



AUTOMATED QUALITY ASSURANCE METRICS TO ASSESS ADEQUATE BREAST POSITIONING IN MAMMOGRAPHY

{ GERALD KOLB, KAIER WANG, ARIANE CHAN AND RALPH HIGHNAM } VOLPARA SOLUTIONS LTD



INTRODUCTION

Breast positioning is one of the key factors that can affect the performance of mammographic screening and is a leading cause of mammography units failing to get accreditation in the United States [1]. Optimal positioning can reduce unwanted artifacts and ensure that the maximum amount of breast tissue being included in the image.

OBJECTIVES

The aim of this study was to assess the performance of a novel algorithm for automated assessment of several breast positioning metrics from digital mammograms, by comparison to a visual clinical image review and automated breast volume estimates.

MATERIALS & METHODS

The dataset used to evaluate the breast positioning algorithm comprised of standard four-view mammographic studies (i.e left cranio-caudal (LCC), right CC (RCC), left mediolateral oblique (LMLO) and right MLO (RMLO)) from 23 women. The algorithm was run over the raw images to automatically assess the following metrics:

- The location of the nipple;
- That the length of the posterior nipple line (PNL) on the CC views was within 1 cm of that on the MLO views; and
- That the lower edge of the pectoral muscle on the MLO views was at or below the level of the nipple.

The results of the algorithm were visually assessed to determine its accuracy. Comparisons of the breast volume estimates between CC and MLO views and left and right breasts were used as a surrogate measure of the consistency in breast positioning.

CONCLUSION

Automated methods for assessing adequate breast positioning in mammography have the potential to improve the quality of mammographic images.

REFERENCES

[1] Popli, M. B., Teotia, R., Narang, M., & Krishna, H. (2014). Breast Positioning during Mammography: Mistakes to be Avoided. Breast Cancer: Basic and Clinical Research, 8, 119–124. doi:10.4137/BCBCR.S17617

CONTACT INFORMATION

Web www.volparasolutions.com

Email info@volparasolutions.com

Phone +1 855 607 0478

NIPPLE DETECTION ALGORITHM

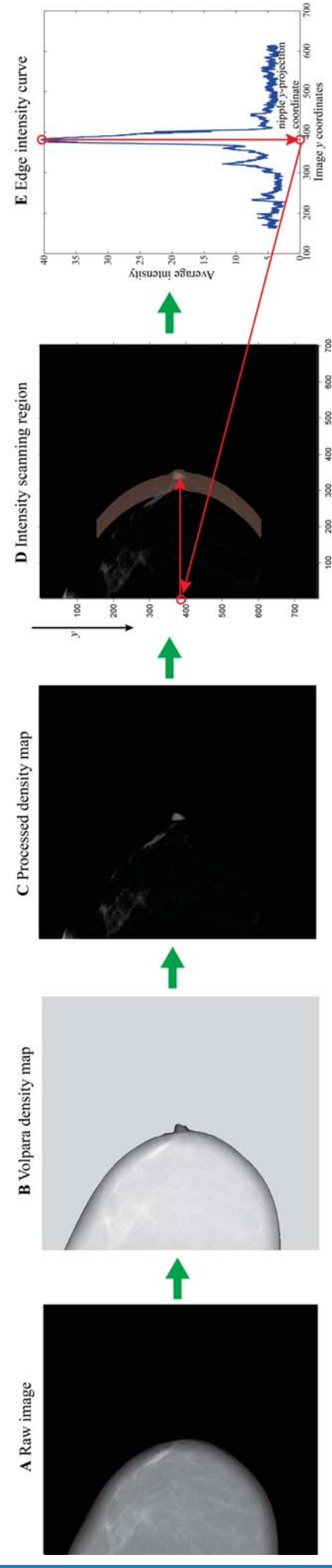


Figure 1: Procedure for nipple detection. **A** Raw mammogram image; **B** Volpara Algorithm™ processed density map indicating dense tissue height; **C** Morphological filter processed density map highlighting the nipple-object. **D** Extracting breast edge strip; **E** Average pixel intensity changes at the breast edge strip.

The initial nipple detection was carried out using the following methods:

- Volpara Algorithm™ was applied on the raw mammographic image to obtain a Volpara density map which contains the height of dense tissue at each image location. As the breast edge (which includes the nipple) does not contain fibroglandular (dense) tissue, the image is processed to separate the breast edge from the inner breast (see Fig. 1B, dark pixels describe the breast edge).
- The density map was then filtered by a morphological operation to highlight only the nipple object (see Fig. 1C).
- The breast edge area was extracted for nipple detection (see Fig. 1D).
- Scanning the edge strip downwards, its average pixel intensity evolution was analysed for a global maximum value, the *y*-coordinate of which corresponds to the nipple projection position on the breast edge (see Fig. 1E).

The detected nipple is served as a reference point for PNL length measurement.

RESULTS

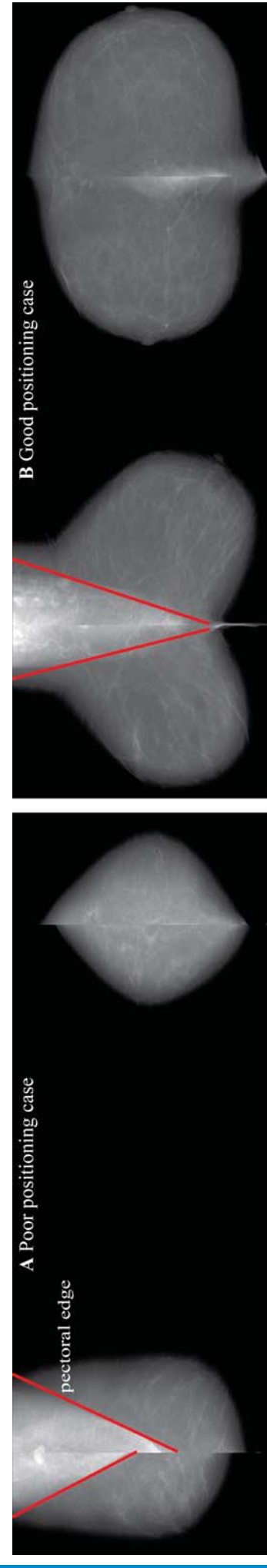


Figure 2: Mammographic examples showing **A** poor and **B** good positioning cases. The pectoral edge was identified by Volpara Algorithm™ (red line). The PNL was then measured as the perpendicular distance between the detected nipple and pectoral edge. Case **A** is judged by its: missing infra-mammary fold; insufficient pectoral muscle shown in MLO; PNL length-difference between CC and MLO over 1 cm; asymmetric left and breast views.

The algorithm was able to correctly detect the location of the nipple. The PNL distances for each set of corresponding CC and MLO views were within our 1 cm criteria for 23/46 sets. Including only sets where the MLO view was considered to be well-positioned, the PNL distances were within 1 cm for 17/23 sets. In 14/46 MLO views it was determined that imaging of the pectoral muscle was inadequate (see an example in Fig. 2). Pearson correlation coefficients between the breast volumes for the LCC versus RMLO, LMLO versus RCC, CC vs MLO views, and left versus right breasts were 0.9078, 0.9534, 0.9539 and 0.9538, respectively. Furthermore, results from the positioning metrics were significantly correlated with breast volume estimates. The average breast volume ratio between CC and MLO views for images with good positioning based on our automated methods was 6.14% ($p = 0.0475$) larger than the average ratio for images judged to be poorly positioned. These results indicate that automated positioning metrics can predict the risk of posterior tissue being excluded from the image.