Application and Optimization of Wavelet Threshold Denoising Algorithm in Signal Processing

Zhen kong and Shuo kong

Zhongtong TO Consulting Design and Research Institute Co., Ltd, Jiangsu Nanjing,210019,China
18686004285@163.com
Corresponding author. Email:kongshuo321@163.com

ABSTRACT
Wavelet threshold method filters the signal by eliminating the singular value of data in advance. Based on the conventional hard threshold and soft threshold method, a new threshold function is proposed. The function has better mathematical characteristics and clear physical significance. It can accurately eliminate the noise in the signal and effectively extract the main part and details of the signal. Through the simulation experiment, It is proved that the function can better solve the problems of data singular value and system random error in signal processing, improve the accuracy and efficiency of data processing, is a more effective signal denoising method, and has broad engineering application value in the field of signal processing.

Keywords: Wavelet transform; Threshold function; signal processing

1. INTRODUCTION

The measurement data obtained in aviation, aerospace and other flight tests are an important part of the technical conditions of environmental tests. These data are affected by equipment accuracy, equipment quality, environmental noise and other external noise pollution, and cover up the true value of the measurement equipment signal. Therefore, the preferred technical scheme of signal processing is: firstly, the noisy signal measured in the test is transmitted to the ground receiving station through the wireless channel, and then the data is processed and analyzed to filter out the noise, so as to obtain useful information. From the processing results, the data is mostly represented by jumping points and offsets, i.e. singular values and system random errors, this greatly affects the accuracy of data processing. Wavelet analysis method is a multi-resolution analysis tool developed in recent years. At present, it has been successfully applied to engineering fields such as signal processing. There are many ways to displace the sofa. In this paper, we propose a new threshold function based on the sofa threshold method and the soft threshold method. It is proved that the function can better solve the problems of data singular value and system random error in signal processing.
This paper consists of the following parts. The first part introduces the relevant background and significance of this paper, the second part is the related work this paper, and the third part is application of wavelet threshold denoising in signal processing. The fourth part is conclusion.

2. RELATED WORK

Chistyakov v v et al. proposed nonlinear-regression based algorithm of chemical sensor's signal processing for selective de-tecting of various species in artificial air[1]. Wang x et al. proposed radar life signal processing algorithm based on improved eemd[2]. Sc a et al. proposed signal processing for slug flow analysis: matlab algorithm - sciencedirect[3]. Bandealinaeini h et al. proposed broadcast distributed voting algorithm in population protocols[4]. Liu x et al.proposed correction to: pulse radar randomly interrupted transmitting and receiving optimization based on genetic algorithm in radio frequency simulation[5]. Cheng x proposed a travel route recommendation algorithm based on interest theme and distance matching[6]. K zhao et al. proposed general fuzzy c-means clustering algorithm using minkowski metric[7]. Kaloorazi m f et al. proposed projection-based qlp algorithm for efficiently computing low-rank approximation of matrices[8]. Gao x et al. proposed mimo-sar: a hierarchical high-resolution imaging algorithm for mmwave fmcw radar in autonomous driving[9]. Wang h p et al. proposed application of pole-

zero cancellation circuit in nuclear signal filtering and shaping algorithm[10]. Nabil i et al. proposed ssg-lugia: single sequence based genome level unsupervised genomic island prediction algorithm[11].

The transformation of the couch is actually an influence process. The sofa transform can perform nonlinear radio waves based on different characteristics of signal and noise. It has higher signal time ratio and has higher temporal resolution and is not sensitive to signal form. It has incomparable advantages over traditional filtering methods. Therefore, wavelet transform method is especially suitable for weak signal detection.

3. WAVELET THRESHOLD DENOISING PROCESS

The finite length signal overlapping the provisional noise is assumed as follows:

$y = x + n$ (1)

where: X is the original signal. Y is a noise signal. N is a noise signal. In general, n is a high frequency signal, and X is generally a low frequency signal or a relatively stable signal. Generally, the noise n is assumed to be a gentle gosback noise, and the mean power and scale of the sofa coefficient are inversely proportional to each other. The basic purpose of the sofa transform is to restore the original signal x and to suppress or remove noise in the contaminated signal. In general, the noise reduction process of the one-dimensional signal can be divided into the following three stages.

(1) sofa decomposition of one-dimensional signals. The sofa decomposition coefficient WJ, K for each scale was obtained by selecting the sofa decomposition level n, and the signal Y with the n-class sofa decomposition.

