Wavelet based Area Matching of Satellite Imagery

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Abstract: In this paper, we propose a new scheme for matching specified areas in a satellite image, which is a very efficient method because it can be effectively applied to images that have various features. These features may include different spatial resolution and brightness; sometimes they may different geometrical property. The proposed method can be applied to some application fields such as mosaicing of satellite imagery, GCP matching.

Keywords: Area Matching, Wavelet Transform.

1. Introduction

Area matching on satellite imagery is very useful for assisting to solve the problem in GCP chip matching, or to interpret specified areas [1]. For example, we can acquire a geometrically corrected image from matching a number of GCP chips, however, the matching is not only time consuming process, but also requires unnecessary preprocessing. The noise and errors in preprocessing of images make to hard the matching problem [2]. This paper is not studied on condition for solving above problem, but will present the possibility that proposed method can be used in many application fields.

The proposed method is time efficient, brightness and rotation invariant method. In other words, images obtained from different satellites can be applied to the method without any preprocessing such as brightness adjustment. Moreover, the matching between geometric image and raw image is possible as well. The idea is based on image retrieval scheme in which a similar image is retrieved after giving a query image. In the proposed method, the wavelet transform is combined with the retrieval method to enhance performance of the system.

General properties of satellite image and wavelet transform will be described in section 2, the proposed system in section 3.

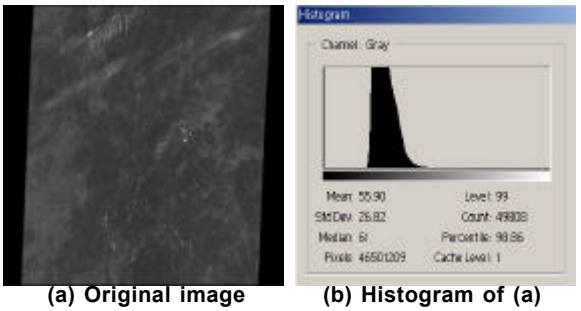
2. Satellite Image and Wavelet

Multispectral images have high correlation between each other band, and each band has his peculiar characteristics. Statistical properties of multispectral images with low and middle resolution are somewhat different from natural images in general. Distribution of pixel does not spread into wide range, only appears to the specified level [3]. This is the reason why we use wavelet in this paper.

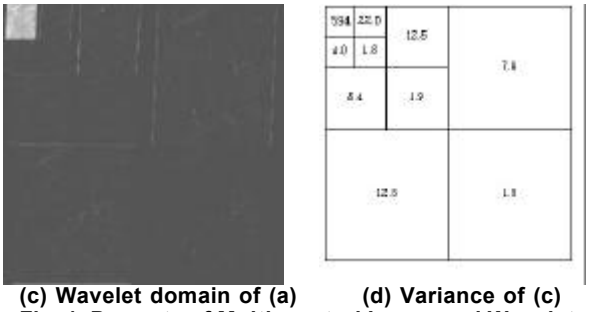
Wavelet that has been developed in mathematics, quantum physics, and statistics is functions that decompose signals into different frequency components and analyze each component with different resolution. Energy concentration is one of the most important characteristics of wavelet transform. Because the wavelet expansions of an image have coefficients that drop off rapidly, the original image can be efficiently represented by a small number of wavelet coefficients. This feature will be used in this paper.

1) Relation of Wavelet and Images

In most of multispectral images, their pixels are distributed in narrow range as Fig. 1-(b). If wavelet transform is applied to such images, the image will be transformed with high energy-compaction. This appears to Fig. 1-(c), 1-(d). Fig. 1-(c) is the wavelet domain with 3 layers, numbers in 1-(d) means variance of each band.



(a) Original image (b) Histogram of (a)



(c) Wavelet domain of (a) (d) Variance of (c)

