Available online at www.elixirpublishers.com (Elixir International Journal)

Computer Science and Engineering

Elixir Comp. Sci. & Engg. 49 (2012) 10084-10088

ISSN: 2229-712X

Satellite imagery cadastral features segmentation using canny and morphological methods for a sustainable cadastral science

Usman Babawuro and Zou Beiji

School of Information Science and Engineering, Department of Computer Science, Central South University, Changsha, 410083, Hunan, PR China.

ARTICLE INFO

Article history:

Received: 30 June 2012;

Received in revised form: 16 August 2012;

Accepted: 20 August 2012;

Keywords

Geo-rectification,
Cadastral Surveying,
Morphological operation,
Canny method.

ABSTRACT

Satellite images are used to extract linear features, like roads, etc. The extraction of linear features or boundaries defining the extents of lands, land covers features are important in Cadastral Surveying. Cadastral Surveying is the cornerstone of any Cadastral System. A two dimensional cadastral plan is a model which represents both the cadastral and geometrical information of a two dimensional labeled Image. This paper aims at using a combination of canny and morphological operations for extracting representations of cadastral boundaries from high resolution Satellite imagery hence minimizing the human interventions. The Satellite imagery is initially rectified hence establishing the satellite imagery in the correct orientation and spatial location for further analysis. We, then employ the much available Satellite imagery to segment the relevant cadastral features using the above mentioned methods. We evaluate the potential of using high resolution Satellite imagery to achieve Cadastral goals of boundary detection and extraction of farmlands using image processing algorithms. This method proves effective as it minimizes the human demerits hence providing another perspective of achieving cadastral goals as emphasized by the UN cadastral vision for an improved socio economic development.

Introduction

The degree to which a computer extracts meaningful information from the image is the most powerful key to the advancement of intelligent image understanding systems [1]. The ultimate goal of computer vision is to use computers to emulate human vision, through learning, making inferences and taking actions based on visual inputs [2]. Image processing is a rapidly growing area of computer science. Its growth has been fueled by technological advancements in digital imaging, computer processors and mass storage devices [3]. It is primarily concerned with the extraction of useful information from images of different kinds using different algorithms like those of image enhancement and object detection [4]. Image processing algorithms could be classified at three levels. At the lowest level are those techniques which directly deal with the raw, possibly, noisy pixel values, with de-noising and edge detection algorithms being typical ones. In the middle are algorithms which utilize low level results for further means, such as segmentation and edge linking. At the highest level are those methods that attempt to extract semantic meaning or certain features from the information provided by the lower levels, for instance, handwriting recognition or geometric feature extraction. Image features are loosely classified into low-level features and high-level features. Low-level features can be extracted directly from the original images, whereas high-level feature are extracted based on low-level features. Satellite images are either panchromatic, multispectral, hyper spectral or ultra spectral. The multispectral images have higher spatial resolutions while the panchromatic ones relatively have lower spatial resolutions but they are rich in spectral information [5]. Research on image processing using multi resolution satellite imageries have attracted computer vision and image processing communities since most environmental and socio-economic needs are based on these imageries [6,7,8]. Additionally, satellite imageries, contain vast remotely sensed data, which offers a huge source of data for studying spatial and temporal changes of the environment. It contains both spectral and spatial information [9]. The digital analysis of satellite imagery data has become an important component of a wide range of land studies [10]. With the advent of multi-spectral and high resolution satellite imagery, more information that is processed and analyzed to generate better representations of the features of the earth are available [8,11]. Before, due to the low resolution of the former generation of satellite imagery, the use of satellite data in the surveying or geomatics field has been very limited, but this has gradually changed with the introduction of high-resolution satellite imagery amongst other geomatic or geo-information technologies. The few investigative cadastral work conducted using high resolution satellite imagery have shown that a spatial resolution of 2m or better is required to support most cadastral applications [11]. This threshold of spatial resolution is realized with the launch of systems offering the potential of up to <1m panchromatic and <4m multi-spectral spatial resolutions [10]. This encouraged us to do more research in this direction. Feature extraction in Satellite imagery is an important operation in computer vision. It has many applications, especially in geomatics or surveying, and hydrography [12], photogrammetric and remote sensing tasks. It is used to extract linear features, like roads, from satellite or low resolution aerial imagery [13]. For some of these mapping tasks, the extraction of boundaries that define lands or other features can be quite important in Cadastral Surveying. [14], gives an detailed overview of cadastral surveying. Cadastral plan is technically an extension of 2 dimensional images. The 2D

Tele:
E-mail addresses: wuroabu@yahoo.com

property and the planimetric nature of the satellite imagery allow an efficient implementation of the main topological and geometrical operations of image processing algorithms, especially image segmentation using high resolution satellite imagery [15].

