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Fusion of Multi-Sensor Satellite Images using Non-Subsampled Contourlet Transform

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Abstract

The presented research work proposes fusion of multi-sensor satellite images using non subsampled contourlet transform. In the proposed work, trade-off between the spectral distortion and enhancement of spatial information is witnessed while fusing two multi-sensor images. The ills of wavelet based fusion techniques such as limited directionality, lack of phase information and shift invariant are addressed with the help of Non subsampled contourlet transform. The Non subsampled contourlet helps to retain the intrinsic structural information while decomposing and reconstructing the image components. Decision based rules are applied for component substitution for fusion. The experiments are carried out against the current state of art and observed that the proposed system provides promising results visually and quantitatively. The efficiency of the proposed system in the fused product is analysed qualitatively by Isodata classification algorithm.

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Keywords: Fusion; Intrinsic structural information; Multi-sensor Images; Non subsampled contourlet transform; Spectral distortion.

1. Introduction

Geographical scenes obtained through a particular sensor may not contain the desired information of the particular scene. The pattern recognition will gets fail when desired outcome is needed[1]. Images from different sensors having different resolution and different viewing angles. In most of the applications image requires to be rich in both spectral and spatial quality. It is observed that there is always trade-off between spatial, spectral and radiometric resolution, hence user must continuously make efforts to maintain trade-off between these three resolutions. To obtain more information, two or more images are merged together to form super resolution images. Process of integrating supplementary and complementary information from different images referred as fusion[1]. The fused image should produce the major supplementary information along with the complementary information. The fusion of remote sensing imageries is an active area in the field of remote sensing. The fusion is an application oriented task in context with the resolutions and quality. Possible combinations of fusion is as follows only passive images, only active images and the combination of passive and active imageries. Passive images are the one which is obtained through sensing the natural illumination of any object or area with the help of external source. In passive imageries, climate and clouds are

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considered as the hindrances in pattern recognition[2]. Active imagery system uses its own source to capture the content of object or area. Active imagery systems is having the capability of acquiring images at any time and any weather conditions. The satellites which uses such kind of sensor to gather the information about the earth is called as "All Time All Weather" Satellites. Such active images can be captured using Radar signals called as Synthetic Aperture Radar (SAR) images. Speckle noise is present in SAR imageries, an inherent noise produced due to the phenomenon of active imagery systems .The reflected signals captured through the sensors have the path difference $\lambda/4$. The path difference gives a rise to the captured object with the granular noise called Speckle[3]. This noise is multiplicative in nature. The speckle noise deteriorates the quality of acquired image and makes the interpretation of image difficult. It is always recommend to perform despeckling before using active images for fusion. The fusion related works are provided in the later section. The paper is organised as follows; the related work is provided in the section 2, a brief introduction about the non-subsampled contourlet transform is provided at section 3, the proposed system is provided at the section 4, Experiment, results and discussion is provided in section 5.

2. Related Work

Most of the investigators exercised the fusion of images using different methods. The conventional methods have followed the pixel based fusion techniques, which lacks in spectral and radiometric information. Some of the Pixel conventional methods such as PCA (Principal Component Analysis) based[4,5] Color Normalised transform[6] and HSI/HSV (Hue, Saturation and Intensity/Value) transform based[7]. The fusion algorithm should maintains a trade-off by minimizing the spectral information and enhance the spatial information. Most of the algorithms failed to maintain the aforesaid trade-off which primarily have to be witnessed[8]. Some of the investigators adaptively regularize the parameters to maintain the trade-off between spatial and spectral information[9]. These methods are computationally high.

The object based fusion techniques came to existence to overcome the problem of pixel based drawback. The investigators used multi-resolution techniques for fusing with the help of wavelet transforms[10].

The Multi-resolution based techniques usually carried out as follows

1. Extraction of high frequency components from the High Resolution Image (Ex: Panchromatic Images)
2. Substitution of high frequency components into the low resolution Image (Ex: Multispectral Images)

The general object based fusion technique is based on spatial and frequency decomposition of images using Multi-Resolution Analysis (MRA) and component substitution using rules based systems[11]

These techniques provides comparatively good results when compared to the conventional pixel based. The wavelet based techniques holds the spectral and spatial information to a good extent, where the pixel based techniques failed[12]. Discrete wavelet transform (DWT) is one of the widely used tool for image decomposition for fusion. The wavelet transform based fusion schemes such as maximum selection (MS) uses the maximum coefficient from each band with high magnitude[13].

The wavelet is having a severe problem while reconstructing the decomposed components and due to blurring operations[14]. Such ills leads to the presence of artifacts in the fused products[15]. DWT provides directionality in limited directions such as horizontal, vertical and diagonal[16]. The wavelet based fusion technique fails to retain the intrinsic geometrical information due to lack of directionality in decomposing the images. The DWT is sensitive towards the shift and lack of phase information. These drawbacks are witnessed while using wavelets for fusion[13].

In the proposed work the Multi-Geometric Analysis (MGA) is achieved with the help of non-subsampled contourlet (NSCT) transform, which overrules the drawback of wavelets. The MGA helps to retain the intrinsic geometrical information in an image while decomposing for processing. The MGA provides the full directionality, shift invariant and also provides the phase information. The representation which obeys the MGA is the contourlets. Constructing filter banks for contourlets is tedious and computationally complex one[17]. Sampling problem is identified while using contourlets and to avoid the drawbacks of contourlets non-subsampled contourlets is introduced[18]. To utilize the full advantages of MGA in fusing multi-sensor images, Non-Subsampled transform (NSCT) is used in the proposed system. The later section provides the brief discussion of NSCT with the properties.