Fig. 1. Property of Multispectral Image and Wavelet

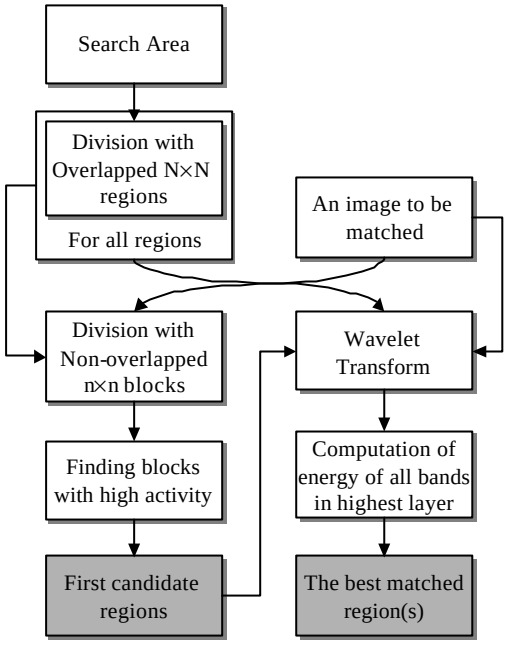


Fig. 2. The proposed System

Energy over 90% will be compacted to the highest layer in the wavelet domain if activity of images in spatial domain is not fairly great. The word ' energy' is one of important facts to distinguish properties of image.

2) Preliminary for Area Matching

Area matching in satellite image can be used to extract GCP by GCP chips, or to make a mosaicked image using images obtained from different satellites. In most of traditional literatures, GCP chips was acquired from raw image, because of matching GCP chips obtained from geometric corrected image to raw image was technically difficult and complex. Moreover, the matching is not efficient for processing time.

The result of area matching may different according to satellite images because the accuracy of matching is influenced by properties of the image such as brightness, rotation, etc. The objective of this paper for area matching is to reduce the processing time, to enhance the accuracy with simple system.

3. Proposed Method for Area matching

This paper proposes a method to improve efficiency of area matching system. The proposed method is especially useful if regions to be matched are considered as wide area. It is due to prompt processing of the method. Fig. 2 shows the proposed system.

The system consists of two steps. To find candidate regions in spatial domain is the first step. In second, the final region is extracted from search area by wavelet transform. The purpose of first step is to reduce the processing time by getting rid of regions with low probability for matching. Therefore, the method must be selected

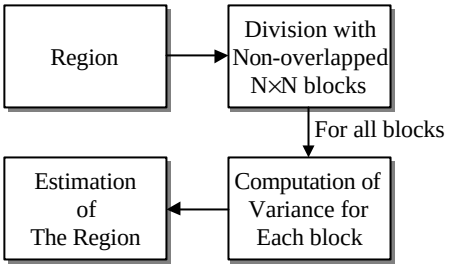


Fig. 3. The estimation of activity of a region

carefully because it does not only influence on decision of first candidates that means accuracy of system, but also processing time.

1) Extraction of the First Candidates

As mentioned above, the first candidate regions can be extracted by proposed method in short processing time. In order to satisfy these conditions this paper adopts a concept, ' activity' of regions. The block diagram for estimating activity of a region is shown in Fig. 3. The word, ' activity' means variation of pixels in a region. In other words, we can say that a region is the low activity region if most of blocks consist of background, otherwise high activity region.

Activity that was estimated from blocks is almost unchanged regardless of outward appearance of images, which can includes brightness and rotation, translation of images. However, pixel based methods for area matching are not only essentially required preprocessing to make same histogram, but must do repeated trial and error to get a proper result.

2) Final Candidates by Wavelet Transform

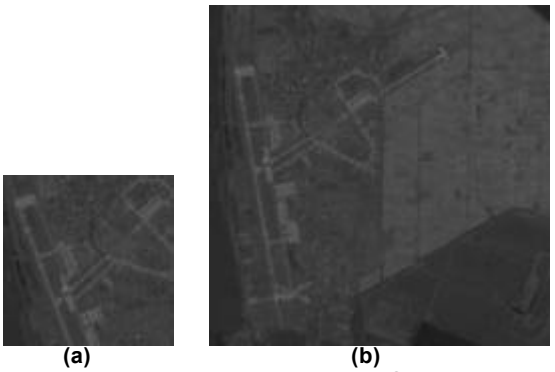
Wavelet as a tool for image analysis is very useful to understand relation between frequency and variation in spatial domain. Through the relation, technology in image processing has developed steadily.

One of the first candidate regions will be chosen as a final region through Wavelet transform. If a region is rotated, coefficients of each band in wavelet domain will be considerably changed even though brightness of the region is always constant. However, in this case, it was known as energy of all bands remains the same.

This paper uses only energy of highest layer, which corresponds to low frequency band. That is because of high frequency components will be inserted when an image is rotated geometrically.

4. Experiment Results

Two images are prepared for experiment. One is the image to be matched, known as query image, with 128×128 resolution, other is the image for search area, or search window with 256×256. The image as search area is geometrically corrected image.



