MEDICAL SENSORS

PROJECT REPORT

PET/CT Image Denoising and Segmentation based on a Multi Observation and Multi Scale Markov Tree Model

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Contents

Chapter 1

Introduction

Chapter 2

Literature Review

2.1 HMT

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2.2 2D Discrete Wavelet Transform

2.2.1 Overview

A wavelet is a wave-like oscillation with an amplitude that begins at zero, increases, and then decreases back to zero. It can typically be visualized as a "brief oscillation" like one recorded by a seismograph or heart monitor [1]. As a mathematical tool, wavelets can be used to extract information from many different kinds of data, including – but certainly not limited to – audio signals and images [2].

In numerical analysis and functional analysis, a Discrete Wavelet Transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier Transform (FT) is temporal resolution: it captures both frequency and location information (location in time) [3].

In signal processing, wavelets make it possible to recover weak signals from noise . This has proven useful especially in the processing of X-ray and magnetic-resonance images in medical applications. Images processed in this way can be "cleaned up" without blurring or muddling the details [4].

2.2.2 Definition

In 2-Dimensional dyadic multiresolution, a wavelet orthonormal basis in $L^2(\mathbb{R}^2)$ is built up from (tensor) products involving:

- A scale function φ associated to a multiresolution $\{V_j\}_j \in Z$ of $L^2(\mathbb{R})$
- An orthonormal wavelet $\psi \in L^2(\mathbb{R})$ to define a complete orthonormal system, for the Hilbert space $L^2(\mathbb{R})$ of square integrable functions.

The orthonormal wavelet ψ is constructed as the family of functions:

$$\psi^k_{jn}(x) = 2^{\frac{j}{2}} \psi^k \left(2^j x_1 - n_1, 2^j x_2 - n_2\right) \tag{2.1}$$

for integers $j, k \in \mathbb{Z}$.

For this purpose, one defines three wavelets:

$$\psi^1(x_1, x_2) = \varphi(x_1)\psi(x_2) \tag{2.2a}$$

$$\psi^2(x_1, x_2) = \psi(x_1)\varphi(x_2) \tag{2.2b}$$

$$\psi^3(x_1, x_2) = \varphi(x_1)\varphi(x_2) \tag{2.2c}$$

In the case of the discrete wavelet transform, the mother wavelet is shifted and scaled by powers of

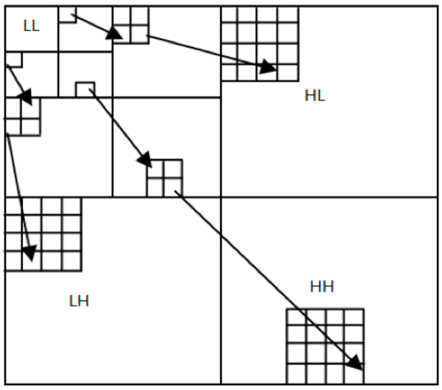

Figure 2.1: Wavelet coefficients arrangement

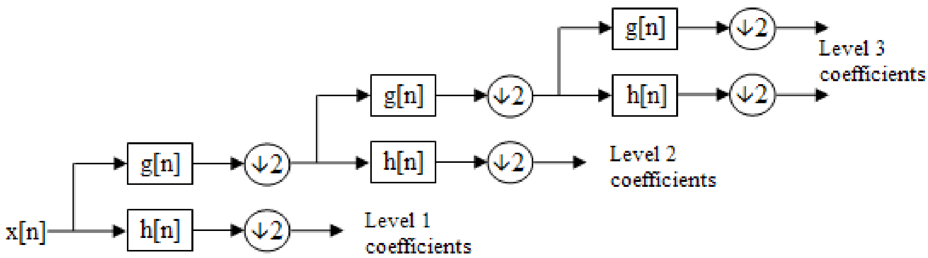

Figure 2.2: A 3 level filter bank

two:

$$\psi_{j,k}(t) = \frac{1}{\sqrt{2^j}}\psi\left(\frac{t-k2^j}{2^j}\right) \tag{2.3}$$

where j is the scale parameter and k is the shift parameter, both which are integers.

Recall that the wavelet coefficient γ of a signal $x(t)$ is the projection of $x(t)$ onto a wavelet, and let $x(t)$ be a signal of length 2^N. In the case of a child wavelet in the discrete family above:

$$\gamma_{jk} = \int_{-\infty}^{\infty} x(t)\frac{1}{\sqrt{2^j}}\psi\left(\frac{t-k2^j}{2^j}\right)dt \tag{2.4}$$

This decomposition, which can be seen in Figure 2.1 [5], is repeated to further increase the frequency resolution and the approximation coefficients decomposed with high and low pass filters and then down-sampled. This is represented as a binary tree with nodes representing a sub-space with a different time-frequency localisation. The tree is known as a filter bank, see Figure 2.2.

2.3 Contourlet Transform

2.4 PET IMAGE DENOISING

2.5 PET/CT Image Segmentation

Chapter 3

Implementation

Chapter 4

Result and Discussion

Chapter 5

Conclusion

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