Geo referenced high-resolution satellite image is used for acquisition of topographic information, navigation and visualization for various environmental studies [11,16], such imagery could as well be used as a topologic map. Geo referenced high resolution satellite imagery is used in a number of applications, that include reconnaissance survey, identification and classification of spatial features for geographical uses, creation of mapping [11] products for military and civil applications, for the inventory, monitoring, and management of natural resources, surveillance, evaluation of environmental damages, monitoring of land uses for physical planning, urban and town planning, growth regulation, soil assessment, etc. Satellite Imagery offers as part of its merits, imperative coverage, mapping and classification of land-cover features, namely vegetation, land cover, soil, water, coastline [12]forests, etc. Some of the major strengths of high resolution satellite image, as a source of information for Cadastral survey are high geometrical resolution, multispectral capabilities, radiometric sensitivity, good positional accuracy, revisit capabilities and larger image size. More research is needed as stated by [17,18] to explore these potentials as such our research is tailored towards this direction. So the focus of this research is an attempt to provide an alternative solution using computer vision approach. The research aims at widening the concepts of using high resolution satellite imagery data for extracting representations of cadastral boundaries with minimum human intervention. We, employ the much available Satellite imagery to extract the relevant cadastral features, farmlands, using computer vision and image processing algorithms. We evaluate the potential of using high resolution Satellite imagery to achieve Cadastral goals of boundary detection through reduced time, cost and human effort, hence having some crucial improvements for better and faster digitized Cadastral decisions making process using computer vision and satellite image processing algorithms.

The paper is structured as follows. Chapter 2 covers the related works, while chapter 3 contains the implementation. The discussions of the research are contained in Chapter 4, whereas chapter 5 concludes with conclusion and future works.

Related Works

Satellite imagery feature extraction according to H. Liu, et al. [19] was done using image segmentation, based on a locally adaptive thresholding technique. They didn't carry out imagery rectification as such feature boundary orientation could not be used for further analysis. A.A.Vakilian et al. [20] used Level Set Method (LSM) and Snakes Method (SM) to determine objects location and boundaries M. Boldischar et al. [21]presented feature extraction from the point of view of automated fingerprint identification system. T. Gustavsson et al. [22] implemented and compared four different boundary detection algorithms for quantitative measurements of the human artery. Hyper spectral image feature extraction based on generalized discriminant analysis was presented by G. Yang et al. [23]. H. G. Momm et al. [24] investigated the use of genetic programming to aid the feature extraction process from high-resolution satellite imagery. O. Sharmay et al. [8] described a method where the boundary extraction algorithm converts detected image features into connected sets of vectors that are topologically equivalent to the segmented objects. G. Damiand et al. [15] define the two dimensional, 2D, topological map, as a model which represents both topological and geometrical information of a two dimensional labeled image.

In our work, we apply georectification process to the imagery. We apply canny and morphological operations to the imagery. Then apply Canny again to the output imagery in order to segment the field boundaries, separating the farmland from all others. Prior to these, the image is dimensionally reduced to get rid of some redundant data.

Implementation

The high resolution Satellite imagery is initially georectified to have a planar orientation that would make it suitable for cadastral quantitative analysis. For details on Geo rectification of Satellite imagery refer to U. Babawuro et al. [25]. Then because of the huge redundant information embedded therein, image dimensionality reduction is necessary in order to remove certain unwanted information This was applied using Discrete Wavelet Transform (DWT). Since computational image quality metrics are designed to predict contrast detection thresholds [26], the quality of the imagery is also tested using image metrics to determine its quality both qualitatively and quantitatively. These metrics are useful in image quality evaluation as they are used to predict the visibility of image distortions introduced by imaging devices and processing methods. For details on Satellite imagery quality evaluation for quantitative cadastral analysis, refer to B. Usman et al.[5].To segment the image, the gray imagery of the original image is subjected to Canny and Sobel edge detection methods to make a practical choice. From the outputs, Sobel edged image contained a lot of edge discontinuities as such it is discontinued, whereas that of Canny method contained smooth and continuous edges. To further extract the object boundaries, which are the farmland boundaries, from the Canny edged detected image, morphological operations, dilation and erosion are applied. Equal number of dilation and erosion was applied to the imagery using a 2x2 structural element, which provides an image with black and white patches. Then a 4x4 structural element is applied separately. At this stage, the entire farmlands are segmented and depicted as black objects against white background. Very clear thin boundaries of the segmented black farmland-objects are obtained against a black background with the application of Canny method to the image again.

