A new Approach to Fast Contour Interpolation

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Abstract. This paper presents a new contouring approach which comes from the idea of morphology-based interpolation algorithm.. Three main steps are carried out for the recovering of the missing contours: firstly, a so-called difference image is formed from original two slice contours; secondly, shape deformation vectors of the contour points on the upper slice are calculated; thirdly, instead of the image based dilation and erosion operation, we directly calculate the points along the shape deformation vectors to generate the intermediate contour points. Compared to known interpolating methods, our approach utilizes the simplicity and robustness of morphology-based algorithm but overcomes its disadvantage of low speed.

1 Motivation

In medical application, contours are usually extracted from serial slices of 2D images to represent objects such as medical anatomy, tumor and ROI etc. While it is not practical to densely sample the object of interesting slice by slice manually, contours are usually extracted from several unconsecutive image slices, and the interpolation schemes are necessary to recover the missing contours in those intermediate slices.

Generally , for each pair of the key slices; one by one contour interpolation, i.e. there is only one contour in one slice, can be solved by first making triangular connection between the key points drawing ,manually, then according to the slice position to be interpolated, forming a cutting plane to cut the generated triangular connection lines in order , these intersection points forming the intermediate contour points. There are some problems when dealing with concave contours ,as well as branching contours. For concave contour interpolation, the “making triangular connection step” sometimes leads to unreasonable connection; for branching contour interpolation, there is not a reasonable “triangular connection” rule to decide when and where contours in a slice should be intersected or not.

Recently, Guo and col[1]. proposed a morphology-based approach to intermediate image interpolation. Here, the interpolation is implemented by means of a combined operation of morphological dilation and erosion for each of the target object boundary points, the size of the structure element is a weighted factor, it is calculated according to the contour shapes. Since the morphology operation avoids the geometry shape complexity by using a simple structure element, this approach has advantages compared with other interpolation methods, it works well when dealing with concave contour and branching contour interpolation.

Base on this method, We have made further development to meet our special need: contour interpolation by handling only the contour points to obtain the intermediate contour points , since the amounts of contour points dealing with are much smaller than the number of the pixels in a fame of image , interpolation speed is much faster using our new approach. In the following sections, in section 2 the original weighted morphology interpolation method is introduced, in section 3 our new approach is stated with a corresponding result.

2 Weighted morphology interpolation

Consider there are two object regions C1 is the source one, C2 is the target one, The method deforms the boundary of C1 to C2 by a weighted dilation and erosion operation using a structure element ,whose size is a weighted factor in order to get an accurate result.

1. A so called morphology difference image is generated by overlapping C1 an C2, see Fig.1 . I is specifies the area belong to C1; II specifies the area belong to C2; III is the overlapping region of C1 and C2.
2. Trace the boundary of C1.
3. Calculate out normal vector of each boundary point of C1, see Figure 1, vector x1x2 is the dilation normal vector for point x1.
4. Decide shape deformation vectors , i.e. the dilation and erosion trends of the contour points by searching the maxim dilation and erosion length according to the morphology difference image. In figure 1, suppose x1 is a point of contour C1, the green line is the normal vector of x1, and the maxim dilation length is the length between x1 and x2 along the normal vector direction.
5. Select a structure element , according to the maxim dilation and erosion length and the slice position to be interpolated . See Figure 1, d_E is the radius of the erosion structure element, d_D is the radius of the dilation structure element. Apply dilation and erosion operation .
6. In order to avoid the going out error, the whole process should be done iteratively, that is , C_{i+1} in slice i+1 should be conducted from C_i in slice i ,so repeat from step 1 to 5 ,till the target slice is reached.

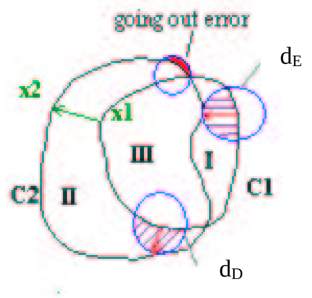

Fig. 1. Weighted morphology Interpolation

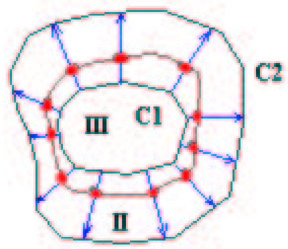

Fig. 2. Contour-based interpolation

We have noticed that , since this is a iterative process, the dilation and erosion operation, as well as boundary tracing are all rather time consuming

3 Contour based interpolation

We have made some improvements , use the contour points information as much as possible, in order to reach a fast intermediate contour interpolation.

