Assessing breast density changes over time

Poster No.: C-1770
Congress: ECR 2013
Type: Scientific Exhibit
Authors: X. Lin, N. Sauber, R. Highnam; Wellington/NZ
Keywords: Computer Applications-Detection, diagnosis, Imaging sequences, Mammography, Breast, Screening, Cancer, Quality assurance
DOI: 10.1594/ecr2013/C-1770

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Purpose

Breast density is known to be a significant predictor of breast cancer risk, with studies reporting up to a 6-fold increase in the risk of developing cancer in women with very dense breasts compared to women with very fatty breasts [1-3]. In addition to single timepoint assessments of breast density, studies have now suggested that abnormal changes in breast density over time could also be associated with an increased risk of developing breast cancer [4, 5]. As an example, Vachon et al (2010) found that breast cancer risk was reduced by 28% for women whose breast density decreased by at least one BI-RADS category over approximately 6 years, compared to women who experienced no change.

In addition to predicting breast cancer development, temporal changes in breast density may also be useful in judging the effects of age, body mass index (BMI), and menopause on the breast, as well as assessing the effectiveness or otherwise of certain drugs. For example, hormonal replacement therapies (HRT) and endocrine therapies (e.g. tamoxifen) have also been shown to increase and decrease breast density, respectively [6, 7]. Temporal changes in breast density could potentially be used to stop the drug treatment if it's having an adverse effect on density [6, 8, 9].

To date, no efficient method has been identified that can objectively assess temporal changes in breast density. Limitations associated with current methods include intra- and inter-reader variability, which is made even more difficult by the inherent differences in the "For Presentation" mammographic images generated on different vendor x-ray machines. In this paper, a novel, objective method for transforming sequential mammograms into temporal density movies is introduced, which addresses some of these issues.
Methods and Materials

Digital mammography: For Processing and For Presentation data

Digital mammography generates two types of images. The "For Processing" (Raw) images are acquired from the imaging sensor when a mammogram is taken and the pixel value is related directly to x-ray attenuation. The "For Presentation" (Processed) images are generated using each manufacturer's own proprietary processing algorithms, which essentially enhance the features of the raw mammogram (e.g. contrast) for easier viewing by radiologists but lose any quantitative data associated with the raw image. In this paper, we demonstrate how viewing "For Presentation" mammograms over-time is far from ideal and how viewing the quantitative information inherent in the "For Processing" image is far superior for detecting change over time.

Consistency of automated density measurements across different x-ray vendors using Volpara™

Volpara™ is an automated, objective volumetric breast density assessment system that is also FDA cleared to report a BI-RADS density score. A by-product of the Volpara processing is the generation of a "density map" in which each pixel value is set to represent the breast density between that pixel and the x-ray source. So, for example, a higher pixel value represents a higher breast density. The idea is that by viewing those "quantitative" images over time as a movie, the eye will pick up the changes in densities that are occurring.

Of course, it is by no means certain that a woman will be imaged on the same x-ray machine each time she visits a clinic. Thus, our first task was to assess the ability of Volpara™ to produce consistent density measurements, using mammograms taken from the same woman, imaged on different imaging systems.

Using datasets of mammographic images from US sites, we obtained:

(A) 105 cases where a woman had craniocaudal (CC) and mediolateral oblique (MLO) mammograms taken of both breasts, on either a GE or Hologic x-ray system. The women in this dataset ranged in age from 40-93 years and the median age was 61 years. The sequential mammograms were taken one (102/103 women) or two years (3/103 women) apart.

(B) 18 cases where women were imaged sequentially on either Fuji CR or Fuji DR systems were also obtained with CC and MLO views of each breast taken.
The "For Processing" images for all cases were run through Volpara™ to obtain average volumetric breast densities for each timepoint. A Pearson correlation co-efficient was then obtained for each dataset, to assess the agreement between mammograms from the same woman on different vendors' x-ray systems.

Transformation of Volpara™ density maps into temporal movies

The temporal analysis process is to make density maps, from mammograms taken over multiple years, more comparable when appended into a movie for visual presentation. Density maps were generated, by Volpara™, for the left and right CC mammograms from 12 women, screened every year over a 4-8 year period, on a mix of GE, Hologic and Siemens x-ray units. Temporal movies were made of the density maps (as described below) and, for comparison, of the "For Presentation" images.

In order to avoid introducing distracting deformation to the density maps, we set up image pairs by mapping each previous density map to the latest one. The mapping process for each pair includes two steps, which starts with a feature based image registration followed by a pixel based image registration. For the pre-processing feature based registration, a robust method was developed to identify corresponding landmarks and boundaries on the density map pair to be registered (for example, nipples, axilla or rib points, breast contours etc.). Pixel based registration was then used to improve the texture matching inside the breasts. Texture mapping was constrained within a limit distance to avoid false deformation. After the two-step image registrations, the corresponding dense tissues in the breasts were very close to each other, facilitating the visualization of any density changes over time.
Results

Volpara™ generates consistent results across different x-ray vendors

We observed consistent volumetric breast density measurements, as determined by Volpara™, from mammograms taken on the same woman using different x-ray systems (see Figure 1). A 0.940 and 0.974 correlation was observed using Volpara™ on the Hologic and GE, and Fuji CR and Fuji DR datasets, respectively. Given that the images were taken at different timepoints, some genuine variation should be expected.

