

CHAPTER 5: DETECTION OF BREAST CONTOUR IN MAMMOGRAMS

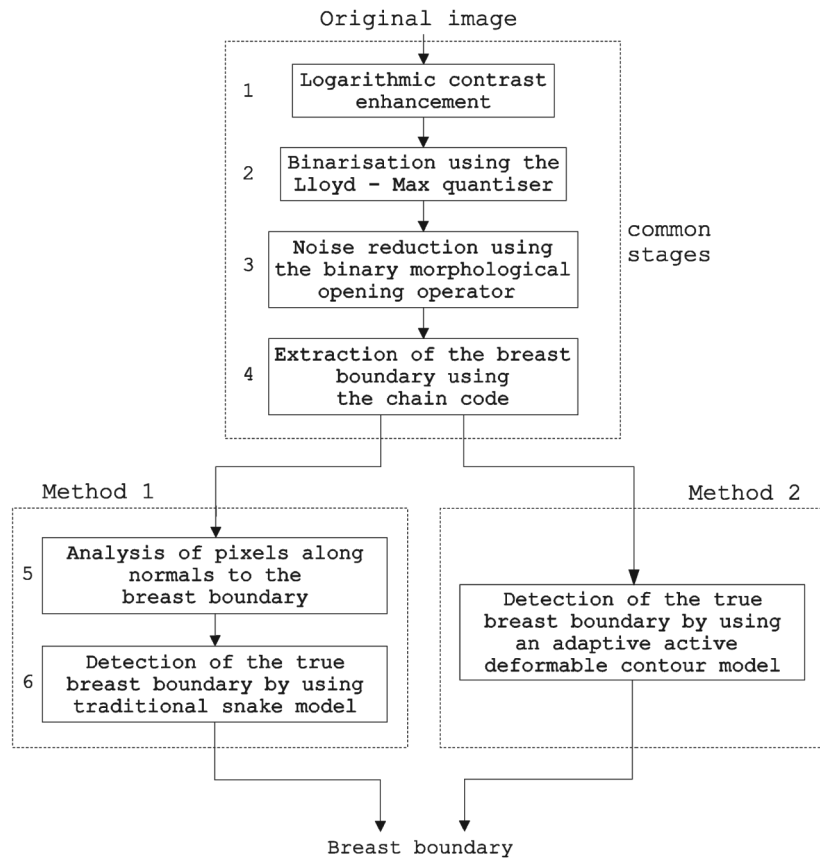
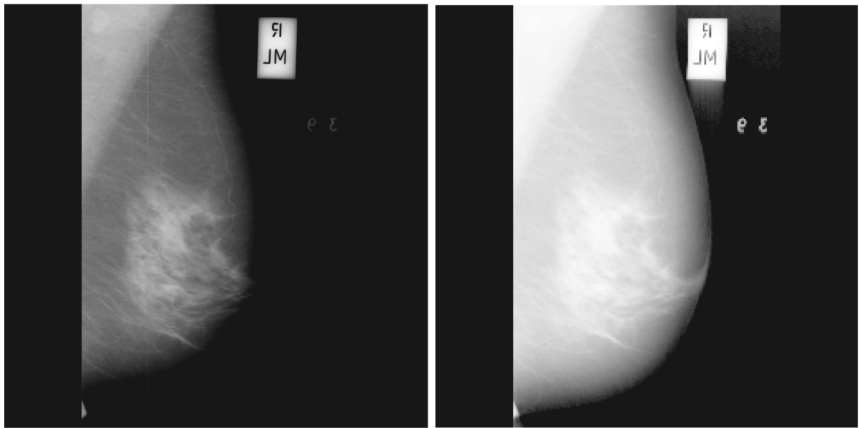
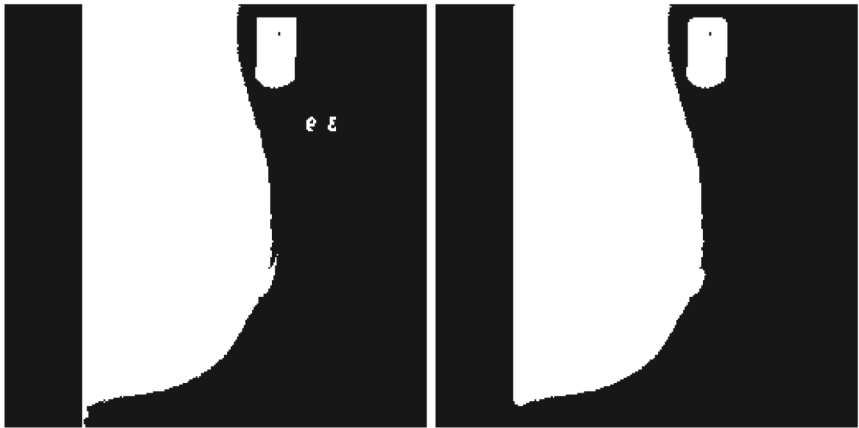


Figure 1. Flowchart of the procedures for identification of the skin-air boundary of the breast.



