CAD system using case-based information

Poster No.: C-2201

Congress: ECR 2013

Type: Scientific Exhibit

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Keywords: Cancer, CAD, Mammography, Breast

DOI: 10.1594/ecr2013/C-2201

Purpose

Breast cancer is considered one of the most frequent tumor in women. However, an early detection considerably increases the life expectancy. So, a key point in the fight against this type of disease is to achieve its detection in early stages.

Computer Aided Detection (CAD) mammographic systems are automatic or semi-automatic software tools developed to assist radiologists in breast cancer detection. Nowadays, CAD mammographic systems are starting to be integrated into clinical workflow in hospitals and these systems are becoming part of the cancer diagnosis process. The success is, in part, due to the past and ongoing efforts on research and development of CAD systems[1].

The purpose of this work is to present a mass detection multi-image CAD system that uses bilateral, temporal and ipsilateral comparison of mammograms within each patient (Fig. 1 on page 2). The idea of adding this additional information from different views is based on the workflow of the radiologists, that compare different views of the same patient when reading mammograms.

Images for this section:

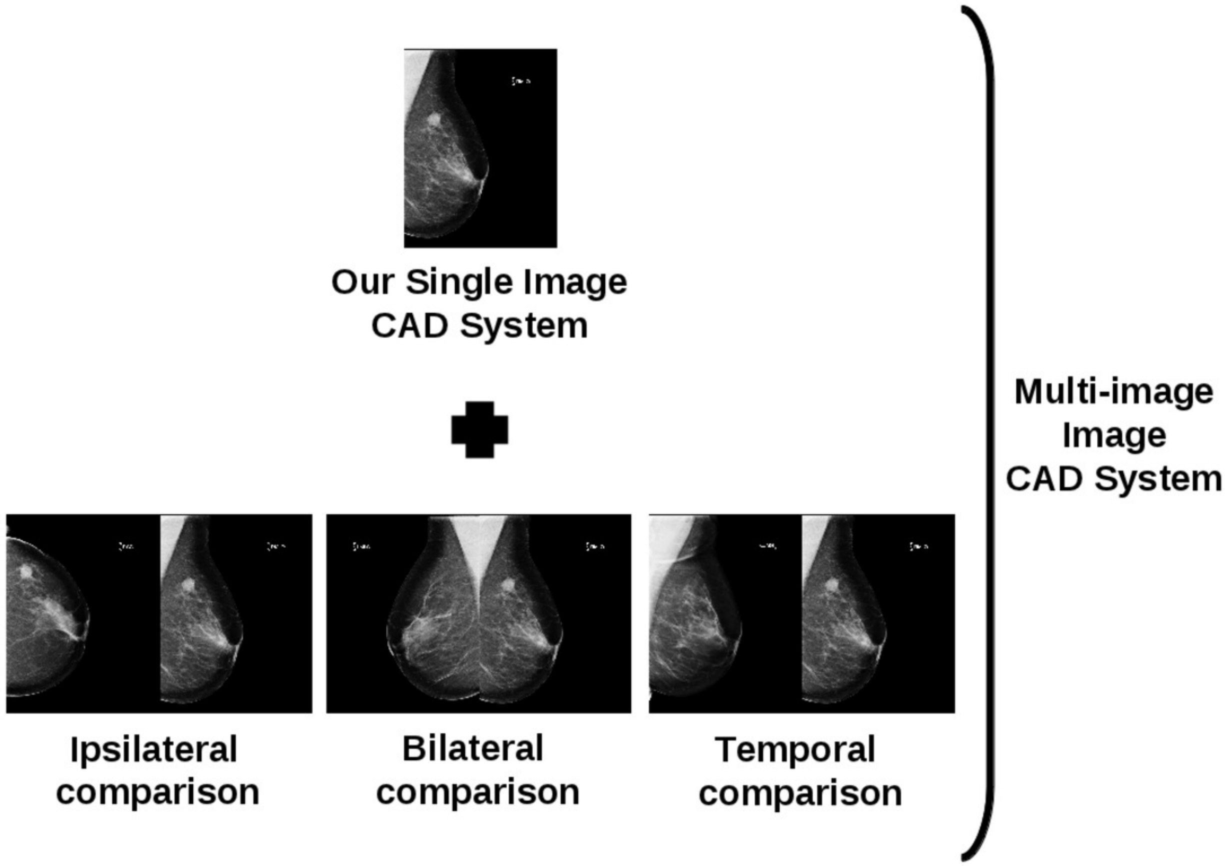

Fig. 1: Layout of the purpose.

