Deep Learning Based CT Thermometry for Ultrasound Tumor Ablation

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High intensity focused ultrasound (HIFU) is a rapid, non-invasive tumor ablation procedure that heats tissues to 50-90 degree (C) in seconds. In this context, real-time control of the ultrasound-induced thermal dose distribution is critically important to eliminate abnormalities while sparing healthy tissues. A tomographic thermal mapping will make HIFU surgery precise, paving the way to a future robotic surgery in general. In the past decades, the relationship between temperature and Hounsfield units (HU) mapped by a CT scanner was investigated (F. Fani, E. Schena, P. Saccomandi, S. Silvestri, et. al.). However, the accuracy and reproducibility have been problematic. Now, artificial intelligence algorithms for computer vision and image analysis have outperformed classic methods and even human experts. Hence, we are motivated to improve CT thermometry with deep learning techniques. In this project, we adapt a convolutional autoencoder to reduce noise and artifacts in a CT image for an optimal temperature estimation. To demonstrate the feasibility and merits of this neural network, we trained and tested the autoencoder on simulated CT images with low-dose data characteristics. It is observed that our autoencoder is capable of predicting the HU number accurately in the low-dose CT setting. Phantom experiments with PID control are in progress to validate our method and translate to animal studies.

Awards Won: