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Support vector machines in sonography Application to decision making in the diagnosis of breast cancer

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Abstract

We evaluated a series of pathologically proven breast tumors using the support vector machine (SVM) in the differential diagnosis of solid breast tumors. This study evaluated two ultrasonic image databases, i.e., DB1 and DB2. The DB1 contained 140 ultrasonic images of solid breast nodules (52 malignant and 88 benign). The DB2 contained 250 ultrasonic images of solid breast nodules (35 malignant and 215 benign). The physician-located regions of interest (ROI) of sonography and textual features were utilized to classify breast tumors. An SVM classifier using interpixel textual features classified the tumor as benign or malignant. The receiver operating characteristic (ROC) area index for the proposed system on the DB1 and the DB2 are 0.9695 ± 0.0150 and 0.9552 ± 0.0161, respectively. The proposed system differentiates solid breast nodules with a relatively high accuracy and helps inexperienced operators avoid misdiagnosis. The main advantage in the proposed system is that the training procedure of SVM was very fast and stable. The training and diagnosis procedure of the proposed system is almost 700 times faster than that of multilayer perception neural networks (MLPs). With the growth of the database, new ultrasonic images can be collected and used as reference cases while performing diagnoses. This study reduces the training and diagnosis time dramatically.

Keywords: Breast cancer; Computer diagnosis; Support vector machines; Textural analysis; Ultrasonography

1. Introduction

Breast cancer is one of the leading causes of deaths from cancer for the female population in both developed and developing countries. The most useful way to reduce deaths due to breast cancer is to treat the disease at an earlier stage. Earlier treatment requires early diagnosis, and early diagnosis requires an accurate and reliable diagnostic procedure that allows physicians to differentiate benign breast tumors from malignant ones. The most frequently adopted medical imaging studies for the early detection and diagnosis of breast cancers include mammography and ultrasonography. Mammography gained publicity, whereas breast sonography does its job quietly behind the scenes [1]. Usually, breast sonography was used as an adjunct to mammography. Although mammography can visualize nonpalpable and minimal tumors, and sonography is suitable for palpable tumors, sonography is more convenient and is safer tool than mammography is in the evaluation of a breast mass in daily clinical practice. However, sonography is an operator-dependent examination technique, there is a considerable overlap of benignancy and malignancy in breast sonography, and interpretation is subjective. The sonographic examination is much more extensive than the usual examinations performed at most breast imaging centers. Stavros et al. [2] found that the sensitivity of breast ultrasound for malignancy is 98.4%, the specificity is 67.8%, the overall accuracy is 72.9%, the positive predictive value (PPV) is 38%, and the negative predictive value (NPV) is 99.5%. We noticed that the above diagnostic results are achieved by experienced

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radiologists. In practice, many invasive diagnostic procedures are still required in most cases. Most of these procedures could be avoided if a more specific diagnostic test was available, because the rate of positive findings at biopsy for cancer is low, between 10% and 31% [3–5]. The biopsy is expensive because of a great quantity of indeterminate lesions, which need to be differentiated.

Recent technical advances in ultrasound image have expanded the potential utility of this modality for the evaluation of breast lesions [6–10]. In these approaches, Chen et al. used 2-D auto-covariance coefficients and the neural network (NN) classifier to determine whether the breast tumors are benign or malignant in breast sonography. The computer-aided diagnostic system (CAD) utilizes a multilayer perception neural network (MLP) to perform a good diagnostic result. However, the learning procedure of MLP is very time consuming and initial parameter dependent; that is, the number of neurons, learning rate, and moment values are hard to decide. Unfortunately, the selections of initial parameters will affect the results drastically. Whereas, the support vector machine (SVM) reveals the feasibility and superiority to extract higher order statistics and has become extremely popular in terms of classification and prediction. This study employs this SVM model as a classifier instead of MLP to determine whether the breast tumors are benign or malignant. The diagnosis system proposed herein can classify the ultrasonic images of a breast more accurately and efficiently. The SVM is a reliable choice for the new proposed system because it is fast and excellent in ultrasonic image classification.

