ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 1, Issue 4, December 2014

Interpretation Based Building Extraction From Fusion Of LIDAR And Aerial Imagery

S.VELLAI SAMY[1], S.BEEMA SABEENA[2]

Professor, EEE, SCAD College of Engineering and Technology, Tirunelveli, India[1]
Student, M.E. VLSI design, SCAD College of Engineering And Technology, Tirunelveli, India [2]

Abstract—Better fusion of Light Detection and Ranging (LIDAR) and aerial imagery for building extraction is very much needed application for continues updates for urban planning and survey information. This reason motivates to develop a seamless fusion of LIDAR and aerial imagery on the basis of aspect graph driven method. The feature of houses such as geometry shapes and structure is also explored. An aspect represents either projection or part of projection of 3D house primitive. By using aerial image processing in combination with results of LIDAR data processing, hierarichal graph of aspect are constructed. In the aspect graph describe the node represents the face aspect and the arc is described by attributes obtained by the formulated coding regulations, and the co-registration between the aspect and LiDAR data is implemented. As the result , the aspects graphs are interpreted for the extraction of houses by using MATLAB.

Keywords: Aerial imagery, LIDAR, extraction, image processing

I. Introduction

Now a day, spatial information has become one the most important information source in human life. Spatial information is clearly expected that more information shall be associated with survey information provided through system such as GIS geo information system. Building extraction is most important application used for continues updates for urban planning, cartographic mapping, and civilian and military emergency responses. The efforts for building extraction using a variety data sources have made in image processing, and computer vision communities. Light Detection and Ranging is determine distance by using analysis laser light to reflect mirror. This LIDAR data can be used for mapping areas of building and application of industry and aerial image is defined to the image from elevation to ground lidar has high resolution techniques it has high accuracy.It is remote sensing technology that emits focused beams of light and measures the time it takes for the reflections to be detected by the sensor. This information is used to compute ranges, or distances, to objects. In this manner, LIDAR is analogous to radar (radio detecting and ranging), except that it is based on discrete pulses of laser light. The three-dimensional coordinates (e.g., x,y,z or latitude, longitude, and elevation) of the target objects are computed from 1) the time difference between the laser pulse being emitted and returned, 2) the angle at which the pulse was "fired," and 3) the absolute location of the sensor on or above the surface of the Earth. Early methods can be grouped into three categories in terms of the employed data sources. The first category uses optical imagery, such as aerial imagery and high-resolution satellite imagery. Building-detection method may not detect buildings

if the contrast between their rooftop and the background is low. Since only using the gray scale information in the satellite image, this is reasonable. Moreover, some closely spaced buildings may not be detected correctly.This method attempted to extract the boundary of a building to identify the buildings, but separating building boundaries from non-building objects, such as parking lot is difficult. It is especially difficult to extract the complete boundaries of a building from single optical image due to unavoidable occlusions, poor contrast, and shadows. The second category utilized active imagery data, such as Light Detection and Ranging (LiDAR) data and radar imagery. The third category integrates both high resolution optical and active imagery data. Therefore many efforts have been made on the fusion of Light Detection and Ranging (LiDAR) and aerial imagery for the extraction of houses, on taking advantage of a building's geometric features, properties, and structures for assisting the further fusion of the two types of data has been made**.** Applications are urban city or town planning is the discipline of land use planning which explores several aspects of the built and social environment of municipalities and communities. Using fusion of LIDAR and aerial imagery on the basis of aspect graph method to create digital building models therefore large area

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models to create very short space of time.Recently, the methods of third category have been widely used the efficient fusion of the two types of data sources can compensate for the weaknesses of one data to another. However, most current efforts have still staying the study of the gray level fusion and few efforts on utilization of the geometric or chromatic features of buildings to support the deep data fusion for building extraction. To confront these issues, develops an aspect graph-driven method to explore how the features of houses are utilized for the data fusion between aerial imagery data and LiDAR data. The method attempted to extract the boundary of building to identify the buildings and non buildings.

II. DESIGN GOAL

The proposed methodology consists of aerial image processing, and principle of aspect code.

The block diagram of the proposed methodology is shown in Fig. 1. The details of each phase are given below.

