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MULTIRESOLUTION SIGNAL DECOMPOSITION OF WAVELET REPRESENTATION

Binoy Kumar Datta.

Associate Professor in Mathematics,

Military Collegiate School Khulna (MCSK), Bangladesh.

Email: bkdattamcsk@gmail.com.

Abstract: *Wavelets are mathematical functions that cut up data into different frequency components and then study each component with a resolution matched to its scale. Wavelets were developed independently in the fields of mathematics, quantum physics, electrical engineering and science geology. In this study I try to represent multiresolution analysis in signal decomposition. The mathematical property of the operator which transfer a function into an approximation at a resolution 2j. Then I will show that the difference of information between two approximation at the resolution 2j+1 and 2j is extracted by decomposing the function in a wavelet orthonormal basis. This decomposition defines a complete and orthogonal multiresolution representation called the wavelet representation.*

Keywords: *Multiresolution , Decomposition, Wavelets, Orthonormal.*

INTRODUCTION: Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other function. This idea is not new. However, in wavelet analysis the scale that we look at data plays a special role.

The wavelet analysis procedure is to adopt a wavelet prototype function, called an analyzing wavelet or mother wavelet. Temporal analysis is performed with a contracted, high-frequency version of the prototype wavelet, while frequency analysis is performed with a dilated, low-frequency version of the same wavelet. Because the original signal or function can be represented in terms of a wavelet expansion (using coefficients in a linear combination of the wavelet functions), data operations can be performed using just the corresponding wavelet coefficients. Wavelet analysis is an exciting new method for solving difficult problems in mathematics, physics and engineering with modern applications as diverse as wave propagation, data compression, signal and image processing, pattern recognition, computer graphic, the detection of aircraft and submarines and other medical image technology. Wavelet allow complex information such as music. Other applied field that are making use of wavelet including astronomy, acoustics, nuclear engineering, sub-band coding.

HISTORICAL INTRODUCTIONTON OF WAVELET:

The main Contribution to the History of wavelets are as follows:

1. Jean Baptiste Joseph Fourier
2. Alfred Haar
3. Paul Levy
4. Jean Morlet and Alex Grossman
5. Stephane Mallat and Yves Meyer
6. Ingrid Daubechies

The first known connection to modem wavelets date back to a man named Jean Baptiste Joseph Fourier in the nineteenth century. He was born in Auxerre, France in the year 1768, and he died in Paris in 1830. Although much of Fourier's life was spent in French politics under the great Napoleon, his love for science and mathematics was very apparent. Fourier laid the foundations with his theories of frequency analysis, which proved to be enormously important and influential. The attention of researchers gradually turned from frequency-based analysis to scale-based analysis when it started to become clear that an approach measuring average fluctuations at different scales might prove Jess sensitive to noise.

Alfred Haar was born on October 11, 1885 in Budapest, Hungary. In 1904, Haar traveled to Germany to study at Gottingen where be studied under Hilbert. It was here where his doctoral thesis work was done on the orthogonal systems of functions. Unlike Fourier, Haar spent the better part of his career either studying mathematics or teaching it. Haar's contribution to wavelets is very evident. There is an entire wavelet family named after him. The Haar wavelets are the simplest of the wavelet families. After Haar's contribution to wavelets there was once again a gap of time in research about the functions until a man named Paul Levy. Paul Levy was born on September 15, 1886 in Paris, France. He came from a family known for their mathematical abilities. Before 1975, many researchers had pondered over the idea of Windowed Fourier Analysis (mainly a man named Dennis Gabor). This idea allowed us to finally consider things in terms of both time and frequency. Windowed Fourier analysis dealt with studying the frequencies of a signal piece by piece (or window by window). These windows helped to make the time variable discrete or fixed. Then different oscillating functions of varying frequencies could be looked at in these windows.

MULTIRESOLUTION ANALYSIS OF WAVELET:

A signal is given as a function f which has a series representation $f(x) = \sum_{n=0}^{infinity} a_n x^n$

SIGNAL TRANSMISSION:

Modern technology often requires that information can send from one place to another; one speaks about signal transmission. It occurs, e.g., in connection with wireless communication, the internet, computer graphics, or transfer of data from CD-ROM to computer. All types of signal transmission are based on transmission of a series of numbers. The first step is to convert the given information (called the signal) to a series of numbers. We know that a signal is given as a function f, which has a power series representation.

SCALING FUNCTION:

Another name of Scaling function is Father wavelet. The scaling function is very similar to the mother wavelet. Mother wavelet is defined by the wavelet function Ψ(t) and father wavelet is defined by Φ(t). A scaling function is an aggregation of the effect of the analyzing wavelet for large scales. It is defined by any function $\Phi(t) \epsilon L_2(R)$ in the frequency domain such.

APPLICATION OF WAVELET REPRESENTATION:

In a wavelet representation the detail signals reveal some information about edges, oriented text uses and gross structures which are not as easily accessible in the original image. Let us suppose we want to analyze a photograph taken by a satellite whose distance to the earth is known. We can compute at which resolution will appear the patterns we are looking for and therefore select the relevant detail signal images which contain the interesting information. In order to recognize a continent it is clear that we only need a very coarse description of the image which can be found in S_j and the D_J^k(k = 1,2,3) for j small. Conversely, to characterize the local vegetation we just have to analyze the D_J^k for j large. Another important application is signal matching. The goal is to find the position of a given pattern in an image. This kind of problem arises when we try to find some feature correspondence between several images in order to extract the depth or to measure the local motion. We can compute the wavelet representation of both the reference pattern and the image and then correlate the two representations with a coarse-to-fine strategy. First the coarser levels of the representations are put in correspondence and if the matching seems admissible we continue with the higher resolution image details. For most cases, the coarse resolution information is sufficient to eliminate the mismatches so we do not have to process the finer details, which saves computation. The orientation discrimination of our representation has some interesting applications when there is a preferred orientation in the matching problem. If we want to match a pair of stereo images for example, we know that the disparity is horizontal so the matching has to be found on a horizontal line called unipolar line. Such a matching can only be achieved by using the horizontal high frequencies (vertical edges) so we do not have to correlate the D_J^1 images.

CONCLUSION:

We have described which enables us to understand the concept of resolution and how it relates to scale. We have seen that it is possible to compute the difference of information between different resolutions and thus define a new complete representation called the wavelet representation. It corresponds to an expansion of the original continuous signal in a wavelet orthonormal basis but can also be interpreted as a decomposition in a set of independent frequency channels with orientation tunings. The wavelet functions can be well localized both in the spatial and frequency domains so that this decomposition gives an intermediate representation between both domains. The representation is not redundant because the wavelet functions are orthogonal; it thus keeps constant the number of pixels to code the image. The wavelet representation can be efficiently implemented with a pyramid architecture using quadrature mirror filters and the original signal can also be reconstructed with a similar architecture. The numerical stability is well illustrated by the quality of the reconstruction. The orientation selectivity of this representation is useful for many applications. We have discussed in particular the application of the wavelet representation to signal matching, data compression, edge detection, texture discrimination and fractal analysis.

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