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Advanced Pixel –Level Enhancement Technique for NOAA satellite image using PCA and Morphological Operations

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Abstract
This Paper proposed advanced fusion technique for National Oceanic and Atmospheric Administration (NOAA) of Multispectral satellite image for high quality pixel information in terms of spatial and spectral quantities. The Principal component Analysis technique is one of the best technique in fusion operations, but due to limitation of non directionality and distortions in spectral cases not given Optimize values, to overcome this problem advanced technique in pixel level fusion enhancement is used. These Experimental Results are compared with other fusion methods Independent Component Analysis, Brovey Transform and Wavelet Resolution Merge and Color Transformation Techniques in terms of visual and Statistical parameter metrics. It improves the interpretability of human observers and accuracy.

Keywords: Morphological Operations, Principal Component Analysis, Brovey Transform, Wavelet Resolution Merge.

INTRODUCTION
Multispectral Image Enhancement [1] [13] is one of the important applications in remote sensing data like land use, broad leaf and narrow leaf forest, cadastre, flooding, agriculture, mapping vegetation or developing urban areas, etc. These images contain individual information in each band. It gives various information depending on application level. Multispectral images contain spatial and spectral information. This contains information in the form of pixel and color levels in terms of intensity and color. Compare with panchromatic image (PAN), multispectral image contains low resolution due to lack of sensory acquisition capability, atmospheric distortion or other problems. Each image contains low and high frequency components maximum information contains in low frequency, but in satellite images, each pixel represents kilometer distance, each pixel is considered for analyzing information. The high frequency components like borders, lines and edges are not visible in case of color images, these high frequency values are sharpened by using suitable techniques. Different Multispectral images are available with different resolution in remote sensing, small resolution (less than 30m) gives the clear data about earth object, in case of large resolution of a pixel, the image covers large areas like sea level, forest, haze and detection of clouds.

The present study of spatial and spectral information [14] provides detailed analysis of visual and quality measures of finding objects on earth. To improve the spatial and spectral resolution using various pan sharpening methods, various traditional methods are available for pan sharpening technique, this is a tradeoff between spatial and spectral values, overcome this problem using the proposed technique with help of combination of dimensional reduction technique and erosion based morphological operations. Brovey Transformation, HIS fusion [2] [5], Multispectral Fusion methods [3][16], wavelet fusion methods[7][12] are mostly used in case of protection of both spatial and spectral values, beyond the limitation of these methods proposed method got optimized values, given sophisticated results compare with other methods. In this fusion operations replace the high and low frequency components in the National Oceanic and Atmospheric Administration (NOAA) multispectral image for retaining the original data for remote sensing applications.

This paper is structured as follows. Section II gives the information about the present study Principal Component Analysis, section III about Morphological operations, Section IV gives proposed method and Section V Results compare with previous methods. Finally, section VI summarizes the conclusions and provides Recommendation.

PRINCIPAL COMPONENT ANALYSIS IN REMOTE SENSING
Multiband NOAA Satellite images contain five individual bands and this image is high dimensionality and redundant information available, very difficult to analysis computationally and very expensive. Due to this decrease the overall accuracy of classification in case of training samples and spectral dimensions. The segmentation or feature extraction is easy with the reduce the dimensionality and discarding redundant information in Multispectral image for improving Accuracy. It is one of the statistical technique useful for image compression, enhancement, change

detection, multi-temporal data dimensionally and fusion operations.

The maximum information is available in first four PCA components (PC1, PC2, PC3, and PC4), these components given maximum spatial and spectral information of NOAA image. This PCA depends on Eigen values and Eigen Vectors matrix. These PCA components are orthogonal to individual components and maximum variance with the original image. This PCA developed with Eigen values and Eigenvector matrix of input image [6]. Where A is a n x n matrix, X is an eigenvector and λ is an eigen value of the matrix A. The expression shows the relationship between eigen values and Eigen vectors.

$$(A-\lambda I)X=0 \text{ ---------- (1)}$$

$$\left(\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} - \lambda \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}\right)\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = 0 \text{ ----- (2)}$$

PCA can be transformed a database into a new coordinate system, each PC components are orthogonal to each other. From above equations (λ 1, λ 2, λ 3) and Eigenvectors (e1, e2, e3) are determined. The inner dot product of e1, e2, e3 is zero because of these are orthogonal to each other.