2. System description

In this paper, we supposed that the physician has already identified the tumor. The proposed system can use the intensity variation and interpixel texture information from the sonography to diagnose the tumor. The physician first extracted the rectangular subimage of the region of interest (ROI), and then the computer analyzed the ROI to make a differential diagnosis.

2.1. Ultrasonic image databases

This study evaluated two sonographic image databases of solid breast nodules. All images in these databases contained only one image from each patient. The ultrasonic images were captured at the largest diameter of the tumor. Sonography was performed using an ALOKA SSD 1200 (Tokyo, Japan) scanner and with freeze-frame capability and a 7.5-MHz linear transducer. No acoustic standoff pad was used in any of the cases. The databases were supplied by the coauthor, an experienced physician, Dr. Chen, from the Department of General Surgery, Changhua Christian Hospital, Changhua, Taiwan. The sonographic gain setting remained unchanged throughout the entire period of study, except for changes made to obtain the best view.

2.1.1. Ultrasonic image database 1 (DB1)

To compare the performance with the CAD that was proposed by Chen et al. [9], the identical sonography

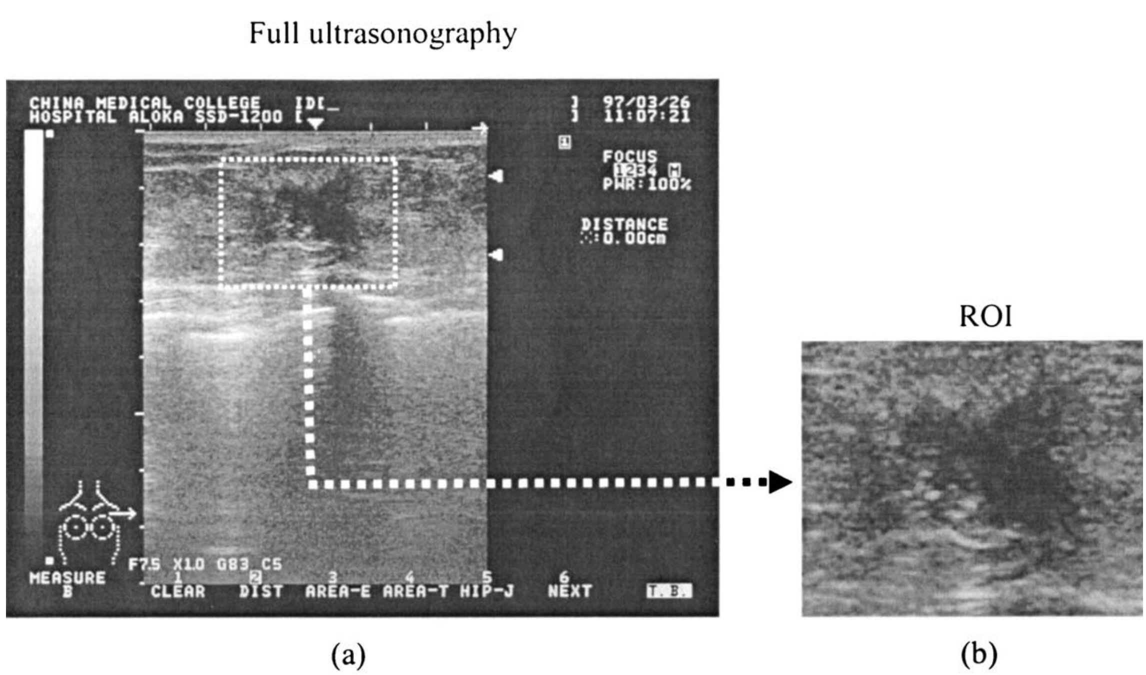

Fig. 1. Full ultrasonography. (a) A 736×556 full breast sonography. (b) The ROI rectangle is approximately 2.91×2.33 cm in size, captured with a resolution of 169×135 pixels (a 1×1 cm rectangle contains 58×58 pixels).