Pan-Sharpening of Satellite image with LBP and Adaptive IHS Basis

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ABSTRACT
Pan-sharpening is the process of combining low spatial resolution MS image and low spectral resolution Panchromatic image. IHS based method is popular pan-sharpening method used for efficiency, however result obtained by this method have spectral distortion. In this paper we propose a extension of AIHS method,in which edges are extracted from PAN image by applying LBP coding then HRMS is determined by weighting matrix ,which depends on edges of the PAN image and MS image .experiment is carried out on Quick bird Satellite image. Results shows that it has improvement in image quality parameter compared with IHS,HPF,Brovey, AIHS and other methods of Pan-sharpening.

Keywords
IHS transformation, MS(Multispectral) image,PAN(Pan-chromatic) image, Pan-sharpening, AIHS,LBP coding.

1. INTRODUCTION
Many satellites like IKONOS, Quickbird,landsat,Geo-eye-1,Geo-eye-2 provides two types of images .high resolution panchromatic and low resolution multispectral. The multispectral image lacks high spatial resolution and panchromatic image lacks high spectral resolution. Due to this restriction, many pan-sharpening methods have created to fuse two image and to get resultant image which have high spatial and high spectral resolution which mainly used in remote sensing and navigation purpose.

Spatial resolution is defined as information covered by each pixel of the image .Spectral resolution is how well we can differentiate each shades of colours[1]. Temporal resolution is after how many days satellite will capture the image of same area measured in days and radiometric resolution is identification of different shades of grey generally measured in bits .signal to noise ratio of sensor is fixed, increase in spatial resolution requires collections of large number of reflected photons. But this requires collection of signal over a larger Instantaneous field of view reducing the spatial resolution due this there is trade-off between SNR and IFOV [2].

Many Pan-sharpening method proposed over the past decades. The procedure for them is extraction of spatial detail from PAN image and inject it to MS image. A few popular pan-sharpening methods are: IHS [3],PCA based image fusion[4] is of CS family, in which direct replacement of band and many times replaced bands have different spectral component so it's have spectral distortion. Brovey [6],andIntensity modulation is of RCS methods in which instead of direct replacement some linear combination of band is substituted. High pass modulation and High frequency injection method[2] which have ripples are present in their frequency response. Wavelet-based image fusion [5],NSCT [2], Laplacian pyramid based image fusion is multiresolution image Pan-sharpening. each methods have trade-off between a spatial and spectral quality. Pan-sharpening is process of adding high frequency detail of PAN image to each MS band. If high frequency details are much then it's have spectral distortion .if less than its have spatial distortion. The principal interest of fusing two images is to create composite image of enhance interpretability. Pan-sharpening should not distort the spectral characteristic of data, ensuring that the target ,which are separately separable in original image must be separable in fused image. further there is limitation to the data volume that satellite sensor can store on board and and transmit to ground receiving station. The size of PAN image is many times larger than size of MS image .The PAN image for quick bird, SPOT 5and Orbital view is sixteen times larger then original MS image.[2].

The IHS technique is the class of component substitution family in which directly intensity band is replaced by PAN image.it is computationally efficient method and have good spatial quality but due to direct replacement of the band it have spectral distortion. To overcome this problem different strategies have been developed over the years[7].Spectrally adjusted IHS(SAIHS) method[7]proposed on the basis of an observation of the spectral response of the IKONOS sensor. The SAIHS is effective on IKONOS image. An adaptive IHS (AIHS) method has recently been formulated by adaptively adjusting the linear combination coefficient of the MS bands in the spatial detail extraction step. In lack of adaptively ,however the weights induced by the PAN image is too large.so it has spectral distortion in vegetation area, in this paper it is extension of AIHS method. spatial details of PAN image is extracted by applying Local Binary pattern and edges of MS image is extracted using exponential edge detector. Finally weighting function is obtained by MS and PAN edges product.This weighting function is applied on the spatial detail which are not present in PAN image ,which is added in each multispectral band to produce Pan-sharpened image.

2. AIHS METHOD
The original IHS method was based on colour space conversion principal and it is normally suitable for the MS image with three colour bands the intensity band is calculated using:

$$I=\sum_{i=1}^{M} \alpha i.Mi \qquad (1)$$

Where Mi are the multispectral bands, and the standard value for the αi=1/3.However the most multispectral image consists of four bands ,RGB and near Infrared. whereαi=1/N, N number of bands. For IKONOS satellite image value of α can be experimentally calculated by using gradient descent method.

