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Fusion of VNIR and SWIR Bands of Sentinel-2A Imagery

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Abstract - *Pansharpening is important process for creating high resolution image by fusing panchromatic image and multispectral image. To get the complete detailed information about land cover area or water cover area, 60m image is used but it has low spatial resolution where it is impossible to identify the exact information of the land/water so it has to down sample to 10m image which has high resolution. So in this work the visible and near-infrared (VNIR) and shortwave infrared (SWIR) spectral bands with spatial resolution of 10m is obtained by using the bands of a Sentinel-2A image with spatial resolution of 20m and 60m are sharpened to a spatial resolution of 10m i.e. is nothing but the sharpening. There are many algorithms used for sharpening of images such as CS, MRA and CNN etc. This paper summarizes some of the algorithms/methods used for sharpening and how quality of the image is maintained in each of the algorithms/methods used.*

Key Words: **Pansharpening, multispectral, panchromatic, spatial, spectral, Component substitution, Multiresolution analysis, convolution neural network.**

1. INTRODUCTION

Sentinel-2 is Copernicus Program that has the earth imagery of high resolution of land and coastal water areas. It has two twin satellites (Sentinel-2A and Sentinel-2B). This programme supports a wide range of services and applications such as emergencies management, agricultural monitoring, land cover classification or water quality. Sentinel-2A and Sentinel-2B were launched on 23 June 2015 and on 7 March 2017. It has single multi-spectral image with 13 bands in the visible, near infrared, and short wave infrared part of the spectrum and spatial resolution of 10 m, 20 m and 60 m. To get the detail information of any land cover area, 60m image is used but it has low spatial resolution where it is impossible to identify the exact information of the land so it has to down sample to 10m image which has high spatial resolution. For this Pansharpening process is used which is the fusion of high resolution panchromatic image and low resolution multispectral image to obtain the high resolution multispectral image. Google Maps and nearly every satellite use this technique to get the good image quality. Pansharpening itself is sufficient for getting high multispectral images of bands upto four to five bands but while considering the satellite images it has more number bands which result in spectral distortion as the result of panchromatic images. So to overcome the spectral distortion some of the algorithms are used.

Techniques such as intensity hue-saturation (IHS), high-pass filtering (HPF), principal component analysis (PCA), Brovey and wavelet transforms which are widely used for image fusion. Leaving these there are other algorithms used for pansharpening such as (i) Component Substitution (CS): here images are linearly transformed, then some of the original bands are replaced with the transformed ones. Examples are methods using IHS and PCA. For IHS method, the R, G and B bands are transformed to obtain I, H and S bands. Then pan image is formed by replacing I band and pan sharpened R ,G and B bands are obtained once it is applied to IHS backward transform. MS image is substituted by spatial details extracted from the PAN image, using a high pass filter. An example is HPF, MTF filters. Methods based on the statistics of the image, as Bayesian-based and super-resolution methods.

(ii)Multiresolution (MRA): In this algorithm some of the methods such as wavelet transform, contourlet and Laplacian pyramid methods based on multiresolution analysis are used. Moreover, like combination of other methods with multiresolution analysis such as wavelet and HIS belong to this group.

(iii)Convolutional neural network (CNN) is a class of deep neural network which does little preprocessing, that means that the neural network learns the filter before doing the real classification. It consist of single or more than one layer, CNN can do lot of things when they are fed with bunch of signals as input to it. For computer system it is difficult to consider whole signal hence by using Convolutional neural network it uses a part of signal instead of considering entire signal, CNN is a type of neural network where input variables are related spatially to each other. CNN were developed specially to take spatial positions into account.

2. LITERATURE SURVEY

Honglyun Park , Jaewan Choi, Nyunghee Park and Seokkeun Choi[1] they created panchromatic image using layer-stacked bands with modified selected and synthesized band schemes using the original multispectral bands to down scale the 60m image to 20m image and then to 10m image of Sentinel-2A.While authors comparing to the existing selected and synthesized band scheme they obtain the visible and near-infrared (VNIR) and shortwave infrared (SWIR) spectral bands with the spatial resolution of 10m with improved spatial and spectral properties. They proposed algorithms based on component substitution (CS) and a multiresolution analysis (MRA) for sharpening as the result of experiment CS-based algorithms present higher spatial quality compared to those by the MRA-based algorithms.

