Shape Preserving Edge Enhancement in Remote Sensing Imagery

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***Abstract*- A novel approach to geometric shape preservation of remote sensing SAR sea ice images is presented in this paper. This approach will complement the existing edge detection schemes. The final edge is evolved by iterations. During each iteration all existing edges are checked for missing link and missing links are found by checking the orientation of the existing edges and by searching for best gradient path. When open edges are reduced considerably, opening of the features that are critical for shape preservation are found by tracing the edges and closing the boundary.**

Index Terms-Shape preservation, edge detection, remote sensing imagery.

I. Introduction

In many image processing and analysis applications, the preservation of the edges is a desired goal. The reason is that the edges of an image are perceptually very significant and convey considerable image information. In addition, in some applications [4] the image structures are characterized by shape measures and a pre-processing stage that does not preserve shapes can make the computed measures useless. However, the task of preserving shapes while at the same time eliminating superfluous details and spurious signals (noise) is both difficult and complex. Even existing edge detection algorithms do not produce a satisfactory result to preserve shape. The method treated in this paper adds an additional step to preserve the shape after initial edges are found using the modified Canny edge detector [1].

One of the problems in sea ice classification using SAR images is that the floe shapes may be not be very clear. One object can be fused with adjacent object such a way that even human observer find it difficult to draw the separation line. This approach will try to recover the shape information from the binary edge image. This method uses several successive operations to close the boundary to recover the shape. The operations are called point to point connection, point to line connection, best gradient path connection and final blind connection.

Teboul et al. [2] tried to do restoration and shape recovery simultaneously using two partial differential equations. Their technique will not work very well on noisy nature of SAR images and no attempt is taken to close the boundary to preserve the geometric shape. Ali and Clausi [1] propose a modified Canny edge detector to enhance edge detection of remote sensing images. Their edge detection enhances the edges but does not preserve the shape. In this paper, the modified Canny edge detector is used to produce an initial binary edge image and the proposed technique is applied on this binary image to preserve the shape.

II. The Proposed method

The block diagram of the proposed method is shown in Fig. 1. After initial edges are found by modified Canny edge detector, noisy edges are removed and a thinning operation is applied to make edges one pixel thick.

A. Point to point connection

The result of the modified Canny edge detector is used as a preliminary binary edge image. The orientation of each existing line is calculated by placing the origin to the end point of a line and calculating orientation of certain number

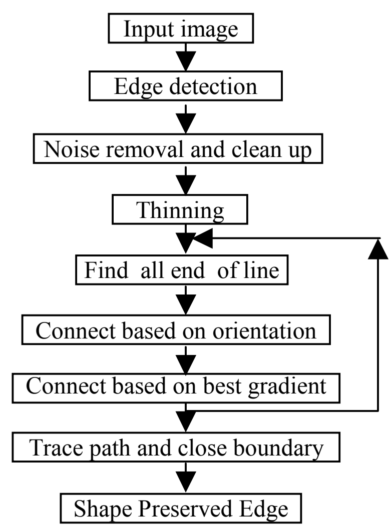


Fig. 1: Block diagram

of point on that line from that origin. The orientational map is shown in Fig. 2. In Fig. 2, it is shown that two broken lines can be part of a same line if the difference between the orientation of that two broken line are 180° or close to 180° with certain deviation. When some line has its neighboring line with matching orientation, it is most likely the continuation of the same line. So if the path between the two end points satisfies a minimum average gradient and matching orientation, the missing lines are connected. In Fig. 2, the line between endpoint A and endpoint B are missing lines and falls in the category described above. As a result, points A and B are connected.

