Advances in Information Mining, ISSN: 0975–3265, Volume 2, Issue 2, 2010, pp-14-18

Detection of Spatial Changes using Spatial Data Mining

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Abstract- This paper uses the techniques of spatial data mining (SDM) and change detection (CD) in the field of geospatial information processing. Assuming the feasibility of discovering knowledge from spatial database and the demands of knowledge for change detection, the paper presents that change detection needs knowledge and technology of SDM should be integrated into applications of change detection. Special knowledge for change detection of linear feature, area feature and terrain are studied. Relationship between accuracy of change detection and errors of image registration is discussed. Change detection of linear feature, area feature and terrain based on SDM are investigated respectively. Change detection based on multivariate statistical analysis and training samples are analyzed. Land use/cover change detection based on SDM is discussed.
Keywords- Land use and Land Cover (LULC), Change Detection, Spatial Data Mining, Photogrammetry

1. INTRODUCTION

In this 21st century the developments in spatial data acquisition, mass storage and network interconnection, volume of spatial data has been increasing dramatically. Vast data satisfied potential demands of exploring the earth's resource and environment by human being, widening exploitable information source, but the processing approaches of spatial data lag behind severely, and are unable to discover relation and rules in large amount of data efficiently and make full use of existing data to predict development trend. Due to lack of advanced means to find knowledge hidden behind, it has become an imminent bottleneck that data are excessive while knowledge is scarce. For geospatial data, the ability of production and transmission is far greater than the ability of interpretation and analysis [4]. Demands on novel effective methods for extracting attractive knowledge and information from various spatial database or warehouse are more and more urgent. SDM was proposed under the weight of application requirements. And it provides significant ways for discovering valuable knowledge to realize automation and intelligence of processing spatial data. On the other hand, with construction and variation of all kinds of spatial database, a growing attention on timely data updating and change detection has been paid to. Self-driven real-time on-board change detection techniques are needed. Therefore, key problems such as automatic image registration, image matching, feature extraction, object interpretation, image fusion and data cleansing need solving. And automatic spatial data mining and knowledge discovering (SDM & KD) also need to be resolved in order to construct intelligent change detection system [3].

2. DETECTION OF SPATIAL CHANGES REQUIRES SPATIAL DATA MINING

Prior knowledge could be provided for selecting source data and approaches of change detection by research on reasons and discipline of terrain change. It is of instructive significance for investigation on effective change detection method to analyse origins of change, study rules of change, and explore relationship of image variation and terrain change. There are three categories of change reasons: abiological action in nature, biological action, and human activity among which human activity is most notable factor. Especially, research on change detection of urban area is focused on recently. Many theories and methods on change detection of urban area is put forward, lots of indices and models for ranking urban development are devised, and they contribute to proper planning and advance alert of cities greatly. Terrain changes are synthetic reflect of three kinds of changes spatially and temporally. Complexity of terrain change severely affects the automation of change detection. Change forms on multi-temporal remotely sensed imagery include positional deviation, radiant variation and spatial structure alteration. It comprises actual relief change and other imaging factors. Study on change detection is to decrease and weaken difference caused by other non-object change and acquire real change information. From above analysis, it can be concluded that (1) Terrain change is regular, regularity needs to be studied, and knowledge database may come into being, which can help to change detection; (2) Changes especially resulted from human activity can help to change detection using planning information; (3) As for changes caused by imaging factors, 3D, multi-source, pixel level and feature level integrated detection approach; (4) SDM can discover further knowledge to aid change detection. An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

3. CHANGE DETECTION KNOWLEDGE

The spatial data are inclined to high autocorrelation. Knowledge types discovered from spatial database include general geometric knowledge, object oriented knowledge, spatial characteristic/discriminate rules, spatial classification/regression rules, spatial clustering/association rules, spatial dependent/predictable rules, spatial serial rules, ISPRS Workshop on Updating Geo-spatial Databases with imagery. All sorts of knowledge interrelates each other, and multiple rules are required for given occasions.

