AN EFFICIENT METHOD FOR SATELLITE IMAGE MATCHING AND MANAGEMENT

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ABSTRACT:

A method for matching two different images is discussed in this paper. Image matching is to match an image with other image that may has different properties. In the matching, generally the images are the same in appearance, may contain quite different contents. If there is no noise, identical pixel value and unchanged edges in those, image matching process can be operated by very simple model. However, natural images to be matched in the most application do not have such an ideal circumstance. This paper proposes a compression method for archiving satellite images and matching scheme which is to match GCP images with a raw satellite image. The proposed method is based on wavelet transform, not required any pre-processing such as histogram equalization, noise reduction.

1. INTRODUCTION

Satellite images are material of great interest for many applications such as minerals management, investigation of environmental change and meteorology, etc. However, management of satellite images requires massive resources in terms of storage and data transmission. Therefore, viewed in the storage management and the fast transmission of data through network, techniques that are able to reduce the amount of satellite images are highly desirable(Ghassemian, H., 2001, Mittal, M.L., 1999).

On the other hand, in order to use the satellite images in many applications, geometrical correction of the images is required essentially. One of methods for the correction is to utilize GCP chip images. GCP can be acquired from the chips, and then the correction will be effectively processed if DB for the chips was established. The first step of correction using GCP is to get GCP images by matching the chips to a raw image which will be corrected. Sometimes, the matching process requires a lot of time as well as it may cause matching error if spatial properties of the chip images have different ones of raw image.

If satellite images are managed in storage before applying geometric correction to them, massive secondary storages are necessary. This paper proposes an efficient method for matching and management of the chip images and the raw images. All the raw images will be managed in compressed stream form, but can be expressed by a little parameter. Because variance of frequency bands can be one of useful parameters to analysis the spatial image, only the parameters and GCP will be stored into database before the matching method is applied.

In this paper, an area matching method will be used for the matching, and the method is only to compare the parameters. Therefore, the proposed method is able to implement fast matching and is not required pre-processing to make similar circumstance as well. The main feature of our system is that all information of the raw images and the chips is managed in compressed stream by wavelet transformation, and chip matching in frequency band is accomplished.

2. SPATIAL IMAGE AND WAVELET

Transformation in image processing decreases correlation between pixels, and makes simple environment for the analysis of signal. Especially, because wavelet transform has not only these properties, but makes possible to decompose an image into multi-scale, wavelet is used in many application fields related to image processing.

To analysis the relationship a spatial image and wavelet transform domain, we prepare an extreme image with definite direction as shown to figure 1.

Figure 1. A spatial image with horizontal direction and its wavelet transform with 3 layers

Figure 1 shows an extreme case, and never appears in the real image. However, from the figure, we can understand the fact that direction by variation of pixel value is exactly reflected in the wavelet transform domain. The other fact is that all significant coefficients only appear to each band according to the same direction. This means the change of brightness of pixels have great influence on energy distribution of the frequency bands.

Of course, the real image consists of random change of pixel value, and it is not simple problem to reveal the relation between variation of spatial image and energy of transform domain. In this paper, simple model will be used to implement the proposed system instead of using complex mathematical structure.

3. IMAGE MATCHING AND MANAGEMENT

In this section, image matching method and satellite image management will be discussed. Figure 2 shows the structure diagram for realizing them. The system consists of two major components, compression and matching part.

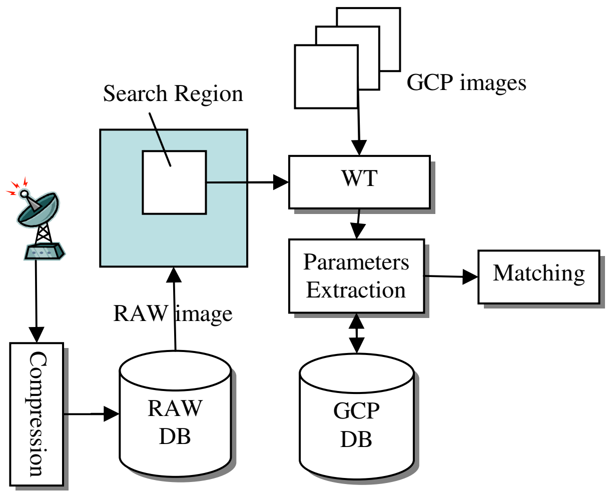


Figure 2. The whole structure of proposed system

The raw images obtained from satellites or off-line medium are stored with bit stream after compression. These images will be decompressed when they need to be corrected geometrically. In case of GCP image, after all GCP images are applied to wavelet transform, some parameters which can express properties of the GCPs are stored. These parameters will be compared with that of raw image for matching.

