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Statistical Methods in Medical Image Estimation and Sparse Signal Recovery

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Akademisk avhandling

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Abstract
This thesis presents work on methods for the estimation of computed tomography (CT) images from magnetic resonance (MR) images for a number of diagnostic and therapeutic workflows. The study also demonstrates sparse signal recovery method, which is an intermediate method for magnetic resonance image reconstruction. The thesis consists of four articles. The first three articles are concerned with developing statistical methods for the estimation of CT images from MR images. We formulated spatial and non-spatial models for CT image estimation from MR images, where the spatial models include hidden Markov model (HMM) and hidden Markov random field model (HMRF) while the non-spatial models incorporate Gaussian mixture model (GMM) and skewed-Gaussian mixture model (SGMM). The statistical models are estimated via a maximum likelihood approach using the EM-algorithm in GMM and SGMM, the EM gradient algorithm in HMRF and the Baum–Welch algorithm in HMM. We have also examined CT image estimation using GMM and supervised statistical learning methods. The performance of the models is evaluated using cross-validation on real data. Comparing CT image estimation performance of the models, we have observed that GMM combined with supervised statistical learning method has the best performance, especially on bone tissues.

The fourth article deals with a sparse modeling in signal recovery. Using spike and slab priors on the signal, we formulated a sparse signal recovery problem and developed an adaptive algorithm for sparse signal recovery. The developed algorithm has better performance than the recent iterative convex refinement (ICR) algorithm.

The methods introduced in this work are contributions to the lattice process and signal processing literature. The results are an input for the research on replacing CT images by synthetic or pseudo-CT images, and for an efficient way of recovering sparse signal.

Keywords
Computed tomography; magnetic resonance imaging; Gaussian mixture model; skew-Gaussian mixture model; hidden Markov random field; hidden Markov model; supervised statistical learning; synthetic CT images; pseudo-CT images; spike and slab prior; adaptive algorithm.

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