Methods and Materials

We have developed a model-based multi-image CAD system for mass detection for full-field digital mammograms extending a single-image CAD system to use bilateral, temporal and ipsilateral information. The single-image CAD system [2] is divided into two blocks: detection and false positive reduction. First, in the detection stage, the system learns the morphology of the lesions from a training set of real masses and uses this information to create a set of mass templates and their possible deformations. Afterwards, these templates and their deformations are used in a probabilistic matching schema yielding a set of suspicious regions. Finally, in the false positive reduction stage, the system is trained to distinguish between lesion and normal tissue, so the suspicious regions considered as normal tissue are deleted and only the ones considered as real masses are kept.

The multi-image CAD system is developed including information from the automatic registration of bilateral and temporal mammographic images and from the automatic correspondence between ipsilateral mammographic images (Fig. 2 on page 5). On one hand, the comparison between bilateral and temporal mammograms is integrated into the probabilistic CAD detection framework as a priori information [3,4]. On the other hand, the correspondence between ipsilateral mammograms is integrated into the CAD false positive reduction framework as a posteriori information [5].

Bilateral and temporal comparison:

Image registration is used in order to detect differences between bilateral and temporal images that could be due to the development of lesions.

Specifically, before the detection starts, a registration algorithm combining two intensity-based methods is applied. We use an affine transformation to recover the main pose and scaling differences and a B-Splines registration method for localized non-linear deformations. Once the images are aligned, the difference between the registered and the fixed images is calculated. Subtraction image is multiplied with the original image, therefore similar structures are darkened, while regions with different structures are highlighted. To avoid adding noise to our CAD system, only the most significant differences are used to enhance the image that contains the lesion [6].

Ipsilateral comparison:

With the aim of reducing the number of false positives, we propose to take advantage of the correspondence between CranioCaudal (CC) and MedioLateralOblique (MLO) views. The suspicious lesions with no ipsilateral correspondence are considered as less probable to be real lesions than the ones with positive correspondence.

Detection is applied to CC and MLO images independently. After detection, a CC/MLO correspondence approach based on using curved epipolar lines [7] is applied over each suspicious region in CC. Given a point in the CC mammogramm, its corresponding line in the MLO view is calculated through simulation of the deformation and the projection of a 3D line corresponding to the point. If a lesion is detected in the MLO view and is situated along the epipolar line, the suspicious region in CC is considered as a true lesion.

Images for this section:

