Neural Network Assisted Multi-modality Microwave Inverse Scattering for Brain Dielectric Imaging

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Microwave imaging, which can noninvasively acquire the dielectric images of an object, plays an important role in biomedical applications, such as medical diagnostics, medical procedure monitoring, and bioelectronics study. However, due to its non-uniqueness, ill-posedness and nonlinearity, microwave imaging still faces major challenges in reconstructing high-quality dielectric images adequate for clinical usage. In previous work, attempts were made to address these issues by adding constraints to the inverse problem via regularizations. These approaches aimed to bring additional information into the image reconstruction process with different prior assumptions or knowledge of the unknown objects using various regularization methods, such as smoothness assumptions using L2 norm, sparseness assumptions using L1 norm or group sparseness assumptions using L12 norm. However, these simple priors only add limited information which is still insufficient for reconstructing high quality dielectric images.

We propose a novel approach of using convolutional neural network (CNN) to bring the abundant information from other imaging modalities (such as MRI or CT) into microwave image reconstruction process, effectively utilizing the mutual information between different imaging modalities, and providing a pathway to achieve high-quality microwave imaging. We will demonstrate the construction of a CNN which learns the nonlinear relationship between a MRI T1 image and a microwave dielectric image of the brain. To train the CNN, image pairs of the T1 and dielectric images of the brains are generated both synthetically and experimentally. After the training, the CNN can take in MRI T1 images and output initial dielectric images. Then those initial dielectric images, which already contain abundant structure and tissue information of the patient's brain, are used as the starting background for microwave imaging. As those initial dielectric images are already quite close to the true dielectric images, image reconstruction based on those backgrounds can significantly reduce the nonlinearity and non-uniqueness of the corresponding microwave inverse scattering problem. We will demonstrate a quantitative comparison of the brain dielectric images reconstructed through our CNN based multimodality microwave imaging method and the traditional Born iterative method (BIM) based microwave imaging method. Last, several cases of brains with abnormities will be used to test the capability of our proposed method in detecting tumors.