DETECTION OF SITUATION CHANGING IN REMOTE SENSING IMAGES BASED ON ENERGY MOMENTS

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Abstract. The task of situation changes in remote sensing images is analysed. An effective algorithm for changes detection based on energy moments is proposed. Results of practical experiments are shown.

1. INTRODUCTION

Permanent control of environment by using remote sensing images (RSI) requires effective techniques to detect changes that happened from the previous date. Data volume used in this task is usually enormous and that leads to necessity of using powerful computers and is usually a time consuming.

One of the main problems related to change detection methods based on the "difference image" lies in the lack of efficient automatic techniques for discriminating between changed and unchanged pixels in the difference image. Such discrimination is usually performed by using empirical strategies or manual trial-and-error procedures, which affect both the accuracy and the reliability of the change-detection process [1].

There are several approaches for change detection in remote sensing images. In paper [1], the authors propose two automatic techniques (based on the Bayes theory) for the analysis of the difference image. One allows an automatic selection of the decision threshold that minimizes the overall change detection error probability under the assumption that pixels in the difference image are independent of one another. The other analyzes the difference image by considering the spatial-contextual information included in the neighborhood of each pixel. Both proposed techniques require the knowledge of the statistical distributions of the changed and unchanged pixels in the difference image. In paper [2], a new feature-based approach to automated multitemporal and multisensor image registration was developed. Feature matching was done in both feature space and image space based on moment invariant distance and chain code correlation. The characteristic of this technique is that it combines moment invariant shape descriptors with chain code correlation to establish the correspondences between regions in two images. Then, the algorithms for an automated change detection system utilizing neural networks were developed and implemented.

A popular satellite-based land cover change detection technique is to use the spectral information to set up a binary "change/no-change" mask [3]. For each pixel, if there is a big enough difference between the reflectance values for two images acquired at different times, the area represented by that pixel is considered to have changed. The different change detection methods are different in how they determine a "big enough difference". The analyst is left to choose which function of the reflectance values to use and where to set the "change" threshold. This choice is often subjective and effects the accuracy of the change detection. The paper [3] explore the use of generalized linear models (GLM) as a way to enhance satellite based change detection by helping determine the most appropriate function of the reflectance values to use then apply the modeling to select the threshold. The main idea is that reflectance values from satellite imagery can be incorporated into a GLM to predict the probability of change from one land cover to another and that this method of change detection will provide more information than current change detection methods. There are approaches based on application of Trace transform [4], mathematical morphology [5], and principal component transform [6].

One of the main requirements in this task is necessity to detect changes in real-time. It is also desirable that even small change in one pixel should be immediately detected. Other desired feature is to have such techniques worked in standard PC. However, most of the analysed above approaches can not meet these requirements.

In this paper, we propose a new and effective approach that allows to detect all changes based on analysis of image lines that allows real-time image processing. The approach is based on the idea of energy moments and computing energy moments for image strokes and/or columns. The approach has been tested in remote sensing image processing system that has been developed in IBM PC and showed high quality and speed.

2. ENERGY MOMENTS

Image can be considered as a registration of energy field of a scene in a concrete time. Scene consists of many objects each of them is characterised by a reflection coefficient in a given length of electromagnetic waves.

Image histogram is a function of distribution of pixel brightness and it allows one to evaluate image quality and sometimes processing results. However, histogram `does not feel` changing of object placement and it does not allow to detect place of new object appearing in image.

Let B = {bij} is an image with size MxN. Idea of our approach is to transform the image in distribution of centres of energy moments of image strokes and columns. To do this, energy moments are computed for every stroke and column.

It is always possible to find a point L in i-th stroke that will make energy moments of its elements as equal. Let us call this point as a center of stroke energy moments (CEM) and denote it as Li.

CEM can be expressed through stroke geometric moments of first and zero order:

$$L_i = m_{i1}/m_{i0}, \qquad (1)$$

where $m_{i1} = \sum_{j=0}^{n} (j * bij)$, a $m_{10} = \sum_{j=0}^{n} bij$.

For CEM of higher order, L_i satisfies the following condition:

$$\sum_{j=0}^{Li} (bij\text{-}bmin)^n (L_i - j) = \sum_{j=L}^{n} (bij\text{-}bmin)^n (j - L_i). \qquad (2)$$

Solving the equation (2) for L_i, we obtain

$$L_i = \sum_{j=0}^{n} j*(bij\text{-}bmin)^n \Big/ \sum_{j=0}^{n} (bij\text{-}bmin)^n \qquad (3)$$

Model of i-th stroke can be represented by the following function:

$$M_i(J) = F_i(b_{ij}, L_i \mid j=1,2, \dots, N) \qquad (4)$$

Taking into account that distribution of energy in stroke is defined as brightness values $\{b_{ij} \mid j=1,2, \dots, N\}$, CEM is a function of vector of brightness of image pixels, i.e.

