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# A review of fusion methods of multi-spectral image

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ABSTRACT

As an important branch of data fusion taken images as the research objects, image fusion perform multiple images to get a more accurate image using redundant information and complementary information. Multi-spectral image is a kind of remote sensing image, and fusion of multi-spectral image combine image features of multi-spectral image together to get a more comprehensive and clear image using the spatiotemporal correlation and information on complementary. Consequently, fusion of multi-spectral image, which is a hot issue, is an important way of information processing of remote sensing image. Fusion methods of multi-spectral image is an important issue of fusion of multi-spectral image of remote sensing image, and effective selection of an appropriate fusion method of multi-spectral image is especially significant for improving image accuracy. Along with the development of remote sensing technique, traditional fusion methods of image are difficult to meet the requirement of image accuracy. Recently, fusion methods of multi-spectral image attract increasing attention and become a new hot topic. In this paper, characteristics of different fusion methods of multi-spectral image as well as the research prospect are analyzed. This paper provides a scientific reference for the development of fusion technique of multi-spectral image.



## 1. Introduction

Data information obtained from a single sensor is limited, and it is difficult to meet the requirement of practical applications. At the same time, technologies of multi-sensor have been developed quickly, which make information variety [1,2]. Accordingly, fusion of different kinds of data has attracted increasing attention [3–5]. As an important branch of data fusion taken images as the research objects [6,7], image fusion performs multiple images to get a more accurate image using redundant information and complementary information [8]. Multi-spectral image is a kind of remote sensing image, and fusion of multi-spectral image combine image features of multi-spectral image together to get a more comprehensive and clear image using the spatiotemporal correlation and information on complementary [9]. Multi-spectral image fusion technology is mainly used in geology, agriculture, military, etc. It can improve the spatial resolution, reduce the ambiguity, improve the classification accuracy, and achieve the goal of image quality enhancement [10].

According to the types of source images involved in fusion, fusion methods of multi-spectral image can be divided into three categories [11]: fusion of multi-bands images, fusion of multi-spectral and panchromatic images, and fusion of hyper-spectral images. This paper provides a scientific reference for the development of fusion technique of multi-spectral image, including the above three categories.

## 2. Fusion of multi-bands images

Fusion of multi-bands images is the process of generating or composing new images of multi-bands images using certain algorithm in uniform geographic coordinate system [12]. In this section, several common fusion methods are introduced, followed by discussion of their characteristics.

### 2.1. Low-pass contrast pyramid

Low-pass contrast pyramid is compatible with human visual characteristics [13]. The advantage of low-pass contrast pyramid is to preserve the high contrast and high bright information [14], which can be applied to different resolution images fusion

### 2.2. Wavelet transformation

Wavelet transformation is to resample fusion images, and to decompose sub-images with different resolutions. New high frequency sub-images can be obtained by processing high frequency

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sub-images. Fusion results can be computed by wavelet transformation [15]. The disadvantages of the approach are having a domino effect, and influenced by wavelet decomposition order number [16].

### 2.3. Contrast modulation

Contrast modulation modulates low resolution gray images using clear gray images [17]. Contrast modulation is suitable for the pairs of images, and the fusion effect is proportional to the difference of sensor spatial and gray-scale resolution [18].

### 2.4. Bayesian inference

Bayesian inference deletes error information with low credibility by analyzing the compatibility of information, Bayesian estimates the retained information, and then generate the optimal fusion results [19]. On the basis of it, multi-Bayesian classification inference is proposed. It regards each sensor as a Bayesian classifier, and then generates the optimal fusion results [19]. The disadvantages of multi-Bayesian classification inference are that the uncertainty expression is not very good, and the calculation is complicated [20].

### 2.5. Parameter template

Parameter template completes pattern recognition with complex correlation by comparing observing data with prior template [21]. Parameter templates usually contain Boolean conditions, parameter table, threshold, weight coefficient, etc.

### 2.6. Clustering analysis

Clustering analysis groups the similar predefined data [22]. Clustering analysis is to group data into classification table, not using the statistical theory [23]. Clustering analysis is very useful for interpreting properties and analyzing observed data. It is mainly used for target classification and recognition.

### 2.7. Artificial neural network

Artificial neural network is to emulate biological information processing method of the nervous system [24]. Artificial neural network contains multiple units, which is used to input data as a nonlinear transformation for the classification from data to property. However, the theory of neural network image fusion method has problems still need to be solved. For example, the way of combination between neural network and the traditional classification method [25], neural network model layer and the choice of node number [26], choice of neural network model [27], and training strategy of neural network model [28], etc.

### 2.8. Color space transformation

Color space transformation is a fusion method based on IHS (Intensity, Hue, Saturation) model and the processing methods of gray images and color images [29]. According to application scope and purpose, color space transformation models can be divided into two categories [30], which are models oriented to hardware devices and models applied to color processing applications. RGB model is the most commonly used model oriented to hardware [31], and HIS model is the most commonly used model oriented to color processing [32].

## 3. Fusion of multi-spectral and panchromatic images

Fusion methods of multi-spectral and panchromatic images can be divided into two categories [33], which are fusion methods based on color space component replacement and fusion methods based on multi-resolution analysis. In this section, several common fusion methods are introduced.

### 3.1. Fusion methods based on color space component replacement

Fusion methods based on color components are to linear separate and replace images of each band. Final fusion images are obtained by band restructuring [34].

#### 3.1.1. IHS

IHS is one of the most typical color component replacement fusion methods of multispectral and panchromatic image fusion [32,35,36]. It is noted that the fusion results using IHS may produce spectral distortion more or less [36].

#### 3.1.2. Brovey

Brovey is a fusion method usually used in ratio transformation of images enhancement [37]. Brovey cannot only simplify the process of image color space conversion, but also can keep the spectral information of the original multispectral images [38]. However, if the spectral range of the original multispectral image and panchromatic image is large, it will cause color distortion of spectral information in fusion images [39]. Brovey is mainly used when multi-spectrum images of low spatial resolution and panchromatic images of high spatial resolution are similar. In addition, it will ensure that the gray value range of fusion images after gray space stretching should equal to that of original multi-spectral images with different bands [40,41].

#### 3.1.3. PCA

PCA is a fusion method that multi-dimensional orthogonal linear transformation is carried out based on statistical properties [42], and can transform multi-spectral and panchromatic images with highly correlation into irrelevant variables [43]. The disadvantage of PCA is that it will distort the spectral information of images after PCA transformation of panchromatic and multi-spectral images [44].

### 3.2. Fusion methods based on multi-resolution analysis

Fusion methods based on multi-resolution analysis can be divided into fusion methods based on pyramid transform, fusion methods based on wavelet transform, and fusion methods of multi-scale geometric transform [45,46].

#### 3.2.1. Fusion methods based on pyramid transform

Laplace pyramid transform is used for multi-resolution analysis of image fusion by Gaussian pyramid sequence and interpolation sequence [47]. On the basis of it, Saleem et al. [48] propose an improved fusion method of multi-source images based on contrast pyramid transform. However, it has structural disadvantage such as extraction ability is poor after multi-scale decomposition [49]. For this purpose, Li et al. [50] propose an improved gradient pyramid multi-source image fusion method, which obtain high band coefficient by gradient direction operator. Furthermore, Li et al. [51] improve Gaussian pyramid decomposition, and propose a fusion method based on local neighborhood window feature value selection.