use multi resolution approaches like laplacian pyramid, wavelet transform and contourlet transforms. Wavelet transform is frequently used one for its properties such as multi resolution, localization critical sampling and limited directionality (horizon, vertical, diagonal) but fail to capture the contour[8]. contourlet transform seems to be overcome the drawback[7]. It is multi resolution transform it has has the high directionality, high correlation among the neighbouring pixels, but introducing the artifacts during the inverse transformation and poor texture features[1]. The NSCT is a shift –invariant version of contourlet transform.

### III. STATIONARY WAVELET TRANSFORM

Stationary wavelet transform is one of the recent wavelet transform used in image processing[25]. In short, SWT is similar to DWT but it does not use down- sampling, hence the subbands will have the same size as the input image[25]. Stationary wavelet transform is a type of signal representation that can give the frequency content of time or spatial location . it decompose the image into different subband image 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 low frequency subband contain 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 images. Fig.1 Shows the decomposition flow of SWT.

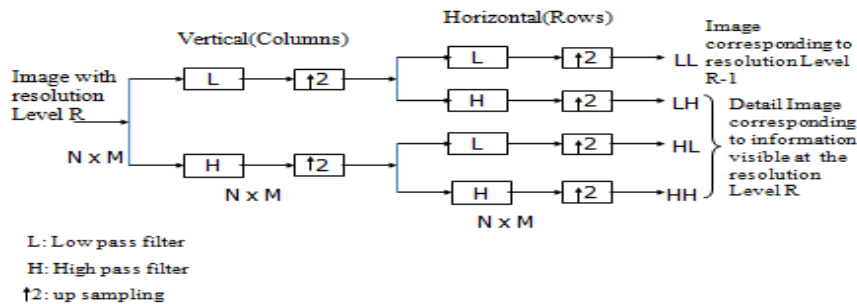


Fig.1 SWT Decomposition Flow

### IV. NON-SUBSAMPLED CONTOURLET TRANSFORM

NSCT is developed because of the shift invariant property computed with a trous algorithm.

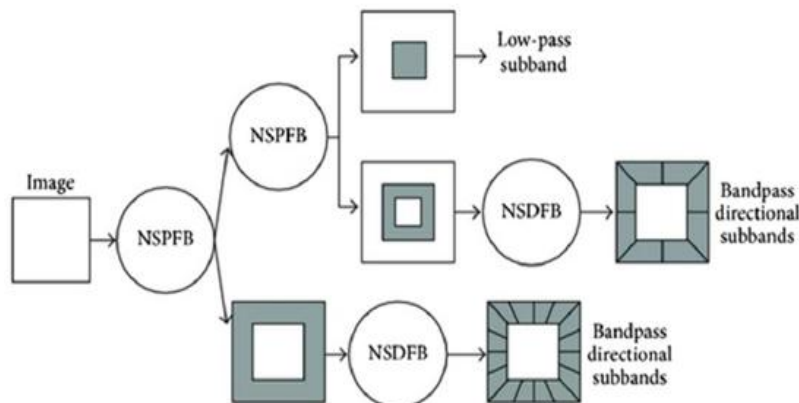


Fig.2 NSCT decomposition flow structure

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It is very efficient in representing the directional information and capturing the intrinsic geometrical structures of the objects. It has the characteristics of high resolution, shift invariance, perfect reconstruction, sharp frequency response, easy implementation, linear phase filter and high directionality. It built upon the non-subsampled pyramid filter banks (NSPFBs) and the non-subsampled directional filter banks (NSDFBs), It eliminates the downsamplers and the upsamplers during the decomposition and the reconstruction of the image in Fig.2 [10] both the upsampling and down sampling are lie in the laplacian pyramid and directional filter banks, NSP structure to retain the multiscale property then directional filter bank for directionality and it provides the better contour edges. contourlet transforms finding the laplacian pyramid for multiscale decomposition and the DFB for directional decomposition. Shift invariant properties reducing the frequency aliasing of CT [9]. NSCT decomposition is to compute the multiscale and different direction components of the discrete image, it involve two stage such as NSPFB and NSDFB to extract the texture and contours and the detailed coefficients. NSPFB decompose the image into low and high frequency subbands at each decomposition level and it produces  $n+1$  subimages if the decomposition level is  $n$ . NSDFB extracts the detailed coefficients from the direct decomposition of high frequency subbands obtained from the non-subsampled pyramid and it generates 'm' power of two sub images if the number of stages be 'm' [11]. NSCT is obtained by combining NSPFB and NSDFB as shown in Fig.2.

