PhD Thesis title: '**Development and Validation of Quantitative Imaging Methods for Patient-Specific Targeted Radionuclide Therapy Dosimetry**'

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ABSTRACT:
In targeted radionuclide therapy (TRT), accurate *in vivo* dosimetry is essential for treatment planning. Currently dose estimation is based on the medical internal radiation dose (MIRD) schema, which requires the cumulated activity estimated from a series of patient scans as input. The patient scans can be 2D planar scans or 3D SPECT images. The goal of this work was to develop and evaluate both 2D and 3D methods to improve the accuracy and precision of organ activity estimates.

The Quantitative Planar (QPlanar) processing method was proved to provide more accurate organ activity estimates than Conventional Planar (CPlanar) processing methods. However, two assumptions of the QPlanar method limit its application to clinical data. Therefore, we developed an Extended QPlanar (EQPlanar) method and validated it using both Monte Carlo Simulation and ^{111}In-Zevalin patient data. We showed that EQPlanar method provided improved organ activity estimates compared to standard QPlanar method and CPlanar methods, with accuracies approaching those from quantitative SPECT (QSPECT) method.

For SPECT processing methods, we studied the quantitative accuracy of I-131 SPECT images. During I-131 imaging, due to the high energy of imaging photons (364 keV) and the presence of photons with even higher energies (637 and 722 keV respectively), quantitative I-131 imaging is quite challenging. We developed a model-based downscatter compensation method and proposed a comprehensive compensation method for I-131 images. We showed that SPECT images reconstructed using the proposed method provided more accurate organ activity estimates than standard methods. It was observed that the effects of anatomy variations and organ uptakes were more significant than the effects from statistical noise. This demonstrates the importance of developing quantification methods that are robust to these changes.

In summary, both 2D and 3D quantitative imaging methods were developed and evaluated. The 2D EQPlanar method addressed the limitations of the standard QPlanar method and provided accuracy and precision approaching that from the pure QSPECT method while using simpler imaging protocols. Among the 3D methods, the proposed model-based compensation method, including the newly-developed downscatter compensation model, provided more accurate organ activity estimates than conventional methods.

References to author publications that relate specifically to the dissertation:

1. **N. Song**, Y. Du, B. He and E. C. Frey, "Development and Evaluation of a Model-based Downscatter Compensation Method for Quantitative I-131 SPECT", ***Medical Physics,*** **38 (6)** 3193-3204, **2011**.
2. **N. Song**, B. He, R. L. Wahl and E. C. Frey, "EQPlanar: A Maximum-Likelihood (ML) Method for Accurate Organ Activity Estimation from Wholebody Planar Projections", accepted by ***Physics in Medicine and Biology,*** 56(17):5503-24, **2011**.
3. **N. Song**, B. He and E. C. Frey, "The Effect of Volume-of-Interest Misregistration on Quantitative Planar Activity and Dose Estimation", ***Physics in Medicine and Biology,*** **55 (18)** 5483-5497, **2010**.