Research Progress in Remote Sensing Image Texture Analysis

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Abstract: Current remote sensing image texture analysis and research is based texture feature. Specialist, who home and abroad, has been continuously explore an optimal extraction process and texture analyze method or through a variety of methods to realize extraction of remote sensing texture information. There are three directions, which including the research of optimal scale, the fusion of method, the proposal and improvement of new algorithm, could comprehensive summary about recent research progress in remote sensing image texture analysis by sorting and analyzing information extraction of remote sensing texture features, the progress of texture analysis methods and the application of analysis methods in recent years. At the same time, a prediction was made for future development of remote sensing image texture analysis. Five development directions are summarized: fusion method, scale selection, continuation and improvement of traditional methods based on symbiotic gray matrix and wavelet analysis, research and exploration of object-oriented and deep learning methods, and research of new algorithms to improve the information extraction effect.

1. Introduction
Since the 1960s and 1970s, many researchers have started the study of image texture analysis. The texture feature is an important feature of remote sensing image, and texture analysis plays an increasingly important role in the recognition of remote sensing image. After decades of development, texture analysis has gradually become an important technology, and has been an active field of remote sensing image pattern recognition.

At present, texture analysis pays more attention to the extraction and analysis about texture-features of high-resolution remote sensing images [1]. Traditional texture analysis methods include statistical analysis, signal processing, geometric feature and model methods, etc. Among them, the most common and effective extraction method is to extract the texture features of remote sensing images in the experimental area by using the gray level co-occurrence matrix method. The extracted texture information is used for modeling, then estimating the experimental objects [2].

The processing and analysis of remote sensing images are extremely dependent on texture features at domestic and overseas [3], as well as it has been made prominent progress in the recognition, processing and classification of remote sensing ground objects, and many analytical methods have been developed. Therefore, this paper summarizes the current research status, development trend and future prediction of texture analysis.

2. Research status at home and abroad
Many domestic scholars have proposed newer extraction methods, such as object-based texture information extraction (Zhao Junyang, Lai Geying, 2020), optical flow dynamic texture, etc. (Yan Li,
Gong Yilong, et al., 2014). Some improved analysis methods have been proposed by scholars that are better than traditional methods, such as the fractal segmentation method of unsupervised remote sensing images combining spectral information and texture information, object-oriented and Log-Gabor wavelet extraction (Ma Changhui, Huang Dengshan, 2019). Other scholars use a variety of methods to combine analysis, such as vegetation index and texture features for fusion and reclassification (Jia Hong, Li Yang, 2020). In addition, there are some original algorithms improved or reconstructed since the beginning of this century, such as discrete wavelet algorithm (MALAT algorithm) and reconstruction (Zhang Yifan, 2004), and multi-channel texture analysis algorithm.

The algorithm of image texture feature description was studied earlier in foreign research territory. Haralick proposed the algorithm of gray level co-occurrence matrix as early as 1979, which is still widely used up to now. In addition, there are also improvements to existing algorithms. For example, Rao proposed to extract texture feature information based on convolutional neural network (2018), and S.E.Franklin began to explore the scale in 1996. The window size was transformed through the semi-variogram function, so as to select the appropriate scale for improving texture analysis. At present, the research work mainly is improving efficiency of algorithm or using the texture analysis method to extract the texture feature to solve specific problems in foreign countries, such as forest tundra precise drawing, forest biomass estimation, etc. Taking a different image classification methods to classify, and comparing the classification results of different characteristic value, summarizing the effect of the texture analysis method.

3. Advancement in methodology for research

In recent years, texture feature is an extremely important role in remote sensing image recognition analysis. With the application of high image more and more extensively, suitable new ways are more needed to improve for the precision of the high marks in feature extraction of image, and in many researchers have about texture analysis method, extraction method, and optimization of the texture analysis method.

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3.1. Texture analysis method

3.1.1. Common texture analysis methods

Texture analysis methods are generally divided into statistical method, model method, mathematical transformation method and structural analysis method, among which structural analysis method is seldom applied according to "texture-element" analysis, so it will not be considered. This is shown in Figure 1.
3.1.2. Recent advances in texture analysis

In recent years, with the continuous improvement of the quality and accuracy of remote sensing image acquisition to adapt to the increasing difficulty of texture analysis, texture analysis methods are also constantly improved. Three kinds of research directions are summarized here for reference.

3.1.2.1. Scale selection class methods

In the digital image processing of remote sensing data, texture analysis can be improved by changing the window size. Foreign scholars use semi-variogram to generate geographic window and determine the window according to the range of observation. Wei Chunyang et al. [4] used variation parameters to quantify the land surface pattern parameters and then selected the optimal scale, which improved the effect of texture analysis (2017). Clifford wavelet transform proposed by Sun Hui [5] uses the third phase parameter to reflect texture structure information, constructs texture feature parameters, classifies textures according to texture features, and realizes the optimization of texture analysis (Sun Hui, 2016). However, Zhao Junyang and Lai Geying (2020) adopted the object-oriented texture feature extraction method. From the spatial domain and the frequency domain, they selected the representative small-scale terracing texture for smooth denoising, edge enhancement and other processing, which overcame the interference of ground object information and fully retained the texture of the terracing object.