Before fusing two images first we up sample the MS image by a factor of four to make it size of PAN image. then we normalize the each band of image to the range[0,1].After completing initial step histogram matching of the PAN image P to ensure that the mean and standard deviation of PAN and MS image are within the same range using.

$$P= \frac{\sigma I}{\sigma P} (P-\mu_p)+ \mu_I \quad (2)$$

whereσ and μ are the standard deviation and mean, respectively. After the calculation of Intensity component (AIHS) can be determined by

$$Fi=Mi+\mathbf{W}p\ (P-I) \quad (3)$$

Where **W**p is weighting matrix calculated by the edges of the PAN image and defined as

$$\mathbf{W}p = exp(-\frac{\lambda}{grad(P)4+\varepsilon}) \quad (4)$$

Where , λ is a parameter indicating how large the gradient should be in order to be an edge and controls the smoothness of the image, and ε is a small value that enforces a nonzero denominator.in this method edges of the PAN image is extracted by weighting function and added with each MS bands, but many times PAN image MS image have different spectral contents so it's have color distortions and less spectral quality of resultant image. And under the limited approximation the optimization problem of (1) cannot reach the spectral response of the MS band perfectly overlap with the spectral bandwidth of the PAN image. So, difference of the PAN and Intensity image is missing details of MS band .due to adaptability of the Intensity band for spatial detail extraction the performance of AIHS is significant but can be improved in the following section.

3. PROPOSED APPROACH

PAN image is generally four times larger than MS image. So for pan-sharpening MS image and PAN image should be of same size, so by interpolation resize the MS image.in proposed approach for extraction of spatial detail from PAN image LBP is used. The basic idea of the approach is to compare the order of a given pixelwith its neighbouring pixels to compute a binary code for the pixel. Such a binarycode is invariant to monotonic changes in the intensity of the region around a pointand hence is quite useful as a feature when intensity changes can be quite drastic.LBP was originally proposed for texture classification by Ojala[12]. The LBP operator and its variants were then employed various applications such as object detection , face recognition, license plate recognition [12] and smoke detection. Consider a 3 X 3 image segment, let M be the pixel intensity at location (i , j) ,BK be the pixel intensities of the neighbouring pixels and 'θ' represents the threshold value. For a pixel at location (i; j), the LBP code is computed using the following equation.

$$L(i,j)=\sum_{k=0}^{7} f(Bk-M)2^k \quad (6)$$

Where f(x)= 1 |x|>θ

|x| <= θ.

The centre pixel is taken as reference and as per the decided threshold level the remaining pixels are compared. If the compared pixel lies in the decided threshold level it is remarked as 0 and if it falls outside the decided level it is remarked as 1.

40	65	64
36	44	37
49	56	32

(a)

0	1	1
0	(i,j)	0
0	1	1

(b)

B7	B6	B5
B0	M	B4
B1	B2	B3

(c)

LBP : 01101100

LBP Code : 108

Threshold : 10

Fig. 1. (a)A 3x3 image patch,(b)its binary pattern, (c)LBP coding

Advantage of AIHS method is that it does not have problem of miss-registration and aliasing. AIHS method will be good and practical if spectral distortion can be reduced.In Pan-sharpening spatial detail of PAN image is added with each MS bands. If added spatial details are less then it's have spatial distortion and if more details are added then it's have spectral distortion ,with the goal of transferring edges from the PAN image to the fused image edge extraction is done by applying LBP to PAN image, and applying exponential modulating function

$$Fp = exp\ (\frac{-\lambda}{abs\,(P)^4+\varepsilon}).(5)$$

Where P = LBP applied PAN image.$\lambda=10^{-9}$ and $\varepsilon=10^{-10}$. The spectral details of PAN image and MS image may differ. Thus it is not appropriate to include only spatial details of PAN image, edges of MS bands also considered to modulate each MS bands.So weighting matrix for each MS band is

$$\mathbf{Fmi} = exp(-\frac{\lambda}{grad(Mi)4+\varepsilon}) \quad (6)$$

Applying such MS induced weight produce smooth resultant fused image compared to AIHS based approach. Result induced by considering the PAN induced weights and MS induced weight ,it is reasonable to infer that an appropriate weighting matrix for each MS bands. denoted as Wi,

$$\boldsymbol{Wi}= Fp\ .Fmi(7)$$

Finally resultant Pan- sharpened image can be obtained by applying modulating function to the spatial detail not present in MS band ,then it is added with each MS band

$$\mathbf{Fi = Mi +Wi\ (\ PAN\text{-}Intensity)}\ (8)$$

The result of sharpening the MS image[Fig. 1(a)] by the proposed approach is shown in [Fig. 1(h)].compared with the original MS image and the results obtained by other methods. It is found that proposed approach can improve the spatialquality while maintaining simultaneously the spectral quality. We compare our approach with other methods in following section