Maximum 95% information is available in PC1, PC2, PC3 components[6][10].

$$PC_1 = e_1^t xs \text{ --------- (3a)}$$
$$PC_2 = e_2^t xs \text{ --------- (3b)}$$
$$PC_3 = e_3^t xs \text{ --------- (3b)}$$

xs1, xs2, xs3 are random variations of NOAA image.

$$\text{Where } XS = \begin{bmatrix} xs_1 \\ xs_2 \\ xs_3 \end{bmatrix} \text{ ------------ (4)}$$

MORPHOLOGICAL OPERATIONS

Satellite images are good to analyze brightness levels and color levels. This information fully available without loss of spatial and spectral information of pixels. Multispectral images are lower clarity comparable with panchromatic images, for retaining the full information of lower and higher frequency data use morphological operations [18][19][21]using erosion and dilation operations. There are lot of techniques, local and global enhancement techniques in image processing, but these are works in spatial domain but the pixel intensity spread all over frequency, due to this some pixels are gaining some information, and some pixels are loss the intensity levels. Overcome this method using fusing of images. Using the Thresholding technique in image enhancement its effect with distortion of the image due to noise. Selection of the object is also one of the main tasks in image processing, satellite images there are different objects and each pixel represents different information. So imperfections exist in the structure of the image in thresholding technique.

The main advantage of morphological operation is protected from imperfections on the shape and texture of images in segmentation technique directly deals with the 'shape extraction' in the satellite image. Mainly used in image processing for description of shape and structure of the object in an image. It works on the basis of set theory and rely more on the relative ordering of the pixel instead on their numerical value. These operations are well suited for binary images and are found useful for gray scale images also.

Morphology operations depend on the size and shape of the neighborhood images [18], each pixel on output image based on comparison on corresponding input image; these are based on erosion and dilation operations. Adding or removing the pixels depends on the size and shape of the structuring element (kernel) in the operation of dilation or erosion. This Proposed technique depends on two factors, one is the image which is to be eroded and another one is a kernel. The Kernel determines the accurate effect of the erosion of the given input image. In Filtering operation Kernel elements in morphological image processing are same as convolution masks. The below equations represents the Dilation and Erosion in Morphological operations. With remote sensing application Morphology concept is common allocated because of sectioning for objects in case of different types of texture and edges in images. Another application is extracting the features in Photogrammetric. Using this process, extract the exactly the same set of features from different views of the same object. In removing of noise case when applying filters the information is over smooth the surfaces without clear information in texture, so matching techniques is applied after the extracting the regions of interest in the satellite image. The extraction of edges, borders is very important in NOAA satellite image for analyzing the clouds, vegetations, sea surface and ground surface of the image, regret the high frequency values using erode morphological operations. Hit-or- Miss Transform tool is basically used for identification and detection of shapes of objects in an image, it relies on the morphological erosion along with fits and miss disjoint structural elements. The first structural element in the foreground on the satellite image and the second structural element have to 'miss' it. If B1 and B2 are structural elements, then the hit or miss transform is defined as the

$$A \otimes B = (A \Theta B_1) \cap (A^C \Theta B_2) ------[5]$$

Where B1=D and B2=W-D and

A^C is the complement of the image 'A'.

f(t), g (t) are two functions, both are subsets of Euclidian space E. Where f (t) is 1-D time series data, g (t) is predefined Kernel element. Using Minkowski addition and subtraction methods the functions can be described as

Addition:

$$(f \oplus g)(t) = \max\{f(t-u) + g(u)\} ----[6]$$

Subtraction:

$$(f \Theta g)(t) = \min\{f(t-u) - g(u)\} ----[7]$$

In morphological filter operations opening and closing are used for detecting peaks and valleys in the image.

