Chapter 2

IMAGE ZOOMING: USE OF WAVELETS

Narasimha Kaulgud
Department of Electronics and Communications
SJ College of Engineering
Mysore 570 006, India
kaulgud@sjce.ac.in

U. B. Desai
Department of Electrical Engineering
Indian Institute of Technology, Bombay
Mumbai 400 076, India
ubdesai@ee.iitb.ac.in

Abstract  Here we propose a method to zoom a given image in wavelet domain. We use ideas from multiresolution analysis and zerotree philosophy for image zooming. Wavelet coefficient decay across scales is calculated to estimate wavelet coefficients at finer level. Since this amounts to adding high frequency component, proposed method does not suffer from smoothing effects. Zoomed images are (a) sharper compared to linear interpolation, and (b) less blocky compared to pixel replication. Performance is measured by calculating signal to noise ratio (SNR), and the proposed method gives much better SNR compared to other methods.

Keywords:  Wavelets, Multiresolution, Zooming, Zerotree

1.  Introduction

Image interpolation or zooming or generation of higher resolution image is one of the important branch of image processing. Much work is being done in this regard even now. The recent IEEE conference on Image Processing (ICIP-2000) had a full section on interpolation. Classical methods include linear interpolation and pixel replication. Linear inter-
interpolation tries to fit a straight line between two points. This technique leads to blurred image. Pixel replication copies neighboring pixel to the empty location. This technique tends to produce blocky images. Approaches like spline and sinc interpolation are proposed to reduce these two extremities. Spline interpolation is inherently a smoothing operation, while sinc produces ripples (the Gibbs phenomenon) in the output image. Researchers have proposed different solutions for the interpolation problem. Schultz and Stevenson [21] propose a Bayesian approach for zooming. In the super-resolution domain, Deepu and Chaudhuri [19] proposes physics based approach. Knox Carey et al. [25] proposed wavelet based approach. Jensen and Anastassiou [6] proposes a nonlinear method for image zooming. In this paper, we propose a simple method to estimate high frequency wavelet coefficients to avoid smoothing of the edges. We use the ideas of zerotree coding [22] and multiscale edge characterization [12].

This article is organized as follows: Section 2 gives some background on wavelets, multiresolution analysis (MRA) and KL transform. In Section 3 we overview some of the existing methods. Section 4 discusses the proposed method using MRA, Karhunen Loève (KL) transform and scaling function based interpolations. Section 5 extends Section 4 to color images. Section 6 presents discussion on simulation results to illustrate superiority of the proposed method. Section 7 provides some concluding remarks.

2. Background

Here we present some background on multiresolution (wavelet) analysis of signals and KL transform.

2.1. Wavelets

Let \( L^2(\mathbb{R}) \) be the space of all square integrable functions. Then, it has been shown [1]-[2] that there exist a multiresolution analysis of the form: \( L^2(\mathbb{R}) = \bigcup_{j \in \mathbb{Z}} V_j \), (\( Z \) is set of integers) where, the subspaces \( \{V_j\} \) have the following properties: [1]

1. \( V_j \subset V_{j+1}, \quad V_{-\infty} = \{0\}, \quad V_{\infty} = L^2(\mathbb{R}) \)

2. Let \( \phi(t) \in L^2(\mathbb{R}) \) be a scaling function; then, \( V_j = \text{span}_k\{\phi_{j,k}(t) \mid k \in \mathbb{Z}\} \) and \( \phi_{j,k} = 2^{j/2}\phi(2^j(-t - k)) \) for all \( j \in \mathbb{Z} \). As a consequence, \( f(t) \in V_j \Leftrightarrow f(2^j t) \in V_{j+1} \)

3. According to property-2, we see that \( \phi(t) \in V_0 \), then \( \phi(2t) \in V_1 \). Moreover, \( V_0 \subset V_1 \), therefore, \( \phi(t) \in V_1 \). Consequently, \( \phi(t) \) can...