(a)

(b)



(c)

(d)

CHAPTER 5: DETECTION OF BREAST CONTOUR IN MAMMOGRAMS

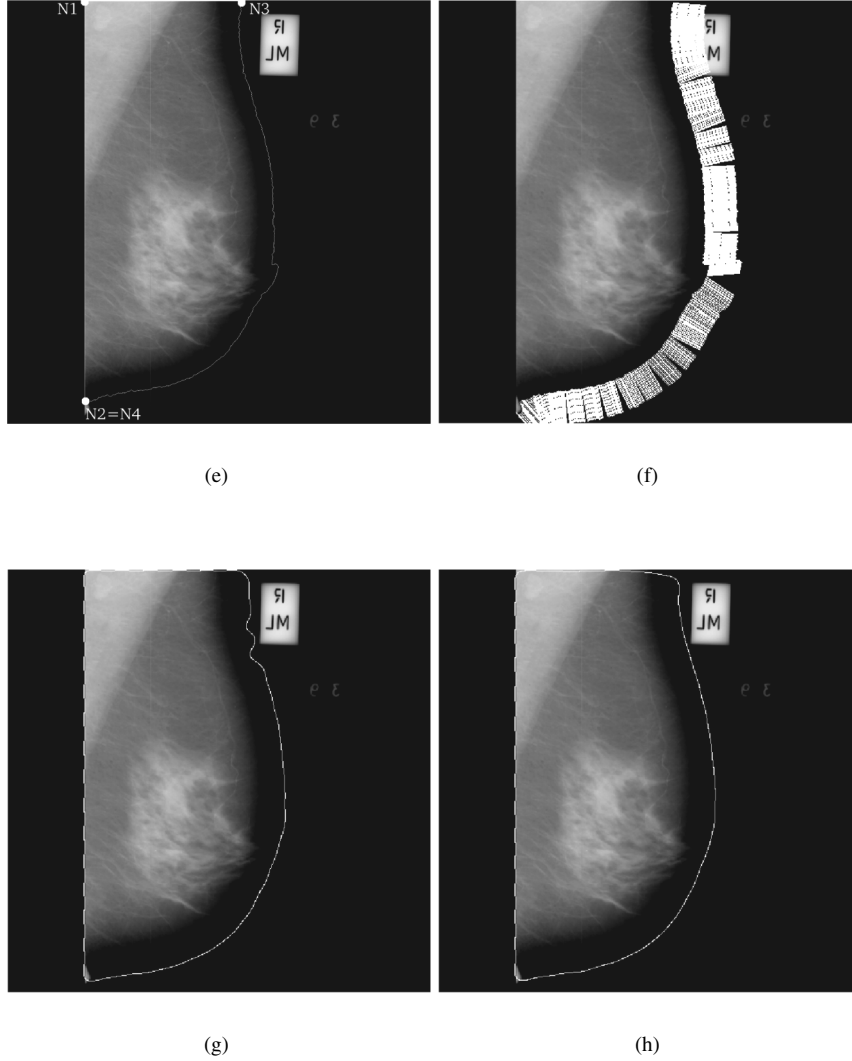
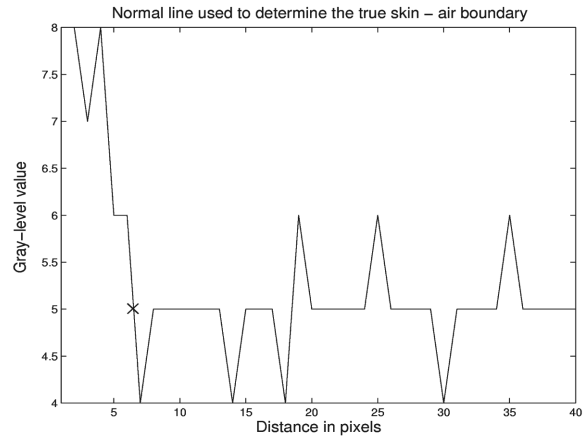
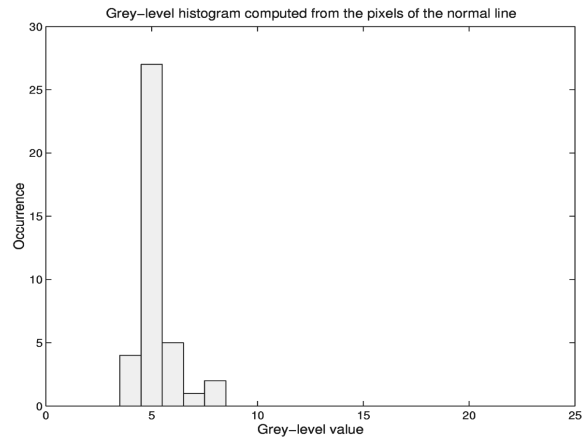


Figure 2. Results of each stage of Method 1 for identification of the breast boundary. (a) Original image mdb042 from the Mini-MIAS database [13]. (b) Image after the logarithmic operation. (c)–(d) Binary image before and after applying the binary morphological opening operator. (e) Control points N1 to N4 (automatically determined) used to limit the breast boundary. (f) Normal lines computed from each pixel in the skin–air boundary. (g) Boundary resulting after histogram-based analysis of the normal lines. (h) Final boundary.