High frequency coefficient of sofa decomposition. The high frequency coefficients (2) WJ and K of the respective layers are selected by selecting the threshold t so as to perform the threshold function processing so as not to change the whole of the signal, and from the one layer to the N layer.

(3) reorganization of one dimensional sofa. After the sofa degrades the low frequency coefficient and threshold of the N layer, the high frequency coefficient of one layer from n layer is processed, and the one-dimensional signal is recombined to the couch to obtain the overwritten original signal estimation value I.

According to the basic principle of the sofa muffling, the core of the sofa threshold is the estimation of the sofa coefficient, i.e., the threshold processing of the high frequency coefficient. Choice of threshold and threshold processing is directly related to the sofa effect.

3.1 Selection of threshold function

The estimation of the sofa coefficient is also called threshold processing. A different sofa coefficient estimation model is a silencing method corresponding to different sofa thresholds. The most common threshold function is the soft threshold function as shown in Figure. 1 and the hard threshold function (as shown in Figure. 2).

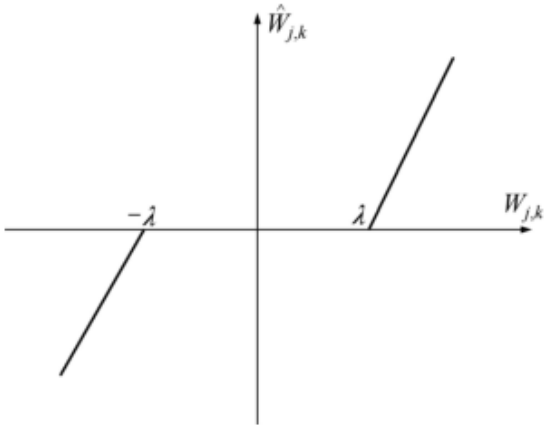

Figure 1 Soft-threshold function

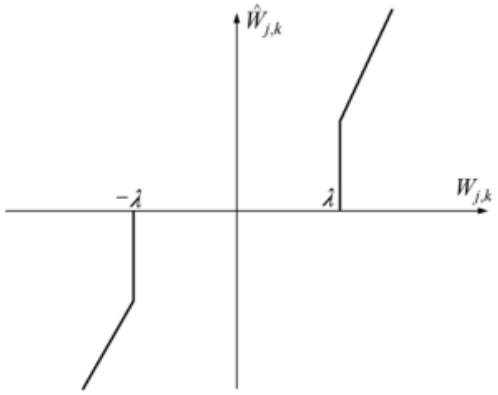

Figure 2 Hard-threshold function

The hard threshold algorithm and the soft threshold algorithm are two general contraction rules, but each has limitations and disadvantages. The hard threshold algorithm changes the sofa coefficient smaller than the threshold value to 0, preserves the sofa coefficient larger than the threshold value and does not require any processing. The hard threshold algorithm can successfully store local features such as edge of the original signal. The contraction coefficient is discontinuous, and it is difficult to deal with mathematical method. Accordingly, when the signal is reconstructed, some interference occurs.

A soft threshold algorithm does not completely conserve softer coefficients than threshold but reduces. This reduces the coefficient. Sofa coefficients are estimated

using a soft threshold method. The overall continuity is good, but if the sofa coefficient is large, constant deviation exists between the decomposition coefficients. This directly affects the proximity of the reconstructed signal and the actual signal, resulting in an unavoidable error in the reconstruction signal.

3.2 Application of wavelet threshold denoising in signal processing

In this paper, by using MATLAB software, through experiments on unstable noisy signals, three improved sofa threshold silencing methods were compared with conventional soft and hard threshold silencing techniques.

3.3. Comparison of denoising effects of different wavelet functions

Using the same data, the soft threshold method is applied, the number of decomposition layers is 3, and the general threshold is selected λ_1. DB4 and sym4 are selected as wavelet functions to denoise the signal, and then the results are analyzed. The effect is shown in Figure 3, and the performance is shown in Table 1.

