Wavelet transform image coding using lattice vector quantisation

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Indexing terms: Image coding, Vector quantisation, Wavelet transforms

A novel method for the efficient coding of image wavelet coefficients using zerotree multistage lattice vector quantisation is presented. This method achieves high compression ratios with good picture quality, maintaining a very simple implementation. Simulation results demonstrate that the coding performance of this algorithm favours some of the best reported image compression results.

Introduction: Recently, wavelet transforms have been employed for image and video compression applications. Several investigations have been reported regarding the development of efficient methods for coding wavelet coefficients. The most successful of these methods take into consideration the structural similarity between bands of the same orientation by generating zerotree roots. Shapiro [1] has proposed a very efficient coding method referred to as the embedded zerotree wavelet algorithm (EZW), where wavelet coefficients are coded using zero-tree successive-approximation arithmetic-coded scalar quantisation. The EZW coder produced some of the best image compression results reported so far.

It has been shown that vector quantisation can offer better coding performance compared to scalar quantisation, mainly due to its inherent advantage of fractional bit allocation among the vector components [2]. This motivates the investigation on the development of efficient wavelet coding algorithms based on vector quantisation. Lattice vector quantisation (LVQ) is a type of VQ where the codebook is designed based on regular lattices. A regular lattice is a discrete set of points in k-dimensional space, which can be generated by the integral linear combination of a given set of basis vectors [3]. The main advantage of LVQ is the significant reduction in the encoding complexity, typically required by full-search VQ [4]. This is accomplished by exploiting the structural properties of regular lattices.

This Letter contributes a novel method for wavelet transform coding using zero tree multistage lattice vector quantisation. Simulation results demonstrate that this method outperforms EZW, and it offers 2-3DB improvement over the standard JPEG coder.

Wavelet transform coding using lattice vector quantisation: A new wavelet transform coder has been developed. The coding algorithm is outlined in Fig. 1. In this method, blocks of the most significant coefficients are coded using a zero tree multistage lattice vector quantiser. At each stage, the residual quantisation error of the previous passes is further refined, until a certain level of distortion is achieved, or the bit rate budget is exhausted. This provides the means to guarantee an arbitrary level of average distortion for each band is met (noise shaping), which is convenient for performing bit allocation among the wavelet coefficients taking into consideration the human visual system (HVS) sensitivity to each frequency band [5]. It also offers control over the maximum level of quantisation error made in each wavelet coefficient. This is important for reducing unpleasant artefacts in picture quality, because the error introduced by a poorly quantised single wavelet coefficient can be spread over an area of the reconstructed image [6]. Furthermore, similarities among the bands of the same orientation are exploited by producing zero tree roots, so that a single symbol is used to indicate a wavelet coefficient and its corresponding ones are zero [1].
Method of lines for analysis of arbitrarily curved waveguide bends

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Indexing terms: Method of lines, Optical waveguide theory

The analysis of arbitrarily curved optical waveguide bends is described with the method of lines.

Introduction: Optical waveguide bends are part of many circuits, e.g. in connecting lines of couplers, power dividers.

Analysis: In this Section we will give the basic equations for the modelling of waveguide bends. We start with the bend in Fig. 1a. We divide the bend into sectors with suitable angles $\alpha_n$. Each sector is approximated by a straight waveguide with end planes equal to the sector planes, which are not normal to the propagation direction. Therefore the propagation steps are individual on each discretisation line. The basic element is shown in Fig. 1b. The MoL-BPM uses not only guided but also radiation modes in the structure. Therefore the fields in the two optical waveguides I and II including reflections are given by

$$\phi^I = e^{-\gamma \tau} A^I + e^{\gamma \tau} B^I$$

$$\phi^II = e^{-\gamma \tau} A^{II} + e^{\gamma \tau} B^{II}$$

For all quantities a subscript c or h for the TE or TM mode case, respectively, must be added. The components of the vectors $A$ and $A^I$ are the amplitudes of the modes in the $+z$ and $+z'$ direction, and the components of $B$ and $B^i$ are the amplitudes in the $-z$ and $-z'$ direction. $\Gamma$ is the diagonal matrix of the propagation constants.

Fig. 1: Model of waveguide bend and its basic element

a Model of waveguide bend
b Basic element

The next step is the field matching in cross-section $M$ in which each point has another distance to the reference planes I and II. The distances are equal to the individual propagation steps $\Delta z$.

The main components which have to be matched are

$$TM: E_x = \frac{\partial}{\partial y} \left( e^{-\gamma \tau} \frac{\partial \phi}{\partial y} \right) + \phi_n \eta_B H_y = -j \frac{\partial \phi}{\partial z}$$

$$TE: E_z = \frac{\partial}{\partial y} \left( e^{-\gamma \tau} \frac{\partial \phi}{\partial y} \right) + \phi_n \eta_H H_y = j \frac{\partial \phi}{\partial z}$$

Because the two waveguide cross-sections are identical instead of the field components the potential and its derivative according to $z$ and $z'$, respectively, are to be matched. From eqns. 1 and 2 we...