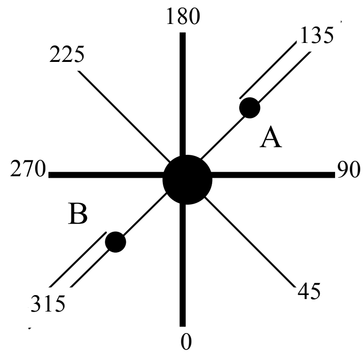


Fig. 2. Orientation map

B. Point to line connection

Some of the missing lines do not fall in the previous category. In this case, there is no neighboring end point with matching orientation but extending the line will hit another curve or line. Fig. 3 shows a typical scenario where there is a missing line (dotted) between one end point A to a line L. When endpoint A has a neighboring lines in the line of its orientation then the missing line is connected when the line is close enough to the end point. This missing line may not be apparent in the image but for the sake of making best guess at preserving the shape, this line is necessary.

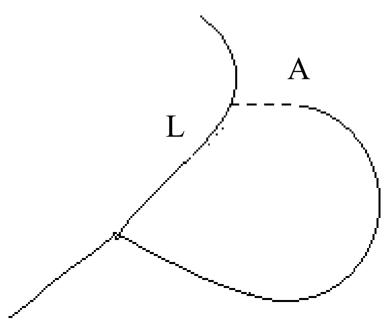


Fig. 3. Extending line in the same orientation

C. Best gradient path connection

There are some missing lines which does not fall in the above category. Fig. 4 shows a typical scenario. In Fig. 4, endpoint A has three close neighboring end points B,C and D. None of them are in the matching orientation as line A. In this case, the search is continued from point A to each of the points B, C and D by following the best gradient path. During searching, neighboring search points are selected so that the search continues towards the target point. After reaching the target point, the average gradient of the path is calculated. Among all candidate paths, the highest average gradient path is selected and if the average gradient of that path is above a certain threshold, that path is connected. The threshold here is much lower than the threshold selected for initial edge detection but its purpose is to make certain that there is some

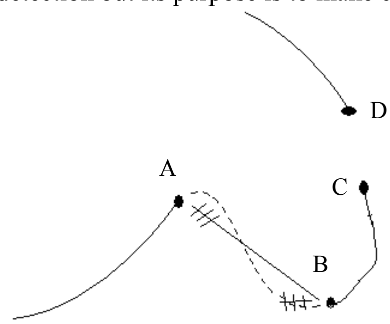


Fig. 4. Candidate for the best gradient search

weak trace of line in that path. This method can follow any missing curve lines between two points.

D. Blind connection

This step assumes that by the action of previous steps most of the missing links are connected, even though some links may be still unconnected. This step will close the boundary if there is only one link is still missing to preserve the shape. In Fig. 5, point A does not have an appropriate neighbor to connect and no line in its matching orientation. So we follow the path starting from point A and calculate the Euclidean distance of each point from point A. Usually when we follow a closed boundary, in one point we will reach to the same point with zero distance. But we are trying to find the missing line which is preventing to preserve the shape. When we plot the distance of the points from point A, we will see at least two peaks one for the furthest point and another for the minimum distance between point A to the other points on that path. If the minimum and maximum distance support that it is likely a closing boundary, then a line is drawn blindly between point A to the minimum distance on B.