(a) **(b)**

(c) (d)

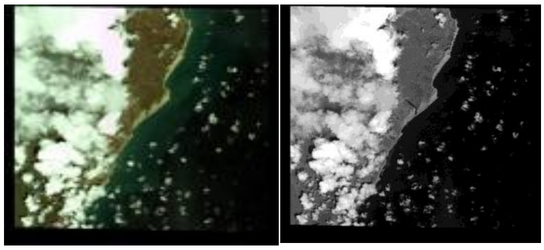
(e) (f)

(g) (h)

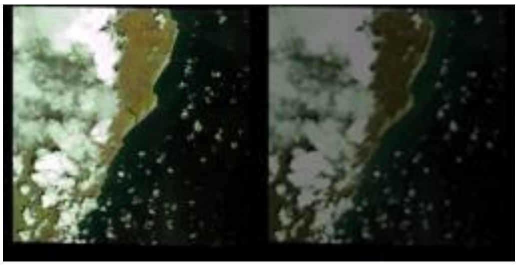
Fig 2 .Comparision of (a) MS image(512 X512) (b) PAN image(512 X 512) (C) IHS method (d) High Pass filtering (e) Intensity modulation method (f) AIHS method with PAN edges function (g) AIHS method with MS edges function (h)Proposed apporch.

4. EXPERIMENTS

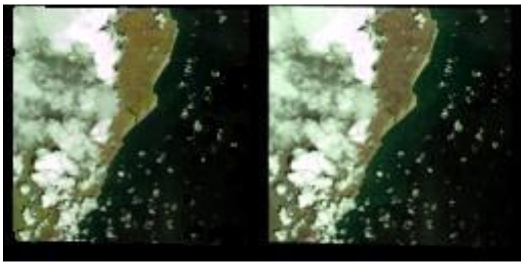
In general, the performance of a Pan-sharpening method can be subjectively and objectively evaluated, methods are being compared for their spectral and spatial quality. spatial qualitycan be judged visually, but subtle color changes are more difficult to notice in this manner.so performance matrix to evaluate the spectral quality. For spatial quality analysis correlation coefficient (CC) which find out the correlation between the MS image Pan-sharpened image.CC is insensitive to a constant gain and bias between two images and does not allow for suitable discrimination of possible Pan-sharpening artifacts.CC should be as close as 1.The RMSE measures the changes in the radiance of the pixel values [1].UIQI evaluate the difference of spectral information between each band of merged and reference image. ERGAS is quality parameter for spectral quality, it relative global dimension less error .is global quality index sensitive to mean shifting and dynamic range changes. The lower value of ERGAS indicates the good spectral quality of resultant image. RASE (Relative average spectral error) characterized the average performance of the method of Pan-sharpening in the spectral bands.other quality parameters also considered in quality analysis.



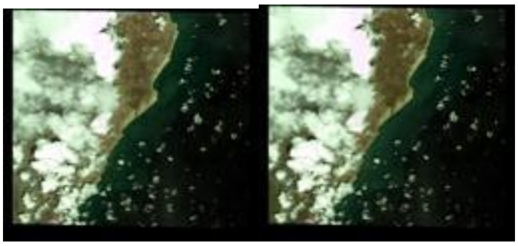
(a) (b)



(c) (d)



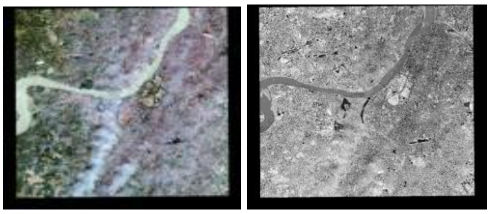
(e) (f)



(g) (h)