1.0 Satellite Image Compression

Image compression is an important work in image processing. The common feature for most of application using image is that without compression, the data to be handled is too large. For example, in order to store one scene of Landat-7, storage over 300MB is required. In this section, the efficient compression method which was introduced to (Park, J.H., 2002) is briefly referred.
As stated (Park, J.H., 2002), the proposed method is based on the fact that some region in spatial image and wavelet coefficients in time-frequency domain are closely related. The method could be implemented by applying proper coding methods to each block which are non-overlapped region of spatial image.
The region or block with low activity in the spatial image, so-called background region(BR), appears not only as insignificant coefficients in the wavelet domain, but also has little influence in the reconstructed image. In general, compression efficiency for these regions is known to higher than complex region. On the other hand, high activity blocks, edged region(ER), are related to significant coefficients, which give a great influence to image reconstruction. Observably, the high activity regions are mostly linked to edges or boundaries of images.
The objective of our proposed image compression algorithm is to obtain an efficient coding result by using the relationship. In order to accomplish our purpose, BR regions are encoded by color information coding method, which is similar to encode the inner parts of the object in the conventional object oriented coding(OOC); this scheme is appropriate to represent the region with low activity. To encode ER regions, a technique similar to the conventional bit plane coding is applied to ER region; this scheme is efficient to represent significant coefficients by connecting to quantization stage. Moreover, this method is feasible to implement a progressive transmission by simple operation. More detailed information about this method can be obtained from [1].
Compressed data stream is archived in the RAW database as shown at figure 1.

2.0 Image Matching

Experiment for image matching using Wavelet

In order to investigate that image matching using wavelet is possible, the simple experiment is performed. Figure 3-(a) is the original image and Figure 3-(b) is the changed image that is increased both contrast and brightness about 20% compared to the original image.

(a) Original image (b) Changed image
Figure 3. Experimental images for analyzing relation between image matching and wavelet

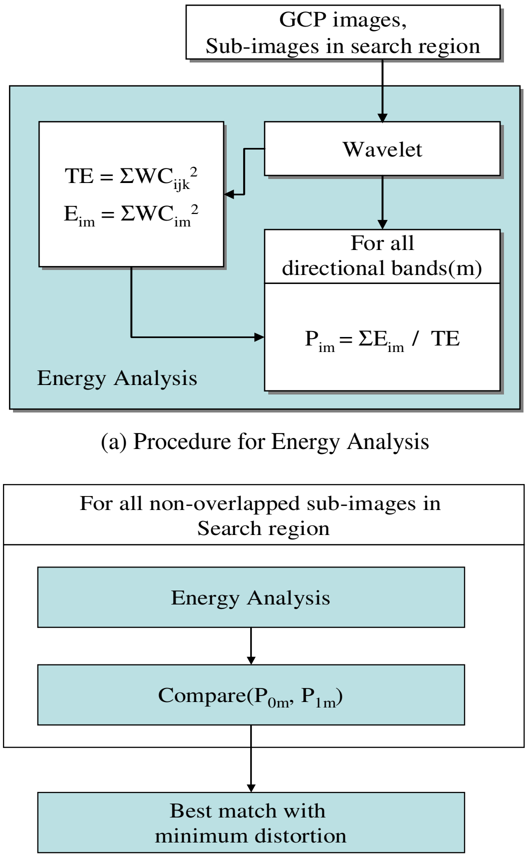
We applied wavelet transform to above two images, and investigated energy of each image in transform domain. The result is shown at table 1.