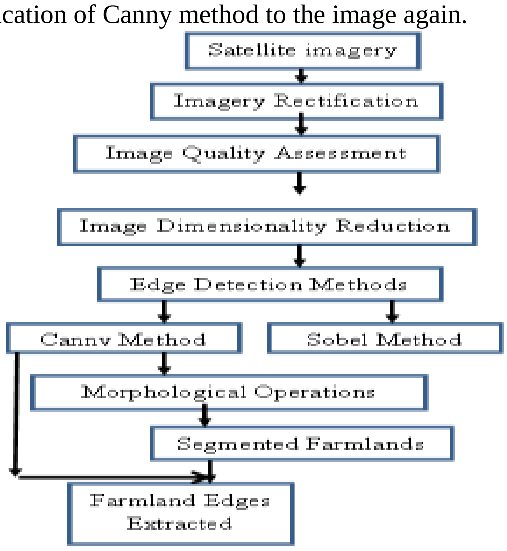

Fig 3.1 Flow Chart of the Farmlands Extraction

Satellite Imagery dataset

The Satellite imagery used in this study is a high resolution Quick Bird Satellite imagery with a 2.4m resolution acquired in 2005, over a relatively flat landscape in Changsha city, Hunan province in the South Central region of PR China. This, imagery, 593X533, has a total number of pixel vectors, N, 316069. The imagery is composed of a residential matrix textured with farmland patches of varying sizes and shapes which are excellent features with cadastral values. The three land-use classes dominating the scene are residential, agriculture and commercial.

Fig 3.2 shows the Original image and the region of interest for rectification

Fig. 3.3a Shows the Gray Image

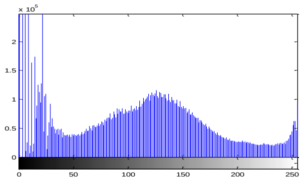

Fig 3.3b Shows the Histogram of the Imagery

Fig. 3.5 Both Original and Gray image for edge detection

Dimensionality Reduction using Wavelet Decomposition

Using the three level discrete wavelet transform, the input image is decomposed into two frequency coefficients, the approximation coefficients as the low frequency part and the detail coefficients as the high frequency part. This is called wavelet decomposition. Fig.3.6 shows the wavelet decomposition of the satellite imagery.

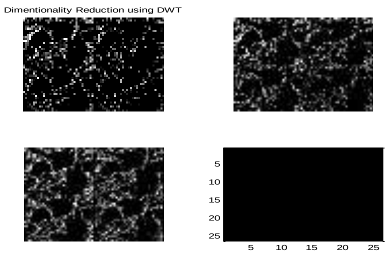

Fig 3.6 Imagery dimensionality Reduction

Image Segmentation

Segmentation refers to the process of partitioning a digital image into multiple regions, sets of pixels. These regions may be associated with ground cover type or land use, but the segmentation process simply gives generic labels. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries in images. The regions consist of groupings of multispectral image pixels that have similar data feature values. These data feature values may be the multispectral data values and/or they may be derived features such as band ratios or textural features [7]. It means the quality of image processing heavily depends on the quality of segmentation process. In this work, we applied Canny method to segment the imagery. Image segmentation has two objectives. The first is to decompose an image into parts; the second is to perform a change of representation. Segmentation stops when objects of interest is isolated.

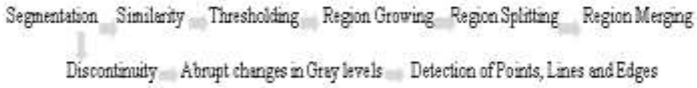

Fig 3.7 Shows types of Segmentation

Fig.3.8 Shows Canny and Sobel edges

Morphological Operations using Satellite Imagery

Morphological operations are excellent mathematical tools for filtering images. They are used to remove noise and to as well provide shape and boundary description of objects within an image. The main operations are dilation and erosion. Dilation is a kind of vector addition while erosion is a kind of vector subtraction. Morphological opening and closing tends to smooth the contours of objects. Unlike opening, closing joins narrow breaks, fills long thin gulfs, and holes smaller than the size of the structural element [27].

Dilation and Erosion operation

Conducting the dilation and erosion operations on the gray imagery with a 5x5 structural element gives the following results: fig 3.9 and fig 3.10. Despite, the gray image is the same for the two morphological operations; the dilated image appears thicker in boundary and having better contrast, fig 3.9, vis-à-vis the eroded image that has relatively thinner boundary and less contrast, so much darker, fig 3.10. This shows that dilation adds pixels to boundaries making them thicker whereas erosion removes pixel from boundaries, making them thinner.