## V. DIFFERENT METHODS OF NSCT

STANDARD NSCT- First Apply transform for both Panchromatic and Multispectral images then to decompose the images of fine and coarser coefficients by the decomposition structure flaws, like low frequency component use the pyramid filter bank(NSPFB) and for high frequency component use the directional filter bank(NSDFB) . Second apply the energy based fusion rule for pixel level approach of the coefficients. At last generate the pan sharpened image by performing the inverse transformation. Here the decomposition level for both pan and multispectral are same.

### Method 1. NSCT with different levels of decomposition

A lower number of decomposition levels preserve better the spectral quality, whereas a higher number of decomposition levels is to maintain the spatial quality. Thus, the improvement of fused images may be achieved if an adequate number of decomposition levels are used[6]. Consequently, hence propose to use the NSCT-based pan-sharpening with a different number of decomposition levels, where the number of decomposition levels for MS bands is lower than the number of decomposition levels for Pan images. Therefore, if  $n$  decomposition levels are used for MS bands, then  $n+2$  decomposition levels are used for Pan image. Decomposition flow to be same as such as the fig.2 .it is clear that the proposed method (method1), based on different numbers of decomposition levels, gives better results, in terms of most of the indices, compared to the standard method based on a fixed number of decomposition levels for both the MS and the Pan images, it shown in the fig 3. It is also important to note that the proposed method allows a gain in terms of execution-time, the proposed method not only improves the spectral quality but operates with lower processing time compared to the standard method.

### Method 2. NSCT based upsampling with different levels of decomposition

Typically, MS images are resampled to the same pixel size as the Pan image before the pan-sharpening process. It was shown that a good upsampling method can improve considerably the results [12] and [13]. Upsampling is an important step in a pan-sharpening process. The best technique for image resolution enhancement is interpolation. It is performed during upsampling can improve the quality of the pan-sharpened images [12]. The authors in [13] proposed a technique, based on NSCT, to upsampled images for remote sensing applications. At first, an MS image is decomposed using NSCT, then the interpolation is conducted on the resulting NSCT coefficients, that is high frequency subband coefficient shown in the fig.3. Finally, the upsampled image is generated through inverse NSCT, applied to the interpolated coefficients. This technique relies on an important property stating that there is some similarity between high-frequency coefficients of the same direction regardless of the level. In our experiments, the bilinear interpolation algorithm is used. The efficiency of this method was proven quantitatively and qualitatively through a comparison with existing methods.

### Method 3 NSCT and SWT decomposition

To enhance the spatial resolution of multi spectral satellite images based on pan sharpening using SWT-NSCT

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decomposition and pixel level fusion with gabor texture to retain edge texture information at fused image.

