Automatic Extraction of Power Line Towers with the Help of Image Segmentation Using a Remote Sensing Data

Kamran Hafeez, M. Aamir, and Shehzad Afzal

***Abstract*—Image Segmentation and its performance evaluation are very difficult but important problems in computer vision and image processing. Segmentation is the process of partitioning an image into non-intersecting regions such that each region is homogeneous and the union of no two adjacent regions is homogeneous. In spite of the vast research published on Image Segmentation and Texture detection in several disciplines for the last few decades, the concept still gives scope for research and applicability .The goal of segmentation is typically to locate certain objects of interest which may be depicted in the image. Image segmentation methods can be subdivided into region-based vs. edge-based methods. feature extraction has been applied in many areas widely including roads, buildings but extraction of power line towers are very difficult due to its vertical structure .This paper clearly presents an efficient and simple segmentation algorithm which is based on smoothing filters to extract a power line structure from a remote sensing image.**

***Index Terms*—Edge detection, computer vision, image processing.**

I. Introduction

Image segmentation in general is defined as a process of partitioning an image into homogenous groups such that each region is homogenous but the union of no two adjacent regions is homogenous (Pal and Pal, 1993). Efficient image segmentation is one of the most critical tasks in automatic image processing (Pavlidis, 1988; Haralick and Shapiro, 1985; Pal and Pal, 1993; Zhang, 1997; Cheng et al., 2001). Image segmentation has been interpreted differently for different applications. For example, in machine vision applications, it is viewed as a bridge between low level and high level vision subsystems (SpirKovska, 1993), in medical imaging as a tool to delineate anatomical structure and other regions of interest whose a priori knowledge is generally available (Pham et al., 2000) and in statistical analysis, it is posed as a stochastic estimation problem, with assumed prior distributions on image structure, which is widely used in remote sensing (Kerfoot etal., 1999). In remote sensing, it is often viewed as an aid to landscape change detection and land use/cover classification. Aforementioned examples state that image segmentation is present in every kind of image analysis [1]. In [3] the author investigates the extraction of the power transmission tower series (PTTs) in high resolution full polarimetric SAR images. Firstly, he gets the filtered image by applying the multi look polarimetric whitening filter (MPWF) to combine the information in the different polarimetric channels and reduce the speckle. Then the point-like targets are detected by an adaptive region classification CFAR detection approach, among which only a few are the potential PTT. Then reduce the number of candidate points by take a post-processing which using the polarimetric signatures of targets. Finally, connect the remainder targets into a graph and obtain the extracted PTTs based on MRF model. The above method has limitations as the algorithm is also extended to extract some other point-like targets group.

To extract the complex power transmission network in urban scenes is difficult job using Polsar images based on MRF model. The aim of our study is to automatically extract power line tower from an aerial photo with the help of algorithm.

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II. Background

The separation of the image into object and background is a critical step in image interpretation. When we imitate the human visual system by using computer algorithms, quite a lot of problems can be encountered. Segmentation subdivides an image into its constituent regions or objects. The level to which the subdivision is carried depends on the problem being solved. A wide variety of segmentation techniques has been proposed but there is no one standard segmentation technique that can produce satisfactory results for all imaging applications. Segmentation techniques can be divided in to classes as follows:

- Manual, semiautomatic, and automatic .
- Pixel-based and region-based .
- Low level segmentation (thresholding, region growing) and model-based segmentation (feature map techniques, dynamic programming) [46] and
- Classical (thresholding, edge-based, and region-based techniques), statistical, fuzzy, and artificial neural network techniques (ANN) [2].

The Canny operator is a sort of edge detection operator. It has good performance of detecting edge, which has a wide application. The Canny operator edge detection is to search for the partial maximum value of image gradient. The gradient is counted by the derivative of Gauss filter. The Canny operator uses two thresholds to detect strong edge and weak edge respectively. And only when strong edge is connected with weak edge, weak edge will be contained in the output value [4].

III. Study Area

The original aerial photo taken of the study area is shown in figure (1) .By applying a Contrast filter the result is shown in figure (2).

Fig. 1. Aerial photo.