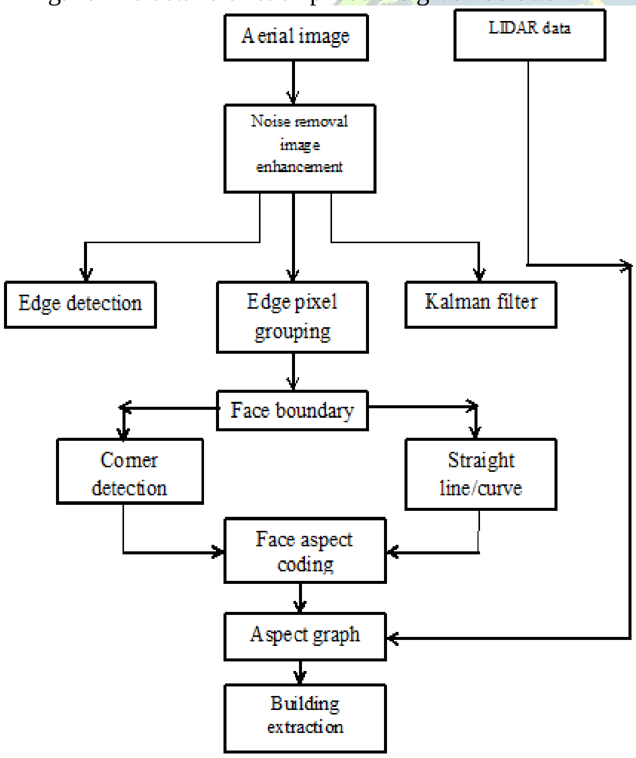


Fig. 1. Proposed method

1.AERIAL IMAGERY PRE PROCESSING

Aim of image pre-processing is an improvement of the image data that suppress undesired distortions or enhance some image features relevant future processing and analysis task.There are following steps they are image enhancement and noise removal, edge detection, edge grouping, Kalman filter to track line.

Step 1- Image enhancement and noise removal:

The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image for a specific application It accentuates or sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis. The enhancement doesn't increase the inherent information content of the data, but it increases the dynamic range of the chosen features so that they can be detected easily as shown in Fig. 2a and 2b.Captured aerial image is unavoidable for the image to involve noise. Considering is used to accentuate edges. As shown in figure has used median filter If the objective is to achieve noise reduction instead of blurring, this method should be used. This method is particularly effective when the noise pattern consists of strong, spike-like components and the characteristic to be preserved is edge sharpness. For each input pixel $f(x,y)$, we sort the values of the pixel and its neighbours to determine their median and assign its value to output pixel $g(x,y)$. The typical high-pass filter mask is

The original image can be converted to the enhanced image

Fig.2. (a) original image and (b) enhanced image

Step2-Edge detection

There are many ways to perform edge detection but in proposed method canny method has used mask for edge extraction fig 3. Directly this method for house extraction. When the mask are convolved with a moving window strongest response is taken as edge and corresponding orientation is taken as the direction of an one building the mathematical model of output value of gray value can be expressed as

$$g(m,n) = \max \left\{ \sum_{i=0}^{2} \sum_{j=0}^{2} f(m+i, n+j) \times w_k(i,j) \right\}, \quad k = 1,2,3,4 \qquad (2)$$

where f(m,n)is gray value of original image and w is the mask value are obtained. Using edge detection mask the gray values of building edges are enhanced and the background noise is refined efficiently.

Fig. 3 Result of extracted edges

Thus the candidate pixel of the building edges can be extracted .after thinning of edges result can be extracted.

Step3-Edgegrouping:

A building boundary is segmented into several segments after detecting the building edge pixel. For this reason, the following task it to trace the edge fragment pixels and then group them. The method to group two neighbour edge fragments into one new edge “fragment” is proposed as follows Fig. 4.

1) The slopes of two neighbour edge fragments meet the condition of $|\alpha - \beta| \leq$ slope threshold, where α and β represent the slopes of two edge fragments, respectively.

2) The distance D between the ending point of an edge fragment and the starting point of another edge fragment should meet the condition of D ≤ dist_threshold.

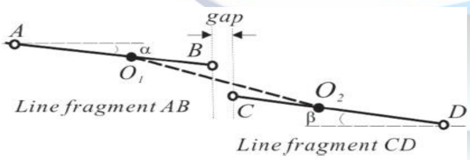


Fig. 4. Merging neighbour edge fragments.