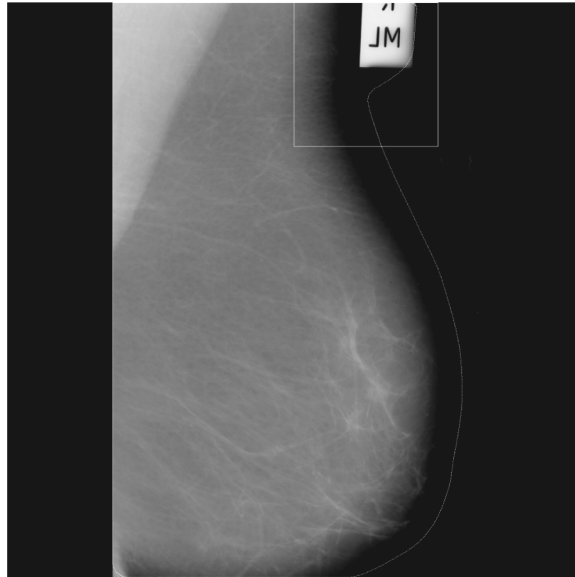
(a)



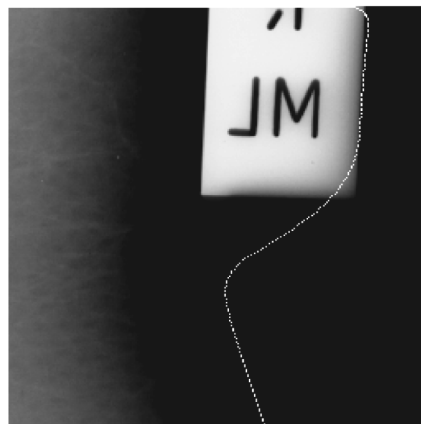
(b)

Figure 3. (a) Profile of a sample normal line used to determine an approximate skin–air boundary. The symbol “x” indicates the skin–air intersection determined in Stage 5. (b) Histogram computed from (a).

CHAPTER 5: DETECTION OF BREAST CONTOUR IN MAMMOGRAMS

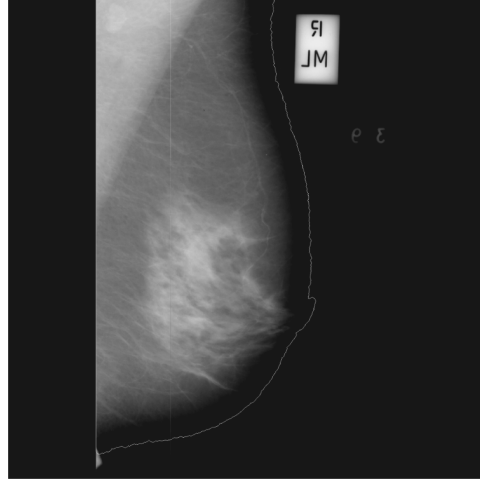


(a)

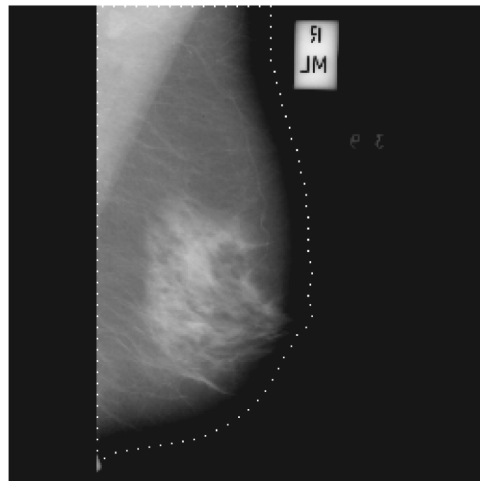


(b)

Figure 4. Result of the segmentation algorithm (Method 1) showing wrong convergence of the breast contour into a region of high gradient value. (a) The breast boundary detected automatically, superimposed on the original image (mdb006) from the Mini-MIAS database. (b) Details of the breast contour attracted to the image identification marker (corresponding to the boxed region in the original image).



(a)



(b)

Figure 5. (a) Approximate breast contour obtained from Stage 4 of Method 1, as described in Section 2, for image mdb042. (b) Sampled breast contour used as the input to the AADCM.

