Segmentation of DCE Breast MRI Masses: Pilot Observer Study

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PURPOSE

To evaluate a novel computerized segmentation method for breast MRI masses. A pilot study was performed in preparation for a future clinical study. This includes testing the manual and computerized segmentation procedure, data analysis, and defining required changes.

METHOD AND MATERIALS

The pilot study included manual segmentations from two observers of 11 biopsy-proven BMRI masses along with placement of seed pixels for automated segmentation. Both observers repeated the evaluation of each case in three different sessions, allowing inter- and intra-observer variation to be measured. Evaluation included manual tracing of the borders of the lesion on all slices and the placement of seed points using a direct method and a robust method. These seed pixels were used to initialize the computerized segmentation. The computerized segmentation of DCE breast MRI lesions involved: (1) robust seed point selection to minimize the impact of variations in seed-point placement. This is done using 2 methods as shown in Figure 1: The first method requires the user to place a seed-point into the enhancing portion of the lesion. In the second method the lesion is selected by placing a circular ROI around the lesion. A seed-position is selected automatically as the maximum intensity voxels within the ROI. (2) automated thresholding and connected component analysis of the subtraction images. The 6-connected block of voxels (x, y, z) which fulfill the threshold criterion $I(x, y, z) \geq T$ and which contains the seed-voxel is identified as the initial segmentation result. (3) a 3D post-processing steps to include non-enhancing portions of the lesion as shown in Figure 2, and to remove blood vessels as shown in Figure 3. This produced 18 segmentations for each lesion (6 manual, 12 computerized). The segmentations were compared pair-wise using the measured size and overlap to evaluate similarity.

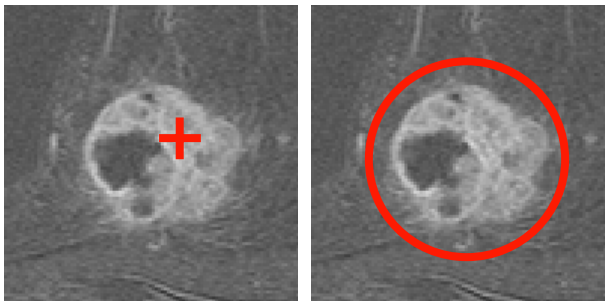


Figure 1: Robust seed point selection. Using a seed point inside the lesion on the left, and a circular ROI on the right. Seed point is placed on the first dynamic series.

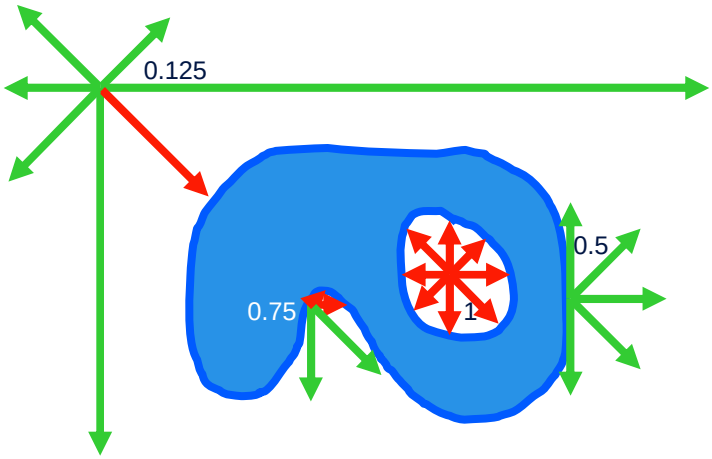


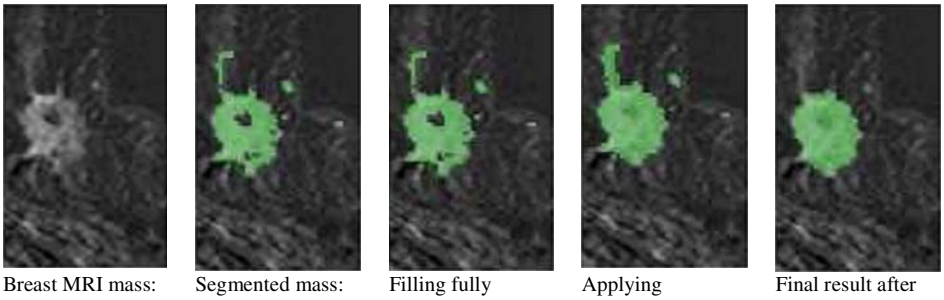
Figure2: The blue object is the lesion segmented by connected component analysis. The interiorness is computed at four different locations. The rays intersect with the lesion are drawn in red, the others in green. The interiorness is defined as the rate of rays intersects with the object. The interiorness computation is preformed in 3D.

RESULTS

The observed inter and intra-observer variation was similar ($p>0.05$). Segmentation with the robust seed-point placement was significantly ($p<0.001$) more reproducible in measuring lesion size (stDev 1.8%) than either manual contouring (11.7%) or directly placed seed-points (13.7%). The percent overlap between two computer readings (median 82%) was significantly ($p<0.001$) higher than either the overlap between two manual readings (66%), or the overlap between computer and manual readings (64%). If the 95% confidence interval of relative difference has length of 5%, then the sample size is 50 cases using seven observers.

CONCLUSION

This pilot study showed that the computerized segmentation methods, especially with robust seed-point selection, are more reproducible and reliable than manual method in terms of measuring the size and shape of a lesion.



Breast MRI mass: subtraction image. | Segmented mass: automatically estimated threshold. | Filling fully enclosed holes. | Applying interiorness measure. | Final result after removal of leakage.

Figure 3: Results of the processing steps.