

XII. MICROWAVE THERMOGRAPHY

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RESEARCH OBJECTIVES AND RESEARCH PROGRESS

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During the past year our microwave thermography research has continued in four directions: clinical evaluation of microwave thermography for breast cancer detection, development of new radiometers, development of new antennas with improved resolution, and development of new techniques for measuring sensitivity and resolution.

The clinical work has continued at Faulkner Hospital in collaboration with Dr. N. L. Sadowsky, Chief Radiologist. At present, we have examined more than 2000 normal patients and more than 30 with breast cancer confirmed by biopsy. The cancer detection performance of the 3.3 GHz radiometer depends on the choice of detection criterion. In the cases that we have investigated, the optimum criterion involves the mean right-left temperature difference, averaged over 9 right-left pairs for each patient. When the magnitude of this difference exceeds a chosen threshold value, the criterion indicates "cancer"; if the difference falls below the threshold, the criterion indicates "normal". With the threshold set at 0.32°C, this criterion correctly identifies approximately 70% of the cancers and 75% of the normals. The criterion is inherently one of coarse resolution, since it involves a spatial average over each breast; most of the cancers that were not detected by the microwave method have tumor size <1 cm. The need for a higher resolution antenna to detect early cancers is clearly indicated. Thus far, the detection performance of microwave thermography for patients examined by these three methods is comparable to that of infrared thermography but inferior to xeromammography. We find, however, that when the infrared and microwave techniques are combined so that either a positive microwave examination or a positive infrared examination indicates "cancer", then the cancer detection rate rises higher than 90%, and is comparable to that for xeromammography. Unlike xeromammography, the microwave and infrared methods send no radiation into the body; thus they cannot be considered dangerous.

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In October 1976, we installed a 1.3 GHz radiometer in the examining room at Faulkner Hospital to operate side-by-side with the 3.3 GHz instrument. This new system was developed in order to begin determining the optimum frequency for detection. A 6.0 GHz system is now being tested in our laboratory for the same purpose. These new radiometers can achieve a rms temperature sensitivity of less than 0.1°C in an integration time of 1 s.

Work has continued on development of higher resolution antennas. Evaluation of a dual-mode antenna, which propagates the TE_{10} and TE_{20} modes in order to form a difference beam, has been aided by implementation of a modulated-scattering technique for measuring the antenna power pattern at close distances.

A microprocessor system is being developed by arrangement with the Harvard-M. I. T. Biomedical Engineering Center for Clinical Instrumentation. This system will be a powerful adjunct to the present radiometer systems. It will be used to compute temperatures from the radiometer output voltages, automate the process of calibration and data taking, display measured temperature maps on a cathode-ray tube screen, compute diagnostic measures, and drive an automatic antenna scanner in order to permit greater flexibility in mapping and analysis.

We have begun to construct artificial phantom models of tumors embedded in fatty tissue, in order to evaluate our instrument detection capabilities in a more quantitative way than is possible with hospital data. By using a combination of epoxy, aluminum powder, and lampblack, whose recipe is readily available, we have made slabs of solid material that has the same dielectric properties as fatty tissue at microwave frequencies. We have made glass-walled, water-filled shells, with enclosed heating resistors and sensing thermistors, to simulate tumors whose temperature, size, and location beneath the top slab can be varied conveniently. With these models, we shall evaluate the sensitivity-resolution tradeoffs of our radiometer and antenna systems.