CHAPTER 5: DETECTION OF BREAST CONTOUR IN MAMMOGRAMS

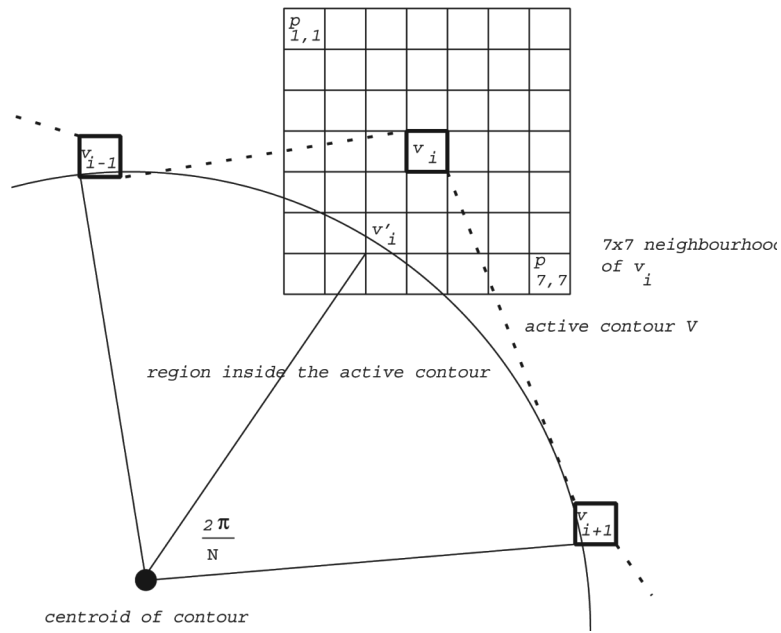
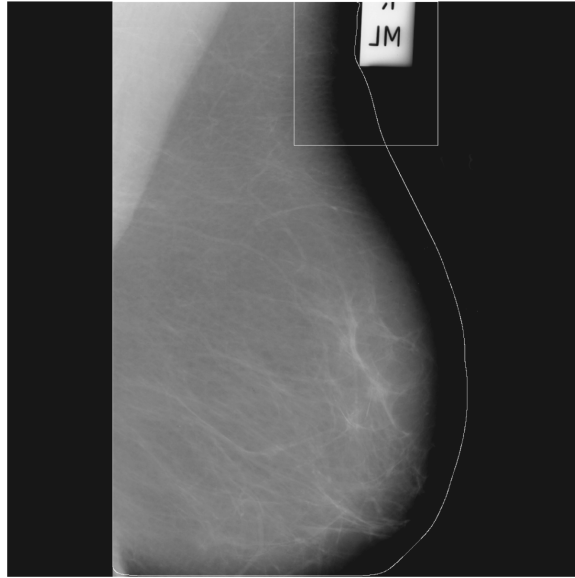
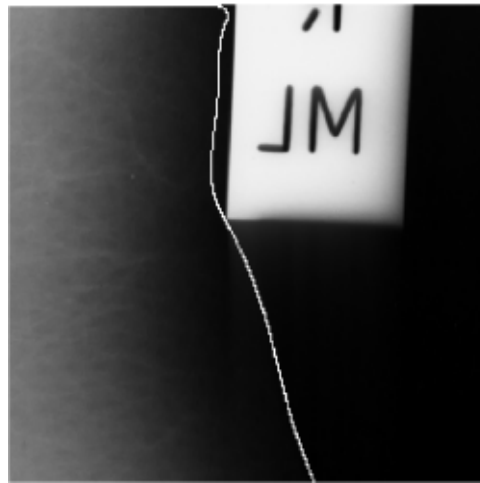


Figure 6. Characteristics of the continuity energy component in the adaptive active deformable contour model. The contour pixel, v_i , is moved to position v'_i by application of the continuity requirement. Adapted with permission from B Mackiewicz, JEL Desautels, RA Borges, AF Frère. 2004. Intracranial boundary detection and radio frequency correction in magnetic resonance images. *Med Biol Eng Comput* **42**(2):201–208. Copyright ©2004, The Institute of Engineering and Technology.



(a)



(b)

Figure 7. Application of the gradient direction information for avoiding attraction of the boundary to objects near the true boundary. (a) Breast boundary detected automatically, superimposed on the original image (mdb006) from the Mini-MIAS database. (b) Details of the detected breast boundary close to the image identification marker (corresponding to the boxed region in the original image).