Opening: $(f \circ g)(t) = [f \Theta g^s) \oplus g](t) ----[8]$

Closing: $(f \bullet g)(t) = [f \oplus g^s) \Theta g](t) ----[9]$

The Erode operations depends on the total above equations in Morphological operations and it's mainly used for reducing the light details in the image, Dilation also dual relationship with erosion, used for reduced dark details in the image.

$$(f \Theta g)c = fc \oplus \hat{b} --------[10]$$

$$f^c(x, y) = -f(x, y) ------[11]$$

$$\hat{b}(x, y) = b(-x, -y) ------[12]$$

Principal Component Analysis is one of the best techniques for reduction of n-dimensional reduction, it is reliable and simple. In this proposed method combination of PCA and morphological are used for enhancing the details of satellite images, compare with the Independent Component Analysis method[4][8][9] , PCA is less complexity with dimensional reduction, it is not possible only using with ICA, use higher order or Genetic algorithms are combined with ICA, so it is more complexity compares with PCA. Brovey Transformation method [7] one of the best methods in the fusion of multispectral images [17][20], but it is suitable for panchromatic combination of satellite images or individual bands. In The Wavelet Resolution merge it is good for spatial information, but some tradeoff between spatial and spectral values. Mostly prefer HIS transformation technique [10], the image is converted into Illumination and chrominance components, but the selection of bands levels are difficult task.

PROPOSED METHOD

Transformation techniques shown broad range of applications in image processing applications like image analysis, compression enhancement and restoration techniques. This paper introduced a novel method which aims the improve the spatial resolution of a Multispectral satellite image using Higher order statistics and Morphological operations[22], Multispectral Satellite images are very difficult to analyze the spatial, spectral and temporal information depending upon the applications. Every image have low and high frequency component, these frequency component uses different techniques for enhancing the image. Panchromatic (PAN) images have resolution data compare with Multispectral image, these images are used to resize the high frequency components.

Steps for proposed method:

1. Collect the MS images from the NOAA Multispectral satellite Receiver
2. Perform geometric and radiometric corrections
3. Perform Principal component Analysis operation for dimensional Reduction or compression of images.
4. Apply the morphological operation to PAN image.
5. Merging high frequency components of the same image using Morphological operations.
6. Apply color transformation technique..
7. Convert back to original model.

MSE & PSNR: Mean Square Error and Peak Signal to Noise Ratio parameters are used for quality after a recover of input images. The minimum value of MSE and maximum value of PSNR represents good quality of images after enhancement technique.

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \text{ ------------- (13)}$$

$$PSNR = 20.\log_{10}(MAXI) - 10.\log_{10}(MSE) \quad \text{(In dB) ----------- (14)}$$

Entropy: It is the statistical parameter for finding average information on the statistical parameter. After processing of image information will be loss, this type of losses is identified using this parameter.

$$H(X) = \sum_{i=1}^{n} p(x_i) I(x_i) = -\sum_{i=1}^{n} p(x_i)\log_b p(x_i) \text{ ----(15)}$$

ERGAS & RASE: Using these parameters find out the spatial and spectral quality of enhanced image. The ERGAS index value to zero the processed image equal to original image. ERGAS stands for Erreur Relative Globalet Ademensionnele de Synthese. The Relative average spectral error (RASE) it gives the average performance of the spectral bands, low index value of RASE gives the better spectral information of processed image.

$$ERGAS = 100\frac{h}{l}\sqrt{\frac{1}{N}\sum_{K=1}^{N}\frac{RMSE(B_K)^2}{\mu(k)}} \text{ -------------- (16)}$$

$$RASE = \frac{100}{M}\sqrt{\frac{1}{k}\sum_{i=1}^{k} RMSE^2(B_i)} \text{ ---------------(17)}$$

Where h: spatial resolution of enhanced image,

$\mu(k)$: mean radiance of the Band

M: mean radiance of the K spectral bands (Bi) of the MS images.

