AbstractID: 8537 Title: Real time Magnetic Resonance Imaging (MRI) guidance and thermal modeling to focus hyperthermia delivery

Purpose:

Hyperthermia is an effective adjuvant modality for treatment of locally advanced cancer. However, focusing heat in the tumor using an external microwave applicator can be difficult, due to electromagnetic wave reflections at tissue interfaces. We present a methodology to steer heating towards the desired focus in real-time, using MR thermal images for feedback.

Methods and materials:

The treatment control platform is based on repeated MR proton resonance frequency shift thermal imaging of the treatment volume over the course of the treatment. A cylindrical applicator with 4 independent pairs of dipole patch antennas (140MHz) is used as a heat source. The control process consists of iteratively constructing and updating a model for the heated object. At each iteration, the current model is employed to compute the optimal antenna settings (settings that the model predicts to focus heating in the target). These settings are applied to obtain the next thermal image, which is utilized in the next iteration to update the model. Thus, the algorithm progressively steers focusing while updating the model. We report on the convergence efficiency of the algorithm and importance of prior system knowledge (pretreatment simulations).

Results:

The experiments conducted on a cylindrical muscle-equivalent phantom demonstrated that, for the 4-antenna applicator, 16 iterations were sufficient to converge to the optimal thermal coverage of tumor. If prior knowledge was used, only 12 iterations were necessary to reach convergence from a starting focus that is positionally rotated 90° with respect to the desired focus. For a smaller positional rotation of 50°, 3 iterations were sufficient for convergence. The ratio of tumor to normal tissue heating after convergence improved by a factor of 3-6, compared to the initial ratio.

Conclusions:

Real-time adaptive thermal modeling enables fast convergence to the optimal treatment of the patient and corrects for dynamic system changes.