When the two conditions above are met, two neighbour edge fragments are merged by

AD = AO1 + O1O2 + O2D. (3)

The same operation is above repeated for each edge fragments until all edge fragments are finished. After this step, most of the edge fragments are smoothly connected.

Step4-to Track line using Kalman filter:

Noisy data in→Hope fully less noisy data out

The above operations unavoidably cause the gaps along the edges of a house. Kalman filter algorithm is proposed to track the broken-off edges to fill the gaps. The basic idea of this method is that each edge is considered as a track of a moving point on an edge. When the broken-off edge fragments are not detected, the Kalman filter keeps track of the next fragment. If there exist two edge fragments, which meet the two conditions in Step 2, they will be merged into one edge fragment. When a broken-off edge is detected, a number of the pixels are prefilled. The filled number is required to assure that the methods can the next edge fragment. This computational process is mathematically described as follows: If an edge is tracked, let X (k) be the state vector of movement, x (k) be the moving location, x’(k) be the velocity, y(k) be the observation location that is the location of the detected edge point, T be the step size, and k be the tracing time; the state equation of constant velocity of point D is

X ((k + 1)/k) = AX(k) (5)

Where X = [x x’] T, and A = . The measurement model is simplified as

Y (k) = CX^T (k) (6)

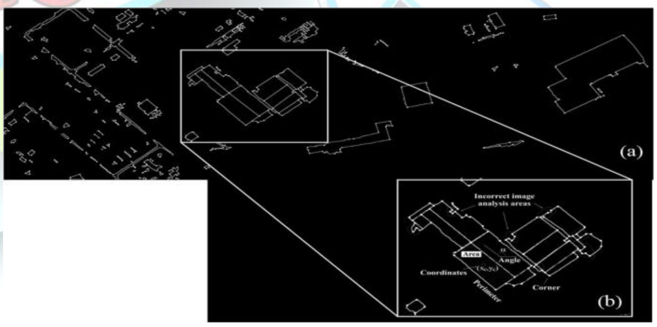
Where X = [1 0] T, and Y(k) =[y y’]. The predicated state equation

X ((k + 1)/k) = A^X (k). (7)

The output of the filter is

$$\hat{X}(k+1) = \hat{X}((k+1)/k) + K(k+1) \left(Y(k+1) - C\hat{X}((k+1)/k) \right) = \hat{X}((k+1)/k). \qquad (8)$$

Fig.5. Using the formulated coding regulation the area, perimeter, and the central coordinates of a face are calculated



After the Kalman filter in combination with step 2 is carried out, an entire building boundary is extracted.

2. CREATION OF ASPECT GRAPH

With the detected edges above, the next task is to create aspect and aspect graphs using the proposed method in principle of aspect code and creation of aspect code database

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ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
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and then create a digital building model. To this end following steps are proposed algorithm, each face is filled with gray value, 255. An example shown in Fig.5

Face coding:

The first step of aspect creation is face coding to the boundary detected in precious section. The following steps are conducted.

Face filling:

Example with face filling, the area of each face is obtained by accounting the number of the filled pixels. After filled, a binary imagery is created. Procedures of coding a house using the formulated coding regulation, in which the small circles indicate an endpoint or the corner of a line or a curve. The orientation and length of a straight segment are calculated. The area, perimeter, and the central coordinates of a face are calculated as well.

TABLE I
ATTRIBUTE VALUES OF NODES AND ARCS

Attribute values for Node	Attributes values for Arc
1.Area 2.Perimeter 3.Central coordinates 4.Orientation angle of a face aspect 5.Codes describing face aspect	1.The coordinates of a shared edge 2.The types connected edges 3.The slope of straight line 4.The curvature of a curve 5.The information of two end points

Boundary detection:

` With the binary imagery created above, a gray threshold of 100 is setup to detect the boundary. After this, thinning edges and deleting edge burrs are implemented consequently. Finally, the boundaries with a pixel width are obtained.

***Boundary vectorization*:**

With the result obtained above the boundary of each face is vectorized using an eight neighbour tracking operator. With the operation, the perimeter of each boundary can be obtained and is used as an attribute value of the face aspect.

***Corner detection*:**

With the vectorized boundary of each face above, the corner detection is conducted using a method called maximum curvature difference between forward K steps and backward K steps.

