TEM Pretreatment Methods and Application Based on Wavelet Analysis

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ABSTRACT
The Transient Electromagnetic Method (TEM) is one of the conventional methods of exploration geophysics. TEM is commonly used to exploring for low-resistivity objects in engineering geological, such as aqueous karst cave, goaf of coal or metal ore, tunnels of road or railway. But in a high background noise conditions, the signal acquisition is disturbed, especially transmit electricity equipments have in the work place, the exploration has brought great difficulties. In order to effectively remove interference, during the transient electromagnetic pretreatment, according to the characteristic decay curve, using db4 wavelet decomposition and reconstruction method of data, effectively suppress the noise. Compared and analyzed the preprocessing field observation data and the data of less interference, pretreatment not only suppress noise but also be able to retain the integrity of the desired signal.

KEYWORDS: Transient Electromagnetic Method, Pretreatment, Wavelet analysis, De-noising

INTRODUCTION
In recent years, with the development of TEM interpretation method, the method has been more and more applications. In crisis mines and goaf of coal TEM is widely applied, but in high noise level area, especially high-voltage power lines and power cables in the work place, TEM signal will be interfered, not only affect the deep abnormal body, but also cause collected data scrapped. In order to make better use of the transient electromagnetic method, Let TEM play an important role in coal electrical prospecting, mineral crisis to replace resources exploration[1-3]. It is necessary to use data pretreatment in high noise test area. As the large area of the work carried out, the data of signal acquisition is expanded infolds, the method of automatically original data pretreatment need to study.
The data measurement of TEM is purely secondary field signal, the late signal has been attenuated to microvolts, it is difficult to obtain a useful signal in high noise background. Wavelet analysis is a method for the treatment of non-stationary signals, it is suitable for detecting normal signal that is entrained by abnormal transient signal, particularly suitable for dynamic, transient signal processing. This paper is using wavelet decomposition and reconstruction of the original signal of TEM to pretreat to remove noise.

BASIC PRINCIPLES

The concept of wavelet transform put forward based on the analysis of processing exploration data of the earth by French geophysicists J.M orlet in 1984. Then, the concept develop and grow by experts and scholars of various disciplines, until 1989 S.M allat put forward the concept of multiresolution analysis, United the wavelet structure methods, especially the fast algorithm of binary wavelet make the wavelet transform to the practical application entirely.

\[ x(t) = \sum_k cA_0(k)\phi_{j,k}(t) = \sum_k cA_j(k)\phi_{j-1,k}(t) + \sum_k cD_j(k)\omega_{j-1,k}(t) \quad (1) \]

Wavelet decomposition and reconstruction method is applied more widely denoising method. In the discrete wavelet transform, we expressed the signal in the space \( \mathcal{V}_j = \mathcal{V}_{j-1} \oplus \mathcal{W}_{j-1} \), for each single \( x(t) \) in \( \mathcal{V}_j \) can be expressed by basis functions which is mentioned in two spaces.

Among them, \( A_j(k) \) and \( D_j(k) \) is coefficient for scale metric space \( j-1 \), \( A_0(k) \) is coefficient for scale metric space \( j \). Scale metric space \( j \) decomposed coefficient \( A_0(k) \), then obtained two coefficients \( A_j(k) \) and \( D_j(k) \) for scale metric space \( j-1 \). The same, we can reconstruct two coefficient of \( A_j(k) \) and \( D_j(k) \) get the coefficient of \( Z \). The specific calculation of decomposition and reconstruction can be done by certain filter bank. When wavelet and scale is orthogonal in space, we can use inner product formula to calculate the coefficient \( cA_j(k) \) and \( A_j(k) \), As shown in formula (2), the inner product calculation formula as shown in formula 3. The specific derivation and the coefficient calculation method can be seen in references[4].
\[ cA_j(k) = \langle x(t), \phi_{j-1,k}(t) \rangle = \left\langle \sum_n c_{j,n}(t) \phi_{j,n}(t), \phi_{j-1,k}(t) \right\rangle \] (2)

\[ \langle \phi_{j,n}(t), \phi_{j-1,k}(t) \rangle = \int_{-\infty}^{\infty} \sqrt{2^{j}} \phi(2^{j} - n)\sqrt{2^{j-1}} \phi(2^{j-1}t - k) dt \] (3)

Generally, the noise signal more contained in high frequency, after the wavelet decomposition of the signal, by using the methods of threshold to weight the decomposed the wavelet coefficients, and then reconstruct the small signal can achieve the goal of signal denoising. In this paper, select db4 wavelet decomposition reconstruction method for the noise data with the aid of Matlab toolbox function.

THE MEASURED DATA DENOISING PROCESSING

In a certain testing ground, choose two points as an example to verify the effectiveness of algorithm. The experimental zone is the coal goaf, transient electromagnetic measurement near the power supply line. Due to the work area to support, we collected two groups of data which horizontal distance from the power line about 20 m and 50 m. These data include contains power interference and no interference of data when the power is cut off, and use the method given in this paper has carried on the pretreatment, process the results as shown in figure 1 and figure 2. When electricity affected by the interference, the tail of measuring signal beat seriously. After power, less interference measuring point, curve is smooth, after denoising processing curve coincided basically with the no interference experimental data[5].

![Figure 1: Fitting (filtering) effect offset powerline 20 m](image-url)
To illustrate the denoising effect, further to preprocessing the measured data from a risis mines, The result is shown in figure 3. The figure 3a is original measurement signal, signal attenuation curve is convergent and the interference influence is big, cannot be directly processed. Figure 3b for the wavelet denoising result, the figure shows that the denoising decay curve basic conform to the attenuation characteristics of transient electromagnetic. In order to further verify the method's ability to retain the effective signal, the data after filtering processed by transient electromagnetic, and the results compared with the known ore body, the results are shown in figure 4. Have mine in 4750-4950 points, contact zone as indirect sign of looking for mineral deposits has obvious electrical shown in the figure. Therefore, the pretreatment method can effectively retain the useful geological signal.
a. (4150-5600) The measured curve of V/I under strong interference;

b. (4150-5600) The measured curve of V/I after processing

**Figure 3:** Contrast figure before and after wavelet denoising
Through the analysis of the field model results, it can be seen, wavelet transform has better denoising effect. When interference is not too big, the recovery signal is close to the signal which without interference. Wavelet transform investigate the time and frequency domain of signal at the same time, so the signal has good noise suppression effect, and the useful information less loss. In addition, the wavelet filter does not need to give strictly estimate parameters as kalman filter, It only need to choose a reasonable a wavelet and determined the decomposition levels, then can well realize the denoising process.
REFERENCES


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