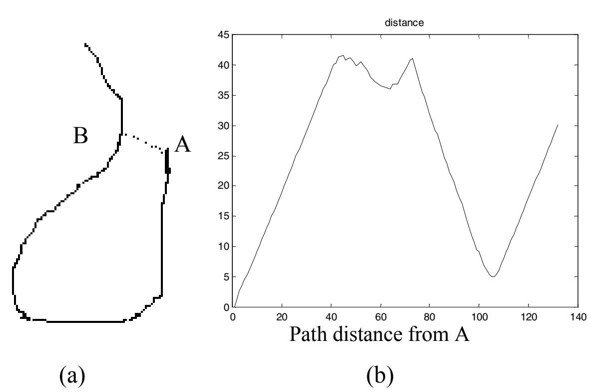
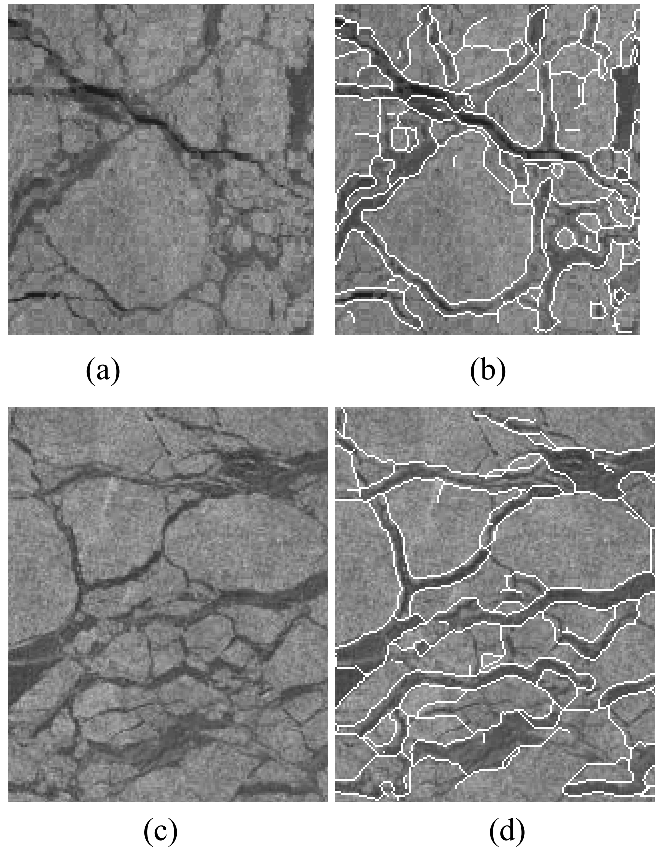


Fig. 5. (a) Candidate for blind connection (b) Path distance from point A.

III. RESULTS

The proposed scheme has been tested on SAR images. Even though much of the edge boundary has noticeable contrast, there are some places in the boundary where there is no clear line separation. The proposed technique is able to find the missing edges to preserve the geometric shape. The results obtained from this method may not be perfect but good enough for knowledge base sea ice classification [4] from SAR images. This method will work well when there are many missing edges between the existing edges. Before applying this algorithm, we make sure that edges are only one pixel thick. This is done by a morphological thinning operation. This step will help to find endpoints and make it easy to follow a line path. It does not improve edges but helps to implement other operation with ease of programming. The results are obtained without enhancing the images. In each iteration, it will close the missing lines and curves searching within a smaller neighboring area. In successive iterations it will increase the search area and relax the condition for matching orientation.

Results are shown in Fig. 6. All major features shape is preserved but there are some edges that appear which are not present in the image. These are due to the false edge that appears in the edge detection process. In some cases shape is not preserved due to weak or no trace of edge found in the preliminary edges. This method will do better shape preserving if there is some trace of edges found in the initial edge detection process. Shape is not preserved for all features but results are encouraging for knowledge based sea ice classification.



(a) (b) (c) (d)

Fig. 6. (a) & (b) Original image (c) & (d) Resulting edge image superimposed on original image

IV. FUTURE WORK

Results of the developed edge enhancement algorithm are encouraging for knowledge base sea ice classification. Additional works is underway to prevent the false connection and find the missing visible edges. Usually preliminary edges are greatly depend on proper threshold selection. One way to tackle this issue by choosing multi threshold to generate a layer of edge map and find the missing edges by searching from higher threshold edge map towards the lowers threshold edge map.

V. CONCLUSIONS

This paper has presented a new approach of edge enhancement for geometric shape preservation of RADARSAT SAR images. This approach is not for replacing edge detection schemes but for add an additional step to enhance it. This approach will work better for images where there is a trace of edges are found near the missing edges. This shape preservation approach can assist to improve sea ice classification of RADARSAT images. Additional work is required to make this process robust

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