A NOISE REDUCTION BASED COMPUTED TOMOGRAPHY IMAGE ENHANCEMENT

ABSTRACT
of
THESIS

SUBMITTED TO

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Abstract

Today, Computed Tomography (CT) is one of the highly efficient indispensable tools in medical science for clinical purpose. Due to software and hardware limitations, and statistical uncertainty of all physical measurements in Computed Tomography, the unwanted noise appears in CT images. The presence of noise is one of the main factors to degrade the visual quality of the CT images. Because of the image degradation, the experts are not able to identify the correct information from the medical images. Therefore, this thesis investigates the methods for noise reduction in CT images while preserving their main structures. The goal of work is to improve the signal to-noise ratio without loss of spatial resolution or structures of the CT images. Hence, image denoising is an essential processing step preceding visual and automated analyses.

This thesis is concerned with the methods for CT image enhancement using image denoising concepts which can be capable to preserve edges and maintain high visual quality. Before start the CT image denoising, a brief description of CT imaging is presented which is followed by the problems of CT image denoising, motivation for the studies and a brief review of some salient work in the related fields. Further, some necessary concepts, definitions and algorithms for CT image denoising are also discussed. The thesis is attained by various approaches using spatial and transform based denoising techniques.

The first contribution of the thesis has been presented for CT image denoising using total variation (TV) method in spatial domain where a modification on total variation algorithm has been performed. In this work, a new exponentially directional weighted function (EDWF) has also been introduced based on the difference between L_1 and L_2 norms. Furthermore, a numerical algorithm has been designed to solve the minimization problem of EDWF using iterative Split Bregman method.

In next contribution, Wavelet based noise reduction technique has been developed to improve the image quality where adaptive Wiener filtering and Wavelet Packet Threshold (WPT) algorithm are used. The Noisy CT image is decomposed using Discrete Wavelet Transform (DWT), where approximation part is filtered using WPT algorithm and detail part is filtered by the adaptive Wiener filtering. By using the decomposition level, the wavelet packet tree coefficients are calculated using optimal linear interpolation shrinkage function. Denoised image is acquired using wavelet packet reconstruction and inverse DWT. Further, to improve the results, this method has been modified by using the concepts of Wiener filtering and method noise in wavelet domain. In this modified work, a discrete wavelet transform (DWT) is performed over the noisy CT images. The high frequency wavelet coefficients are modified using local Wiener filtering. The first intermediate result is obtained using inverse discrete wavelet transform (IDWT). For better edge preservation, first intermediate result is subtracted from the input noisy image and processed using wavelet packet thresholding. The outcome of wavelet packet thresholding is the second intermediate result. Both intermediate results are added to obtain the final denoised CT image.

Another contribution to denoise the CT images with edge preservation in tetrolet domain (Haar-type wavelet transform) has been developed where a locally adaptive shrinkage rule is performed by using circular shift on high frequency tetrolet coefficients in such a way that noise can be reduced more effectively. Further this scheme is modified using method noise concept. In this modified work, NLM filter and circular shift based wavelet packet thresholding methods are used for CT image denoising.

The next contribution has been designed, developed and evaluated in wavelet domain using intra scale dependency based approach where many intermediate steps are performed using method noise and wavelet based thresholding concepts. This work is divided into two phases. In first phase, input CT image is separately denoised using different patch size where denoising is performed based on thresholding and its method noise thresholding. The outcome of first phase provides more than one denoised images. In second phase, block wise variation based aggregation is performed in wavelet domain to get the final outcome. Further, this scheme is modified using inter scale dependency where bilateral filter and bivariate shrinkage rule is used in dual-tree complex wavelet transform.

The last contribution of the thesis has been designed, developed and evaluated using Wavelet, Curvelet and Non-subsampled Contourlet transforms. In this work, Wavelet and Curvelet transforms based CT image denoising is performed using method concept. Further, this work is modified using Curvelet and Non-subsampled Contourlet transforms where Curvelet and Non-subsampled Contourlet transforms based CT image denoising is performed using thresholding and aggregation concept to get the sharp and smooth CT images.

The salient contributions of the work described in this thesis are given, with the future scope of work in this field.

To verify the performance of all CT image denoising schemes, the qualitative and quantitative evaluations are performed. The experimental results of proposed schemes are visually analyzed. Apart from visual analysis, the proposed schemes are also verified with some standard performance metrics such as Image Quality Index (IQI) and Peak Signal-to-noise Ratio (PSNR) and so on. The proposed schemes are also compared with some standard similar existing methods or state-of-the-art methods, and it is observed that performance of proposed schemes are superior to existing similar methods in terms of visual quality and performance metrics.