Panchromatic and Multispectral Image Registration and Fusion for High Spatial and Spectral Information by Minimizing Registration Error

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ABSTRACT
Image fusion is a process of combining data from multiple images of a single object or same scene to produce an image which retains information from either of the images. The fusion of satellite images will unite PAN and MS images to generate new MS image having the qualities of both the input images. The registration process is to align both the images. Proper registration of panchromatic and multispectral images produces the good fusion result. Proposed Novel Registration and Fusion method uses, Speeded Up Robust Feature (SURF) method with Random Sample Consensus algorithm to combine the PAN and MS images. Eight performance measurement parameters are considered to validate the fusion result.

General Terms
In the field of remote sensing image processing, multispectral (MS) images of a satellite plays very important role in many applications like land slide detection, urban development, forest density detection, change detection, ice berg break detection etc.

Keywords
Panchromatic, Multispectral, Registration, Fusion, Remote Sensing.

1. INTRODUCTION
In the field of remote sensing multispectral (MS) images of a satellite plays very important role in many applications like land slide detection, urban development, forest density detection, change detection etc. however in the present scenario the design of MS sensor with greater resolution is a critical problem due to storage and bandwidth of transmission [1]. On the other side panchromatic (PAN) images are captured from imaging sensor which is sensitive to large scale of frequency of the perceptible part of the spectrum. PAN image is having high spatial resolution. MS images are having high spectral information. The fusion process will unite PAN and MS images to generate new MS image having the qualities of both the input images. Many existing image fusion algorithms require a pre registration of PAN and MS images before image fusion [2]. Both PAN and MS images are having different resolutions so pre registration is a difficult task to perform. Improper registration of PAN and MS images leads to artifacts in the fused result. The proposed novel image registration and fusion process (NRF) uses, Speeded Up Robust Feature SURF [3], [4],[5],[6] method with Random Sample Consensus algorithm [7],[8] to register PAN images with respect to MS images. Finally PAN and MS images are fused using guided filter [9].

This paper is framed as, section II depict the NRF technique. Section III furnishes results and discussion and section IV describe the conclusion.

2. PROPOSED METHOD
2.1. Novel Image registration and fusion (NRF)
Step1. Consider the Multispectral image (MS image) and PAN Image
Step2. Apply the SURF and RANSAC algorithms to register the panchromatic image, as the registration accuracy increases the fusion grade will also increases.
Step3. Remove the misalignments present on the other side.
Step4. Achieve the Geometric Transformation.
Step5. Fuse the registered PAN and MS images using guided filtering.
The detail flow diagram of the proposed method is shown below:

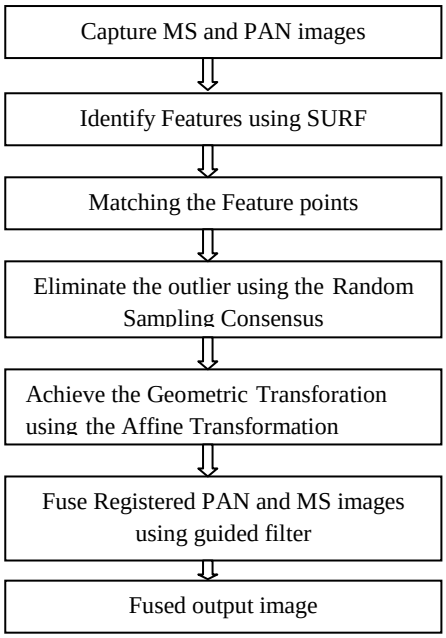


Figure 1 Speeded-Up Robust Features (SURF) flow diagram

3. RESULTS AND DISCUSSION
Simulation experiment is conducted with three image fusion methods like IHS transform [10], PCA transform [11], and proposed NRF method and considered eight performance measurement parameters.

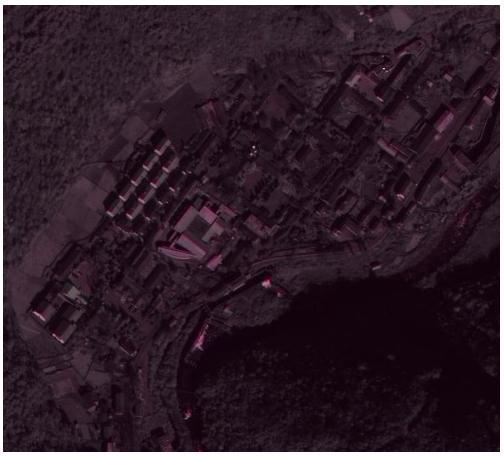
A. Original Panchromatic image

B. Registered Panchromatic image

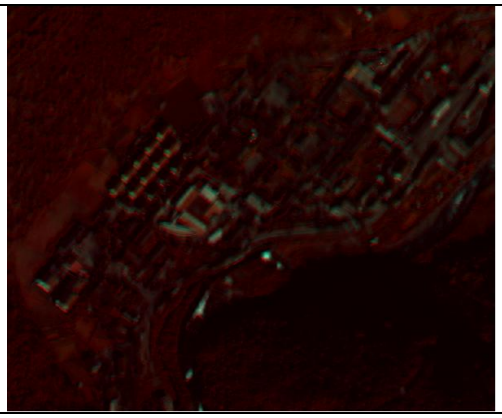
C. Original Multispectral image

D. Fused image using guided filter

Figure 2. A. PAN image, B. Registered PAN image, C. MS image , D. novel image registration and fusion (NRF) method



