Computer-aided design system aids mammography screening

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A computerized tool gives radiologists a second opinion for diagnosing breast cancer.

The drive for early breast cancer detection has significantly increased the number of mammograms radiologists must read. An effective computer-aided design (CAD) system for screening can help relieve that workload and improve diagnosis. Several US Food and Drug Administration-approved CAD systems are currently being used with digital mammography. They can provide detection results, but not classification according to the five categories of the American College of Radiology's Breast Imaging Reporting and Data System (BIRADS). This is primarily because sophisticated characteristics in mammograms are challenging for a CAD system to classify effectively.

For example, microcalcifications (MCCs) and masses exhibit completely different characteristics. MCCs are generally made by foreign substances, not breast tissues. Their presence can be detected by intensity and contrast, and their classification is based on their size and shape. However, masses are considered part of breast tissues. They can only be detected by their texture features, which can be used for classification. Thus, different design techniques are required for each abnormality. Our CAD pilot system is designed to detect and classify MCCs and masses in parallel, using two sets of different techniques.¹

Our system uses five modules: preprocessing, MCCs/masses finding, MCCs/masses detection, MCCs/masses classification, and audit/reporting. A step-by-step implementation of each is shown in Figure 1.^{2,3} The pre-processing module digitizes a mammogram into an 8-bit image with 2048x2048 pixels, as shown in Figure 1(a). It extracts the breast region from the mammogram, enhances that image, and stores the processed and the original unprocessed mammograms in a database for future reference. Since only clustered MCCs or masses provide useful diagnostic information about malignancy, the second module locates suspicious groupings, then segments them from the background image as regions of interest (ROIs) to be

Figure 1. The five modules in a prototype computer-aided design (CAD) mammography screening system.

used for further detection. A suspicious shaded area is shown in Figure 1(b). As soon as ROIs are identified, they are fed into the detection module for processing, as seen in Figure 1(c). This module is a real-time processing system that uses two different window sizes to extract MCCs/masses. It begins with a large 64x64 pixel window to quickly screen mammograms to find large, suspicious areas. This is followed by a smaller

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Figure 2. A step-by-step CAD mammography screening system including an estimation of breast density.

8x8 pixel window to extract small and tiny MCCs/masses. The module shown in Figure 1(d) classifies the segmented clustered MCCs/masses into one of five results: ‘negative’ (no further operation), ‘benign’ (MCCs/masses found to be negative), ‘probably benign’ (short interval follow-up suggested), ‘suspicious abnormality’ (biopsy should be considered), and ‘highly suggestive of malignancy’ (appropriate action should be taken). Finally, the audit/reporting module allows doctors to edit and write their reports as shown in Figure 1(e).

Our system moves one step further toward improving current CAD mammography screening by classifying MCCs/masses according to the BIRADS guideline. Nevertheless, it is still a prototype, and much work remains. Specifically, we will further study BIRADS analysis. For example, density is one feature used to evaluate breast cancer. However, it is difficult for doctors to quantify breast density. We are proposing a quantification tool for breast density in our CAD system (see Figure 2), and we also will study other BIRADS density evaluation tools.

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