Mass Detection on Automated Breast Ultrasound Volume Scans Using Convolutional Neural Network

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***Abstract*— Automated ultrasound volume scan is useful for screening breast cancer as it records the whole breast data allowing longitudinal comparisons and double reading. Unlike examinations with handheld probes, it is less operator independent. However, the number of acquired images is large, which increases radiologists' workload. In this study, we propose a mass detection method on ultrasound volume scans using convolutional neural network (CNN). Using CNN, detection performance greatly improved compared with the conventional filter based method.**

Keywords—breast masses; automated ultrasound volume scans; detection; convolutional neural network

I. Introduction

Breast screening with mammography is considered an effective method for decreasing breast cancer mortality rate for women with normal risk. Recent studies have indicated the utility of breast ultrasound examinations in adjunct to mammograms, in particular for young women and women with dense breasts [1, 2].

An advantage of conventional ultrasound exams with hand-held probes is its real time nature. During the diagnostic exams after suspicious findings in screening, target regions can be thoroughly examined. However, in the screening setting, complete exams take time and the results are operator dependent. Recently, screening exams using automated breast volume scanners are increasing. It is in general operator independent and provides whole breast data, which facilitate double reading and longitudinal comparison.

Current automated breast scanners often acquire whole breast data in several separate volumes. Therefore, one patient exam can include 6 to 10 volumes with many slices, which require radiologists to spend a fair amount of time for review. In order to assist radiologists' efficient diagnosis, computer-aided detection system is studied.

Lo et al. [3] proposed an automated mass detection scheme on automated breast ultrasound images using watershed transform. Ye et al. [4] reported a mass detection algorithm that consists of three major steps: active contour based segmentation, feature extraction and classification.

In our previous study [5], we proposed a mass detection scheme using a vector convergence filter [6] followed by false positive reduction using a convolutional neural network (CNN). In this study, we propose a new scheme using a CNN for candidate detection and compared the result with the filter-based detection scheme.

II. Dataset

Automated breast ultrasound scans (ABVSs) used in this study were obtained at Nagoya Central Hospital using ACUSON S2000 (Siemens Healthcare) as a part of whole body screening program. This study was approved by the institutional review boards of Nagoya Central Hospital and Gifu University, and the patient consents were obtained. Patients' breasts were scanned in supine position with soft compression. Three or four scans (views) per breast were obtained for most of the patients. The original data had axial slices with the horizontal matrix size ranged from 702 to 729 pixels and vertical matrix size from 420 to 573. The number of slices was 318 with 0.53 mm slice thickness. These scans were converted to isotropic data with the voxel size of 0.21 mm by a linear interpolation.

Diagnostic reports were retrospectively reviewed and breast masses were identified. The dataset of this study included 59 volumetric scans with 89 masses. The cases were divided into training and test sets randomly, so that the numbers masses in two groups were approximately equal. The training set included 44 masses from 35 scans, while the test set included 45 masses from 24 scans.

III. Methods

The CNN architecture employed in this study was DetectNet [7], which is a fully convolutional network based on GoogLeNet. The network detects the candidate boxes on the basis of the predictions of box coverage and box corners.

The network was trained with the axial and reconstructed sagittal slices that depict at least one mass. In order to include clearly visible slices, only the slices at the central third portion of the masses were employed. As a result, the number of the training cases was 807 slices.

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For testing, we compared three datasets: axial slices, sagittal slices, and the combination. The number of test slices in the three sets were 15182, 16428, and 31610. If detected boxes were connected in consecutive slices, they were counted as one candidate. For the dataset 3, the regions detected in both axial and sagittal slices were considered as detection.

IV. Results

The mass detection rates were 76, 71, and 69% using axial, sagittal, and combined slices, respectively. The numbers of false positive detections were 15, 18, and 4, respectively, per volume. Figure 1 shows a breast mass detected in both slices. Compared with the previous filter-based detection method, the number of false positives could be reduced by 77%.

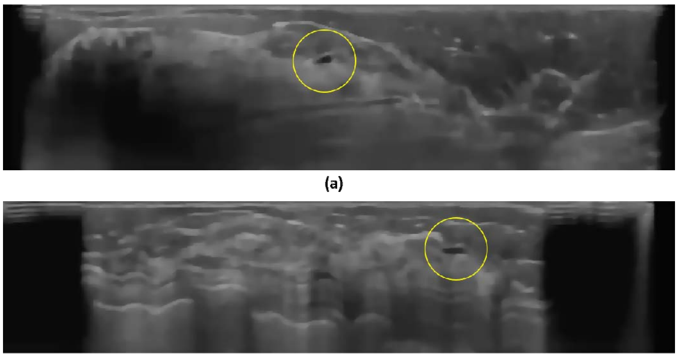

Fig. 1. Detection result in (a) axial slice and (b) sagittal slice.

V. Discussion and Conclusion

In this study, a fully convolutional neural network was employed for detection of breast masses on ABVSs. Using axial and sagittal slices and by retaining only those candidates that were detected in both slices, the number of false positives was reduced. However, the sensitivity rate was also reduced. Further investigation is needed for using multiplanar and multislice data effectively. In comparison with our previous filter-based method, the number of false positives were greatly reduced at the same sensitivity rate of 76%. The proposed automated mass detection method can be useful in assisting efficient reading of ABVSs.

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