Estimating Uncertainty in PET Image Reconstruction via Deep Posterior Sampling

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TL;DR

The paper proposes a conditional GAN-based approach for uncertainty quantification in PET image reconstruction using sampling from the learned posterior distribution.

Abstract

Positron emission tomography (PET) is an important functional medical imaging technique often used in the evaluation of certain brain disorders, whose reconstruction problem is ill-posed. The vast majority of reconstruction methods in PET imaging, both iterative and deep learning, return a single estimate without quantifying the associated uncertainty. Due to ill-posedness and noise, a single solution can be misleading or inaccurate. Thus, providing a measure of uncertainty in PET image reconstruction can help medical practitioners in making critical decisions. This paper proposes a deep learning-based method for uncertainty quantification in PET image reconstruction via posterior sampling. The method is based on training a conditional generative adversarial network whose generator approximates sampling from the posterior in Bayesian inversion. The generator is conditioned on reconstruction from a low-dose PET scan obtained by a conventional reconstruction method and a high-quality magnetic resonance image and learned to output a corresponding standard-dose PET scan reconstruction. We show that the proposed model generates high-quality posterior samples and yields physically-meaningful uncertainty estimates.

Keywords: Bayesian inference, conditional generative adversarial network, deep generative model, inverse problem, positron emission tomography, uncertainty quantification.

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