INTRODUCTION OF A SYMMETRIC TIGHT WAVELET FRAME TO IMAGE PROCESSING: IMAGE FUSION, IMAGE DENOISING and IMAGE INPAINTING

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ABSTRACT

A tight wavelet frame is a natural generation of an orthonormal wavelet if redundancy is introduced into the wavelet system. By allowing redundancy, we gain the necessary flexibility to achieve such properties as symmetry and, more importantly, the short support and high vanishing moments of compactly supported wavelets. In addition, redundancy allows for the approximate shift invariance behavior caused by the dense time-scale plane. We show some applications of symmetric tight wavelet frames (STWFs) for image processing, particularly image fusion, image denoising and image inpainting, and we demonstrate the possibility of using an STWF-based approach for such applications.

INTRODUCTION

We consider some examples of how we can apply symmetric tight wavelet frames (STWFs) to the area of image processing, particularly image fusion, image denoising and image inpainting.

Image fusion

Image fusion, also called pan-sharpening, is a technique used to integrate the geometric detail of a high-resolution panchromatic image and the color information of a low-resolution multispectral (MS) image to produce a high-resolution MS image [1]. This technique is very useful in many remote sensing applications that require both high-spatial and high-spectral resolution.

Wavelet-based fusion methods are widely used to fuse images. In general, these methods are better than other fusion methods in terms of preserving the spectral characteristics of MS images. However, due to the lack of shift invariance, some artifacts arise when a critically sampled discrete wavelet transform (or a DWT) is used for image fusion. One solution to this problem involves the use of an undecimated DWT (UDWT), which can be implemented by removing the down-sampling operations in the DWT. However, the UDWT, which is six-times more expansive than DWT, has the same properties as the DWT except for the shift invariance. In light of these findings, we introduce an STWF to an image fusion method that is based on wavelet decomposition, and the experimental results show that our approach can be an alternative to the DWT approaches to image fusion [2].

Image denoising

Image denoising is the process of removing noise in images corrupted by noise in the acquisition and transmission process. The best way of denoising images is to remove the additive noise while retaining as many important features as possible from the available noisy data. Of the hundreds of image denoising techniques, we focus on a method that uses wavelets to exploit the decomposition of a noisy image: that is, we shrink the wavelet coefficients in order to effect the denoising. This method typically relies on a memory-efficient DWT, though a UDWT more efficiently minimizes the artifacts in a denoised image [3]. As an alternative approach, we introduce an STWF to image denoising. This approach is based on wavelet shrinkage [4].

Image inpainting

To reconstruct missing or damaged portions of images, we can use a technique called inpainting, which fills in the missing areas or modifies the damaged areas in an undetectable way. Inpainting applications cover a wide range of fields, from the restoration of damaged paintings and photographs to the removal or replacement of selected objects [5]. We apply the idea of the two-phase scheme of Chan *et al.* [6] to the recovery of missing data. We can summarize the two-phase scheme of [6] as follows:

(1) Noise detection: The noise candidates are found by the application of an adaptive median filter to the noisy image, f.

(2) Restoration: A specialized regularization method that applies only to the selected noise candidates is used to restore the noise-corrupted domain.

In the first phase of the scheme, the set of noise candidates corresponds to the areas of the missing data. In the second phase, the wavelet shrinkage method is used instead of the existing partial differential equation (PDE)-based approach.

CONCLUSION

We highlighted several applications of STWFs for image processing and demonstrated the possibility of using an STWF-based approach in such applications. In particular, we introduced the STWF as a possible alternative to the existing popular DWTs for image fusion, and we concluded that the STWF-based approach to image denoising compares favorably with approaches based on well-known DWTs. Furthermore, we showed that the STWF-based approach is a potential alternative to the existing PDE-based approach to variational problems, and that it can be successfully applied to image inpainting.

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