3.1 Knowledge for Change Detection for Line/Area features

In order to identify and detect geospatial linear feature or area feature exactly, it is inevitable to describe and comprehend practical linear objects accurately and model them properly. As to characteristics of linear feature, many scholars have published their research findings [2], and they can be concluded as follows:

(1) Geometric property

For linear objects, it mainly includes width, width consistency,figure, size and orientation, curvature, link mode etc. For area objects, it mainly includes area, perimeter, compactness, divergence, ductibility, rectangle similarity, orientation, curvature etc.

(2) Radiometric property

It means reflecting trait and contrast comparing with surroundings of linear objects or area objects.

(3) Topologic property

It expresses completeness degree of linear objects as a part of the network. Mostly, topologic properties of roadway and water system are focused on. A common descriptor for area objects is Euler number E=N-H, where N represents number of connected parts and H represents number of holes.

(4) Context property

It mainly includes correlative property of around area and local context clues.

(5) Functional property

Functions born by linear objects or area objects in objective world and therefore other relative properties can be inferred. All paragraphs must be indented.

3.2 Knowledge for terrain detection

Applications of terrain data are generally classified as two sorts. One is direct application, i.e. regarding DEM as vital component of digital mapping and elements of geospatial database. The other is user-oriented indirect application, i.e. transforming DEM to various derived products that satisfy all kinds of specialized requirements [5]. Terrain knowledge that can be used in change detection is summarized as follows:

(1) Primary terrain factors

Slope/aspect. Area/volume. Slope change rate/aspect change rate.

(2) Topographic feature

Topographic feature means significant surface points, lines or areas that can represent terrain details properly, and they make up the relief backbones. Terrain feature points include peaks, valleys, neks etc. Terrain feature lines include ridges, valley lines etc. Terrain feature areas include concavity or convexity, and are often relative to curvature of perpendicular orientation.

(3) Hydrologic analysis It mainly comprises analysis of catchments, stream network, and drainages.

(4) Complicated terrain factors

Terrain complexity index (TCI) [7], terrain granulation degree, ravine density, landform curvature, terrain fractal index (TFI), hypsography degree etc.

4. CHANGE DETECTION USING SPATIAL DATA MINING

After rasterization of vectors are done, corresponding pixels and GIS objects are related. On a certain scale, edge extraction of remotely sensed imagery is performed, and registration of vector and imagery is realized based on extracted line feature and geometric registration model. And registration is an iterative process during which mismatching of corresponding objects is deleted and expected registration with higher precision in the next iteration. The result comprises of well registered objects which are also unchanged ground objects. Therefore geometric model parameters with high precision are obtained. As for deleted GIS objects, their polygons or center lines are used as primary models to extract area objects in corresponding local image region. And extracted objects are compared with corresponding objects in GIS data to determine whether changed or not. After several iterations, all interested GIS objects are processed and changed areas are output.

4.1 Change Detection of Area feature using SDM

The experiment is illustrated as Figure 1, 2 and 3. Figure 1 shows a Google image with image resolution 0.6m. The region consists of farmlands, ponds, vegetation, rivers etc, and is comparatively flat. Figure 2 is a Google image captured in Dec. 2006 with local georeference system. Figure 3 shows change detection results of total solution procedure, and the numbered area objects are changed objects after the period of time. The Figure 1 and Figure 2 are captured from Google earth using following information of our projected area for the next specified change detection experiments.

Location : Near Udgir, Dist. Latur , MS, India
Projection:UTM (Universal Transverse Mercator).
Datum : WGS84

Lon/Lat : 18o.14'.59.69" N
77o.11'.14.15" E
Scale : 1: 1165 feet.
Elevation : 1881 feet from sea level.
Eye : 5900 feet height from surface

The both figure 1 and 2 are of from same projected area and captured in different time slots;

Fig. 1- Google image (April 2004)

Fig. 2- Google Image (December 2006)

4.2 Terrain Change Detection using SDM

Elevations of ground objects are always presumed to be constant for previous theory or applications of change detection in remote sensing. But these presumptions have not been examined, and if elevation of terrain surface has changed assuredly, unexpected trouble could effect on the result of 2D change detection [9]. The existing 4D products need to be fully exploited in change detection in order to augment predictive knowledge to improve efficiency and automation; image registration and change detection should be performed synchronously in order to reduce impact of registration error on results; changes of terrain elevation need to be considered for change detection of large scale spatial database [4].