RESULTS & DISCUSSIONS

Some standard spatial and spectral parameters are used in this work for comparing results with Brovey, HIS Transformation and Resolution Merge with HIS and Independent Component Analysis methods. Fig 2: Represents Original and Processed NOAA images. Brovey Transform (BT) [7] is widely used for fusion of multispectral satellite images, disadvantage of BT is limited bands up to 3 bands only, very difficult to represent above 3 bands, HIS transform image, This technique is very suitable for object classification but it fails in case of high frequency components, and selection of intensity, Hue and Saturation Values, Multispectral Principal component analysis image contains more information of all spectral bands, but due to directionality of PCA and some small frequency components are missing and information is not covered in output image[15], Independent component analysis is same as Principal component Analysis but it is useful for separating the orthogonal component of multispectral images. But additional requirement is Genetic Algorithm or higher order statistical algorithms are useful for dimensional reductions.

Table 4.1: The Results of Spectral and Spatial Quality Assessment using NOAA image1 and Image2.

Image 1:	**RMSE**	**RASE**	**ERGAS**	**ENTROPY**
Brovey	85.7754	72.30016	18.23857	7.518278
BIHS	69.02011	60.82789	15.36026	5.557068
ICAT	70.19386	58.24582	14.58294	7.472627
PCAB	109.1409	86.29012	21.59994	6.994138
PCAIHS	71.94869	64.2278	16.19415	5.167185
IHST	70.3519	59.3124	14.9488	6.7162
RM	103.9796	82.40429	20.56724	6.970065
Proposed	57.39467	47.64244	11.79987	7.579005
Image 2:	**RMSE**	**RASE**	**ERGAS**	**ENTROPY**
Brovey	85.2247	71.1687	18.0067	7.5765
BIHS	60.8352	54.1418	13.7389	5.5679
ICAT	52.6518	44.1685	11.0200	7.1686
PCAB	111.10999	88.6081	22.2635	6.3997
PCAIHS	64.5198	58.1496	14.7458	5.5556
IHST	66.1105	53.9540	13.5780	7.2591
RM	80.0774	70.0590	17.3871	7.5799
Proposed	50.9887	42.9224	10.6565	7.2153

