3D TEMPERATURE IMAGING USING ULTRASONIC BACKSCATTER ENERGY DURING NON-UNIFORM TISSUE HEATING

DISSERTATION DEFENSE
by
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Background: Hyperthermia alone or in conjunction with chemotherapy and radiation is used for cancer treatment. One of its limitations is lack of detailed temperature information. Ultrasound is a cheap, non-ionizing and convenient method with potential for non-invasive temperature imaging. In this study, the volumetric (3D) change in ultrasonic backscattered energy (CBE) was calibrated and used to estimate temperature during both uniform and non-uniform heating.

Methods: For accurate temperature measurement, a grid of thermocouples was calibrated using a NIST-traceable thermometer. 3D ultrasonic datasets were obtained by moving a 7.5 MHz linear, phased-array transducer in 0.6 mm steps in elevation. CBE was computed from a ratio of motion-compensated, envelope-detected images and a reference ultrasonic image. To evaluate the effects of noise, scatterer distribution, and spatial resolution on estimation errors during non-uniform heating, thermal modeling was done using finite element methods. Temperature estimation was tested in both gelatin and tissue phantoms.

Results: CBE curves obtained from turkey breast muscle during uniform heating were well matched by a linear regression that had a slope of 0.3dB/°C. Cross-validation studies with uniform heating had 3D temperature estimation errors <0.5°C over 20 1cm³ volumes. Estimated temperature errors during non-uniform heating were typically within ± 1°C.

Conclusion: This work, which validated the potential of CBE as a non-invasive thermometer during both uniform and non-uniform heating, was the first of its kind. It also helped to identify some of the sources of estimation errors. 3D validation of CBE thermometry in vitro is an important step in making the transition from the laboratory to the clinical application of CBE temperature imaging for hyperthermia and other thermal therapies.

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PLACE: Bryan Hall, Room 305

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