수치변화탐지의 새로운 접근 - 기하거리분석법 -

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요 지

수치변화탐지에 있어서 종래의 단일 밴드 분석법에 대한 대안으로, 선정된 조합에 의한 복합 밴드의 정보를 활용하는 기하거리분석법이라는 새로운 앨고리듬을 개발하였으며, 분석된 두 앨고리듬 중 기하거리분석법이 변화탐지에 보다 좋은 결과를 나타냈다. 기하거리분석법은 식생 형 변화에 대한 복합 밴드의 정보를 활용할 수가 있고, 데이타의 양을 줄일 수 있는 장점이 있다.

하지만, 이 방법에 대해서는 여러 환경에서의 보다 세밀한 정량적 분석이 요구되어진다. 각 변화영상에 대한 최적영역수준은 여러가지 정확도지수를 분석하여 결정하였으며, (변화)구분도에 대한 표준정확도로는 카파일도계수를 적용하였다.

ABSTRACT

A new digital change detection algorithm, Euclidean Distance Analysis, was developed in an attempt to utilize the multi-band information in a selected band-comination, as an alternative to the conventional single-band analysis methods. To evaluate the relative performance of this new method, image differencing was applied. The better performance in change detection between the two algorithms investigated was provided by the Euclidean distance analysis. The new technique of Euclidean distance analysis holds promise for change detection, since it summarizes the multiple-band information on the cover-type changes and reduces the data dimensionality. It is suggested to further evaluate this new method, quantitatively, in the different environments. The use of different accuracy indices was also examined in the determining the optimal threshold level for each change image. As the standard measure for classification accuracy, the Kappa coefficient of agreement was used for evaluation.

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Introduction

One of the most important applications of digital remote sensing data obtained from earth-orbiting satellites is the recording of land use/cover changes through time, because of repetitive coverage at short intervals and consistent image quality (Anderson, 1977; Nelson, 1983; Singh, 1989). Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Essentially, it involves the ability to quantify temporal effects using multitemporal data sets.

Remote sensing-based change detection has been used in diverse applications using different dates of Landsat Multispectral Scanner (MSS), Thematic Mapper (TM), and French SPOT satellite imagery to detect and monitor suburban sprawl, deforestation, shifting cultivation, crop stress and development, and other environmental changes (Jensen and Toll, 1982; Nelson, 1983; Richards, 1984; Adeniyi, 1985; Singh, 1986). Various procedures have been proposed and used to detect changes in land use/cover using satellite imagery. Of the various image enhancement techniques for change detection, however, only single-band information is used, even though satellite digital data provide multiple-band information on the ground cover features. It is thus of great interest to develop a new change detection method which utilizes the multiple band information.

In this study, the potential of two change detection algorithms for the analysis of digital Landsat-5 TM data is examined for the wetland areas of Jackson Hole, Wyoming through the period of 1985 and 1988. A newly-conceived technique, "Euclidean distance analysis" developed for this study, will be explored in an attempt to demonstrate an alternative to the use of single-band information in the image enhancement approach for detecting cover-type change and to reduce the data dimensionality. The performance of this new method will be compared with that of image differencing which is most-widely used for change detection analysis. The wetland-cover changes detected by these two methods will then be compared to the ground-truthed or photo-referenced data for accuracy evaluation. This study also examines the problems in using different accuracy indices to determine the optimal threshold boundary levels for delineating change and no-change pixels in the transformed binary images produced by digital change detection algorithms.

Comparison Between the Change Detection Algorithms

To compare the results of image differencing and Euclidean distance analysis for detecting wetland-cover changes, a pairwise significance test of the Kappa statistics was performed. A Z test statistic between two independent Kappas was calculated based on the Kappa values and their associated variances of both change images as: -0.2929. Since $Z_{0.025} = 1.96$, the calculated Z-statistic indicated no significant difference in the classification accuracy in terms of 0 (no-change) and 1 (change) at the 95 % probability level, between image differencing and Euclidean distance analysis.

Even though there is no significant difference between the two error matrices, the EDA23457 change image, which was produced by the Euclidean distance analysis based on the band-combination of 2, 3, 4, 5, and 7 at a threshold level of 42, had slightly better accuracy indices of 49.6 % Kappa and 89.7 % overall accuracy than those of the image differencing technique.