		(A)	(B)	(C)
		Original	Brightness (+20)	Brightness(+20) Contrast(+20)
3 Layer	HL	80.5	80.5	125.5
	LH	136.0	136.0	211.0
	HH	20.9	20.9	32.6
2 Layer	HL	85.0	85.0	132.2
	LH	75.1	75.1	116.1
	HH	19.3	19.3	30.1
1 Layer	HL	51.9	51.9	80.8
	LH	37.8	37.8	58.8
	HH	6.1	6.1	9.6

Table 1. Energy of wavelet domain

The energy is unchanged when brightness is only changed from the table. However, energy is increased when contrast is changed and brightness as well, but degree of the increase is the same to that of original. For example, in case of original image, the energy of HL in layer 3 is corresponding to 15.7% of total energy and column (C) is equivalent to that.
When the satellite image in the DAW DB needs to be corrected geometrically, the image matching process will be operated after the image is decompressed. The image matching in our

system will be compared GCP image which is generated from satellite image of the past with the current image.
Figure 4 shows the procedure for the proposed image matching.



(a) Procedure for Energy Analysis

(b) Matching Procedure

Figure 4. Image Matching by Wavelet Transform

In the Figure 4-(a), see the equation (1).

$$TE = \sum WC_{ijk}^{\ 2} \tag{1}$$

The symbol WC_{ijk} denotes wavelet coefficients in kth band on the layer j, and if i equals zero, it means chip image, otherwise, non-overlapped images in search region. Therefore, the symbol TE is the total energy of wavelet transform domain except the lowest frequency band. Assume that k denotes the following,

$$k = \begin{cases} HL \text{ band}, & if\ 0 \\ LH \text{ band}, & if\ 1 \\ HH \text{ band}, & if\ 2 \end{cases} \tag{2}$$

The next equation

$$E_{im} = \sum WC_{im}^{\ 2} \tag{3}$$

represents energy of wavelet coefficients as equation (1), however, it's not 'total', but energy of directional bands. It differs from 'k' because 'm' includes all bands on the same direction. The meaning can be expressed with m = {horizontal = 0, vertical = 1, horizontal = 2}. Although two images are almost the same, we can not sure that energy distribution of two images is the same because circumstances of the images such as brightness, noise, may be not identical. So, the final step in the analysis is the normalization of energy.

Figure 4-(b) shows the proposed matching process. For the matching, first of all, search region or reference image must be decomposed into non-overlapped sub images. And then, energy of transform domain will be calculated after wavelet transform is applied to each sub image. From the figure 4-(a) and figure 2, we know that the variable P_{im} is the parameter of GCP database. Final matching step is to compare P_{0m} of GCP with P_{1m} of sub image.

4. EXPERIMENTAL RESULT

Two images are used to the experimental result, Landsat ETM+ image as reference which was down-linked on September, 1999 and GCP image of October 2000.

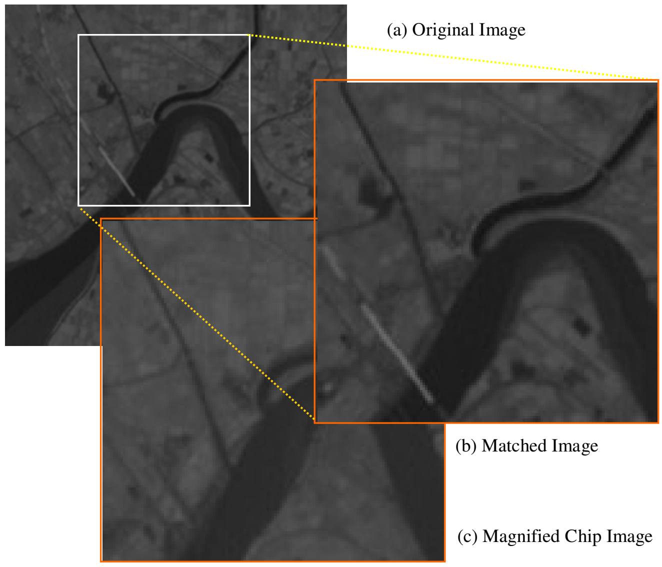


Figure 5. The experimental result

Although the chip image is more blurred than matched image of the original, the simulation result showed good result. This comes from the property of the proposed method that detects directional of energy in transform domain.

5. CONCLUSION

This paper proposed the compression method for an efficient management of satellite image and the image matching scheme. The proposed image matching can be efficiently used in application fields that a reference image has a distinct edge although there is loss in background contents. In the future, the matching method will be developed so that the matching is operated on compressed stream immediately.

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