Wavelet decomposition and multiplexing process

Article Overview

Wavelet decomposition breaks a signal into multiple frequency subbands for analysis, while wavelet-based multiplexing uses these subbands to efficiently transmit multiple data streams simultaneously.

Wavelet Decomposition

Wavelet decomposition is a mathematical technique that transforms a signal into components at different frequency scales, providing both time and frequency localization . The process uses a mother wavelet, which is scaled and shifted to generate basis functions for the decomposition. Key methods include:

o Discrete Wavelet Transform (DWT): Decomposes a signal into approximation (low-frequency) and detail (high-frequency) coefficients. In multilevel decomposition, only the approximation coefficients are further decomposed at each level, forming a hierarchical structure known as Mallat decomposition .
o Wavelet Packet Decomposition (WPD): Extends DWT by decomposing both approximation and detail coefficients, producing a full binary tree of subbands. This allows finer frequency resolution and is useful for feature extraction in applications like vibration analysis, rainfall forecasting, and structural monitoring . In 2D signals, such as images, decomposition produces four subbands: LL (approximation), LH, HL, and HH (details). The LL subband can be further decomposed to achieve multiresolution analysis, enabling efficient representation and reconstruction of the original signal .

Multiplexing Using Wavelets

Wavelet-based multiplexing, such as Filtered-Orthogonal Wavelet Division Multiplexing (F-OWDM), is a multicarrier communication technique that replaces traditional Fourier transforms with wavelet transforms . Key features include:

o Subband Transmission: Each wavelet subband carries a separate data stream, allowing simultaneous transmission of multiple signals.
o Overlapping Subcarriers: Wavelet subbands overlap in time and frequency, eliminating the need for a cyclic prefix and improving bandwidth efficiency.
o Reduced PAPR and BER: Wavelet-based multiplexing reduces the peak-to-average power ratio (PAPR) and bit error rate (BER) compared to conventional OFDM systems.
o Flexibility: Different wavelet families (Haar, Daubechies, Symlet, etc.) can be used to optimize performance under various channel conditions, including flat fading and additive white Gaussian noise. The process involves inverse discrete wavelet transform (IDWT) at the transmitter to generate the multiplexed signal and DWT at the receiver to separate the subbands and recover the original data streams.

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Applications

o Signal Compression and Denoising: Wavelet decomposition allows efficient representation and noise reduction in audio, image, and video signals.
o Fault Detection: WPD is used to extract features from mechanical systems, such as wind turbine gearboxes, for condition monitoring.
o High-Speed Communication: F-OWDM enables reliable, high-data-rate transmission in 5G and beyond wireless networks. In summary, wavelet decomposition provides a multiresolution analysis of signals, while wavelet-based multiplexing leverages these decomposed subbands for efficient, high-performance data transmission. This combination is widely used in modern signal processing and communication systems for both analysis and transmission efficiency.

This new modulation technique makes use of the existing standard (orthogonal frequency division multiplexing) OFDM

It discusses the selection of suitable decomposition level and wavelet function for analyzing non-stationary signals to

Multiscale image decompositions refer to techniques that represent an image at multiple scales, utilizing methods such as Gaussian

The Filtered orthogonal wavelet division multiplexing system based on diferent wavelet techniques has been analyzed, and the

1 . Introduction to Wavelet Analysis Wavelets were developed in the 80"s and 90"s as an alternative to Fourier analysis of signals.

This example shows how wavelet packets differ from the discrete wavelet transform (DWT). The example shows how the wavelet

0 otherwise Its simple definition is helpful for computing wavelet transforms, but because it is not continuous, it is not as useful as

The process of using the discrete wavelet transforms (DWT) to decompose a signal or an image into approximation

This paper proposes an adaptive wavelet division multiplexing scheme for wireless systems serving users with

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A wavelet transform is the representation of a function by wavelets. The wavelets are scaled and translated copies of a finite-length

Pandey et al. proposed a wavelet decomposition approach, the process of the proposed approach is that it first decomposed

Wavelet transform is a method used in computer science to analyze small waves efficiently. It involves changing the time extension

Perform the inverse wavelet transform on the original approximation LL-subband and the modified non-LL subbands. The next figure

Continuous and Discrete Wavelet Transforms This topic describes the major differences between the continuous wavelet transform

Feature Extraction: Wavelets provide features useful for classification in machine learning models. Anomaly Detection:

Wavelet decomposition refers to the process of applying different wavelets to EEG signals to extract diagonal, vertical, and horizontal

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