Fig.3.9 shows dilated image using a 5x5 strel element

Fig.3.10 shows eroded image using a 5x5 strel element

This kind of operation is applied to the edged imagery using two different structural elements. When the satellite imagery is operated using morphological operations, the dilation and erosion operation, three times using 2x2 structural elements, displayed a hopeful image but with black patches as is seen in Fig.3.11. When conducting such operations, the structuring element should be large enough to remove the lines when you erode the image, but not large enough to remove the object needed. So we then repeat the process using a larger 4x4 structural elements. This resulted in a cleaner image showing all the field boundaries as black objects against a white background, Fig 3.12. We successfully applied the morphological closing operations on the gray image to extract the field features as shown in fig 3.12.

Fig.3.11 Shows 3x times dilation followed by 3x times erosion (2x2 structural elements)

Fig. 3.12 Shows 3x times dilation followed by 3x times erosion (4x4 structural elements)

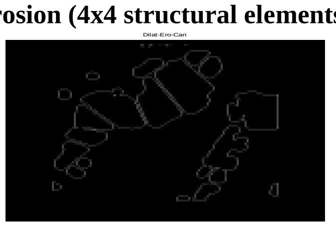

Fig 3.13, shows the thin edges of the farmland's boundaries after the edge and morphological operations

Discussions

When we dilate the imagery with any of the structural elements, the farmlands being the image objects expands but when the opposite operation of erosion, the same image shrinks as compensation. With these operations, the farmland boundaries are detected and clearly extracted, Fig. 3.12 and Fig. 3.13. This will help us to find other geometric parameters of the farmlands in future work. More attention from the image processing community needs to be directed toward studying and extracting cadastral features as a result of their socio economic values. In our work, the features are clearly extracted.

Conclusions

Currently, high-resolution satellite image processing amongst other geo-information technologies is proving useful for cadastral surveys. This research looks at the possibility of integrating machine vision technology into digital cadastral surveying. The study is based on the hypothesis that image processing algorithms together with high resolution satellite imagery could be used to determine the extents of cadastral features for the execution of statutory cadastral functions for more effective development. The results proves that the proposed approach effectively extracts the objects of interest from the high resolution satellite imagery using canny and morphological operations to extract the farmland object boundaries. It is noted that the processing of Satellite imagery using the relevant image processing algorithms provides a powerful visual and management tool for a more comprehensive cadastral land information extraction. This makes Cadastral Surveying not only be in tune with its ever growing and evolving societal demands but also makes it maintains its sustainability within the society.

Further Works

We intend as part of future research to extract more information about each of the extracted object. We can compute the following parameters using object geometry perimeter, area, roundness, aspect ratio, compactness, form factor, etc. In addition, the features extracted may be used for urban planning, ground water estimation, GIS mapping etc.

Acknowledgments

This research work was fully supported by the National Research Foundation Program of Higher Education of China and the Kano University of Science and Technology, KUST, Wudil, Nigeria, through the Educational Trust Fund, ETF, Nigeria.

References

[1] B.J. Lei, E.A. Hendriks, M.J.T. Reinders, On Feature Extraction from Images, Technical report on inventory properties for MCCWS project, Information and Communication Theory Group TUDelft, June 01, 1999

[2] R.C Gonzalez, R.E Woods, Digital Image Processing, 3rd Edition, 2010

[3] T. Seemann, Digital Image Processing Local Segmentation, Monash University Australia, PhD Thesis, 2002

[4] D.V. Rao, S. Patil, N.A. Babu, V. Muthukumar, Implementation and Evaluation of Image Processing Algorithms on Reconfigurable Architecture using C-based Hardware Descriptive Languages, International Journal of Theoretical and Applied Computer Sciences Volume 1 Number 1pp.9–34(2006) http://www.gbspublisher.com/ijtacs.htm

[5] B. Usman, Z. Beiji, Satellite Imagery Quality Evaluation using Image Quality Metrics for Quantitative Cadastral Analysis, International Journal of Computer Applications in Engineering Sciences, vol I, Special Issue on AISC, 2011

[6] K. Perumal, R. Bhaskaran, Supervised Classification Performance of Multispectral Images, Journal of Computing, Volume 2, Issue 2, 2010, Issn 2151-9617