Fig. 2. Contrast filter

IV. Results and Analysis

Now applying a convolution filter the results are shown in fig. 3. The filter implements convolution operator, which calculates each pixel of the result image as weighted sum of the correspond pixel and its neighbors in the source image. Removing color range of terrain and undesired objects for which color tone is determined as shown in fig. 4.

Fig. 3. Convolution filter.

Fig. 4. Euclidian color filtering.

Now canny edge detection method is applied to the image as shown in fig. 5 and one pixel thinned image is fig. 6.

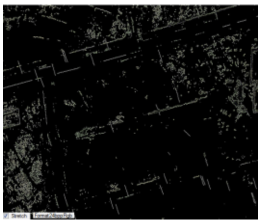


Fig. 5. Canny edge detection.

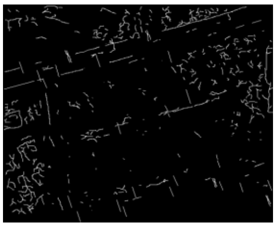


Fig. 6. One pixel thin image.

A. Algorithm

1) First Apply the following filters in sequence ;

   a) Contrast Filter, b) Convolution Filter, c) Euclidean Color Filtering to remove terrain data from image,

   d) Canny Edge detection,

2) Image objects are reduced to a single pixel thickness.
3) Loop through each pixel and mark all those pixel as the lower start end of lines , which are satisfied by the condition for the lower end of line and add the pixel of the line representing the lower end of line , to an array Lines
4) Load next start pixel of line from array Line and traverse the line pixel by pixel until two conditions are matched.

   a) Ignore Line Traverse condition : go to step 4

   b) End of Line being traversed :

   Store the start and end pixel, Length as number of pixel in line, and angle as average of angle shift from pixel to pixel . average angle = (sum of all angles traversed/ pixels In line).

5) If average angle of line is comparable with acceptable minimum threshold of desired angle then mark it as power line otherwise go to step 4.

B. Marking Lower end of Line

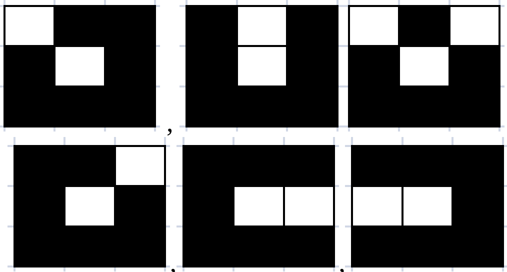
3	4	5
2	1	6
9	8	7

Structure cells are array of nine integer's cell 1 is the pixel where we are performing our calculation. Let its position be I,j on image i.e row no j and column I from upper left corner which is (1,1).Cells[1] = pixel(I, j) Cells[2] = pixel(I-1, j) Cells[3] = pixel(I-1, j-1) Cells[4] = pixel(I, j -1) Cells[5] = pixel(I+1, j-1) Cells[6] = pixel(I+1, j) Cells[7] = pixel(I+1, j+1) Cells[8] = pixel(I, j+1) Cells[9] = pixel(I-1, j+1)

e.g in image Pixel at (16,16) the  cell is

Cells[1] = pixel(I, j) = 1 Cells[2] = pixel(I-1, j) = 1 Cells[3] = pixel(I-1, j-1) =1 Cells[4] = pixel(I, j -1) =0
Cells[5] = pixel(I+1, j-1) =0 Cells[6] = pixel(I+1, j) =1
Cells[7] = pixel(I+1, j+1) =0 Cells[8] = pixel(I, j+1) =0
Cells[9] = pixel(I-1, j+1) =0

- Search for pixel having cell structure like



These are the lower corner of the lines

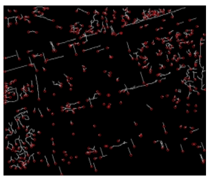


Fig. 7.

Lines mark with lower edge .Fill a queue of all pixels detected as lower ends.

C. Traverse Line Starting from Each Lower End of Line

Initialize a integer angle and integer length with zero. If we have image

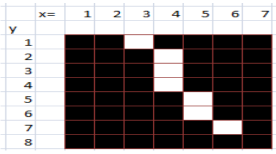
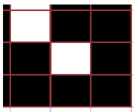


Fig. 8

We will start traversing from lower edge pixel(6,7) .