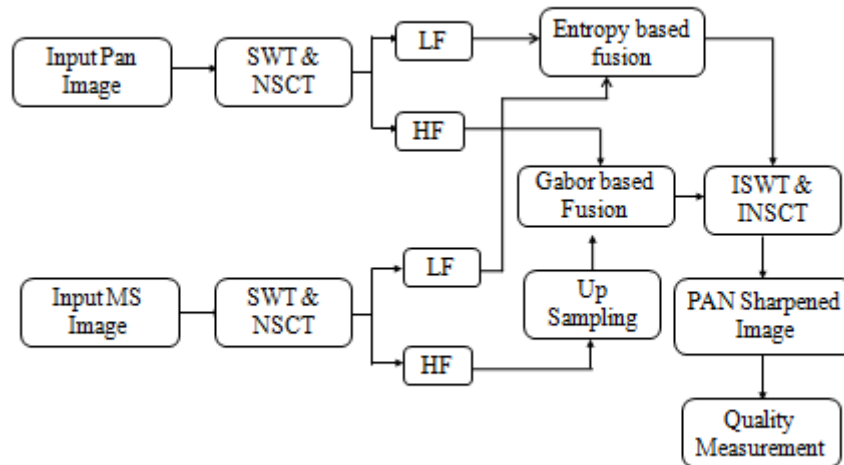


Fig.3 proposed image enhancement block diagram

Apply SWT for both PAN and MS image, from that both the pan and ms image decomposed into four subbands for pan and four subbands like LL,LH,HL, and HH. Combining the pan and ms combinations like LH,HL,HH then apply NSCT decomposition for both LL component, from the non subsampled decomposition transform image will be decomposed low and high frequency then both low frequency component of pan and ms imade take the energy based fusion and for high frequency take the gabor based fusion after fusion result image take the inverse NSCT. at last ISWT for previous fused image, finally obtaining pan sharpened image, measured quality parameters and compare three methods out of all the methods it shows the best quality parameter levels.

### VI. QUALITY INDICIES AND EXPERIMENTAL RESULTS

PARAMETRES	STANDARD	METHOD 1	METHOD 2
CORRELATION COEFFICIENT	0.9842	0.9854	0.9851
RELATIVE BIAS	0.0632	0.0627	0.0627
RELATIVE VARIANCE	0.0602	0.0051	0.0025
STANDARD DEVIATION	7.1613	7.2803	7.2755
RMSE	3.0653	2.9393	2.9803
PRD	0.0271	0.0260	0.0264
PSNR	42.2661	43.4484	43.3883

TABLE.I. QUALITY INDICES

Table I. Shows Quality indices results assessment

1. Correlation Coefficient- It measures the similarity between the fused and original images, a correlation value of +1 indicates that the two images are high correlated, method 1 results gives more correlated image.

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2. Relative Bias- It is the difference between the mean of the original image and that of the fused one divided by the mean of the original image. Here both method 1&2 are biased very nearer value.
3. Relative variance- It is the difference between the variance of the original image and that of the fused one divided by the variance of the original image, results reached upto best level.
4. Root Mean Square Error(RMSE)- error value decreasing gradually depends on the decomposition level.
5. Power Residual Difference (PRD) and Standard deviation parameter not differed at high points