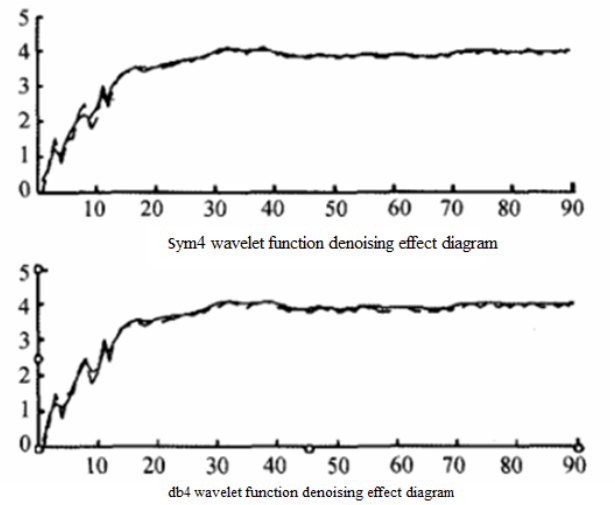

Figure 3 Comparison of noise reduction effects of two wavelet functions

Table 1. Comparison of noise reduction performance of two wavelet functions

Wavelet function signal noise	Ratio (SNR)	Mean square deviation (RSME)
db4	34.5208	0.6409
Sym4	35.6927	0.5600

From the above results, it was found that the sym4 sofa function is superior to the DB4 sofa function, but sym 4 is not the best. Choosing a proper sofa gives you a better sound effect.

3.4. Comparison of denoising effects of two threshold methods

The wavelet function adopts sym4, the threshold is determined by the global threshold and layered threshold methods respectively, the decomposition layer is 3 layers, and the detail coefficient acts as the soft threshold processing. The effect of wavelet denoising is shown in Figure 4, and the comparison of denoising performance is shown in Table 2.

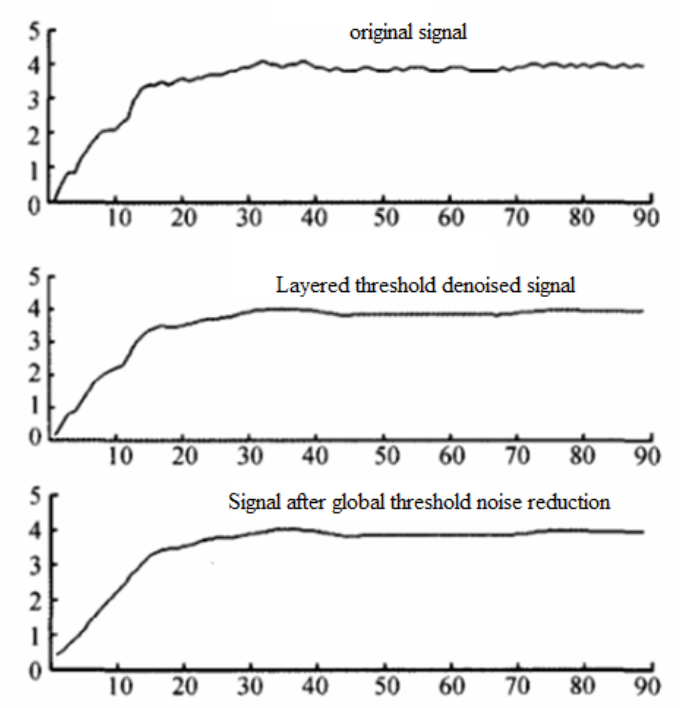

Figure 4 Comparison of noise reduction effects of two thresholds

Table 2. Comparison of noise reduction performance between two thresholds

	Ratio (SNR)	Mean square deviation (RSME)
Layered threshold denoising	32.9080	0.0818
Global threshold denoising	32.5167	0. 0855

From these results, it was found that the noise reduction effect and performance of each layer threshold noise reduction method were superior to the whole range threshold noise method.

4. COMPREHENSIVE COMPARISON OF DENOISING METHODS

In this paper, we compare experimentally with soft threshold algorithm, hard threshold algorithm, soft threshold trade-off method, modal square method, and improved soft threshold trade-off method. Sym4 selects the sofa function, and 3 selects the decomposition layer. The noise reduction effect is shown in Table 5.