Fig. 3- Change Detection results of area object

With existing database of control points or DEM/DOM, by image matching and spatial resection, orientation elements of new stereoscopic pair enhanced can be calculated. VLL matching is employed to interpolate elevation of grid points of entire stereo model, and the elevations are compared with old DEM. If accuracy of some point is eligible, it is an unchanged point. If difference of elevation exceeds acceptable ranges, it is a dubious point. During the process, multiple terrain factors or other related knowledge can be used to help to decide a certain ground point has changed or not. After editing and quality checking, changed points can be discriminated from dubious points, and unchanged points can take part in next iteration. Ultimate products include results of change detection, updated DEM and orientation elements of new stereo pair.

In the process of producing digital orthoimage by digital photogrammetry workstation, two orthoimage generated respectively from left and right photograph of the same stereo model should be coincident in theory, i.e. there should be no parallax. If parallaxes exist, orientation elements are precise assuredly, and there is no problem in the course of orthoimage matching, then the parallaxes occurring on orthoimage pair eflect errors of DEM which is used to produce the orthoimage pair. According to Prof. Kraus' research, elevation measuring accuracy of stereo orthoimage pair is trebly higher than elevation accuracy of DEM used for producing the stereo orthoimage pair. Therefore, traditional process of updating DEM by digital photogrammetry workstation, during which three orientation steps and lots of manual work are inevitable, can be avoided. Parallax occurring on orthoimage pair can be employed to refine outdated DEM directly to realize change detection and updating.

4.3 Land Use/Cover Change Detection using SDM

Image grey levels, texture, relief information and other geodata can be integrated to realize research on land use/cover change detection based on artificial neural network (ANN) as

Figure 4 to 7 show [10]. From vision effect, land type change is firstly represented as grey level change, and texture can only accessorily discriminate partial types such as town and plantation in agriculture lands. So change detection should use imagery's grey levels, texture, or other information selectively and orderly in order not to impair precision of change detection. Proper procedure describes as follows. Imagery should be pre-processed necessarily at first such as geometric rectification, radiometric correction and spectral similarity analysis. Then primary result of change detection is achieved after ANN based change detection, and improvement can be made according to result of elementary detection and spectral similarity analysis. At last, wavelet texture featured quantity and other auxiliary geodata can help to validate change of land types. Figure 4 and Figure 5 show two temporal imagery of the same area. Figure 6 and Figure 7 show change detection result and changed area [13].