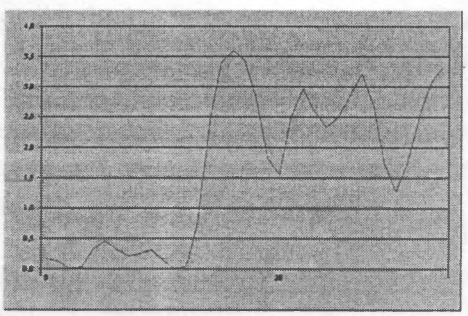
$$L_i = G_i(b_{ij}, \mid j=1,2, \dots, N) \qquad (5)$$

Let as denote distribution of stroke CEM as f(Li), i=1,2,..., M. In the same way, CEM of columns can be computed (denote as g(Lj), j=1,2,...,N). Joint distribution of CEM of strokes and columns is called an image CEM distribution (H(Li,Lj)).

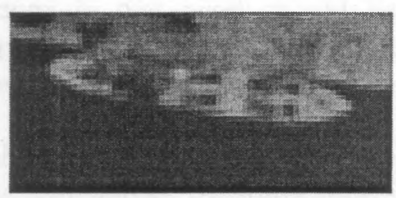
CEM of stroke has the following properties:

1. It is always in $0 \leq Li \leq N$.
2. CEM coordinates are real values.
3. If all stroke pixels have equal or 0 brightness, then CEM has a position Li=(N+1)/2 in even N.
4. Under changing of place or brightness of any stroke pixel, stroke CEM will be changed.
5. CEM is not changed if all stroke pixels will be multiplied into K or they will be added by value b=const;
6. CEM will be changed during image processing operations (filtering, etc).

Fig.1a shows CEM computed for image in Fig.1b. Figure 2 shows CEM computed for the image that has been changed. As one can see CEM distribution is different for these images.

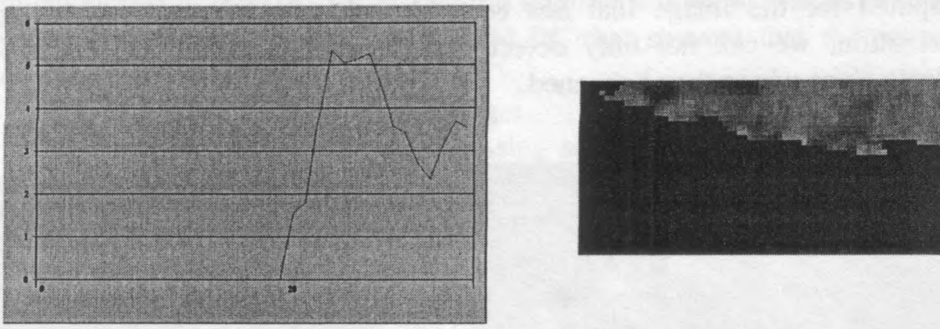


a)



b)

Figure 1.Function of CEM distribution (a) for image (b).



a) b)

Figure 2.Function of CEM distribution (a) for image (b).

3.DETECTION OF SITUATION CHANGING IN IMAGE BY CEM

Detection of situation changing in an image by analyzing CEM distribution is performed in the following way.

For all strokes of original image, CEMs L^0_i are computed and function of CEM distribution is formed that is unique for a given image. When full image is scanned, the function is built and stored.

When a new image is analysed, for every stroke (or column) CEM L_i is computed by using formula (3) and compared with CEM of the same stroke (column) for the previous image. Difference between two CEMs in every pixel is computed by using the formula:

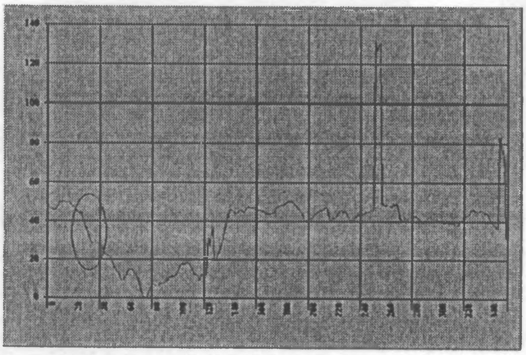
$$D_i(L) = \sqrt{(L_i - L^0_i)^2} \qquad (6)$$

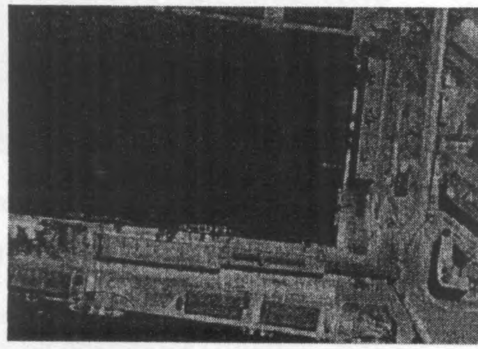
Image CEM is denoted as $D(L) = \{D_i(L) \mid i=1,\ldots,N\}$

Then, number of elements N_D in $D(L)$ exceeding apriori given value $D(L)_{\text{доп.}}$ is counted. If N_D is less then given value N_D^0, the decision is taken that two images have no changes. Otherwise, there are changes.