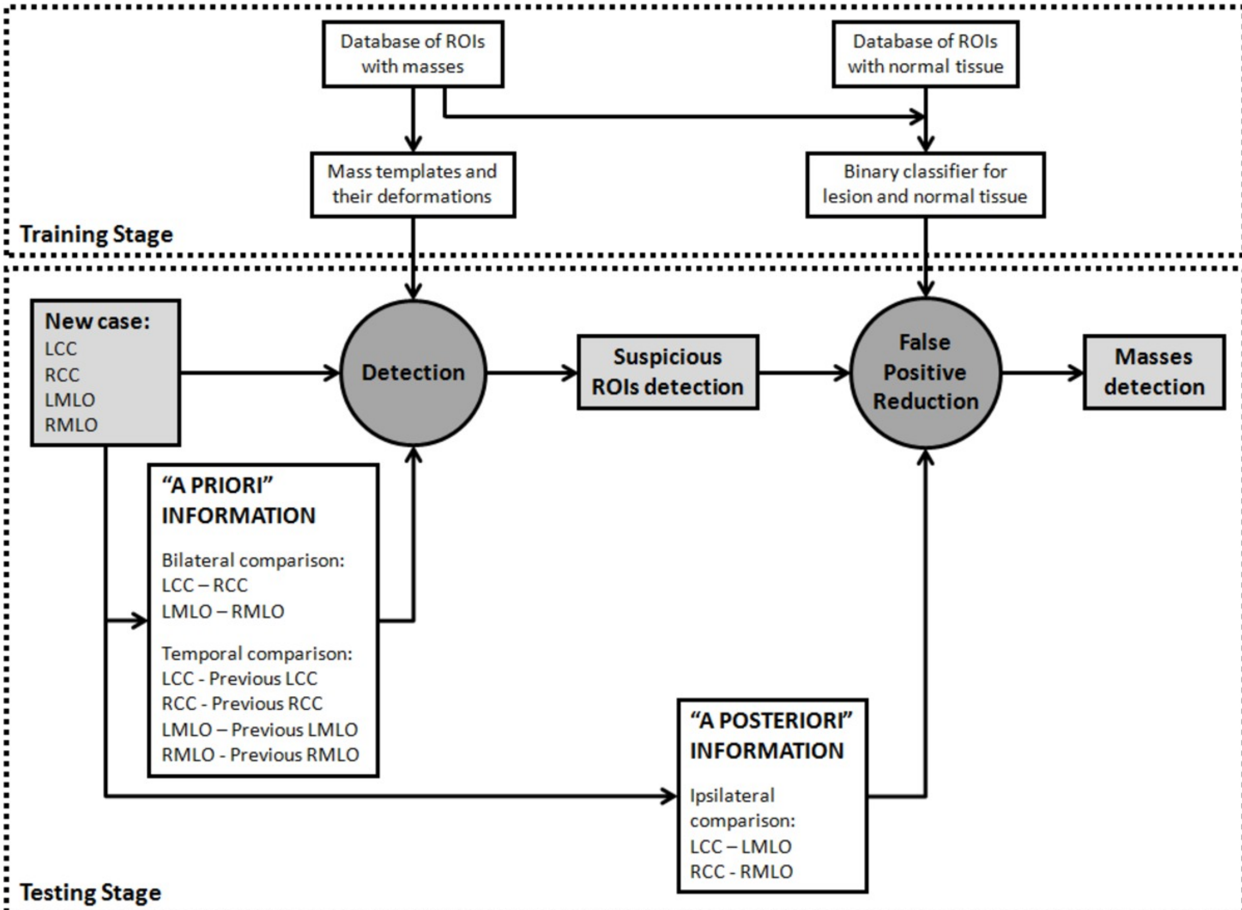

Fig. 2: Proposed multi-image CAD system for mass detection in digital mammograms.

Results

To evaluate the preliminary performance of the multi-image CAD system, a set of 74 cases containing masses from our full-field digital database is used. Each case contains all available acquired mammograms of a patient. A total of 47 cases contain temporal images.

The evaluation of our experiments is done by comparing the detection results of our CAD system when using or not bilateral and temporal information and by comparing the reduction of the number of false positives when adding ipsilateral information.

Initial results indicate benefits of including bilateral information in contrast with our previous developed single-image CAD system (Fig. 3 on page 6). Detection sensitivity is improved by a factor of 10% (from 0.76 to 0.83). Using bilateral information, the main detection errors are found in subtle masses in extremely dense breasts where difference image is not able to highlight the lesion. Regarding temporal information, using only the 47 temporal cases, detection does not significantly improve (sensitivity around 85% with both systems). Simple image subtraction is able to emphasize the lesion when the mass is not present in previous studies, similar to bilateral cases. When current and previous images contain a mass, lesion changes are subtle and can be obfuscated by the changes in the overall structure breast (i.e. dense tissue decrease) or acquisition parameters. In ipsilateral comparison, an accurate correspondence between regions of interest is obtained, as seen in Fig. 4 on page 7, however, further investigation is needed in order to obtain conclusive results about false positive reduction.

