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IV. QUALITY ASSESSMENT:

Quality assessment or evaluation is a process to determine effective quality of the fused image with respect to different quality parameters. The quality metrics used for evaluation of the fusion technique are such as follows:

V. *Correlation Coefficient (CC):*

The similarity between the fused and reference images can be calculated using correlation coefficient. CC of unity indicates that both images are same. It is one of the reference quality metrics.It is defined as

$$CC(I_r, I_f) = \frac{\sum i,j\,(I_{fi,j} - \bar{I}_f)(I_{ri,j} - \bar{I}_r)}{\sqrt{\sum i,j (I_{fi,j} - \bar{I}_f)^2 (I_{ri,j} - \bar{I}_r)^2}}$$

here If and Ir are the fused image and reference image. The mean values of If and Ir are _Ifand _Irrespectively. If €;j and Iri;j are the pixel values corresponding to the ði; jÞthpixel of the images If and Irrespectively.

2. Bias Of Mean(BM):

BM is the difference between the means of original MS image and fused image(Stanislas de Bethune,1998). The value taken is related to original image mean value and zero is the ideal value of Bias of Mean.

$$BM = \frac{MS_{mean} - F_{mean}}{MS_{mean}} = 1 - \frac{F_{mean}}{MS_{mean}}$$

where BM is Bias of Mean, MS is multispectral image or data and F is fused image.

3. Peak Signal to Noise Ratio (PNSR):

The mathematical expression for PSNR is given by

$$PSNR(db) = 20\log \frac{255}{\sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(I_{rij} - I_{fij})^2}}$$

here Ir represents the reference image and If is the fused image, € and j are the row index and column index.

4. Structural similarity measure (SSIM):

The structural similarity of the fused image and the reference image is determined using SSIM. It is better than PSNR. A Higher value of SSIM indicates better structural quality and hence better quality.

$$SSIM = \frac{2(\mu_r \mu_f)(2\sigma_{rf})}{(\mu_r{}^2 + \mu_f{}^2)(\sigma_r{}^2 + \sigma_f{}^2)}$$

here mean values of the reference image Ir and fused image If are denoted by lr and lf respectively, its variance is given by rr 2and rf2 and the covariance of the images is represented by rrf .

5. Entropy €:

It gives the information content in the image. A Higher value of entropy indicates a higher amount of information present in the image.

$$E = \sum_{i=0}^{G-1} P_i \log_2 P_i$$

here G is the total number of grey levels and the probability distribution of each level is given by pi.

6. Universal image quality index(UIQI):

It is used to calculate the amount of transformation of relevant data from reference image into fused image. The range of this metric is -1 to 1. The value 1 indicates that the reference and fused images are similar

$$UQI = \frac{4\sigma_{I_r I_f}(\mu_{I_r} + \mu_{I_f})}{(\sigma^2_{I_r} + \sigma^2_{I_f})(\mu^2_{I_r} + \mu^2_{I_f})}$$

V. EXPERIMENTAL RESULTS AND PARAMETER ASSESSMENT:

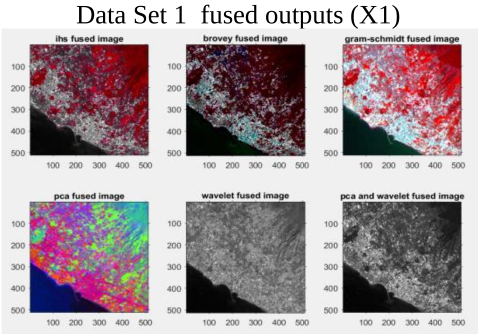
The fusion results are showed in figure, hence the corresponding obtained results and quality assessment are tabulated below.