Summary and Conclusions

Multitemporal Landsat-5 TM data for the period 15 August 1985 and 23 August 1988 were analyzed to detect wetland-cover changes in the Jackson Hole, Wyoming study area. Two automated methods for change detection were examined. These two techniques include image differencing and Euclidean distance analysis. A newly-conceived method, Euclidean distance analysis, was developed for this study in an attempt to improve the change detection capability by incorporating the multiple bands in a selected band combination and reducing the data dimensionality, as an alternative to the traditional single-band approaches.

A thresholding technique was tested at various threshold levels of 0.1 interval, in the lower and/or upper tails of the distribution in order to determine an optimal threshold boundary level which produced the highest change/no-change classification accuracy. I have also examined the use of different accuracy indices to select the optimal levels for thresholding the change images. As Fung and LeDrew (1988) demonstrated, the use of the user's accuracy approach tends to be biased towards the category with a small number of samples. Accuracy indices based on the producer's accuracy and overall accuracy may tend to be biased towards the category with a large number of samples. The degree of bias is found to be a factor of the ratio between the number of either the

classified or reference samples of the change and the no-change categories. Of the several approaches that were used to assess image classification accuracy, the Kappa coefficient of agreement developed by Cohen (1960) was used as the standard measure for accuracy because it utilizes all the elements of the classification error matrix and attempts to remove the influence of chance agreement (Rosenfield and Fitzpatrick-Lins, 1986; Fung and LeDrew, 1988; Foody, 1992).

The conclusions of this study are as follows:

(1) The better change detection accuracy in relation to the available reference data was achieved from the Euclidean distance analysis which was based on a band combination of TM bands 2, 3, 4, 5, and 7. As an alternative to the single-band analysis for change detection, the Euclidean distance analysis holds promise since it incorporates the multiple-band information in a selected band combination, and produces an output image of a single band, thus, reducing the data dimensionality. It is, however, suggested to further evaluate this new technique, quantitatively, in the different environments.

(2) Among the six TM bands enhanced for change detection analysis, the infrared bands were more appropriate than the visible bands in detecting wetland-cover type changes.

(3) A caution is required in thresholding in order to discriminate the change and no-change pixels since an optimal threshold level varies by the change detection techniques used as well as the images enhanced. Commission error for the change category, where TM data incorrectly indicated cover changes, was the major type of misclassification at lower threshold values. Conversely, omission error for the same category, in which TM data fail to indicate a cover change, was greater at higher threshold levels.

References

Adeniyi, P.O., 1985. Digital Analysis of Multitemporal Landsat Data for Land-Use/Land-Cover Classification in a Semi-Arid Area of Nigeria. *Photogrammetric Engineering & Remote Sensing* 51(11):1761-1774.

Anderson, J.R., 1977. Land Use and Land Cover Changes - A Framework for Monitoring. *Journal of Research of the U.S. Geological Survey* 5(2):143-153.

Cohen, J., 1960. A Coefficient of Agreement for Nominal Scales. *Educational and Psychological Measurement* 20(1):37-46.

Foody, G.M., 1992. On the Compensation for Chance Agreement in Image Classification Accuracy Assessment. *Photogrammetric Engineering & Remote Sensing* 58(10):1459-1460.

Fung, T. and E. LeDrew, 1988. The Determination of Optimal Threshold Levels for Change Detection Using Various Accuracy Indices. *Photogrammetric Engineering & Remote Sensing* 54(10):1449-1454.

Jensen, J.R. and D.L. Toll, 1982. Detecting Residential Land-Use Development at the Urban Fringe. *Photogrammetric Engineering & Remote Sensing* 48(4):629-643.

Nelson, R.F., 1983. Detecting Forest Canopy Change Due to Insect Activity Using Landsat MSS. *Photogrammetric Engineering & Remote Sensing* 49(9):1303-1314.

Richards, J.A., 1984. Thematic Mapping from Multitemporal Image Data Using the Principal Components Transformation. *Remote Sensing of Environment* 16(1):35-46.

Rosenfield, G.H. and K. Fitzpatrick-Lins, 1986. A Coefficient of Agreement as a Measure of Thematic Classification Accuracy. *Photogrammetric Engineering & Remote Sensing* 52(2):223-227.

Singh, A., 1986. Change Detection in the Tropical Forest Environment of Northeastern India Using Landsat. Chapter 13 in *Remote Sensing and Tropical Land Management*, Edited by M.J. Eden and J.T. Parry. John Wiley & Sons, New York. pp. 237-254.

Singh, A., 1989. Review Article: Digital Change Detection Techniques Using Remotely-Sensed Data. *International Journal of Remote Sensing* 10(6):989-1003.