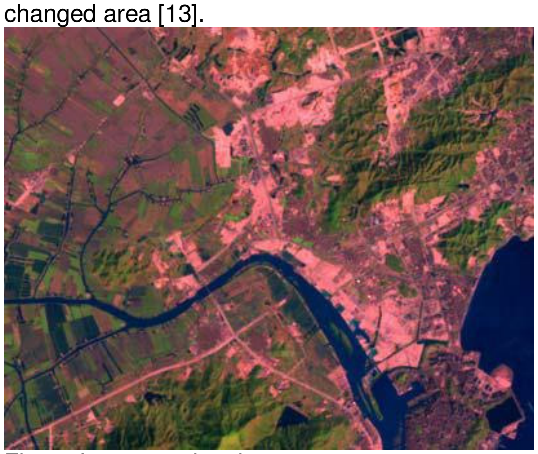

Fig. 4- Imagery taken in 1992

Fig. 5- Imagery taken in 1996

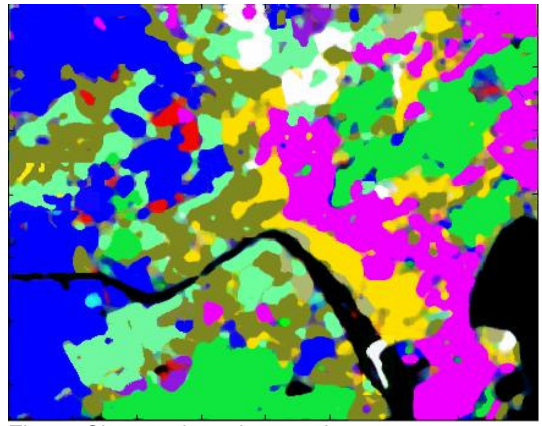

Fig. 6- Change detection results

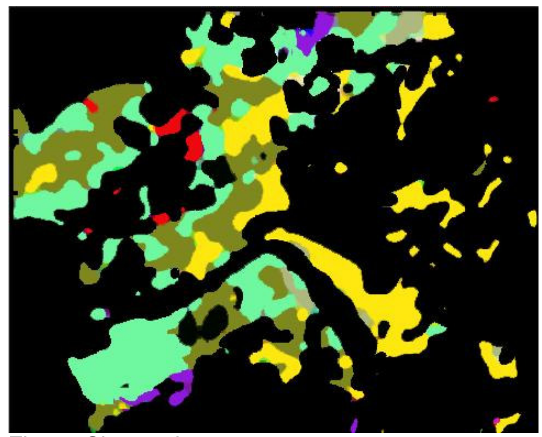

Fig. 7- Changed area

CONCLUSION

Change detection is a complicated process influenced by multiple factors. Knowledge plays an important role in the process. So change detection based on spatial data mining open up prospects for research on land use/cover change. Spatial data mining & knowledge discovering (SDMKD) can explore much effective knowledge in geospatial database to assist the process and validate the result of change detection. Change detection of linear feature, area feature and terrain based on SDM are separately investigated, and elementary experiments are illustrated in the paper. Various semantic and non-semantic information works on different steps. Diverse geodata contributes to integrating different types of data to automatic and intelligent change detection. Later-on research includes further effective use and integration of special context knowledge and course knowledge in change detection of various spatial features.

REFERENCES

[1] Dai Xiaolong, Khorram S. (1998) *IEEE Transactions on Geoscience and Remote Sensing*, 36(5), pp.1566~1577

[2] Gary P., Steve W. (2000) *International Archives of Photogrammetry and*

Remote Sensing, Vol. XXXIII Part B3: Amsterdam: pp.740-747

[3] Li Deren, Sui Haigang, Xiao Ping (2002) *International Archives of Photogrammetry and Remote Sensing, Xi'an, China*, Vol.XXXIV, Part 2, pp.245-251

[4] Li Deren, Wang Shuliang, Li Deyi (2006) Spatial *Data Mining Theories and Applications, Science Press, Beijing, China*

[5] Li Zhilin, Zhu Qing (2003) *Digital Elevation Model (2nd Edition), Press of Wuhan University, Wuhan, China*

[6] Sui Haigang (2002) *Automatic change detection for roadnetworks base on features, Ph.D dissertation, Wuhan University. China*

[7] Wang Lei, Tang guoan, Liu Xuejun, Long Yi, Wang Chun (2004) *Terrain Complexity Index and Its Derivation from DEMs, Bullet in of Soil and Water Conservation*, (24)4, pp.55-58

[8] Wang Yongqing (1998) *Theories and Methods of Artificial Intelligence, Xi'an Jiaotong University, Xi'an, China*

[9] Xia Song (2006) *Terrain Change Detection and Data Updating with Arial Imagery, Ph.D dissertation, Wuhan University,China*

[10] Xiao Ping (2001) *Research on Land Use/Cover Change Detection, Ph.D dissertation, Wuhan University, China*

[11] Zhang Lu (2004) *Change Detection in Remotely Sensed Imagery Using Multivariate Statistical Analysis, Ph.D Dissertation, Wuhan University, China*

[12] Zhang Xiaodong (2005) *The Theory and Methods of Change Detection Based on Remotely Sensed Imagery and GIS, Ph.D Dissertation, Wuhan University, China*

[13] Hiremath P.S., Kodge B.G. (2010) *National seminar on Recent trends in image processing and pattern recognition*.