SUMMARY OF Ph.D. DISSERTATION

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Title

Higher dimensional generalizations of wavelet transforms and filter banks and their applications for image processing

Abstract

Recently, wavelet transforms (WTs) and filter banks (FBs) have been fundamental tools for signal processing. They success in many applications, for example, image coding (JPEG and JPEG2000), image denoising and so on.

Up to now, one-dimensional real-valued WTs and FBs (1DRWTs/1DRFBs) are often used. However, higher dimensional (HD) WTs/FBs (HDWTs/HDFBs), such as one-dimensional complex-valued WT/FB (1DCWT/1DCFB) or two-dimensional real-valued (2DRWT/2DRFB) have much attention because of their attractive properties for applications; flexible structure, shift-invariance and high directional selectivity, which cannot be realized by 1DRWTs/1DRFBs. However, for those properties, HDWTs/HDFBs require complex constraints which make them difficult to design. In this research, efficient design methods of HDWTs/HDFBs are proposed and applied to image processing applications (compression, denoising).

Chapter 1 describes the background of this research. In Chapter 2, basic theories of multirate systems are reviewed. In Chapter 3, related works about 1DCWTs/1DCFBs and 2DRWTs/2DRFBs are reviewed.

Chapter 4, two-channel complex-valued linear-phase pseudo-orthogonal FBs which have a suitable structure for image coding. The proposed filter bank with the image coding scheme is more effective than the conventional WT in JPEG2000.

Chapter 5 and 6 focus on design of 2-band and M-band dual-tree complex-valued wavelet transforms (DTCWT) which have shift-invariance and high directional selectivity. DTCWTs require the fractional sample delay condition which is difficult to design. In this work, an efficient design algorithms using least squares optimization and cosine-sine modulated filter banks are proposed for the 2-band and the $M(>2)$-band DTCWT design respectively, and applied to image denoising.

In Chapter 7, the critically-sampled contourlet transform with non-redundancy and high directional selectivity is proposed for efficient image coding.

Finally, this paper is concluded in Chapter 8.