S.K.Jumlesha, Khadar Babu. Sk, Ch.Satyanarayana , M N Srinivas, M.V.Ramanaiah, Sandeep Kumar P / International Journal of Engineering Research and Applications (IJERA)
ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 3, May-Jun 2012, pp. 221-225

AUTOMATIC URBAN FEATURE EXTRACTION USING MATHEMATICAL MORPHOLOGY

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ABSTRACT
Manual method of feature extraction from remote sensing imagery is a tedious and time-consuming process. The current paper presents the application of Mathematical Morphology for extracting urban features like buildings and roads from remotely sensed imagery. Roads and Buildings are the major features that influence urban planning and development. Also, GIS databases are to be frequently updated for timeliness and accuracy. Hence there is a need to develop automated methods of feature extraction. The proposed methodology is tested on various satellite imagery and the results are evaluated.

***Keywords**: Automatic feature extraction, Mathematical morphology, Urban, Building extraction, Road extraction*

1. INTRODUCTION
The advent of powerful computing devices and very high resolution satellite imagery spurred the development of new image processing algorithms for feature extraction. In urban areas, buildings and roads are the major features that influence effective urban planning and management. Several researchers presented various methods of automatic feature extraction. Csaba Benedek et al, (2010) proposed marked point process method for building detection. Hang JIN et al, (2010) developed an automatic method of extracting roads based on Isodata segmentation and shadow detection from large scale aerial images. T.T. Mirnalinee (2007) proposed Support Vector Machine for feature extraction. Xiaoying Jin et al, (2005) invented a method to extract buildings from high resolution imagery using structural, contextual, and spectral information. In this paper, IKONOS satellite imagery is used for validating the result. Tao Guo et al, (2002), S.D Mayunga et al, (2005),Uwe Bacher et al, (2005) have used active contour model also called as SNAKE algorithm to extract urban features from remotely sensed imagery. Jon Atli Benediktsson et al., (2003) Sebastien Lefevre et al, (2007), F. S. P. de Castro et al, (2010), S.Valero et al., (2009) and Neeti Daryal et al., (2010) have used the concepts of mathematical morphology for extracting urban features from remotely sensed data. In the present study mathematical morphology is adopted due to its efficiency and simplicity.

2. METHODOLOGY
The steps involved in feature extraction are broadly classified as four stages: 1.Preprocessing, 2. Feature extraction, 3. Post processing, and 4. Performance evaluation. In the preprocessing stage, Otsu's Method is used for thresholding the image after operating with Morphological opening. In Otsu's method we exhaustively search for the threshold that minimizes the intra-class variance, defined as a weighted sum of variance of the two classes

3. Methodology for Building extraction
Feature extraction is performed using a set of morphological operators like erosion, dilation, opening and closing etc. Methodology adopted for building extraction is showed in Fig.1. Pre processing stage involves conversion of input image to gray scale image, applying morphological opening operator and then thresholding the image.

ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 3, May-Jun 2012, pp. 221-225

Building extraction is performed using hit and miss transform with square or rectangle as structuring element. In post processing stage, image is refined using morphological filtering and then the image is exported to raster format.

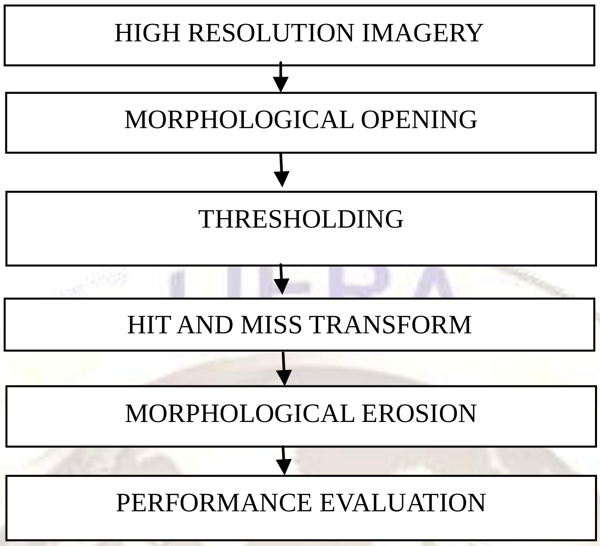

Fig. 1 Flowchart for Building Extraction

Since it is required to detect square or rectangular buildings of various sizes, HMT is adopted to be able to take into account some structuring elements E and F with varying sizes and shape. Hit and Miss Transform applied on image 'I' is defined as

