**PhD Thesis Title:** Generation of pseudo-CT images from MRI images in pelvic and prostate regions for attenuation correction in PET/MRI system

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**ABSTRACT:**

Despite the proven utility of multiparametric magnetic resonance imaging (MRI) in radiation therapy, MRI-guided radiation treatment planning is limited by the fact that MRI does not directly provide the electron density map required for absorbed dose calculation. In this work, a new deep convolutional neural network model with efficient learning capability, suitable for applications where the number of training subjects is limited, is proposed to generate accurate synthetic CT (sCT) images from MRI.

This efficient convolutional neural network (eCNN) is built upon a combination of the SegNet architecture (a 13-layer encoder-decoder structure similar to the U-Net network) without softmax layers and the residual network. Moreover, maxpooling indices and high-resolution features from the encoding network were incorporated into the corresponding decoding layers. A dataset containing 15 co-registered MRI-CT pairs of male pelvises (1861 two-dimensional images) were used for training and evaluation of MRI to CT synthesis process using a five-fold cross-validation scheme. The performance of the eCNN model was compared to an atlas-based sCT generation technique as well as the original U-Net model considering CT images as reference. The mean error (ME), mean absolute error (MAE), Pearson correlation coefficient (PCC), structural similarity index (SSIM) and peak signal-to-noise ratio (PSNR) metrics were calculated between sCT and ground truth CT images.

The eCNN model exhibited effective learning capability using only 12 training subjects. The model achieved a ME and MAE of 2.8±10.3 and 30.0±10.4 HU, respectively, which is substantially lower than values achieved by the atlas-based (-0.8±35.4 and 64.6±21.2) and U-Net (7.4±11.9 and 44.0±8.8) methods, respectively.

The proposed eCNN model exhibited efficient convergence rate with a low number of training subjects, while providing accurate synthetic CT images. The eCNN model outperformed the original U-Net model and showed superior performance to the atlas-based technique.

**References to author publications that relate specifically to the dissertation**:

1. **A. Bahrami**, A. Karimian, E. Fatemizadeh, H. Arabi and H. Zaidi, "A novel convolutional neural network with high convergence rate:Application to CT synthesis from MR images," 2019 *IEEE Nuclear Science Symposium and Medical Imaging Conference(NSS/MIC), Manchester, UK. IEEE, October 26-November 2,* 2019 .**DOI:** 10.1109/NSS/MIC42101.2019.9059908

2. **A. Bahrami**, A. Karimian, E. Fatemizadeh, H. Arabi and H. Zaidi, "A new deep convolutional neural network design with efficient learning capability: Application to CT image synthesis from MRI," *Medical Physics 47(10), 5158-5171 (2020). DOI:* https://doi.org/10.1002/mp.14418