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**Development and Initial Evaluation of an MR Compatible Preclinical SPECT Insert
for Simultaneous SPECT/MR Imaging**

Dissertation Defense by
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Abstract

Multi-modality medical imaging systems have become increasingly important in the biomedical imaging field. Two complementary imaging modalities that have not yet been fully integrated into a multimodality system are Single Photon Emission Computed Tomography (SPECT) and Magnetic Resonance Imaging (MRI). To this end, our team has developed an MR compatible SPECT insert for simultaneous preclinical SPECT/MR imaging. The insert's detector is composed of five rings of 19 Cadmium Zinc Telluride pixelated modules. This dissertation discusses two significant contributions made towards the development of our SPECT insert: the design of multi-pinhole (MPH) collimators and the development of a system calibration method. Additionally, results of experiments conducted to evaluate the performance of the insert are shown.

We developed methods to systematically determine design parameters for cylindrical MPH collimators for the SPECT insert. These methods allowed us to study how MPH design parameters varied as the collimator's diameter increased. Ultimately, these methods were used to design two collimators with imaging resolution of 1 mm and 1.5 mm. Simulation results demonstrated that both collimators can be used to obtain SPECT images with the designed resolution and free of reconstruction artifacts. Prototypes collimators were implemented using nonmagnetic materials.

Without system calibration, images acquired with our SPECT insert have poor image quality. We developed a novel energy calibration method to identify the energy of detected gamma photons at all 24,320 detector pixels simultaneously. We also developed a two-stage detector uniformity correction method to identify and correct for detector nonuniformities as well as dead, hypoactive, and hyperactive pixels. Finally, a method was developed to correct for the drift of charged particles in the insert's detector modules due to the Lorentz Force during simultaneous SPECT/MR acquisition. SPECT images were reconstructed from acquired data with and without application of the system calibration methods. When applied, images showed significant improvement in terms of resolution, uniformity, contrast, and artifact reduction.

To evaluate our SPECT insert, several imaging experiments were conducted, ranging in complexity from standalone SPECT phantom studies to a dynamic simultaneous SPECT/MR preclinical study. Results show that the SPECT insert can obtain high quality SPECT and MR images simultaneously.

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