Volpara™ generated density maps

The density maps generated by Volpara™ provided us with an excellent tool for the analysis of dense tissue changing over time, as they essentially standardized mammograms taken on different x-ray machines. "For Presentation" images are variable due to different processing algorithms used by each x-ray vendor. A single case was selected to illustrate the difficulties in using the "For Presentation" mammograms for temporal studies. We have shown the "For presentation" mammograms (Figure 2) and the Volpara™ density maps (Figure 3) from a woman who had yearly mammograms taken over eight years, on a combination of GE, Hologic and Siemens x-ray systems. The accompanying graphs showing the volumetric breast densities over time clearly do not correspond well visually, to the "For Presentation" mammograms. In contrast, using the Volpara™ density maps clearly showed the decrease in density as this particular woman aged.

Temporal movies

Using the same example case as above, two movies were generated by appending either the eight density maps (Figure 4) or the eight "For Presentation" images (Figure 5). The normalization and image mapping processes worked extremely well and is evident in the temporal movie of our density map. The contrast levels in the mammograms are consistent, even across multiple x-ray systems, and the image mapping processing effectively aligned the appearance of each breast in the sequential mammograms. One can also clearly see the impact of using "For Presentation" mammograms without any prior modification on assessing changes in density. Three radiologists independently confirmed that our temporal density maps offer an easier and more accurate assessment of breast density changes.
Fig. 1: Volumetric breast densities (VBDs) were calculated by Volpara™ for mammograms taken on different x-ray systems. Datapoints represent the VBDs from women who had sequential mammographic images taken (one-two years apart) using different vendor x-ray systems, i.e. either GE and Hologic (A) or Fuji CR and Fuji DR x-ray systems (B). A Pearson correlation co-efficient is presented for each dataset and the identity lines (dashed) provided as a reference.

© - Wellington/NZ
**Fig. 2:** The "For Presentation" images (left CC views) for the same woman imaged over eight years on different x-ray systems (i.e. GE: GE healthcare; SM: Siemens; HX: Hologic). The volumetric breast density changes over time have also been graphed and demonstrate that temporal density changes are very hard to assess using the "For Presentation" mammograms.

© - Wellington/NZ

![Images of mammograms and density maps over time]

**Fig. 3:** The density maps (left CC views) for the same woman imaged over eight years on different x-ray systems (i.e. GE: GE healthcare; SM: Siemens; HX: Hologic). The volumetric breast density changes over time correspond well to the visual changes seen in the density maps. It is much easier to see from these density maps that the density is decreasing with age.

© - Wellington/NZ
Fig. 4: A movie showing the temporal breast density changes for a woman who had mammograms taken over eight years on different x-ray systems. The "For Processing" images (CC views) were first run through Volpara™ to generate density maps of each mammogram. A two-step image registration method was used to modify the density maps and improve the superimposition of the breast in each sequential mammogram.

© - Wellington/NZ
**Fig. 5:** A movie showing the temporal breast density changes for a woman who had mammograms taken over eight years on different x-ray systems. The "For Presentation" mammograms (CC views) were generated using each manufacturers own processing algorithms. These images were appended into a movie without any prior modification.

© - Wellington/NZ
Conclusion

Our results demonstrated a high level of agreement between sequential mammograms taken on Hologic and GE, or Fuji CR and Fuji DR systems using Volpara™ and support the use of the software for determining temporal changes in breast density.

Density maps generated from the "For Processing" images standardizes the mammograms from different vendors, allowing for a better judgement of temporal changes. A comparison of our temporal density map movie with the movie using the "For Presentation" mammograms emphasizes how important it is to normalize the images first, to take into account the different processing algorithms of each vendor. It also highlights the benefits of applying image registration and feature mapping methods before appending sequential mammograms into a temporal movie. The pixel mapping normalizes the breast sizes and positioning on the mammogram, and also allows them to be overlayed for the movies.

Breast density is one of the few modifiable breast cancer risk factors and several studies have now drawn attention to the potential clinical applications of accurately tracking changes in breast density over time [4, 6, 9]. However, the "For Presentation" images that radiologists use to assess breast density are not reliable for monitoring changes over time. We have outlined an objective method for transforming sequential mammogram images into temporal movies, which can be used on any digital mammographic images regardless of the x-ray system used, or the imaging conditions.
Fig. 4: A movie showing the temporal breast density changes for a woman who had mammograms taken over eight years on different x-ray systems. The “For Processing” images (CC views) were first run through Volpara™ to generate density maps of each mammogram. A two-step image registration method was used to modify the density maps and improve the superimposition of the breast in each sequential mammogram.

© - Wellington/NZ
Fig. 5: A movie showing the temporal breast density changes for a woman who had mammograms taken over eight years on different x-ray systems. The "For Presentation" mammograms (CC views) were generated using each manufacturers own processing algorithms. These images were appended into a movie without any prior modification.

© - Wellington/NZ
References

Personal Information

Xiang Lin PhD, Matakina Technology Ltd, Wellington, New Zealand; shane.lin@matakina.com

Natascha Sauber, Matakina Technology Ltd, Wellington, New Zealand; natascha.sauber@matakina.com

Ralph Highnam PhD, Matakina Technology Ltd, Wellington, New Zealand; ralph.highnam@volparadensity.com