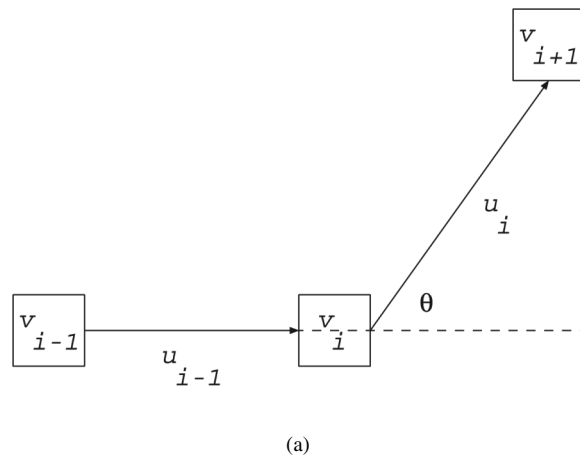
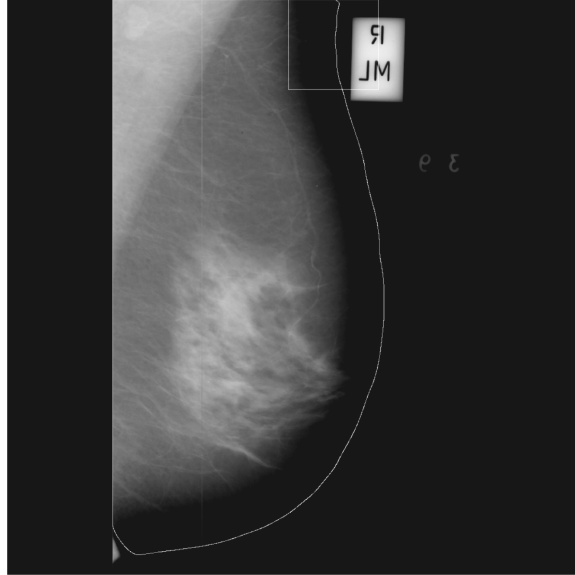
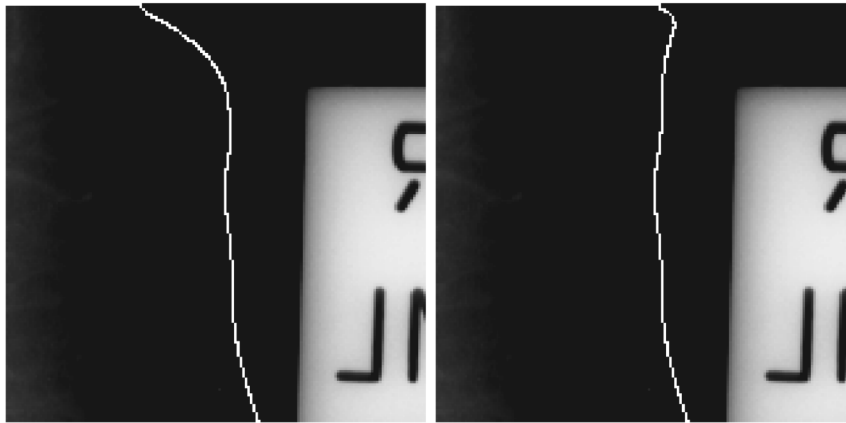


Figure 8. Illustration of the vectors and external angle used in Eq. (14) for calculation of curvature.



(a)



(b)

(c)

Figure 9. Example of the constraint used in the active contour model to correct smoothing effects at corners. (a) Original image; the box indicates the region of concern; (b,c) show the details of the breast contour, with and without the use of the constraint for corner correction, respectively.