## EXPERIMENTAL RESULTS

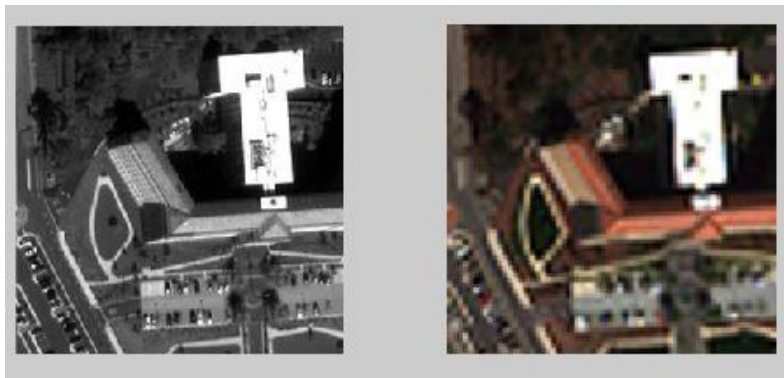


Fig.4 input images



Fig.5 SWT LL output

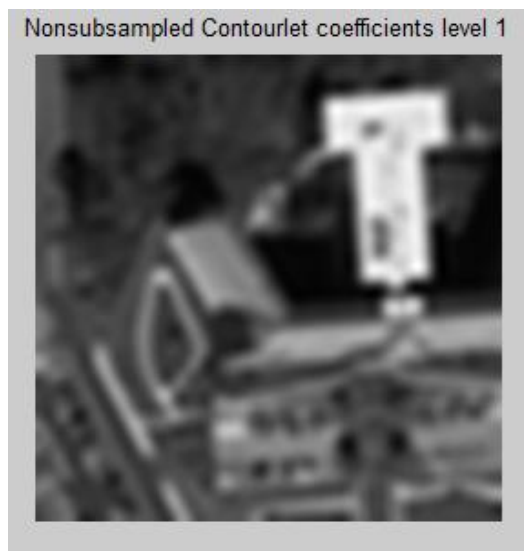


Fig.6 NSCC level 1



fig.7 NSCC level 2

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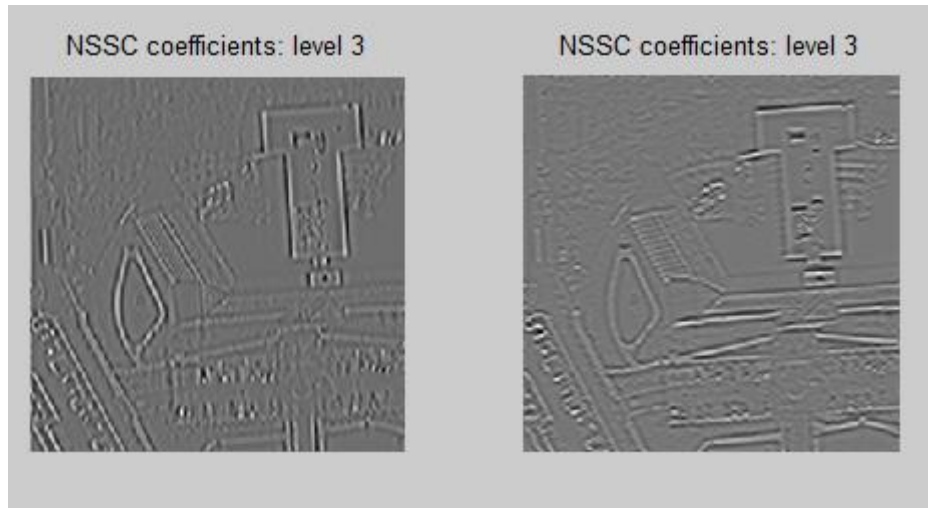


Fig.8 NSCC level 3

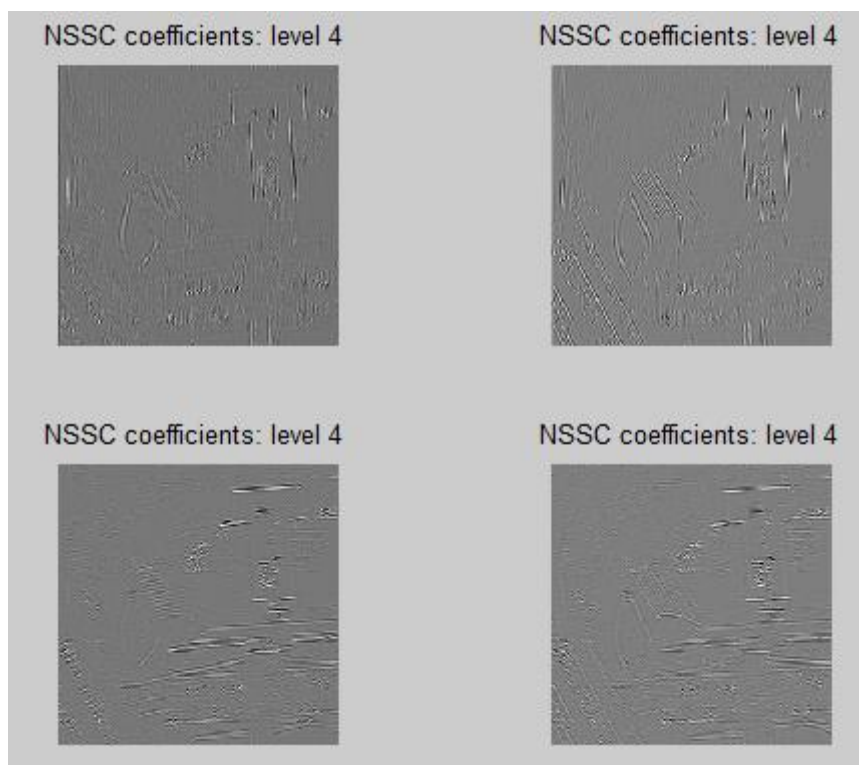


Fig.9 NSCC level 4

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Fig.10 pan sharpened image

## VII. CONCLUSION

Standard NSCT method results in reducing computation time. Method1 - good spectral quality Pan-sharpened image, results are very similar to the standard NSCT method and lower processing time. Method2 - Interpolation is conducted and results in both spatial and spectral resolution. Method 3 - Quality parameters improved with same subband size and without use of the downsampler. Low frequency subbands are used for entropy based fusion and high frequency subbands are used for Gabor based fusion with Lanczos upsampling. [25,26]

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