Selecting one pixel along the boundary, we called central pixel, and calculating the curvatures of the line located in the selected pixel (noted k0), the forward 3 pixels' (noted k+3), and the backward 3 pixels' (noted k−3), respectively. The curvature differences between the selected and the forward pixels (noted k0+3) and between the selected and the backward pixels (noted k0−3) are calculated. respectively. The corner is detected by using the second curvature difference, i.e.,

$$Curvature_0=|k0-3-k0+3|\times \begin{cases} \text{if curvature} > \text{threshold noted as co} \\ \text{if curvature} \leq \text{threshold noted as no c} \end{cases} \quad (9)$$

If Curvature0 is greater than the given threshold, the pixel is determined as a corner; otherwise, it is not a corner pixel. Sometimes, it is necessary to suppress the local no maximum since the multiple Curvature0's surrounding the central pixel simultaneously meet the condition of (9).

• **Determination of straight line or curve**: When using the aspect or aspect graph for house interpretation, the property of line segmentation, either a straight line or a curve, has to be determined. To this end, the curvature of the line segmentation between two corners is calculated. If the curvature is close to zero, the line segment is considered as a straight line, otherwise, as a curve.

• **Face coding:** With the operations above, face coding is conducted in terms of the coding regulation formulated . When the above operations are finished, the face codes are completed.

With the faces coded above, the aspect graph is constructed. The basic steps include: First, each face is given an attribute name using natural numbers 1,2,3..Meanwhile, the attribute values are calculated using the parameters listed in Table I.

Second, the aspect graph is constructed using nodes and arcs. Each face is taken as a node of the aspect graph, and each of the shared edge is determined by the same imagery coordinates and taken as an arc of the aspect graph [as shown in Fig.6. Third, a primitive aspect graph is constructed using the aspect merging regulation described in coding regulation of aspect coding

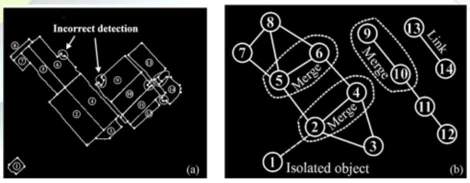

Fig.6. Illustration of aspect and aspect graph construction, (a) the segmented houses, and (b) and their aspect graphs.

For example, face aspects 5 and 6, face aspects 9 and 10, and face aspects 2 and 4 are merged in Fig.6(b). In addition, face aspect 1 is an isolated aspect, which represents an independent house. Fourth, the aspect graphs between the created in this section and the archived in the database are correlated. With this operation, the aspect graph using the proposed face-coding regulation can effectively remove the mis-segmented area .

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3. COMBINATION BETWEEN TWO DATA

The created aspects above unavoidably contain the objects that do not belong to houses, such as vehicles or parking lots.

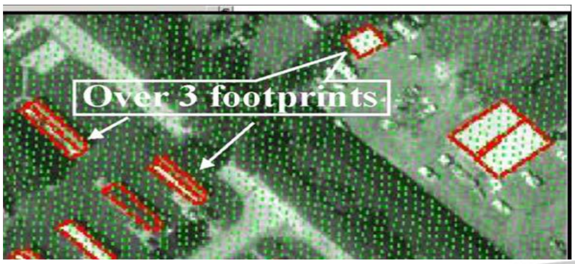

Fig. 7. LiDAR footprints.

For this reason, the application of elevation information driven by LiDAR footprints as shown in Fig.7. will help separate ground objects and non-ground objects. A common method is to co register the LiDAR data and the created aspects, with which the house's boundaries and 3-D co-ordinates can be obtained and are used to further, created.

$$aX + bY + cZ = 1 \qquad (10)$$

where a, b, and c are unknown coefficients, and X, Y and Z are coordinates of LiDAR footprints shot within the house's roof.

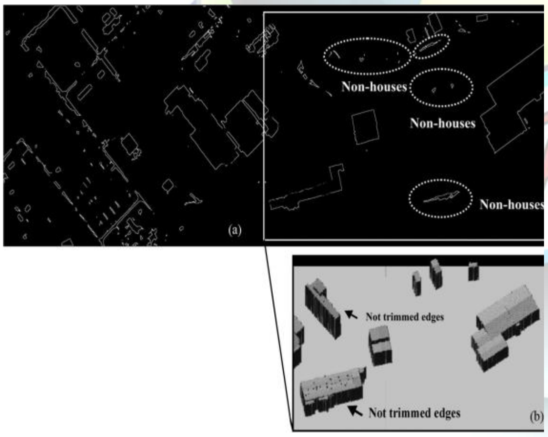

Fig.8. Coarse 3-D models of the houses through co-registration between the aspect and the LiDAR data.