Quality measures \ Fusion methods	TEST IMAGES	IHS	BROVEY (BT)	GRAM-SCHMIDT (GSO)	PRINCIPAL COMPONENT ANALYSIS (PCA)	WAVELET	WAVELET AND PCA FUSED METHOD
CORRELATION COEFFICIENT (CC)	X1	0.292174	0.46070	0.662145	0.73005	**0.857271**	**0.86475**
	X2	0.52777	0.551249	0.63700	0.69970	**0.729938**	**0.7814**
	X3	0.23306	0.2792980	0.299777	0.492396	**0.512496**	**0.583778**
	X4	0.359388	0.3978480	0.471261	0.488316	**0.493583**	**0.624778**
MEAN BIAS	X1	47.8837	47.4979	49.1175	56.0178	**63.22718**	**67.8237**
	X2	20.7190	21.0717	26.2183	27.6249	**41.5981**	**52.7036**
	X3	5.0518	10.6634	24.3320	36.9965	**43.5072**	**54.8587**
	X4	10.8534	19.4067	23.3390	25.2571	**48.9082**	**76.8002**
PEAK SIGNAL TO NOISE RATIO (PSNR)	X1	11.8067	9.441705	12.032770	12.7406	**14.629313**	**16.0242**
	X2	20.784660	23.890294	25.118714	28.349454	**30.123243**	**33.145227**
	X3	13.306930	15.909147	17.191942	18.542310	**20.030651**	**20.394016**
	X4	6.189453	7.655683	9.089749	11.815711	**15.555415**	**16.725125**
Structural similarity measure (SSIM)	X1	0.375738	0.292524	0.400945	0.403003	**0.445249**	**0.508075**
	X2	0.249749	0.254358	0.295821	0.344403	**0.391930**	**0.494081**
	X3	0.349688	0.484702	0.567373	0.629183	**0.652621**	**0.756754**
	X4	0.446656	0.498432	0.532170	0.581020	**0.675847**	**0.774867**
ENTROPY	X1	0.48152	0.4213	0.5238	0.55491	**0.82585**	**0.88639**
	X2	0.23413	0.351180	0.59798	0.79497	**0.83918**	**0.95495**
	X3	0.18856	0.23002	0.39126	0.47252	**0.587905**	**0.67358**
	X4	0.10154	0.14823	0.17052	0.213618	**0.35414**	**0.989903**
UNIVERSAL IMAGE QUALITY INDEX (UIQI)	X1	0.23890	0.272754	0.286942	0.298473	**0.317288**	**0.38586**
	X2	0.27495	0.324078	0.358324	0.375480	**0.436020**	**0.594411**
	X3	0.430232	0.454032	0.458836	0.523319	**0.59450**	**0.646595**
	X4	0.122976	0.167813	0.252293	0.346313	**0.470094**	**0.642871**

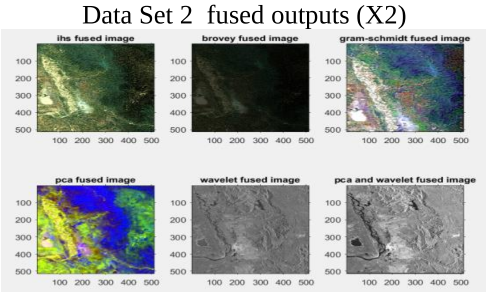
Table 1: Values Of Different Parameters Of Fusion Methods Analyzed To Estimate The Quality Of Fused Images.

The Fig 5 illustrates the corresponding data sets to which the fusion methods are analyzed and quality measures or parameters are assessed and tabulated in Table1 and the following results are shown in figures given below:

Data Set 1 fused outputs (X1)



Data Set 2 fused outputs (X2)



Data Set 3 fused outputs (X3)

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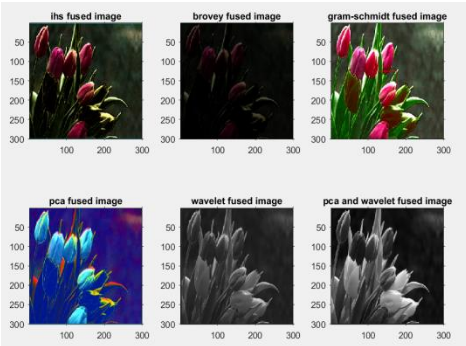

Data Set 4 fused outputs (X4)

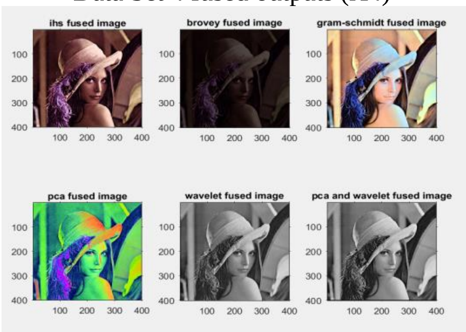

Fig 5: Fused Data Sets(X1,X2,X3,X4).

The results are obtained by using Remote Sensing data (LANDSAT,SPOT and IKONOS) that collects high spatial resolution panchromatic(PAN) image and multiple multispectral(MS) images with low spatial resolution images[2]. The IHS transform separates the spatial information of the multispectral image as the intensity (I) component. By observing the results, IHS method enhances the detail information of image and Brovey transform normalize the three bands used for RGB and multiplied the result by desired data to add the intensity or brightness component to the image. In gram-schmidt image fusion method the low resolution image is pansharpened where small details in the image are observed. PCA separates the spatial information of the image into the first principal component PC1.PCA method introduce less color distortion, but affect spectral responses of the multispectral data. This spectral distortion is caused due to the mismatch of overlap between the spectral responses of the multispectral image, and the bandwidth of the pan image. As compare to other fusion methods wavelets perform better results.

VI. CONCLUSION:

In this paper ,we observed different fusion techniques which are applied to the Remote Sensing or satellite data. Many research papers have reported the limitations of existing fusion techniques. Most significant problems observed in the methods are color distortion**.** To reduce the color distortion and improve fusion quality various fusion techniques have been developed, compared and analyzed. Some of the fusion techniques are utilized in this paper for increasing quality of images or data sets. Various Quality measures are applied to the fused outputs such as PSNR, SSIM, correlation coefficient(CC), Entropy(E), Universal image quality index(UIQI),etc.., are analyzed and studied. The quality of fusion is assessed for different images at different levels. Compared to existing fusion methods proposed fusion techniques shows better results.

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