Compression of 3D Ultrasound Image Data

Armin Schoisswohl* Otmar Scherzer

Institut für Industriemathematik
Johannes Kepler Universität
Altenberger Straße 69, A-4040 Linz, Austria

May 13, 1998

Keywords: data compression; wavelets; medical imaging; JPEG; MPEG

1 Introduction

Our industrial partner, the company Kretztechnik AG in Austria, is one of the worlds leaders in development and manufacturing of 3D ultrasonographic systems for medical diagnostics.

A typical 3D ultrasound data set consists of 256^3 Voxels of 8 bit grayscale and requires 16 MB of storage memory.

It is not possible to exchange 3D ultrasound data sets via Internet or wireless communication channels due to the limitations of current networks. Therefore the data has to be compressed before transmission.

We discuss the method for Wavelet compression for 3D ultrasound data. We compare Wavelet compression with the standard compression methods JPEG and MPEG.

2 n-Dimensional Discrete Wavelet Transform

The tensor products of a one-dimensional scaling function φ and a Wavelet ψ generate a set of multi-dimensional Wavelets

$$\Psi^\iota(x) := \psi^{\iota_1}(x_1) \cdots \psi^{\iota_n}(x_n)$$

where $x = (x_1, \ldots, x_n)$, $\iota \in \{0,1\}^n$ and $\psi^0 := \varphi$ and $\psi^1 := \psi$.

Each function $f \in L^2(\mathbb{R}^n)$ can be represented as

$$f(x) = \sum_{m \in \mathbb{Z}} \sum_{k \in \mathbb{Z}^n} \sum_{\iota \in I} d^\iota_{mk} \Psi^\iota(2^m x - k),$$

*schoisswohl@indmath.uni-linz.ac.at, Phone: +43-(0)732-2468-9224, Fax: +43-(0)732-2468-855

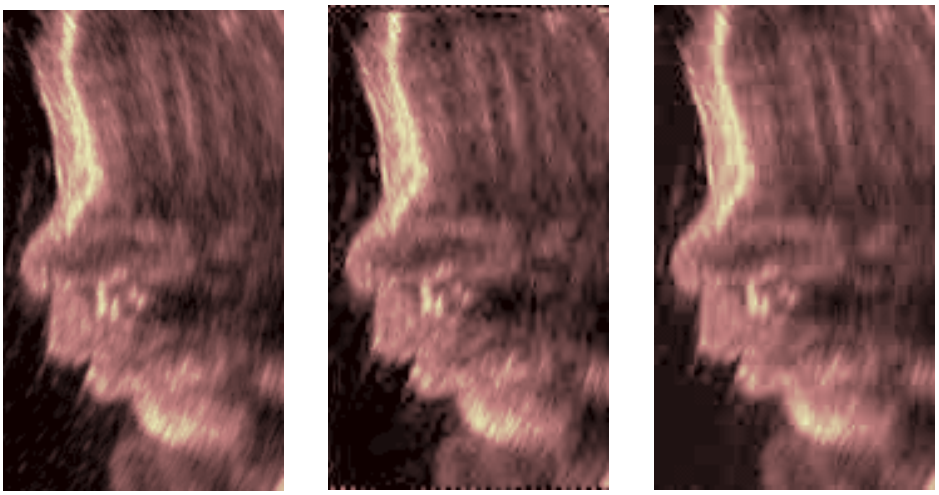

Figure 1: Fetal face: original (left), Wavelet compressed 30:1 (middle) and MPEG 30:1 (right)

where $I = \{0,1\}^n \setminus \{0\}$.

The Wavelet coefficients d^{ι}_{mk} can be calculated efficiently with the Mallat transform represented by a tensor product which reads — using "Einstein's Convention" — as

$$d^{\iota}_{m-1(k_1 \ldots k_n)} = A^{\iota_n}_{2k_n \nu_n} (A^{\iota_{n-1}}_{2k_{n-1}\nu_{n-1}} \cdots (A^{\iota_1}_{2k_1 \nu_1} d^0_{m(\nu_1 \ldots \nu_n)})),$$

where A^{ι_i} are Toeplitz matrices whose entries are the coefficients of the Wavelet ψ^{ι_i}. This tensor product also describes one step of downsampling.

3 Application to Volume Data Compression

After decorrelating the data by applying a few steps of the three-dimensional DWT the Wavelet coefficients are scalar quantized. We discuss quantization effects on ultrasound data.

We compare different methods of encoding: a Zero-Runlength/Huffman-Coder with different symbol tables.

We present some compressed ultrasound datasets obtained with DWT, JPEG and MPEG for visual comparison.

Moreover, the Wavelet transform is compared with JPEG and MPEG from a computational point of view.