Images for this section:

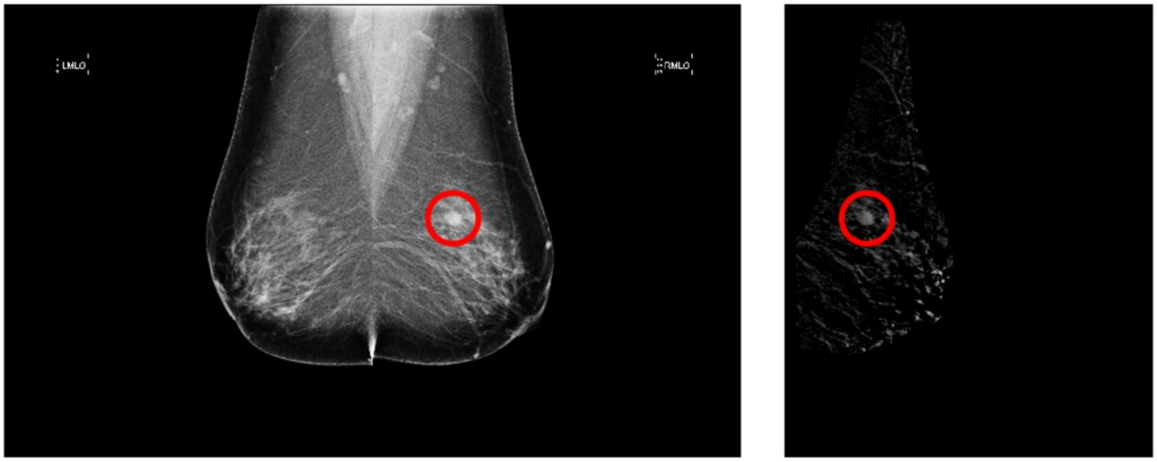

Fig. 3: Example of mass detected only by multi-image CAD system. Bilateral mammograms and difference image.

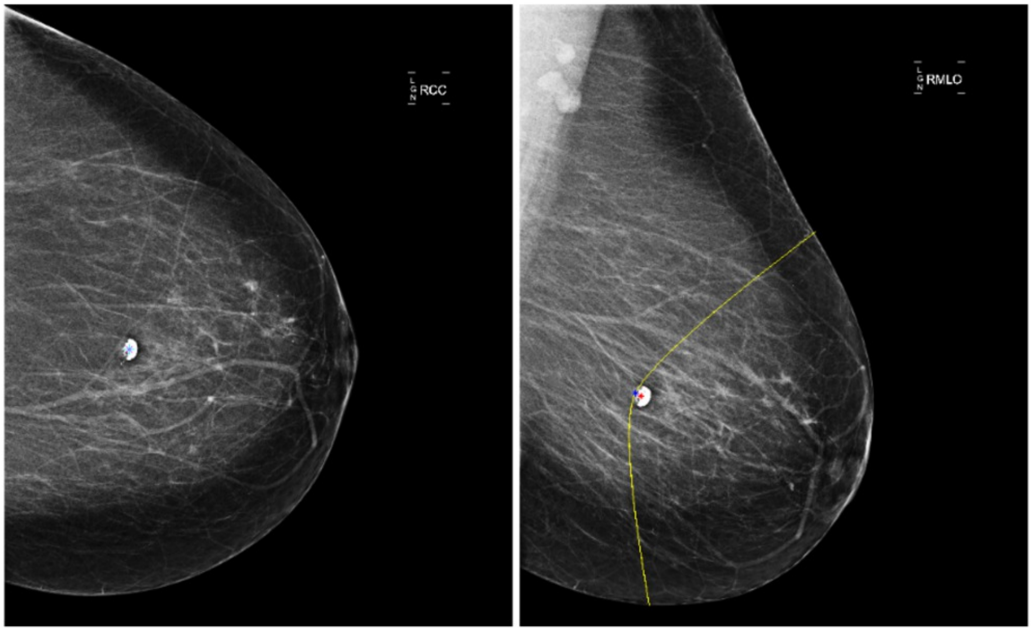

Fig. 4: Example of CC/MLO correspondence.

Conclusion

We integrate bilateral, temporal and ipsilateral information into our previously developed single-image CAD system. According to the obtained results, the introduction of the bilateral information as a priori information can be seen as an improvement of our single-image CAD system. We are currently investigating the use of other intensity-based registration methods [8] and also other image similarity measures like the average norm or the maximum norm of the deformation fields in order to add useful temporal information to our CAD system. Regarding ipsilateral information, our current work is focused on testing our system with a larger number of cases to extract conclusive results.

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