(a) (b)

Figure 4. A query image and Search area

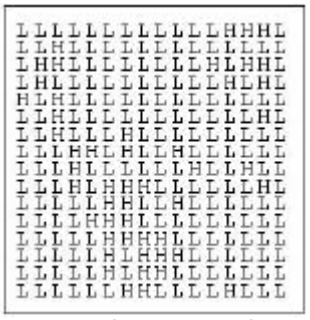
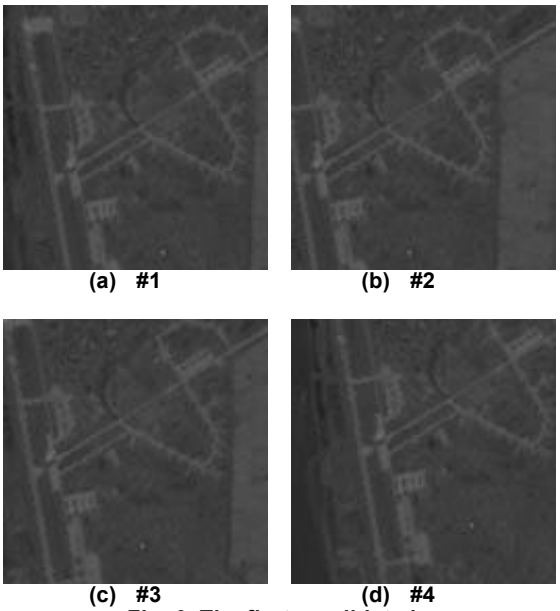


Fig. 5. Map for activity of blocks



(a) #1 (b) #2

(c) #3 (d) #4

Fig. 6. The first candidate images

The query image takes from raw image, on the other hand, the image as search area from geometrically corrected image. Both of them were acquired from different time. To search the first candidate images, high activity blocks of query image are investigated.

The size of a symbol in Fig. 5 corresponds to 8×8 in real image. The symbol 'L' means low activity block, 'H' high activity. Although brightness of images is changed, or the image is rotated, the number of high activity blocks remains the same because edges are always preserved if artificial noise is not added to search image.

Table 1. The number of high activity blocks

	query	candidates			
		#1	#2	#3	#4
Energy	50	49	51	52	52

Table 2. Energy of the highest layer in wavelet domain

	query	candidates			
		#1	#2	#3	#4
Energy	0.295	0.285	0.249	0.257	0.272

Figure 6 shows the first candidate regions that are obtained from comparing activity of regions in search area with that of query image. As expected, all candidates are similar to the query image, and they are retrieved from nearby query image. In this paper, if the activity map of query image corresponds to that of candidates at over 95%, the region is regarded as candidate image. Table 1 shows the number of high activity blocks of candidate images.

To find final image, energy of the highest layer except the lowest frequency (LL) must be computed after wavelet transform is applied to all candidate images. Final image will be selected among candidates if one of their energy is the nearest to that of query image. From table 2, we know that the final image is #1.

5. Conclusions

This paper proposes a method for area matching. Fundamentally, two images which are used to area matching are not required to have same environment. In other words, they may have different brightness, may different geometrically. The proposed method using the properties of spatial domain and wavelet domain is able to match a query image in a very short processing time. The method can be applied to some application fields like GCP chip matching and mosaicing of satellite images if delicate parts such as decision of threshold are supplemented.

References

[1] N. Hinsamooth, F. Cheevasuvit, K. Dejhen, S. Mitatha, and A. Somboonkaew, 1998. Mosaicing of Multi-Resolution Satellite Images, *Circuits and Systems, IEEE Asia-Pacific Conference*, pp. 583 –586.

[2] A. Ghafoor, R. N. Iqbal, and S. Khan, 2003. Robust Image Matching Algorithm, *EURASIP Conference focused on Video/Image Processing and Multimedia Communications*, Croatia, pp. 155-160.

[3] J. H. Park, G. J. Chae, J. H. Park and K. O, Kim, 2003. ROI Coding Method for Multispectral Images, *Proc. of IGARSS*, vol. 6, pp. 3592-3594.

[4] M. Kong, L. P. Leduc, B. K. Ghosh, J. Corbett, V. M. Wickerhauser, 1998. Wavelet Based Analysis of Rotational Motion in Digital Image Sequences, *Proc. of ICASSP*, vol. 5, pp. 2777 –2780.