Novel Denoising Methods for Dynamic Positron Emission Tomography

By

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Abstract

Positron emission tomography (PET) provides inherently quantitative information about physiological and molecular processes, endowing it with great clinical and research potential. This is particularly true of dynamic PET imaging. Unfortunately, PET, and especially dynamic PET, suffers from unfavorable noise properties, limiting it diagnostically and quantitatively. Denoising methods that improve image quality and thus increase diagnostic accuracy and improve estimates of quantitative parameters could be of great benefit, particularly if they are simple, accurate, and easily implemented on a wide range of PET tracer studies.

The aim of this thesis is to develop and evaluate two novel denoising methods for dynamic PET imaging: HighlY constrained back-Projection-Local Reconstruction (HYPR-LR), which has recently been applied to dynamic PET data with promising results, and spatio-temporal expectation maximization (STEM) filtering, a newly developed 4-dimensional iterative filtering process.

An implementation of HYPR-LR is presented that provides the maximum amount of noise reduction that is possible without introducing any significant bias. This is accomplished using multiple time-dependent temporally summed composite images that account for the kinetics of the tracer being studied. The potential of HYPR-LR to improve dynamic PET imaging is demonstrated using phantom, simulated, and human data, with a focus on quantitative parametric images.

The newly proposed STEM filtering combines two well established image processing techniques: 4-dimensional Gaussian smoothing followed by EM deconvolution. In principle, this approach should provide substantial reductions in noise while introducing little bias. STEM filtering is also evaluated using phantom, simulated, and human data, with a focus on parametric images.

The potential of HYPR-LR and STEM filtering to improve PET imaging of [I-124] labeled agents is also studied. [I-124] could be a valuable radionuclide for PET imaging, but its use is often limited by noise because of dosimetry concerns and relatively few decays by positron emission.

Finally, the impact of a more traditional means of controlling image noise at the cost of bias, varying the number of iterations performed during EM reconstruction, on the diagnosis of temporal lobe epilepsy is studied. This also serves as an illustration of how HYPR-LR and STEM filtering might be evaluated in a clinical context.