3.1.2.2. Merge class methods

Some scholars combine spectral information and texture information for unsupervised fractal segmentation of remote sensing images. The model of bilateral filtering is established by using bilateral filtering algorithm to preserve the image texture information. (Bi Xiaoru, Hu Honglin et al., 2020). Some scholars integrate texture features and vegetation index, select common vegetation index, extract features with gray level co-occurrence matrix, and use multispectral images, RGB texture features and vegetation index to establish vegetation moisture content model (Wan Liang, Cen Haiyan, 2020).
There are also many fusion methods, but the selection of methods is different due to the differences in applicability and selected images. For example, Yang Yanrong, Song Rongjie et al. [11] extracted texture features respectively by using fractal theory and gray level co-occurrence matrix (GLCM), and then compared the extracted fractal texture and GLCM texture with spectral features. It is concluded that spectral +GLCM texture recognition is better than spectral + fractal texture recognition. However, Bi Xiaoru et al. [9] believe that spectral information and fractal texture information are better for image segmentation.

In addition, some scholars proposed the combination of object-oriented technology and Log-Gabor wavelet to extract texture features and then classify them (Ma Changhui, Huang Dengshan, 2019). Jin Pengfei, Tang Yuyu et al. [12] proposed a fast classification method for WIS remote sensing images, which combined twin support vector machine (TSVM) with texture features for feature classification.

3.1.2.3. Algorithms optimize class methods
This paper summarizes the relevant literature on algorithm optimization of texture analysis. Among them, Rao[23] proposed a texture feature recognition method based on convolutional neural network. Combined with texture and color information, the overall recognition ability was improved (Rao, 2018). Dai Laser and Xie Shizhe et al. [13] proposed a line segment optimization algorithm based on geometry-texture constraints in order to solve the problem of line segment fracture in high-resolution remote sensing images caused by edge blurring, ground object blocking and edge serrated. Mathieu[14] studied the long-term land surface change of remote sensing images and the simulated coloring of the images. In this paper, a narrow distribution algorithm is proposed to simulate classification variables using multiple grids. Based on the original algorithm, the patterns of the selection should not only be satisfied with the matching of its neighborhood, but also have an additional criterion: the CPDF value (conditional probability density function) of the target pixel must be limited within a certain range.

3.1.2.4. Other methods
Due to the constant changes of texture analysis methods, the previous three classifications may not be enough to summarize the whole development direction of texture analysis, so some new methods with less relevant literature are summarized.

Some scholars have proposed a high-resolution image change detection method based on optical flow dynamic texture, which can automatically obtain land cover and land use change information from multi-temporal high-resolution remote sensing images. This method describes the gradual change process of ground objects in principle (Yan Li, Gong Yilong et al., 2014).

Yang Hongye, Zhao Yindi et al. [15] (2019) proposed the method of depth texture transfer, dividing low-resolution images and corresponding images into blocks, comparing the texture similarity of image blocks, and constructing reconstructed images with rich texture details to achieve super-resolution reconstruction. Chenxiao Z[16] applied deep learning method to the change monitoring of high-resolution bi-temporal remote sensing images and established a deep supervised image fusion network based on depth features to extract the depth features of images for analysis.

Xia, Min[17] proposed the extended multi-scale cascading forest method to realize satellite cloud image classification. The multi-scale scanning method increased the diversity of feature vector extraction and improved the separability of features.

4. Conclusions
1) Traditional methods are widely used for feature extraction of natural features, and are still widely used today. The method of scale transformation is an improvement for texture analysis. Different scales are applied to different textures to improve the classification accuracy and the analysis efficiency.

2) As for the fusion method, it can be seen that many scholars are not limited to one method for texture analysis, but use the combination of multiple methods, or put forward a model to associate multiple methods on the original method to improve the accuracy of feature extraction.
3) Haralick proposed the grayscale co-occurrence matrix algorithm in 1979, but the development is not particularly outstanding in recent years. In China, there are few new algorithms for texture analysis, most of which are improvements of existing algorithms. Some new algorithms have been proposed abroad, but they have not been fully popularized in China at the level of remote sensing application.

4) As for other methods, this paper only selects three, which are relatively new texture analysis methods at home and abroad. It can be seen that adding time dimension, deep learning and multi-scale can improve the effect of feature extraction and the ability of texture recognition.

5. Interrelated Effects and Look Ahead

Domestic research on the application of the texture analysis is relatively broad, gray level co-occurrence matrix used the most, and the algorithm of foreign research more deeply, so the future of the texture analysis algorithm will also continue to optimize, in order to adapt to the band of high resolution remote sensing image more and more, more and more high resolution and accuracy, we need to continue to improve the extraction methods of texture feature. In the application of texture analysis methods, the hybrid texture analysis of multi-source remote sensing images and the combination of multiple methods also expand the application level of texture analysis.

Finally, through the above analysis, the five development directions of texture analysis are summarized as follows:

1) The fusion of multiple texture analysis methods can improve the extraction of texture features and has the potential to improve the classification accuracy.

2) The selection of optimal scale is one of the focuses of texture analysis.

3) Symbiotic grayscale matrix used most, wavelet transform to extract texture effect is remarkable, based on the method of improvement.

4) Object-oriented and deep learning and other cutting-edge method.

5) New algorithm research is committed to a better image classification and extraction effect.

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