Anatomic Breast Coordinate System for Mammogram Analysis

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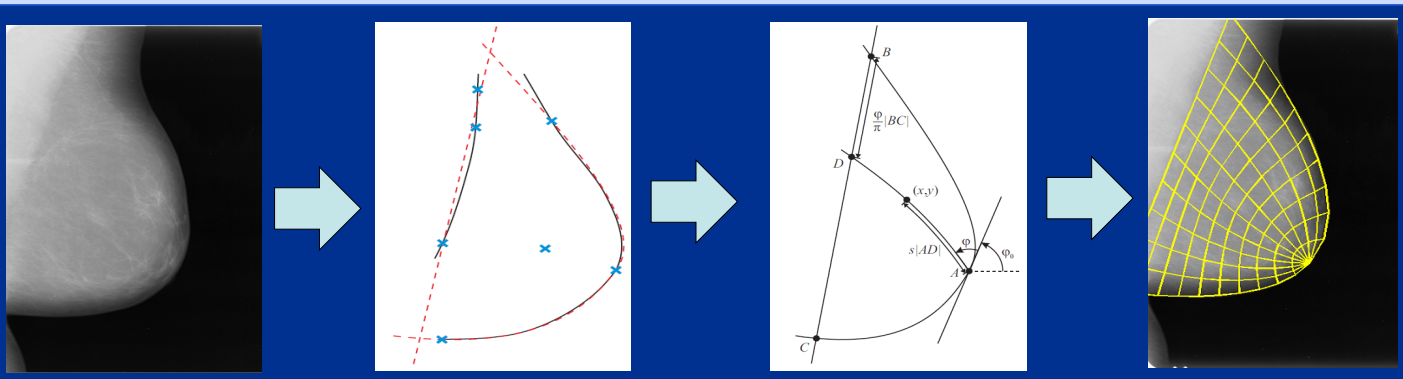
Background

Many researchers have investigated measures also other than density in the mammogram such as measures based on texture to improve breast cancer risk assessment. However, parenchymal texture characteristics are highly dependent on the orientation of vasculature structure and fibrous tissue inside the breast. Most of the risk assessment and CAD modules use a breast region in a image centered Cartesian x,y coordinate system. Nevertheless, anatomical structure follows curve-linear trajectories.

Objective

Design an anatomical breast coordinate system that preserves the anatomical correspondence between the mammograms and allows extracting not only the aligned position but also the orientation aligned with the anatomy of the breast tissue structure.

Construction of Breast Coordinate System



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

Fig. 1. Illustration of the breast coordinate system. (a) A mammogram (MLO view), (b) The parabolic breast boundary approximations are in this case computed from manually selected points defining the nipple, one point on each side of the breast boundary, and a point defining the breast boundary normal at the nipple; the pectoral line is fitted to manually selected points on the pectoral line. (c) The breast coordinates (s,φ) of the point (x, y) in the Cartesian coordinate frame are defined as the relative distance from the nipple along the parabolic line and the direction of the parabola at the nipple, respectively. The parabola is computed from the nipple point A, the direction angle at A, and the point D on the pectoral line, where |BD| = (φ/π)*|BC|. (d) The curves plotted on the images illustrate the breast coordinate lines s = 0.1, 0.2, . . . , 1 and φ =0, π /9, π 2/9, . . . , π.

Results

Coordinate system	Area under ROC
Cartesian (x,y)	0.61 (0.007)
Using proposed breast coordinate (s,φ)	0.64 (0.008)

Table 1: Performance of MTR scoring with traditional Cartesian coordinate and with proposed breast coordinate system measures for the cross-sectional study which includes mammograms (MLO view) of 245 patients diagnosed with breast cancer in the subsequent 2-4 years (123 interval and 122 screen detected cancers) and 250 matched controls. , data shown as AUC (SEM).

Registration techniques	Standard deviation in pixels	Median in pixels
Without registration	51	41
Sum of squared difference	41	31
Normalized correlation	48	36
Mutual information	51	42
Breast coordinate system	24	17

Table 2: Image registration accuracy by various image registration techniques in temporal study which includes 36 patients on placebo for 2 years follow-up. The curve-linear breast coordinate system provided the lowest registration dissimilarity measured compared to the other alignment methodologies

Conclusion

The curve-linear anatomical breast coordinate system facilitated computerized analysis of mammograms. The proposed coordinate system slightly improved the risk segregation by Mammographic Texture Resemblance and minimized the geometrical alignment error. Potentially this coordinate system may be used also for improving precision in CAD systems.

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