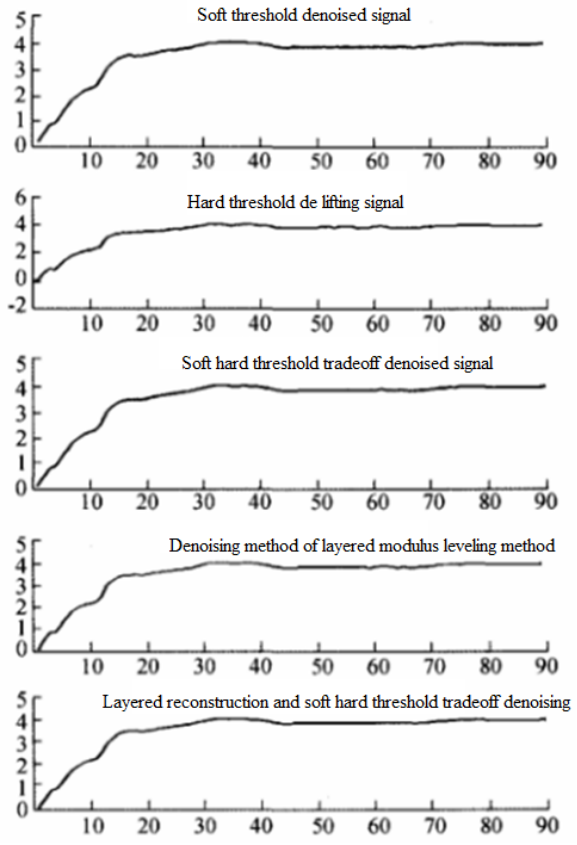

Figure 5 Comparison of noise reduction effects of two thresholds

Table 3. Comparison of noise reduction effects of five threshold functions

Threshold denoising method	Ratio (SNR)	Mean square deviation (RSME)
Soft threshold denoising	32.137 4	0. 089 3
Hard threshold denoising	32.713 2	0.076 4
Soft hard threshold tradeoff	32.908 0	0.071 8
Improved soft and hard threshold tradeoff	33.062 9	0, 0703
Layered modular square denoising	33.759 7	0.064 1

Several improved threshold function silencing is larger than the soft threshold threshold. The hierarchical percentage of the noise is maximum, the mean square deviation is the smallest, and the denoised signal is also very smooth. Therefore, it is concluded that the layered modulus square method is more suitable for the noise reduction of unstable signals.

5. CONCLUSION

In this paper, different wavelet functions and noise reduction methods are used to reduce the noise of unstable signals. Analyze and evaluate the effect of signal after noise reduction; The effects of soft and hard threshold denoising, modulus squared processing, soft and hard threshold compromise and its improved methods are analyzed and discussed. The experimental results show that the layer model squared noise reduction method is very smooth, and the signal noise ratio is maximal, the average variance is minimum, and is relatively suitable for the unstable signal processing. Couch functions used in experiments α And β If selected properly, such a sound reduction method of this specification can embody the superiority of the noise reduction effect.

References

[1] Chistyakov V V, Kazakov S, Grevtsev M, et al. Nonlinear-regression based algorithm of chemical sensor's signal processing for selective de-tecting of various species in artificial air. Technical Physics Letters, 2021, 2021(6):15.

[2] Wang X, Zang J, Shi Y. Radar Life Signal Processing Algorithm Based on Improved EEMD. Journal of Physics Conference Series, 2021, 1948(1):012017.

[3] Sc A, Ep B, Cs B, et al. Signal processing for slug flow analysis: MATLAB algorithm - ScienceDirect. 2021.

[4] Bandealinaeini H, Salehkaleybar S. Broadcast distributed voting algorithm in population protocols. IET Signal Processing, 2021(1).

[5] Liu X, Zhao F , Ai X , et al. Correction to: Pulse radar randomly interrupted transmitting and receiving optimization based on genetic algorithm in radio frequency simulation. EURASIP Journal on Advances in Signal Processing, 2021, 2021(1).

[6] Cheng X. A travel route recommendation algorithm based on interest theme and distance matching. EURASIP Journal on Advances in Signal Processing, 2021, 2021(1):1-10.

[7] K Zhao, Dai Y, Jia Z, et al. General Fuzzy C-means Clustering Algorithm Using Minkowski Metric. Signal Processing, 2021, 188(C):108161.

[8] Kaloorazi M F, Chen J. Projection-based QLP Algorithm for Efficiently Computing Low-Rank Approximation of Matrices. IEEE Transactions on Signal Processing, 2021, PP(99):1-1.

[9] Gao X, Roy S, Xing G. MIMO-SAR: A Hierarchical High-resolution Imaging Algorithm for mmWave FMCW Radar in Autonomous Driving. arXiv e-prints, 2021.

[10] Wang H P, Zhou J B, Ouyang X P, et al. Application of pole-zero cancellation circuit in nuclear signal filtering and shaping algorithm. 2021.

[11] Nabil I, Ishtiaque A , Sabbir A M , et al. SSG-LUGIA: Single Sequence based Genome Level Unsupervised Genomic Island Prediction Algorithm. Briefings in Bioinformatics, 2021(6):6.