Chen Yang , Qingming Zhan, Huimin Liu and Ruiqi Ma[2] showed integrating of the multi-spectral (MS) image and panchromatic (PAN) image for pansharpening process using its spatial information. There many number of sharpening methods based on intensity-hue-saturation (IHS) transform, which gives error of spectral distortion. To address this problem , authors proposed ripplet transform and compression based on IHS pan-sharpening method . Firstly ,In MS image the IHS transform is applied to separate intensity components. Secondly, PAN image is used to obtain multi-scale sub images using discrete ripplet transform(DRT) which is implemented on the intensity component .Then using local variance algorithm high-frequency sub-images are fused and low-frequency images are compressed. Finally, to generate pan-sharpened image the inverse ripplet transform and inverse IHS transform are coupled together. The proposed method by authors is then compared with different dataset such as WorldView-2, Pleiades and Triples through visual and quantitative analysis. The author's experimental result shows that spectral fidelity of image is obtained for higher spatial resolution images.

As we know Deep learning has proven its effectiveness in large number of image processing and computer vision problems, the authors Giuseppe Masi, Davide Cozzolino, Luisa Verdoliva and Giuseppe Scarpa [3] proposed the new algorithm i.e Pansharpening by Convolutional Neural Networks since it is a simple and effective three layer architecture which reduces the complexity with improved performance. In this work they have used 3 large training dataset including several maps of nonlinear architecture for sharpening. For training the datasets caffe and MatCaffe framework is used which the more efficient and faster framework. The experimental result showed by authors proves that this method gives the best image quality compared to other algorithms.

A. D. Vaiopoulos and K. Karantzalos [4] used 21 different fusion algorithms and 3 standard quantitative image indexes which is used for remote sensing experts. The obtained image quality indexes and quantitative analysis didn't manage to give exact spatial information but SWIR band delivered better result for image fusion using standard bicubic interpolation on the low resolution bands.

Rocco Restaino, Gemine Vivone, Mauro Dalla Mura and Jocelyn Chanussot [5] made a survey on Fusion of Multispectral and Panchromatic Images Based on Morphological Operators Nonlinear decomposition schemes which constitute an alternative approaches for facing the problem of data fusion. In this paper, author's found that in remote sensing finding a high-resolution panchromatic image by down sampling is known as pansharpening. Although the properties of morphology-based methods are widely exploited for applications as segmentation and denoising, but only for limited number of data fusion approaches. Author's used the four datasets which are acquired by four different sensors for pansharpening algorithms then compared the results with existing pansharpening algorithm based on mathematical morphology.

Farzaneh Dadras Javan, Farhad Samadzadegan and Peter Reinartz [6] here authors showed the importance of spatial quality of pan sharpening image which is capable for object detection, classification and reconstruction of image, specially urban region.Author used the Edge based image fusion metric (EFM) for finding the spatial quality of high resolution pan-sharpened imagery.And for the measurement of edge response by Modulation Transfer Function(MTF) which is compared to original multispectral and panchromatic images.Datasets and images are capatured from the World View-2.By calculating EFM author describes that this technique is robust and it is easier to find the best fusion technique for pansharpening of satellite imagery.

Qiang qiang Yuan,Yancong Wei, Xiangchao Meng, Huan feng Shen and Liang pei Zhang [7] Here authors used the CNN(Convolutional Neural Network) and deep learning neural networks architecture for multi-scale feature extraction from conversion of low resolution MS image to high resolution image and proposed new CNN architecture model for pansharpening of remote sensing imagery i.e multi-scale and multi-depth convolution neural network(MSDCNN). Author used three different datasets obtained from World View-2 , IKONOS and Quick Bird and calculated both quantitive assessment and visual assessment to confirm that proposed network provides high quality MS image.

Hui Li and Xiao-Jun Wu [8] proposed the single image which consist of all the features of infrared and visible bands using deep leaning framework.Fristly they divided the source images in several parts and then base parts are fused using weighted-averaging.Serveral detail content of image is generated using multilayer features from deep learning networks. Authors used 11-norm and weighted average strategy to get detail content of the fused image. Then finally they constructed the pan sharpened image by combining fused images and detail content.

Gemine Vivone, Luciano Alparone, Jocelyn Chanussot, Mauro Dalla Mura, Andrea Garzelli, Giorgio A. Licciardi, Rocco Restaino and Lucien Wald [9] there are many pansharpening techniques which aims fusing of multispectral and a panchromatic image but comparing each techniques with its spatial and spectral qualities is the critical task. So author's solved this problem by providing state-of-art pansharpening methods. Author's divided several pansharpening techniques into two main algorithms i.e. the component substitution and multiresolution analysis based on protocol named full and reduced resolution validation. Author's used the five different dataset from different satellite for the comparison.