[7] M. Toshniwal, Satellite Image Classification Using Neural Networks, Inter Conf; Sciences of Electronic, Technologies of Information and Telecommunications, 2005

[8] O. Sharmay, D. Miocz, F. Antony, Polygon feature extraction from satellite imagery based on Colour image segmentation and medial axis, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. xxxvii. 2008

[9] J. M. Bardsley, M. Wilde, C. Gotschalk, M.S. Lorang, MATLAB Software for Supervised Classification in Remotely Sensing and image processing , Journal of Statistical Software, Volume VV, Issue II

[10] J.D. Ondulo and W. Kalande, High Spatial Resolution Satellite Imagery For PID Improvement In Kenya, Shaping the Change, XXIII FIG Congress, 2006

[11] P.V. Radhadevi, V.Nagasubramanian, A. Mahapatra, S.S. Solanki, K. Sumanth, G. Varadan, Potential of High-Resolution Indian Remote Sensing Satellite Imagery for Large Scale Mapping, International Society for Photogrammetry and Remote Sensing, Volume xxxviii-5, 2009.

[12] H. Liu, K.C. Jezek, Automated Extraction of Coastline from Satellite Imagery by integrating Canny edge detection and locally adaptive thresholding Methods, Int. J. Remote sensing, vol. 25, no. 5, 937–958, 2004

[13] C. Steger, Extraction of Curved Lines from Images, Forschungsgruppe Bildverstehen (FG BV) Informatik IX, Technische Universitat Miinchen Orleansstr. 34,8 1667.

[14] I.P. Williamson, The Justification of Cadastral Systems in Developing Countries, Canadian Institute of Geomatics, Geomatica, Vol. 51, No. 1. Pp.21-36, 1997. http://www.csdila.unimelb.edu.au/people/rteam/ianpub.html

[15] G. Damiand, Y. Bertrand, C. Fiorio, Topological Model for 2D Image Representation: Definition and Optimal Extraction Algorithm, Computer Vision and Image Understanding-93(2)-pp. 111-154.

[16] K.H. Chi, S.S. Lee, Rectification Technique of High Resolution Images for Mountain Area, 8th International Conference on the Global Spatial data Infrastructure, GSDI-8, International Federation of Surveyors, FIG, 2005

[17] B. Usman, Design & Implementation of Systems for the Management of Land Related Information, MSc Thesis, Central South University, Changsha, Hunan, China, 2002

[18] B. Usman, 2010. "Cadastral Information System for Title Management in Nigeria". Pacific Journal of Science and Technology. 11(2): 408-415, 2010. www.akamaiuniversity.us/PJST.htm

[19] H. Liu, K. C. Jezek, Automated extraction of coastline from satellite imagery by Integrating Canny edge detection and locally adaptive thresholding Methods, Int. J. Remote sensing, vol. 25, no. 5, 937–958, 2004.

[20] A.A.Vakilian, K.A. Vakilian, A new satellite image segmentation enhancement Technique for weak image boundaries, Annals of Faculty Engineering Hunedoara, International Journal of Engineering, Tome XISSN 1584 – 2665, 2012.

[21] M. Boldischar, C.P. Moua, Edge Detection and Feature Extraction in Automated Fingerprint Identification Systems, University of Wisconsin.

[22] T. Gustavsson, R. Abu-Gharbieh, G. Hamarneh, Q. Liang, Implementation and Comparison of Four Different Boundary Detection algorithms for Quantitative Ultrasonic Measurements of the Human Carotid Artery, IEEE Computers in Cardiology Vol 241997

[23] G. Yang, X. Yu, X. Zhou, Hyper spectral image feature extraction based on generalized discriminant analysis, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. xxxvii. 2008

[24] H. G. Momm, B. Gunter, G. Easson, Improved Feature Extraction from High-Resolution Remotely Sensed Imagery using Object Geometry, SPIE 2010 Conf.

[25] U. Babawuro, Z. Beiji, X. Bing, "High Resolution Satellite Imagery Rectification Using Bi-linear Interpolation Method for Geometric Data Extraction," isdea, pp.1430-1434, 2012 Second International Conference on Intelligent System Design and Engineering Application, 2012. http://doi.ieeecomputersociety.org/10.1109/ISdea.2012.457

[26] K. Dong-O, P. Rae-Hong, New Image Quality Metric Using the Harris Response, Signal Processing Letters, IEEE, Volume: 16 Issue: 7, 616 – 619, 2009

[27] R.C Gonzalez, R.E. Woods, S.L. Eddins, Digital Image Processing using Matlab, Pearson Education, Inc, Prince Hall, 2009