ICAT: Independent Component Analysis Transform,

I HS: Illumination Hue Saturation

RM: Resolution Merge

PCAB: PCA Brovey

BIHS: Brovey HIS

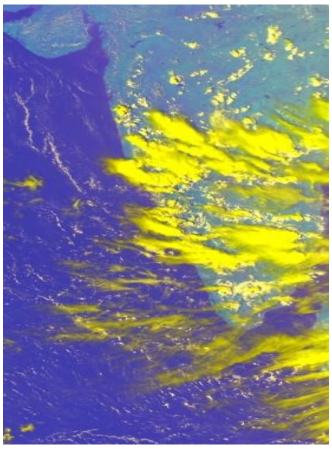

Figure 2.a

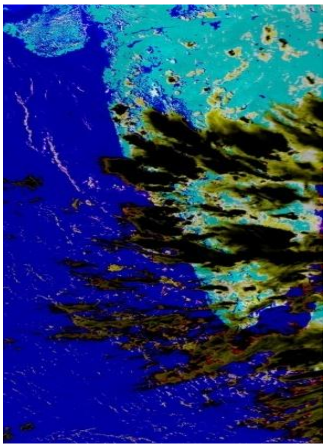

Figure 2.b

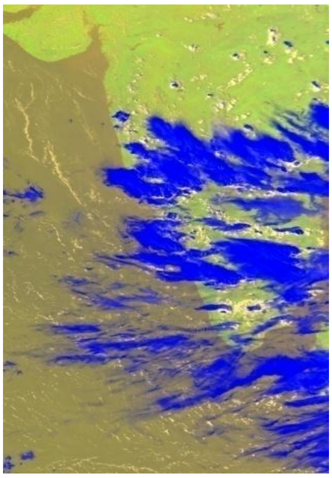

Figure 2.c

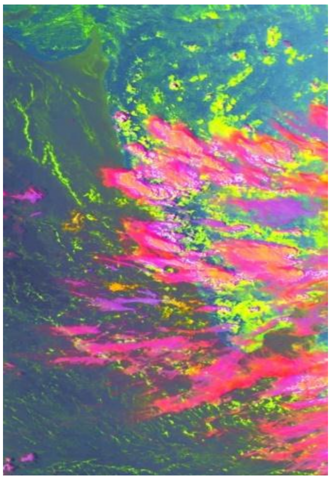

Figure 2.d

Figure 2: (a) NOAA MS image1 (b) Brovey Transformation image (c) Resolution Merge (d) Proposed image

For improving spatial and spectral information this proposed method is useful for classification of pixels in further levels.

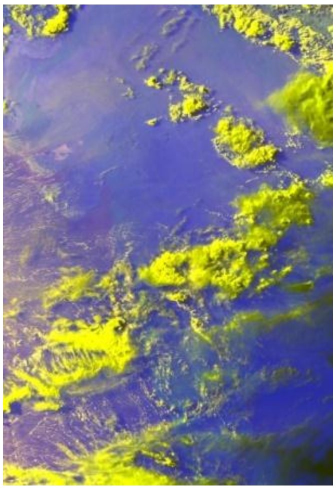

Figure 3.a

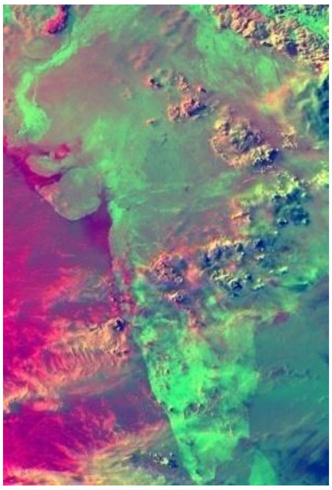

Figure 3.b

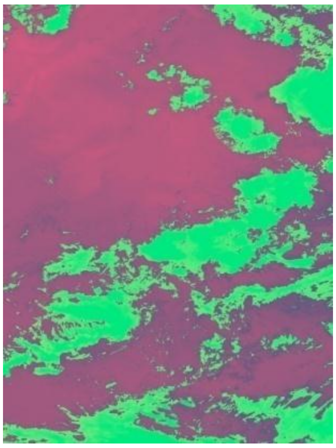

Figure 3.c

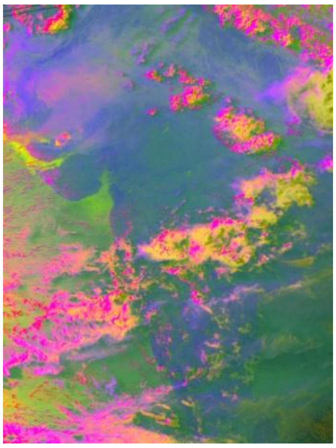

Figure 3.d

Figure 3: (a) NOAA MS image2 (b) ICA Transformation image (c) HIS Transform (d) Proposed image

As proposed technique with principal component analysis and morphological operations. After the processed satellite image prevent the spatial and spectral information compare with above techniques in shown in table 4.1.

CONCLUSION

For Multispectral Satellite images, spatial and spectral qualities[11] are very important for visualizing and analyze the information, for natural image compare with ICA, Advanced level of Principal component analysis are better result in case of dimensional reduction and enhance the details of the NOAA satellite image for finding objects.

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