Arya Krishnan P.S and Chithira Rakshmi .G [10] gave the brief description of all the pansharpening techniques including PCA which are all suitable for remote sensing imagery. They defined pansharpening as combination of colored multispectral image and gray scale panchromatic image which produces high resolution colored image. Then author's differentiated all the algorithms depending on the quality and visual assessment. Totally author described about six different pansharpening methods i.e IHS(Intensity Hue Saturation), PCA (Principal Component Analysis), Wavelet Method, P+XS Method, VWP Method and With Matting Mode.

Gemine Vivone, Miguel Simões, Mauro Dalla Mura, Rocco Restaino [11] proposed the relation between the PAN and MS image of remote sensing by taking two different data sets from IKONOS and quick bird. Basically modulation transfer function are used for MS sensor and gain is calculated by Nyquist frequency. Author's showed its effectiveness by taking reduced scale dataset from IKONOS and fully resolution data from quick bird. In first case author found the performance similar to the degrading of filters and in second case it shows the performs from several state-of- art approach.

Jingxiang Yang , Yong-Qiang Zhao and Jonathan Cheung-Wai Chan [12] proposed the fusion method for hyperspectral image(HSI) and Multispectral image(MSI) using deep learning convolution neural network(CNN).Here CNN uses two branches which extract the features of HIS and MSI imges. In order to get the spectral property of fused image author passed these extracted features of image to fully connected(FC) layers .The output of this layer will be fuuly fused HR HSI .Author used the datasets of Environmental Mapping and Analysis Program (EnMAP) and Airborne Visible Infrared Imaging Spectrometer (AVIRIS).

Table -1: Brief view of all the papers

Sl.No	Paper Name	Author Name	Year of Publishing & journal name	Algorithms used
1	Sharpening the VNIR and SWIR Bands of Sentinel-2A Imagery through Modified Selected and Synthesized Band Schemes	Honglyun Park ID , Jaewan Choi	Remote Sensing environment ,2017	CS & MRA
2	An IHS-Based Pan-Sharpening Method for Spectral Fidelity Improvement Using Ripplet Transform and Compressed Sensing	Chen Yang , Qingming Zhan	Remote Sensing environment 2018	HIS
3	Pansharpening by Convolutional Neural Networks	Giuseppe Masi, Davide Cozzolino	Remote Sensing environment, 2016	CNN
4	Pansharpening on the Narrow VNIR and SWIR Spectral Bands Of Sentinel-2	Pansharpening on the Narrow VNIR and SWIR Spectral Bands Of Sentinel-2	Remote Sensing environment, 2016	CS & MRA

5	Fusion of Multispectral and Panchromatic Images Based on Morphological Operators	Rocco Restaino , Gemine Vivone	IEEE Transactions, June 2016	MRA
6	Spatial Quality Assessment of Pan-Sharpened High Resolution Satellite Imagery Based on an Automatically Estimated Edge Based Metric	Farzaneh Dadras Javan , Farhad Samadzadegan	Remote Sensing environment 2013	Edge-based image fusion metric(EFM)
7	A Multi-Scale and Multi-Depth Convolutional Neural Network for Remote Sensing Imagery Pan-Sharpening	Qiangqiang Yuan, Yancong Wei	IEEE transactions, April 2018	MSDCNN
8	Infrared and Visible Image Fusion using a Deep Learning Framework	Hui Li, Xiao-Jun Wu	IEEE transactions, 2018	Deep learning framework(VGG-network)
9	A Critical Comparison Among Pansharpening Algorithms	Gemine Vivone, Luciano Alparone	IEEE transactions, May 2015	CS & MRA
10	Comparative Study on Pansharpening Methods for Satellite Images	Arya Krishnan P.S and Chithira Rakshmi .G	International Research Journal of Engineering and Technology (IRJET), Dec-2015	IHS, PCA , Wavelet Method, P+XS Method, VWP Method and With Matting Mode
11	Pansharpening Based on Semiblind Deconvolution	Gemine Vivone, Miguel Simões et	IEEE transactions, 2014	Gaussian MTF matched filter
12	Hyperspectral and Multispectral Image Fusion via Deep Two-Branches Convolutional Neural Network	Jingxiang Yang ,Yong-Qiang Zhao	Remote Sensing environment, May2018	CNN

3. CONCLUSIONS

As pansharpening is necessary for getting the clearer images, in this review we have seen algorithms recently used for the pansharpening of satellite images such as CS, MRA and CNN.All these algorithms are been compared with image qualitive and quantitive analysis where qualitive analysis is visualization of images and quantitive analysis are calculation of some of the image indices such as SNR,RMMSE,DD,ERGAS,SAM etc,.

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