Abstract: Physics-informed Conditional Autoencoder Approach for Robust Metabolic CEST MRI at 7T

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Chemical exchange saturation transfer (CEST) is an MRI technique used to identify solute molecules through proton exchange. The CEST spectrum reveals various metabolite effects, which are extracted using Lorentzian curve fitting. However, the effectiveness of the separation of CEST effects is compromised by the inhomogeneity of the B_1 saturation field and noise in the acquisition. These inconsistencies result in variations within the associated metabolic maps. The existing B_1 correction methods necessitate a minimum of two sets of CEST spectra. From these, a B_1-corrected CEST spectrum at a fixed B_1 level is interpolated, effectively doubling the acquisition time. In this study, we investigated the use of an unsupervised physics-informed conditional autoencoder (PICAE) to efficiently correct B_1 inhomogeneity and isolate metabolic maps while using a single CEST scan. The proposed method uses two autoencoders. Conditional autoencoder (CAE) for B_1 correction of the CEST spectrum at arbitrary B_1 levels and Physical Informed Autoencoder (PIAE) for Lorentzian line fitting. CAE consists of fully connected layers whose latent space and input are both conditioned at the B_1 level, eliminating the need for a second scan. PIAE uses a fully connected neural network as an encoder and a Lorentzian distribution generator as a decoder. This not only facilitates model interpretation, but also overcomes the shortcomings of traditional curve fitting, in particular its susceptibility to noise. The PICAE-CEST maps showed improved visualization of tumor features compared to the conventional method. The proposed method yielded at least 25% higher structural similarity index (SSIM) compared to the T_1-weighted reference image enhanced with the exogenous contrast agent gadolinium in the tumor ring region. In addition, the contrast maps exhibited lower noise and greater homogeneity throughout the brain compared to the Lorentzian fit of the interpolation-based B_1-corrected CEST spectrum [1].

References

1. Rajput JR, Möhle TA, Fabian MS, Mennecke A, Sembill JA, Kuramatsu JB et al. Physics-informed conditional autoencoder approach for robust metabolic CEST MRI at 7T. Proc MICCAI. Springer, 2023:449–58.

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