Let current position be pixel(I,j) which is pixel(6,7) .  , at current pixel fill the cell Fig. 9

structure which in our example will be

1	0	0
0	1	0
0	0	0

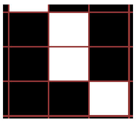
, search only cell nos

3	4	5
2		6

for value 1 which is white color , in the above example cell[3] has value 1 , so changing current pixel to the pixel represented by cell[3] ,Cells[3] = pixel(I-1, j-1) = pixel(6-1,7-1) = pixel(5,6) .Change current pixel (I,j) from pixel(6,7) to pixel(5,6) ,Increment length by 1 i.e Length = length +1

If moving cell is 3, increment angle by 135 i.e angle = angle+135 If moving cell is 4, increment angle by 90 i.e angle = angle+90 If moving cell is 5, increment angle by 45 i.e angle = angle+45 If moving cell is 2, increment angle by 180 i.e angle = angle+180.

Repeat Step2.

Now calculation at pixel(5,6)  , value of cell structure

0	1	0
0	1	0
0	0	1

, search only cell numbers

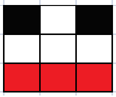
3	4	5
2		6

for value 1 which is white color , in the above example cell[4] has value 1 , so changing current pixel to the pixel represented by Cells[4] = pixel(I, j -1) =pixel(5,6-1)=pixel(5,5) , length incremented by 1 while angle by 90

- Step 2 is repeated until one of two conditions are met

A) Ignore Line Traverse condition

Condition to check for ignoring the processing of current line

, , in structure cells

3	4	5
2	1	6
9	8	7

the lower cell 9,8,7 shown in red color are don't care condition which may be of any value , check cell , 3,1,5 if they have value 1 ,then ignore the current traversing of line or if the cell 1,2,4,6 has value 1 then ignore the current traversing of line and load the next lower end point from the queue.

B) End of Line being traversed

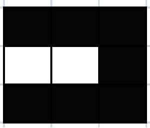


Fig.10.

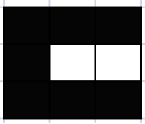


Fig. 11.

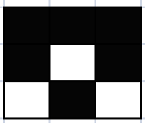


Fig. 12.

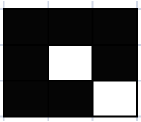


Fig.13.

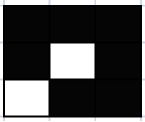


Fig. 14.

Fig.15.

The above conditions when reached, shows end of line now mark the line by filling the structure

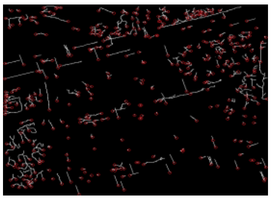


Fig. 16.

Red circle are start pixel , and green circle are end of line those line with start red circle but no end green circle mean they are ignored lines as shown in fig. 7.

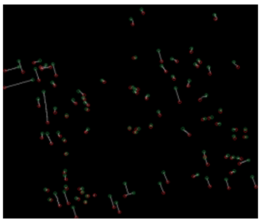


Fig. 17.

Candidates are those lines having both red and green circles that are having start pixel and end pixel means successfully traversed till end of line. Let shadow angle be and integer showing the shadow angle , and shadow_angle_tollarance_threshold be an integer showing allowable limit of shadow If the candidate has angle between (shadow_angle shadow_angle_tollarance_threshold) and (shadow_angle + shadow_angle_tollarance_threshold) then the candidate is added to the array list candidate_arrayList represented by blue lines.

Result with shadow angle = 120 and Shadow angle tolerance threshold = 10 Angle between 110 and 130

These are the expected power lines. The accuracy of the system depends on the terrain of the satellite image. The result is shown in Fig. 11.

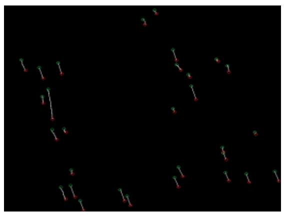


Fig.18

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