DOCTORAL THESIS

Super-resolution image reconstruction based on wavelet-estimation: development and theoretical framework

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Super-Resolution Image Reconstruction based on Wavelet-Estimation: Development and Theoretical Framework

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Abstract

High resolution image reconstruction refers to the reconstruction of a high resolution image from a set of shifted, blurred low resolution images. Many methods have been proposed such as frequency domain method, projection on convex sets (POCS), iterative back projection (IBP), regularization and so on. These methods formulate the framework in the spatial domain or the frequency domain. In this thesis, we propose a high resolution image reconstruction method which is based on using the spatial domain information to estimate the image in the frequency domain. We built up a relationship between the low resolution images and the high resolution image's wavelet subbands by linear interpolation. The high resolution image's wavelet subbands can be expressed as linear combinations of the given low resolution images. The reconstructed image can be easily obtained by taking the inverse wavelet transform of the estimated wavelet subbands. This hybrid spatial/frequency domain approach is conceptually elegant, very easy to implement, and computationally efficient.

To extend our method to work with different types of wavelets, we formulated a numerical algorithm which can derive the relationship between the low resolution images and the high resolution image's wavelet subband for a particular wavelet. Moreover, we developed an error-correction step to improve on the reconstruction. We compute the difference between the simulated low resolution images and the observed low resolution images to estimate the reconstruction error which is then used to update the reconstruction. The results of the enhanced method are better than traditional superresolution methods.

In our methods, some of the low resolution images play more important roles in the reconstruction. To balance the weights of the low resolution images, a balanced high resolution image reconstruction method is developed. This balanced method is extended into an iterative scheme. The results of the iterative scheme showed substantial improvement compared with our previous methods and are superior to the current state of the art method. For deeper understanding of our methods, we formulated a unified

framework for our methods which facilitated analysis and further developments. The convergence property of our iterated reconstruction scheme is discussed and the experimental results verified that our iterative scheme converges. Lastly, we extended our work for multi-sensor arrays and the experimental results are very promising.

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