A. Fused result of IHS transform method



B. Fused result of PCA transform

Figure 3. Fusion Result of IHS and PCA methods

Figure 2(A,B,C,D) shows the original PAN image, Registered PAN image, original MS image, novel register and fusion (NRF) algorithm image respectively. Figure3 (A, B) shows the fused result of IHS transform and PCA transform respectively. From the figure2 and figure3 we can observe that the result of NRF algorithm is having best spatial and spectral quality compared to the IHS and PCA transform based methods.

Simulation experiment is conducted with three image fusion methods like IHS transform, PCA transform, and proposed NRF method and considered eight performance measurement parameters. Table1 shows the result of all three image fusion methods performance measurement parameters. The performance measurement values from the table1 depicts that NRF method performs well compared to PCA and IHS transform methods. Performance measurement parameters and there results are summarized as, 1) Root Mean Square Error (RMSE) : ideally its value must be near to zero, a zero value RMSE indicates that the merged result has best spectral standard. 2) Structural Angle Mapper (SAM): which indicates the spectral similarity between the fused image and original image, ideal merit of SAM is 'zero'. NRF fusion method produces SAM value near to ideal value. 3) Mean Bias (MB): optimum value of the MB is zero. NRF fusion method produced MB value near to Ideal value. 4) Percentage Fit Error (PFE): lesser merit of PFE indicates that the merged and reference images are having similarity. NRF fusion method produced lower PFE value compared to other two fusion methods. 5) Signal to Noise Ratio (SNR): driving value of SNR speaks to that the results are indistinguishable. NRF fusion strategy delivered SNR higher esteems compared with other two combination techniques under consideration. 6) Peak Signal to Noise Ratio (PSNR): ideally PSNR value should be high, a excessive significance of PSNR means both the fused and original images both are same. NRF fusion method is having highest SNR value in the table1. 7) The SSIM value should lie between -1 and +1for good fusion method NRF fusion method meets the requirement. 8) Standard Deviation (SD), leading merit of SD indicates that the merged image is having greater contrast. NRF method is having high SD compared to IHS and PAC transform methods.

3.1. Performance measurement parameters [12].

3.1.1Root mean square error

$$RMSE = \sqrt{\frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{M} (I_r(x,y) - I_f(x,y))^2} \quad (1)$$

3.1.2 Structural angle mapper

$$SAM \triangleq arcos\left[\frac{(u,\tilde{u})}{||u_2|| . ||\tilde{u}_2||}\right] \quad (2)$$

3.1.3 Mean bias

$$MB = \frac{Multispectral_{mean} - MSFUSED_{mean}}{Multispectral_{mean}} \quad (3)$$

3.1.4 Percentage fit error:

$$PFE = \frac{norm(I_{ref} - I_f)}{norm(I_{ref})} x100 \quad (4)$$

3.1.5 Signal to noise ratio

$$SNR = 10\ log_{10}\left[\frac{\sum_{x=1}^{P}\sum_{y=1}^{Q}(I_r(x,y))^2}{\frac{1}{MN}\sum_{x=1}^{P}\sum_{y=1}^{Q}(I_r(x,y) - I_f(x,y))^2}\right] (5)$$

3.1.6 Peak signal to noise ratio

$$PSNR = 20log_{10}\left[\frac{L^2}{\frac{1}{MN}\sum_{k=1}^{M}\sum_{l=1}^{N}((I_r(,l) - I_f(k,l))^2}\right] (6)$$

3.1.7 Structural similarity index

$$SSIM = \frac{(2\mu I_r . \mu I_f + c1)(2\sigma I_r \mu I_f + c2)}{(\mu^2 I_r + \mu^2 I_f + C1)(\sigma^2 I_r + \sigma^2 I_f + c2)} \quad (7)$$

3.1.8 Standard Deviation

$$SD = \left[\sum_{j=1}^{l} [J - j^2 h_{lf}(j)]^2\right]$$

(8)

Table1. Performance measurement parameters results of image fusion methods

Parameters	PCA	IHS	NRF
RMSE	6.5116	5.97	2.1983
SAM	0.3702	0.3961	0.0354
MB	0.6667	0.2531	0.00003
PFE	0.5454	0.4063	0.0358
SNR	5.8908	6.2929	8.4026
PSNR	38.8242	46.8959	89.4200
SSI	6.0952	0.0717	0.8850
SD	10.2653	15.4744	15.5759

4. CONCLUSION

The Novel Image Registration and Fusion (NRF) method performs well compared to other existing component substitution methods and model based methods. As we perform pre registration and fusion the fusion process is insensitive to the sever intensity distortion, noise and pixel misalignment. The fused result produces good spatial resolution as well as maintaining spectral resolution. Further the work can be extended to address the satellite image denoising and registration to improve the quality of the fused image.

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