Looking for abnormalities using asymmetrical information from bilateral mammograms

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Abstract

Radiologists commonly compare the bilateral mammograms to detect asymmetric abnormalities. While fibroglandular tissue is normally quite symmetrically distributed, lesions in one breast and will only rarely have a counterpart in the corresponding area of the opposite breast. Motivated by this experience, we explore a model that can learn to detect asymmetrical information from bilateral mammograms and then find the abnormal areas, similar to what a radiologist does. This can increase model performance and interpretability. We evaluate the proposed methods on the popular INBreast dataset and show improved performance in abnormal classification and weakly supervised segmentation tasks.

Keywords: Bilateral mammogram, asymmetry attention, breast cancer.

1. Introduction

Millions of mammograms are generated in population-based screening programs each year worldwide. Most of the images are from a healthy population. Between 2-10% of women are recalled, and between 1 and 3% are recommended to undergo a biopsy because of the abnormal findings. A large number of studies have utilized state-of-the-art deep learning (DL) methods help to reduce workload and improve the radiologists' performance in adequately detecting breast cancer in this vast amount of screening images. However, most of these models only focus on a single image and ignore the symmetry information that can be very useful when looking for abnormalities. Moreover, many DL models lack the ability to explain the cause of their decision.

In clinical practice, radiologists routinely identify the abnormalities through bilateral analysis of paired mammograms. One important mammographic assessment is "Anatomical Symmetry", which has been authenticated by BI-RADS standard of American College of Radiology (Wang et al., 2021). It indicates that the glandular pattern in the bilateral breast of healthy people is roughly symmetrical. In contrast, most lesions appear only on one side, and even when lesions appear on both sides, they are rarely in symmetrical positions. Inspired by such prior knowledge, we explore training a dual-view (DV) DL model to learn to identify asymmetric structures from bilateral mammograms. As a result, the model can inference like a radiologist, looking for abnormalities by identifying asymmetries in bilateral mammograms.

2. Materials and Method

In this work, we propose a DL based model with asymmetry attention (ASY) and focus on identifying the healthy and abnormal population to reduce the workload for radiologists. Furthermore, instead of pre-processing paired bilateral images by registration, we used supervised contrastive (SupCon) loss (Khosla et al., 2020) to constrain the model to learn the corresponding area mapping from paired bilateral views in an end-to-end manner. To improve the explanation of the diagnosis by the model efficiently and localize the abnormalities, we also provide an online Class-activation map (CAM) (Ouyang et al., 2020) module to produce gradient-based attention for highlighting asymmetrical and abnormality areas.

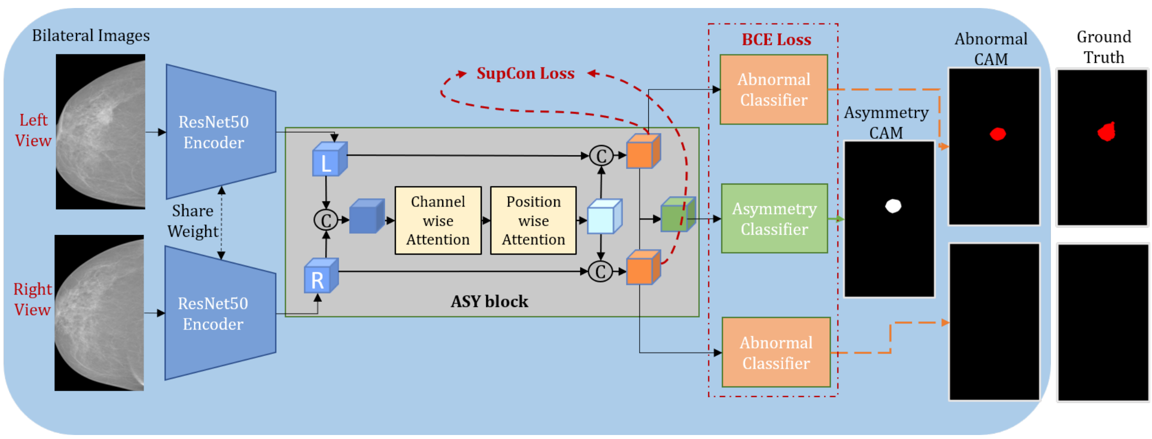

Figure 1: The schematic overview of the proposed method with a example of CAM results

We evaluate our model on the public INBreast dataset (Moreira et al., 2012) which has 115 cases and also provides BI-RADS labels and pixel-wised ground truth for both masses and calcifications. All paired bilateral images were selected, and were randomly divided into training set, validate set and test set with a ratio of 6/2/2. To demonstrate the generalization ability of our proposed method, two settings were considered: only identify the mass abnormalities (BI-RADS > 1 with masses) and identify mixed abnormalities (also BI-RADS > 1, including masses and calcifications). Our framework is illustrated in Figure 1. First, we input paired bilateral images to two weights shared ResNet50 (without final pooling and linear) and link to an asymmetry attention (ASY) block which includes channel-wise and a position-wise attention. Then the attentioned bilateral features are constrained by SupCon loss. Specifically, we define a pair of images from the same normal person as the positive sample and other situations are negative samples. Finally, the features for each side and the residual features (which are obtained by computing the difference between features of each side) are fed into different classifiers that output predictions of symmetry/asymmetry, normal/abnormal and CAMs of these results.

3. Results

The result for classification and segmentation tasks are reported in Table 1. We also report the results of the single view (SV) model. Then the results of the DV model and the DV model combined with the two methods (SupCon loss or ASY block) individually. The best performance is achieved with the proposed model (DV + ASY + SupCon), which combines both the ASY block and SupCon loss while each part alone (i.e., only DV model) yields poorer results, illustrating their complementarity.

Table 1: The results of ablation experiments in two abnormal type setting

Method	**Abnormal Type**	**Asymmetry AUC**	**Image AUC**	**Dice**	**IOU**
SV	mass	-	0.7232	0.1933	0.1244
DV	mass	0.7533	0.7534	0.3293	0.2218
DV+SupCon	mass	0.8075	0.8086	0.3832	0.2627
DV+ASY	mass	0.8089	0.8108	0.3917	0.2847
Proposed*	mass	**0.8476**	**0.8584**	**0.4490**	**0.3169**
SV	mixed	-	0.6914	0.1925	0.1291
DV	mixed	0.7459	0.6972	0.2828	0.1962
DV+SupCon	mixed	0.7647	0.7101	0.3468	0.2375
DV+ASY	mixed	0.7794	0.7235	0.3240	0.2301
Proposed*	mixed	**0.8083**	**0.7812**	**0.3516**	**0.2501**

4. Discussion

In this study, we propose an asymmetrical attention block to extract asymmetry features from paired bilateral mammograms and a supervised contrastive loss to constrain the model to learn real symmetric features. We used the INbreast dataset for model training and testing and challenged our method in classification and weakly supervised segmentation tasks. Based upon these results we are of the opinion that incorporating asymmetry information in AI algorithms for lesion detection in mammography may enhance overall performance and explainability of the AI outcomes.

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