Temperature estimation with ultrasound

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Hepatocelluar carcinoma is the fastest growing type of cancer in the United States. In addition, the survival rate after one year is approximately zero without treatment. In many instances, patients with hepatocelluar carcinoma may not be suitable candidates for the primary treatment options, i.e. surgical resection or liver transplantation. This has led to the development of minimally invasive therapies focused on destroying hepatocelluar by thermal or chemical methods.

The focus of this dissertation is on the development of ultrasound-based image-guided monitoring options for minimally invasive therapies such as radiofrequency ablation. Ultrasound-based temperature imaging relies on relating the gradient of locally estimated tissue displacements to a temperature change. First, a realistic Finite Element Analysis/ultrasound simulation of ablation was developed. This allowed evaluation of the ability of ultrasound-based temperature estimation algorithms to track temperatures for three different ablation scenarios in the liver. It was found that 2-Dimensional block matching and a 6 second time step was able to accurately track the temperature over a 12 minute ablation procedure.

Next, a tissue-mimicking phantom was constructed to determine the accuracy of the temperature estimation method by comparing estimated temperatures to that measured using invasive fiber-optic temperature probes. The 2-Dimensional block matching was able to track the temperature accurately over the entire 8 minute heating procedure in the tissue-mimicking phantom. Finally, two separate *in-vivo* experiments were performed. The first experiment examined the ability of our algorithm to track frame-to-frame displacements when external motion due to respiration and the cardiac cycle were considered. It was determined that a frame rate between 13 frames per second and 33 frames per second was sufficient to track frame-to-frame displacements between respiratory cycles. The second experiment examined the ability of a novel dynamic frame selection based temperature algorithm to track temperatures during ablation of porcine kidney tissue. Here a novel multi-level 2-Dimensional cross-correlation algorithm was required to accurately track the temperature over an 8 minute ablation procedure.