$$I \circledast_{\mathcal{K},\mathcal{L}} (E,F) = \bigcup_{\substack{k\in\mathcal{K} \\ l\in\mathcal{L}}} (I \ominus E_{\alpha k,\alpha l}) \cap (I^c \ominus F_{k,l})$$

Thus, the result of this HMT is defined as the union of all the results of the transform applied with a given pair of structuring elements. The two variable structuring elements $E_{a,b}$ and $F_{c,d}$ are respectively defined as a rectangle of size a× b and a frame (contour of a rectangle) of size c×d, with the constraints c > a and d > b. The sets K and L contain respectively all the possible heights and widths of the structuring element, and α is a coefficient used to determine an uncertain area between E and F. In other words, it helps to mark the area between pixels which surely belong to buildings and pixels which surely belong to background (or not to buildings). At the end of this operation, if the parameters of the HMT have been correctly defined, only the buildings are retained with their respective position.

4. Methodology for Road extraction

In road extraction process the image is subjected to Morphological opening operation with 'Line' as structuring element. This is because roads are generally linear patterns in nature. The length of the structuring element must be properly selected for the better delineation of road features. Methodology adopted for road extraction is shown in Fig.2.

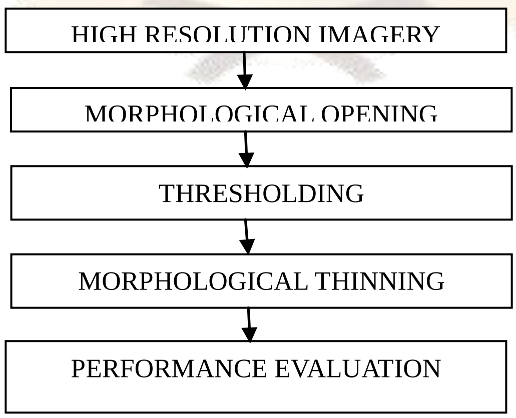

Fig. 2 Flow chart for Road Extraction

Road extraction is achieved by using morphological thinning operation. Thinning is similar to erosion, but it does not cause disappearance of object components. It intends to reduce objects to the thickness of 1 pixel, generating a minimally connected axis that is equidistant from the object edges. The structuring element length used in this phase should be of less value than that used in opening operation.

5. RESULTS

The methods developed are implemented in Matlab environment. Very high resolution satellite imagery like Ikonos and Worldview satellite datasets are used to test the algorithms. The result of building extraction on IKONOS scene is shown in Fig. 3 below.

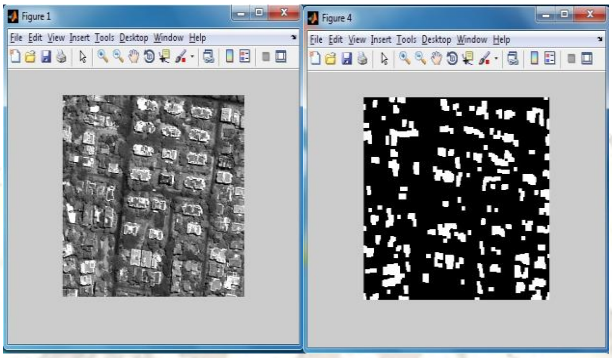

Fig. 3 Building extraction result on Ikonos scene

Result of Building extraction algorithm on World view scene is shown in Fig. 4 below.

