3D Microwave Tracking of Treatment Probe in Thermal Therapy

Guanbo Chen, John Stang, Pratik Shah, and Mahta Moghaddam
The University of Southern California, Los Angeles, CA, 90089

In recent years, thermal ablation has seen increased usage in the treatment of various diseases. However, how to accurately image and track an ablation probe during thermal therapy in real-time remains an open problem for different imaging modalities. In this abstract, we propose a microwave inverse scattering method with group sparsity constraints to image and track an ablation probe during thermal therapy treatment. The contrast source inversion (CSI) method is used to solve the inverse scattering problem, which determines the probe's location by utilizing the scattered field data produced by the contrast source current of the probe. By only solving for the contrast source, the nonlinear inverse scattering problem becomes a linear inverse problem, which could be solved with much less computational cost. In this problem, the value of the contrast source induced by different transmitters is different; however, all of the induced contrast source should be at the same location of the ablation probe in the imaging domain. In addition, as the contrast sources are sparse in the large imaging domain, group sparsity constraints are used to regularize this underdetermined problem and restrain the contrast sources induced by different transmitters to have non-zero elements at the same locations within the imaging domain. A fast spectral gradient-projection method with separable approximation method and group sparsity constraints is used to solve this linear inverse problem, and to reconstruct the shape of the treatment probe. To experimentally validate the proposed method, we use a cubic imaging chamber with 18 transmitting and 18 receiving antennas to collect the scattered data from the treatment probe. The imaging chamber is connected to a 2-port vector network analyzer (VNA) through a 18x18 switching matrix, which provides 324 pairs of the T/R S-parameter measurements. The measurement and imaging process is automated by controlling the switching matrix and VNA with MATLAB instrument control. Imaging results of a treatment probe will be provided for validation purposes.