Thermal Tomography: Breast Cancer Treatment

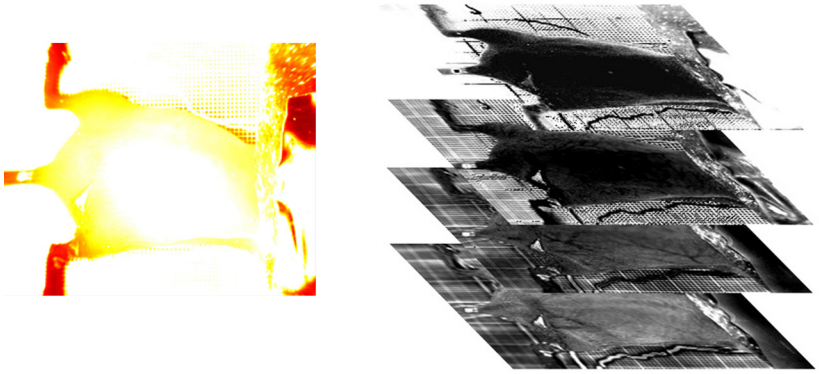
In thermal imaging, heat or cold is applied to a material, and an infrared camera "observes" the resulting temperature change to study its composition. Three-dimensional thermal tomography (3DTT) is a relatively new thermal imaging process used to detect defects in composite materials noninvasively. Thermal imaging has also been widely studied for its application in breast cancer detection.

Cancer cells, because they grow faster than healthy cells, can have temperatures a few degrees higher and will appear as hot areas on the skin. Large-scale studies using passive thermal imaging techniques, which image these temperature distribution patterns, have had generally positive results. Today, most thermal imaging studies focus on active methods (i.e., applying heat and cold to induce a transient skin temperature response), where results are related to conditions on the skin or to tissues under the skin. However, most thermal imaging studies produce qualitative outcomes that lack the specificity of quantitative measures. The 3DTT technique using an Argonne-developed algorithm may overcome this limitation, owing to its quantitative and depth-resolved imaging capability.

Technology Description

Researchers at Rush University Medical Center (RUSH) initiated a collaborative research project with Argonne to investigate a particularly promising application for this 3DTT technique: its use to detect the earliest changes that may trigger a skin reaction in breast cancer patients undergoing radiation treatment. About 80% of patients undergoing radiation are estimated to develop skin reactions during a treatment cycle. The more severe reactions cause discomfort and distress to the patient and can disrupt therapy. Because reactions usually begin to develop from 10 to 14 days after the start of therapy, early detection could result in earlier delivery of preventive treatment.

Clinical tests, initially performed on small animals, used Argonne's 3DTT system to measure thermal effusivity, which is related to a material's ability to exchange heat with its surroundings. In this test, a flash of light from a photographic flash lamp through a patented filter heats the skin, and an infrared camera captures a time series of images that display skin temperatures by color. Argonne's algorithm calculated temperature changes and determined the thermal effusivity of different depths of the skin (its ability to cool is related to the structure underneath). Researchers could detect damaged skin tissues whose effusivity values differed from those of healthy skin tissues. The study's preliminary data show that marked reductions in the effusivity levels of irradiated skin occurred well in advance of development of high-grade skin reactions. Researchers hope to begin study of 3DTT in breast cancer patients soon. Argonne is also developing a new and more sophisticated algorithm for its 3DTT method to improve resolution at subsurface depths.



Change in temperature over time (left) is used to calculate the 3-dimensional effusivity distribution (right). Each slice represents a given depth with thickness ~25 µm.

Potential Benefits

3DTT techniques can be used to measure tissue property changes noninvasively, without interrupting a patient's therapy and providing rapid feedback to the physician. 3DTT may also aid in detecting other skin diseases (e.g., skin cancer), where changes in effusivity would enable researchers to locate and quantify the number of cancer cells. 3DTT may also be used to measure skin damage caused by electricity or lightning and to evaluate the progress of skin grafts.

Technology Area: Medical devices
Product: Three-dimensional thermal tomography
Development Stage: Ready for prototype development
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Contact: Terry Maynard, tmaynard@anl.gov, (630) 252-9771