



Computer Diagnosis of Breast Thermograms¹

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A computer-based technique was developed for the automated diagnosis of breast thermograms. Eighty-five thermograms were digitized and analyzed, and 23 parameters computed for each thermogram. A statistical decision program, based on a linear discriminant analysis technique, classified the thermograms into normal and abnormal categories. The accuracy of classification was evaluated by several techniques and found to be comparable to that of trained thermographers.

INDEX TERMS: Breast neoplasms, diagnosis • Computers • Thermography

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THERMOGRAPHY has recently attracted much attention as a technique for the early detection of breast cancer. Many studies have been conducted which validate the use of thermography in conjunction with mammography and manual palpation, as a reliable and useful diagnostic measure for the identification of carcinomas of the breast (8, 9, 11, 13, 16, 26, and others). These studies demonstrate that a good mass screening system should include thermography, since it is completely safe, is capable of finding some cancers which escape detection by mammography and manual palpation, and increases the overall probability of early breast cancer detection.

The thermal patterns of the female breast have been studied by many investigators. Fay and Henny (7), and later Lawson (19), reported that the skin surface over malignant tumors in the breast was usually 1-3°C warmer than the surrounding skin. No corresponding temperature elevation was detectable over benign tumors. These findings were later confirmed by Lloyd-Williams, *et al.* (20). The cause of the temperature increase is still not fully understood. Carcinomas of the breast are metabolically active and the veins which drain these tumors are generally hotter than normal (18) and could account for at least part of the temperature elevation at the skin surface.

The variation of normal breast thermal patterns makes the recognition of a hot spot a problem. In addition to the variable thermal pattern, hot spots naturally occur in about 15% of normal breasts and 35% of the breasts of women with dysplasias (11). Frequently, both breasts, in normal women, are similar in thermal pattern, but significant asymmetrical patterns do occur (5, 17). Menstrual cycle hormonal activity, and contraceptive pills also affect the thermal pattern (5).

The application of computers to automate the interpretation of breast thermograms is new; the only published report on this topic is by Winter and Stein (29). They have reported preliminary success in using spatial signature analysis, symmetry measurement based on thermal density distributions, and contour coding as image processing techniques to automate the detection of thermographic abnormalities.

IMAGE ANALYSIS SYSTEM

The Diagnostic Radiology Image Processing System (DRIPS) provides the capability for digitization, analysis, processing, and display of breast thermograms.

The thermogram is lighted at the bottom by a high intensity radiographic viewbox and at the top by two fluorescent tubes. The primary imaging device is a General Electric, Model TE/26, closed-circuit television (TV) camera equipped with a 25-100 mm, f 22 zoom lens. The video signal from the TV camera is processed by a Colorado Video, Inc., Model 321 Video Analyzer which samples one point per each horizontal scan line of the TV field, forming a vertical line which is an analogue of the image density.

The Digital Equipment Corp., 8K, 12-bit Linc-8 computer coordinates the scanning, processing, and output functions of the DRIP system. Scanning is under computer control with the vertical scan line position being determined by voltages produced by the Linc-8 D to A converter. Each scan line is digitized by the A to D converter into 192 points with each point being assigned a gray level value. Two hundred fifty-six scan lines are digitized and the values stored on magnetic tape or disk for analysis and output.

Output from the scanning and processing procedure

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