MOVING TARGETS PATTERN RECOGNITION
BASED ON THE WAVELET NEURAL NETWORK

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Abstract Based on pattern recognition theory and neural network technology, moving objects automatic detection and classification method integrating advanced wavelet analysis are discussed in detail. An algorithm of moving targets pattern recognition on the combination of inter-frame difference and wavelet neural network is presented. The experimental results indicate that the designed BP wavelet network using this algorithm can recognize and classify moving targets rapidly and effectively.

Key words Moving targets detection; Pattern recognition; Wavelet neural network; Targets classification

I. Introduction

With the development of science and technology, moving targets detection and classification\(^1\) have been an important task for several applications such as computer vision and video information processing. Wavelet network is a combination of wavelet analysis and neural network, which has become a widely used tool because of its multi-resolution properties and advanced calculation capability. Based on pattern recognition theory\(^2\) and neural network technology and combined with the wavelet neural network, this letter focuses on the research of the automatic detection and classification of moving targets. A category of inter-frame difference detection method and a target recognition algorithm are expatiated in the letter. Using them to detect the moving target can reduce the calculation time, and achieve high resolution. The algorithm is easy to implement on Digital Signal Processing (DSP), which provides a hardware platform for real-time detection and classification.

II. Configuration and Algorithm of Wavelet Neural Network

1. Wavelet analysis

Wavelet analysis\(^3\) has been used widely in recent years. It could extract useful information effectively by performing a local analysis and transform of space (time) and frequency domain. With multi-scale analysis of signals, wavelet analysis can solve many problems that can not be solved by Fourier transform.

Wavelet analysis uses a series of functions to approach signals or functions. And the series of functions are called as wavelet set. They are generated by the dilation and translation of a single prototype function, mother wavelet $\Psi(x)$. Dilation and translation factors

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are \( a \) and \( b \) respectively. The set of basis functions is given below

\[
\Psi_{a,b}(x) = |a|^{-1/2} \Psi \left( \frac{x-b}{a} \right) \quad (1)
\]

The continuous wavelet transform of square integrable function \( f(x) \in L^2(R) \) is defined as below

\[
W_f(a,b) = \langle f(x), \Psi_{a,b}(x) \rangle = \int_{-\infty}^{+\infty} f(x) \Psi^*_a,b(x) \, dx, \quad a \neq 0 \quad (2)
\]

The decomposition of \( f(x) \in L^2(R) \) under the function set \( \Psi_{a,b}(x) \) must fulfill the tolerable condition below

\[
\int_{-\infty}^{\infty} |\Psi(\omega)|^2 |\omega|^{-1} \, d\omega < \infty \quad \text{or} \quad \int_{-\infty}^{\infty} \Psi(x) \, dx = 0
\]

where \( \Psi(\omega) \) is the Fourier transform of \( \Psi(x) \) in the equation above.

Given the dilation factor \( a = 2^j \), translation factor \( b = 2^j k \) in Eq.(1), the discrete radix-2 wavelet can be got as below

\[
\psi_j,k(x) = 2^{-j/2} \psi(2^{-j} x - k), \quad j, k \in \mathbb{Z} \quad (3)
\]

The discrete radix-2 wavelet transform is given below, corresponding to Eq.(2)

\[
W_f(a,b)_{a=2^j, b=2^j k} = \langle f(x), \psi_j,k(x) \rangle = \int_{-\infty}^{+\infty} 2^{-j/2} f(x) \psi^*_j,k(2^{-j} x - k) \, dx, \quad j, k \in \mathbb{Z} \quad (4)
\]

Corresponding to the Fast Fourier Transform (FFT) of traditional Fourier analysis, Mallat brought forward the decomposition and reconstruction pyramidal algorithm based on the multi-resolution analysis. The essence of the idea is, if the discrete approach \( A_j f(x) \) of signal \( f(x) \in L^2(R) \) under the resolution of \( 2^{-j} \) has been calculated, the approach of \( A_{j+1} f(x) \) under the resolution of \( 2^{-(j+1)} \) can be calculated by discrete low-pass filter.

2. Wavelet network configuration

Wavelet transforms are good templates for time-frequency signal analysis because of their excellent localization properties. Back Propagation Wavelet Network (BPWN)[4], as a combination of wavelet transform and BP network technology, could easily identify the specific characteristics of image, and classify in the classification implementation. BPWN replaces the commonly non-linearity sigmoid characteristic function with non-linearity basis wavelet, and the output signal is produced by accumulating linearly the selected basis wavelet. The WN adopted in the letter is a three-layer BPWN including input, output and hidden layer, and the number of node is \( m-r-n \), as shown in Fig.1.

In WN, for the given wavelet function \( \psi(\cdot) \), denoted as \( \psi \), the set of basis wavelet of adaptive outputs, getting from \( j \) cells in hidden layer, is given below

\[
\psi_j = \sum_{k=1}^{m} \alpha_k(t) \psi \left( \frac{x_k - b_j}{a_j} \right), \quad j = 1, 2, \cdots, r \quad (5)
\]

Corresponding to different input mode \( x_k \), \( \psi_j \) could be adjusted to the best conditions adaptively.