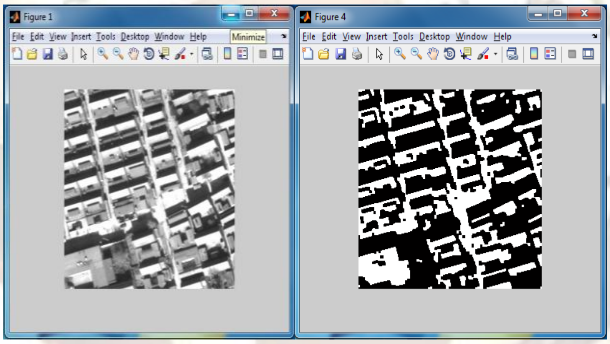

Fig. 4 Building extraction result on Worldview scene

Road extraction algorithm is implemented and tested on IKONOS data and Fig. 5 shows the result of road extraction.

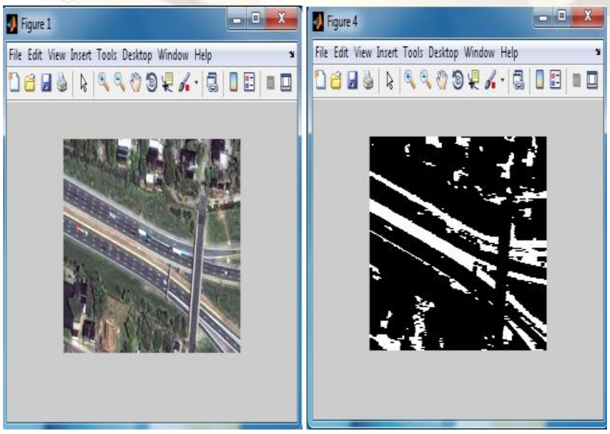

Fig. 5 Road extraction result on Ikonos scene

6. DISCUSSION

The left half of the image shows original scene fed as input and the right side of the image shows result of feature extraction. Confusion matrix is calculated in Envi 4.7 software package. The image given as the input to the algorithms is classified and used as ground truth image. The result obtained from the algorithm is classified and used as input image. Confusion matrix is calculated from the post classification menu and the results are found to be satisfactory. Table 1 shows confusion matrix result in terms of percentage classification, calculated for Ikonos imagery. Overall accuracy observed to be 78.61 with a kappa coefficient of 0.4556.

Table 1 Confusion matrix in terms of Ground Truth (Percent) for Ikonos imagery

Class	Building	Non-Building	Total
Building	46.24	6.45	19.01
Non-Building	53.76	93.55	80.99
Total	100	100	100

Table 2 shows confusion matrix result in terms of no. of pixels belonging to each class calculated for Ikonos imagery.

Table 2 Confusion matrix in terms of Ground Truth (pixel count) for Ikonos imagery

Class	Building	Non-Building	Total
Building	9301	2812	12113
Non-Building	10815	40792	51607
Total	20116	43604	63720

In case of Worldview imagery, the accuracy assessment showed an efficiency of 81.263 with a kappa coefficient of 0.6266. The improved accuracy with worldview scene when compared to Ikonos imagery can be attributed to improved spatial resolution of world view imagery. Table 3 and Table 4 shows confusion matrix results in terms of percentage, and pixel count calculated for Worldview satellite data sample.

Table 3 Confusion matrix in terms of Ground Truth (Percent) for worldview imagery

Class	Building	Non-Building	Total
Building	94.21	31.31	62.30
Non-Building	5.79	68.69	37.70
Total	100	100	100

Table 4 Confusion matrix in terms of Ground Truth (Pixel count) for worldview imagery

Class	Building	Non-Building	Total
Building	30065	10286	40351
Non-Building	1849	22568	24417
Total	31914	32854	64768

7. CONCLUSIONS

Mathematical Morphology is a powerful tool for the extraction of features from the remotely sensed imagery. It is an automated method of feature extraction. It uses the Morphological constraints like shape and texture for the feature extraction. Higher efficiency can be achieved in this method with proper selection of structuring elements. How ever, the efficiency can be still improved with the use of automated methods of obtaining the structuring elements for applying morphological operators, Because the structuring element used in the Mathematical Morphology is the key factor that defines the efficiency of the algorithm. Further, adaptive methods of obtainig structuring elements and proper post processing will improve the efficieny.

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