As shown in Fig.8, at least three LiDAR footprints are required to determine the equation coefficients a, b, and c by least squares estimates. With this algorithm, a coarse 3-D model of houses can be generated. As observed in the boundaries of the 3-D model of each house are very coarse since it is difficult to extract the boundaries of each house from single LiDAR data.

4. ASPECT INTERPRETATION BASED BUILDING EXTRACTED

The primary design for the extraction of houses using aspect interpretation is a correlation operation between the aspect codes created from aerial imagery (called image code) and the aspect codes archived in the codebase (called codebase). The correlation operation is carried out by the attribute values assigned in both the nodes and the arcs of the aspect graphs. Each node and each composed of many attribute values; a linear combination of these attributes is constructed by

$$\text{node}_{\text{attribute}} = \text{Area} + \text{Perimeter} + \text{Central Co-ord} + \text{Orientation} + \text{Code}_{\text{aspect}} \qquad (11)$$

$$\text{arc}_{\text{attribute}} = \text{Co-ord Two-ends} + \text{Type edge} + \text{Slope line} + \text{Curvature}_{\text{curve}} \qquad (12)$$

The correlation coefficient maximum of the note/arc attributes between the obtained from aerial imageries and the archived in the database is taken as criterion. With the new combined variables in (11) and (12), the two criteria are employed to determine their correlation, respectively. The first criterion is the correlation coefficient maximum of the node, which is employed for determining the candidate house under a given threshold of correlation coefficient. The successful operation of this step will be able to interpret and find a significant amount of geometric information of a house, such as aspect property, geometry, gray area, relationship, and separate the ground objects (e.g., parking lots) and non-ground objects (e.g., houses). The second criterion is a correlation coefficient maximum of the arcs between the obtained from the aerial imagery and the archived in the database. The same operation as the node correlation is carried out. The successful operation of this step will be able to interpret and find a primitive graph, which describes an entire projection or partial projection of a 3-D primitive.

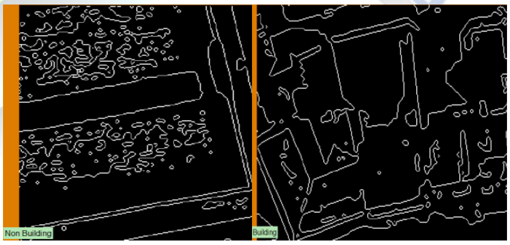

Fig. 9. Building and non building identified

If an aspect is identified as a house, we will further determine how many LiDAR footprints hit its roof .Repetition of the operations in Step 4 and Step 5 is required in order to avoid missing the extraction of houses. Fig.9 shown extraction of buildings can identified when above process can be repeated .

III RESULTS AND DISCUSSION

Create codes in MATLAB main work of the method includes following aerial image preprocessing including edge detection using detector edge pixel grouping gap filling is developed. Select the image primitives and compared data. Aspect graph are interpreted for extraction of building. These methods attempted to extract the boundary of a building from non building objects as shown in fig 9. The proposed method is to extract building.

IV CONCLUSION

In this work, The main work is input captured aerial image can be pre processed including edge detection using a detector mask, edge pixel grouping, and gap filling, is developed. Types of 3-D house primitives are selected, and their projections are represented by the aspects. Then coding regulations are formulated for creation of the (hierarchical) aspect graphs on the basis of the results of aerial image processing and the results of LiDAR data.

In the aspect graphs, the nodes are represented by the face aspect, and the arcs are described by the attributes using the formulated coding regulations. Result aspect graph are interpreted for the extraction of houses and the extracted houses are fitted.

V FUTURE ENHANCEMENT

Future work is multiple target extraction from satellite image using EM method TLCC technique aims at overcoming this problem by also allowing the characterization. The expectation–maximization (EM) algorithm. Pixels belonging to the land-cover classes of interest are identified by means of an iterative labeling strategy based on Markov random fields segmentation model can be developed by K-means based on multi level threshold. Final TLCC are iteratively updated through an MRF-based strategy. Therefore future developments are planned in these two directions, as well as toward comparison with target detection methods.

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