CHAPTER 5: DETECTION OF BREAST CONTOUR IN MAMMOGRAMS

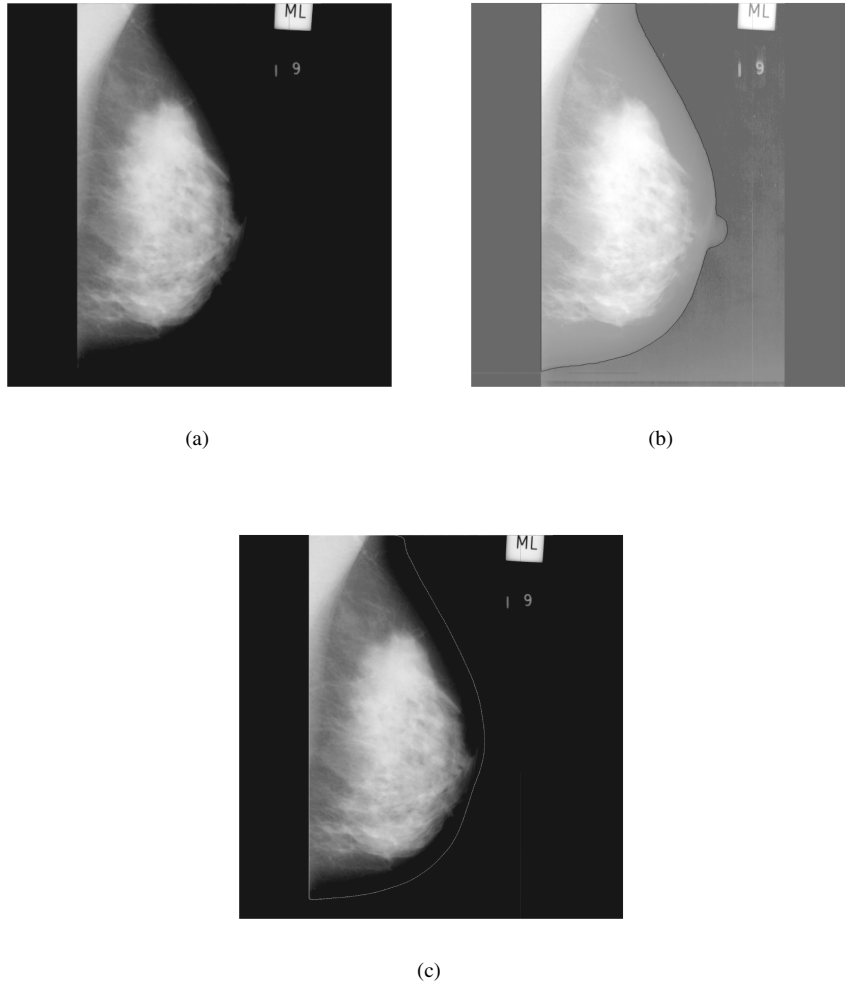


Figure 10. Results obtained for image mdb003. (a) Original image. (b) Hand-drawn boundary, superimposed on the histogram-equalized image. (c) Breast boundary detected automatically, superimposed on the original image.

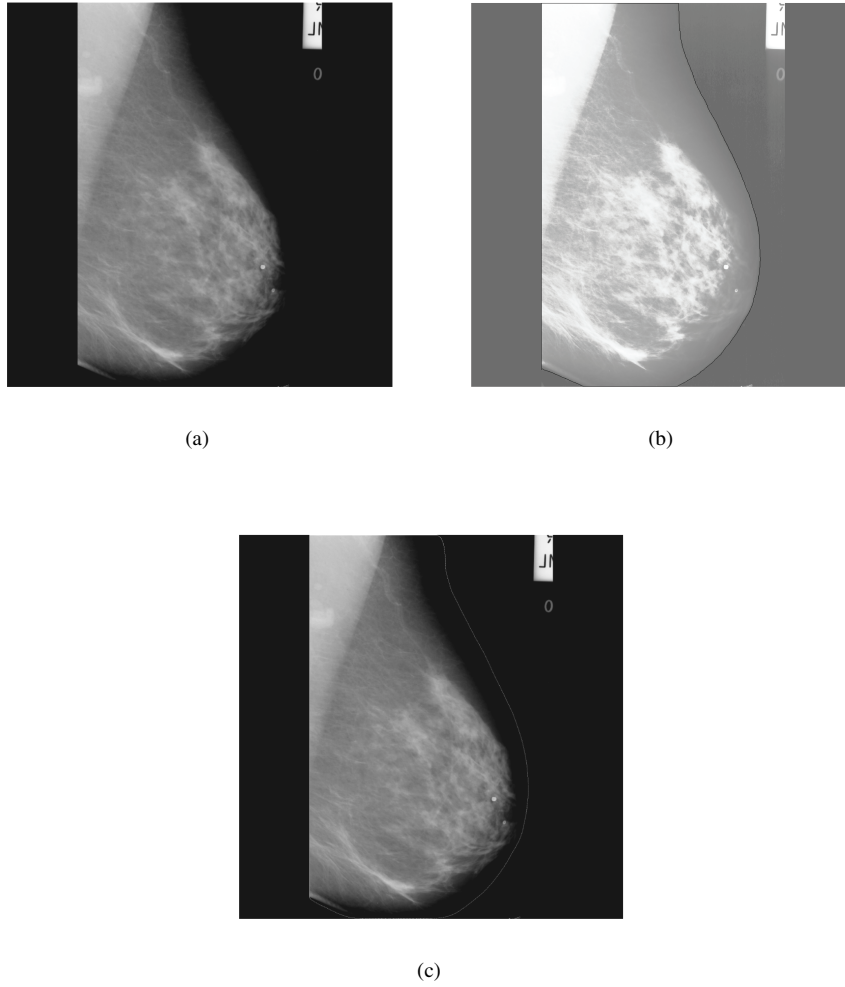


Figure 11. Results obtained for image mdb008. (a) Original image. (b) Hand-drawn boundary, superimposed on the histogram-equalized image. (c) Breast boundary detected automatically, superimposed on the original image.