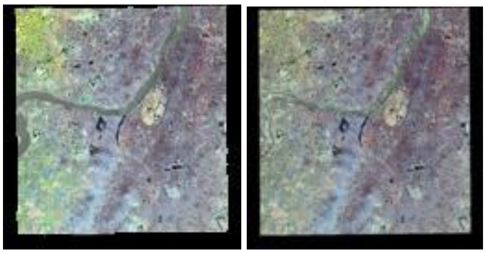
Fig 3 .Comparision of (a) MS image(512 X512) (b) PAN image(512 X 512) (C) IHS method (d) High Pass filtering (e) Intensity modulation method (f) AIHS method with PAN edges function (g) AIHS method with MS edges function (h)Proposed apporch.

Quality parameters for different methods like IHS, High Pass filtering method, High pass modulation, AIHS, modification to AIHS with considering weighting function from MS bands, Improved Adaptive IHS, and proposed method is compared, results shows that proposed method has better spectral and spatial quality compared to other methods.

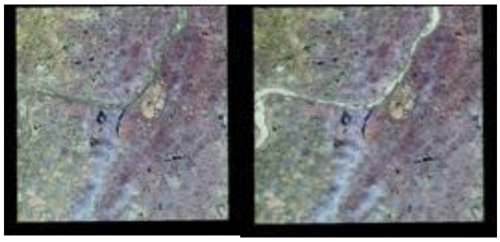


(a) (b)

(c) **(d)**



(e) **(f)**



(g) **(h)**

Fig 4.Comparision of (a) MS image(512 X512) (b) PAN image(512 X 512) (C) IHS method (d) High Pass filtering (e) Intensity modulation method (f) AIHS method with PAN edg0.7622es function (g) AIHS method with MS edges function (h)Proposed apporch.

Table I Value of different parameters analyzed to estimate performance of the pan sharpening methods(Fig.2).

Methods	CC	RMSE	RASE	ERGAS	Q	BIAS
IHS	0.7494	20.6324	32.6732	2.0421	0.7083	-0.2098
HPF	0.8779	32.0694	50.6327	3.1645	0.5942	0.4763
IM	0.7476	2.06863	32.7948	2.0497	0.7069	-0.2114
AIHS (PAN)	0.8827	16.6008	27.3129	1.7071	0.8602	-0.2245
AIHS (MS)	0.8839	16.0594	26.4225	1.6514	0.8631	-0.2115
Proposed Approach	**0.9028**	**7.4959**	**24.2341**	**1.5146**	**0.8841**	-0.**1916**

Table II Value of different parameters analyzed to estimate performance of the pan sharpening methods.(Fig. 3)

Methods	CC	RMSE	RASE	ERGAS	Q	BIAS
IHS	0.9854	16.2819	20.9272	1.3080	0.9804	0.0634
HPF	0.9946	58.5688	75.4662	4.7166	0.6345	0.4988
IM	0.9780	19.3687	24.9328	1.5583	0.9724	0.0788
AIHS(PAN)	0.9902	12.1388	15.7147	0.9822	0.9897	-0.00375
AIHS(MS)	0.9917	11.1625	14.1539	0.9034	0.9913	0.00197
Proposed Approach	**0.9958**	**8.1915**	**10.6061**	**0.6629**	**0.9953**	0.01640

Table III Value of different parameters analyzed to estimate performance of the pan sharpening methods.(Fig. 4)

Methods	CC	RMSE	RASE	ERGAS	Q	BIAS
IHS	0.7622	43.8755	39.6339	2.4771	0.7563	0.0634
HPF	0.9874	63.2269	57.5502	3.5659	0.6300	0.4988
IM	07475	45.4005	41.0109	2.5632	0.7424	0.0778

AIHS(PAN)	0.7872	37.7514	34.0978	2.1311	0.7816	-0.0038
AIHS(MS)	0.8097	35.7813	32.3210	2.0201	0.8040	0.0020
Proposed Approach	**0.8965**	**26.8390**	**24.2351**	**1.5174**	**0.8879**	**0.0164**

5. CONCLUSION
Pan-sharpening method based on Adaptive IHS method attains good results compare to other Pan-sharpening methods. but to reduce spectral distortion extending the AIHS method by applying LBP to extract the edges of PAN image and edges of MS image extracted then modification in modulation function is performed .Proposed method have good spatial and spectral quality compare to other Pan-sharpening methods. Experiments carried out on quick bird satellite image.

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