3.1 One-by-One contour Interpolation

For one-by-one contour interpolation, the main pipeline is as the method stated before, but instead of implementing the structure element to do the image-based morphology dilation and erosion, we obtain the next successive contour points by calculating the next points positions along the shape deformation vectors. See Figure 2, the red points are calculated along the shape deformation vectors (blues lines Figure 2), after that, all of these points are connected using a 2D DDA line connection algorithm. Now, the object boundary tracing step is not needed , hence the interpolation speed is improved. In order to keep a accurate shape, the whole process should also be done iteratively.

For the cases that the two contours in two key slices does not have a overlapping area, we first calculate the geometry center of each shape, than shift the source contour to the target contour so that their geometry centers are overlapped, then doing the interpolation as before. When a new contour is generated, consider again its shift and move it back to the correct position.

3.2 Branching contour Interpolation

Our method has apparently advantages when dealing with the branching contours . In the original approach, each time after image based morphology operation, a object boundary tracing process has to be done , if there are more than one objects in one slice, than multi object searching is not easy to implement. Using our method, the contour points in the next slice can always be obtained by the former contours directly hence can get all of the contours in a intermediate slice immediately.

4 Conclusion

This work presents a new method for interpolating intermediate contours from sparse sampled key contours . Our interpolation technique is morphology-based but use only the contour points to perform the shape deformation. This method works especially well for the branching contour interpolation since it avoids the contour detecting process which is not easy and time consuming as well. Through this approach,, we improved the interpolation speed, we reached a robust and accurate contour interpolation.

5 Literature

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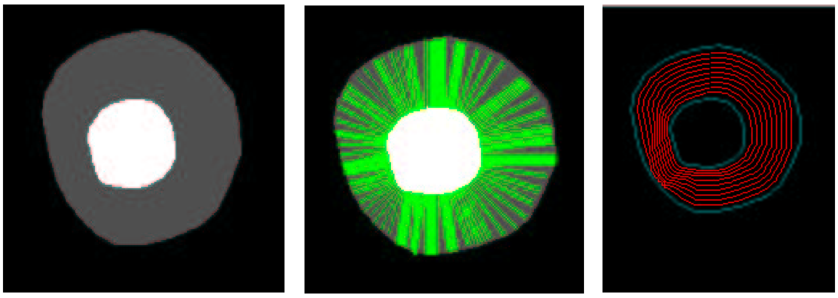

Fig. 3. a. Difference image **b.** shape deformation vectors **c.** Interpolation result

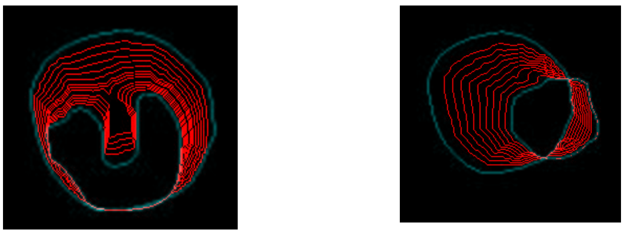

Fig. 4. a. Concave contour Interpolation **b.** Inersecting contours interpolation

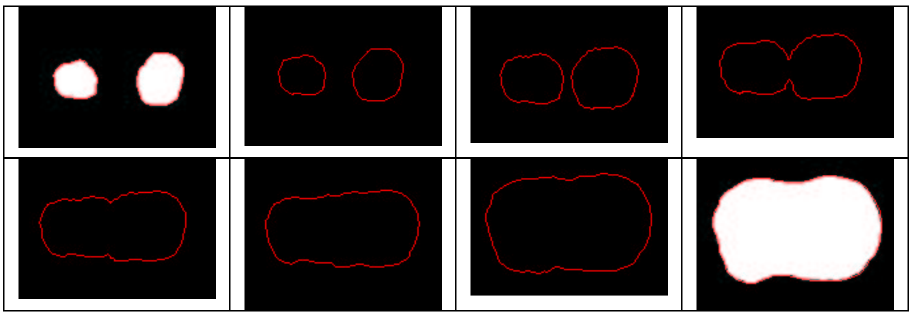

Fig. 5. Branching contour interpolation