CHAPTER 5: DETECTION OF BREAST CONTOUR IN MAMMOGRAMS

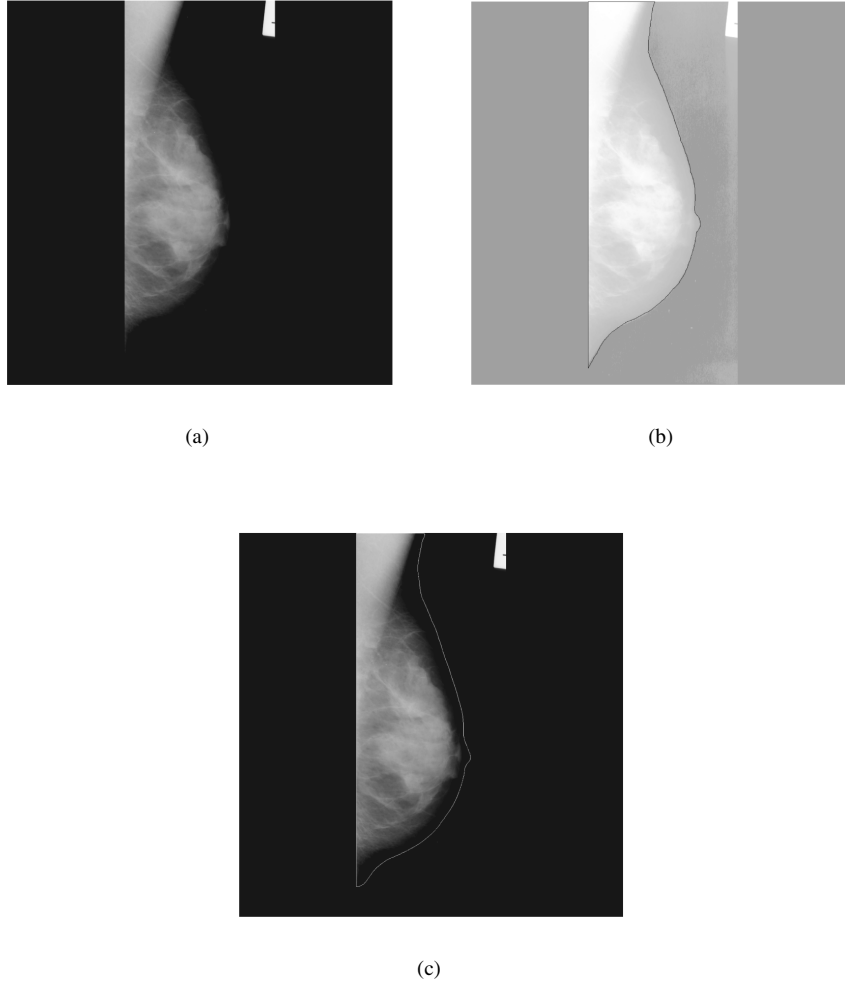
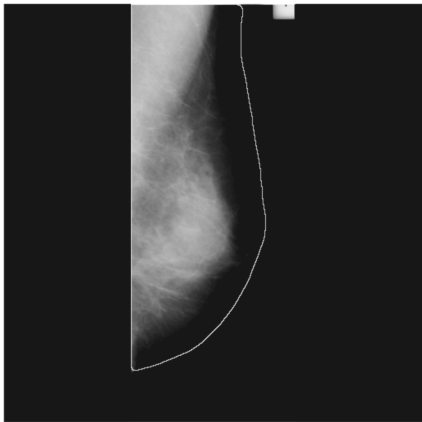
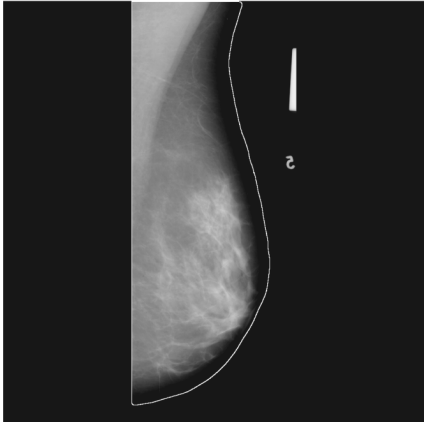


Figure 12. Results obtained for image mdb114. (a) Original image. (b) Hand-drawn boundary, superimposed on the histogram-equalized image. (c) Breast boundary detected automatically, superimposed on the original image.



