Abstract:

The main motivation of this PhD thesis is to improve the reconstruction process for emission tomography in the context of the development of the small animal imaging center at the Department of Nuclear Medicine in Vrije Universiteit Brussel. Pinhole Single Photon Emission Computed Tomography (SPECT) is a popular in vivo non-invasive imaging modality that uses signals from the injected radioactive tracers to obtain information about the spatial and temporal distribution of the studied biomolecules. The gamma camera in pinhole SPECT has a conical collimator equipped with a pinhole aperture that has a diameter of a few millimeters. This imaging device acts as "camera obscura". The obtained image is inverted and magnified, which results in very good resolution at the cost of small field of view (FOV) and low signal-to-noise ratio (SNR). The finite opening of the pinhole collimator is one of the sources of spatial blurring in the resulting tomographic images.

This work focuses on the possibility of enhancing the quality of the reconstruction by using a multi-ray resolution recovery method to model the finite pinhole aperture. We have developed and made a comparative study of the iterative algorithm, which uses multiple ray forward projection-backprojection pair – 7 or 21 rays Gaussian quadrature which integrates exactly any polynomial of degree less than 6 for 7 rays (and less then 9 for 21 rays). It is relatively easy to implement and the results demonstrate excellent accuracy of the 7 and 21 rays methods, and the corresponding improvement of the image quality compared to conventional reconstruction methods.

In this PhD thesis I also studied the problem of efficient image representation during iterative reconstruction. We have applied Kaiser-Bessel window functions (also known as blobs) for the reconstruction in pinhole SPECT. There are different reasons for using blobs: the regularization (noise reduction) and the better fit of the reconstructed object. The developed multi-ray method was modified to include spherically symmetrical blobs as basis functions instead of conventional cubic voxels. Presented data suggest that blobs perform better in terms of image contrast than voxels with Gaussian post-smoothing. The disadvantage of the algorithm with blob basis functions is that it works slower than the voxel based algorithm. Therefore, we have also proposed and investigated some other alternatives to blobs that can improve the reconstruction speed while providing similar image quality, such as the method of sieves.