So, distribution of CEMs, can show where changes had place. Based on it, we can easily detect changed region in the original image. If there are changes in several places in one stroke, analysis of image columns can be applied.

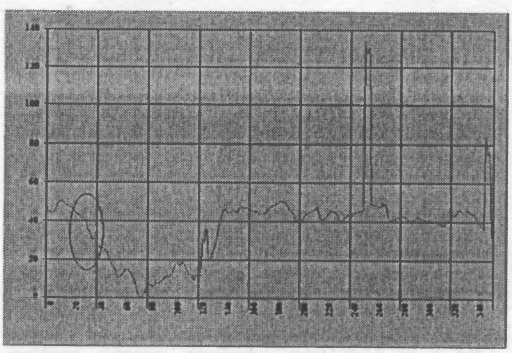
Figure 3a shows CEM computed for image in Fig.3b. Figure 4 shows CEM computed for the image that has been changed. As one can see, using CEM distribution, we can not only detect changes that happened in image but also indicate place where they happened.

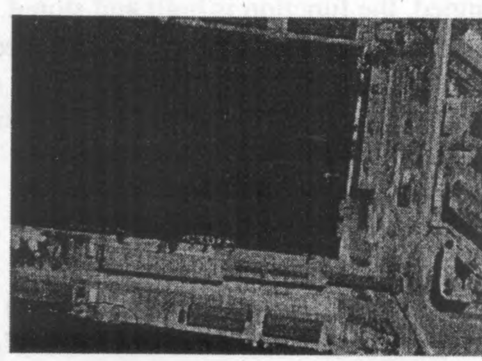




a) b)

Figure 3.Function of CEM distribution (a) for image (b).





a) b)

Figure 4.Function of CEM distribution (a) for image (b).

4. RESULTS AND DISCUSSIONS

The approach has been tested in remote sensing image processing system that has been developed in IBM PC for processing satellite and aerial images of terrain. Experiments have been performed with IBM PC that showed that the proposed approach allows one:

- to detect changes in one pixel in an image;
- to detect changes in line-by-line processing scheme that can be used in real-time image processing;
- to detect coordinates of places where changing occur. To calculate coordinates of rectangle where change had place it is necessary to get CEM representation of image columns;
- it can be realized in standard PC and does not require large memory volume.

The proposed image representation can be considered as an integral feature of the whole image. The detected object (its bounding rectangle) can de cut from the image and given to more detailed analysis.

CEM image representation allows one to compress image in dozens of time but it is not a compressed image representation because an original image can not be reconstructed from its CEM representation. Time of changing detection does not depend on number of objects and changes in the image.

5.CONCLUSION

We proposed a new and effective approach that allows to detect all changes based on analysis of image lines. The approach is based on the idea of energy moments and computing energy moments for image strokes and/or columns. The developed approach allows one to detect any changes (up to one pixel) and detection time does not depend on number of changes. The approach has been tested in remote sensing image processing system that has been developed in IBM PC and showed high quality and speed.

REFERENCES

1. Bruzzone, L., Prieto, D.F., Automatic analysis of the difference image for unsupervised change detection, IEEE Trans. Geosci. Remote Sens., 1171-1182, vol.38, no.3, May 2000
2. Xiaolong Dai, Automated change feature extraction systems in remote sensing, Proc. SPIE, 566-576, vol.3460, 1998
3. Morisette, J.T., Khorram, S., An introduction to using generalized linear models to enhance satellite-based change detection, Proceedings of

International Geoscience and Remote Sensing Symposium, 1769-1771 vol.4 1997
4. Kadyrov, A., Petrou, M., Application of the Trace transform to change detection, Proceedings of International Conference on Advances in Pattern Recognition, 55-62, 1999
5. Le Qu ere, P., Maupin, P., Desjardins, R., Mouchot, M.-C., St-Onge, B., Solaiman, B. Change detection from remotely sensed multi-temporal images using morphological operators, Proceedings of International Geoscience and Remote Sensing Symposium, 252-254 vol.1, 1997
6. Gopal, S., Woodcock, C., Remote sensing of forest change using artificial neural networks, IEEE Trans. Geosci. Remote Sens., 398-404, vol.34, no.2, 1996
7. Yildirim, H., Alparslan, E., Ozel, M.E., Temporal change detection by principal component transformation on satellite imagery, Proc. of International Geoscience and Remote Sensing Symposium, 1227-1229 vol.2, 1995