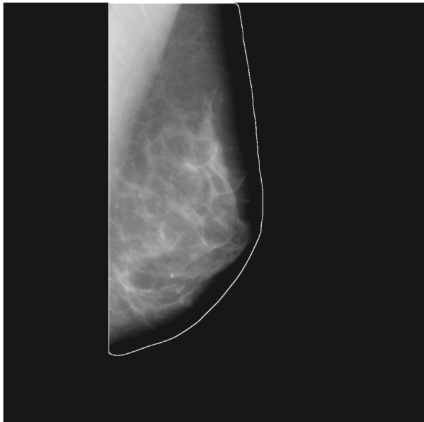
(a) mdb035



(b) mdb044

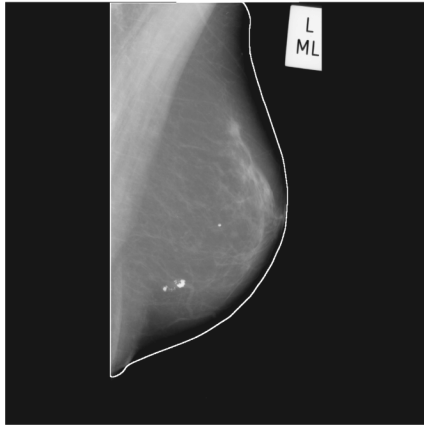


(c) mdb052

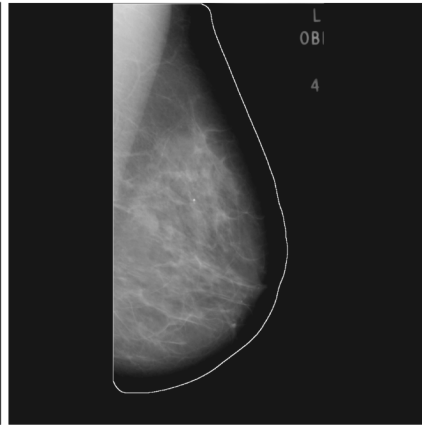


(d) mdb056

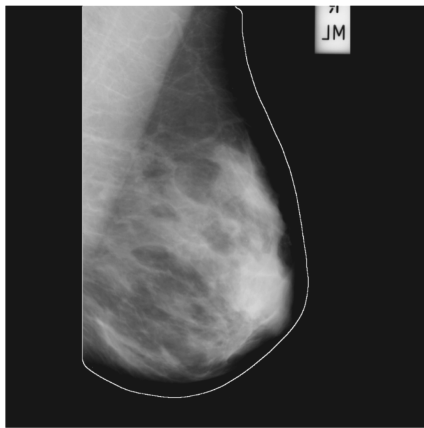
CHAPTER 5: DETECTION OF BREAST CONTOUR IN MAMMOGRAMS



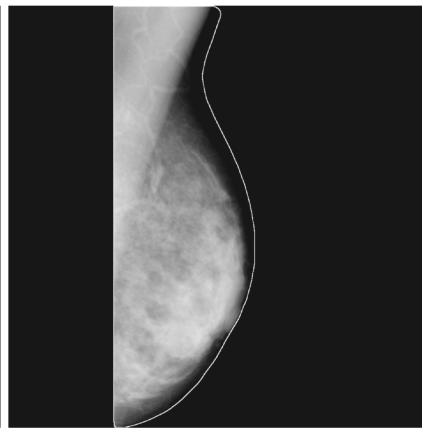
(e) mdb075



(f) mdb091

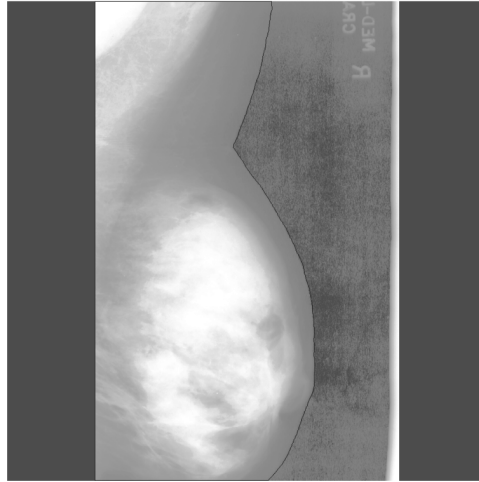


(g) mdb116

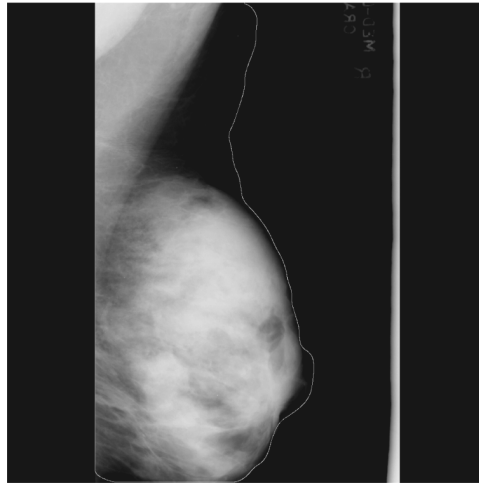


(h) mdb124

Figure 13. Results of segmented images from the Mini-MIAS database.



(a)



(b)

Figure 14. Image mdb068, presenting problems in segmentation of the breast boundary. (a) The hand-drawn boundary, superimposed on the histogram-equalized image. (b) Automatically detected boundary superimposed on the original image. The active contour has been attracted to a high-density region in the breast. Such problems may be solved by equalizing the image contrast before application of the method.