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De-noising audio signals of tool wear based on wavelet packet and wavelet of threshold

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Abstract: *cutting tools in CNC machining is directly related to the processing parts, so the quality of the tool and the degree of wear and tear directly affect the quality of the parts to be processed. It also plays an important role in the modern tools in machining, machining in modern manufacturing factory, in order to improve the efficiency and quality of machining parts, we must know the actual situation of the real time of the tool, the only way to timely tool compensation or timely change the knife, finally to improve the processing efficiency parts and spare parts processing quality assurance. In order to monitor the actual working condition of the cutter better, we use the audio signal produced by the cutting process to monitor the tool wear. But in the actual processing environment, there are all kinds of noise, so the audio signals we collected have a lot of noise, so that we cannot judge the specific situation of the tool very well. However, this problem uses wavelet packet method and wavelet threshold de-noise, finally adopting the simulation experiment to determine the signal-to-noise ratio and the mean variance, which verify the wavelet packet and the wavelet of threshold de-noising method for noise removal effect is better.*

Keyword- *audio signal; threshold; wavelet packet analysis; wavelet analysis; mean square deviation; signal-to-noise ratio*

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I. Introduction

With the rapid development of high technology represented by information technology, to adapt to the variability and diversity of market demand, advanced manufacturing technology is developing towards digital, integrated, precision, flexibility, networking, globalization, virtualization, intelligent, clean and modern management in the direction of the development of [1]. before the machining process, people come to judge the tool wear through the eyes and their work experience, but with the development of science and technology, people need to constantly improve the degree of automation, by monitoring the previous experience was far from the needs of social development, and the method must have a long work experience teacher to complete, which greatly restricts the machining quality and efficiency. It was adopted for the number of actual working time and processing parts of each knife to decide whether to change the knife, so although the solution for technical personnel requirements, but the service life of many knife in the actual process is not to be replaced, it will cause a lot of waste of resources, and for some special reason there is no tool replacement time, this will lead to the damage of machining quality and low instrument[2]. People need a better way to carry out effective monitoring of tool state, so the audio signal processing tool is collected in this study to monitor tool wear, through analysis and processing of the audio signal, thus the real-time monitoring of the situation of the tool, but the audio signal in the process of collection is often disturbed by various noise, such as noise, machine gear noise and some man-made noise, which makes a lot of noise often contain audio signals in the image, so that the effect of the treatment result in great error, which can not accurately judge the actual tool wear condition[3]. Therefore, we need to de-noise the noise, and finally use the acquisition of audio signals to judge the tool wear indirectly.

Two key points of wavelet packet de-noising is to select the best basis of Wavelet Packet Threshold and wavelet packet algorithm using hard threshold function or soft threshold function on the line, these methods can eliminate the noise signal impact on data analysis. Therefore, the wavelet packet and wavelet threshold de-noising methods are studied and analyzed, and the MATLAB simulation results show that the wavelet packet de-noising method is superior to the wavelet method.

II. Wavelet packet analysis

Multiresolution analysis of signal in high frequency band of the frequency resolution is poor, and the time resolution is poor at low frequencies, orthogonal wavelet transform, the high frequency part and detail part of the signal is no longer however decomposition, wavelet packet analysis can provide a more precise method

for analyzing signal, it will classify multi-level bands, the resolution analysis is further decomposed into low frequency band and high frequency, and can be analyzed according to the characteristic of the signal, adaptively choose the corresponding frequency band, which matched with the signal spectrum, so as to improve the time-frequency resolution, and improve the time-frequency resolution of[4]. The understanding of wavelet packet analysis is illustrated here with a three level decomposition, and its wavelet packet decomposition tree is shown in fig1.

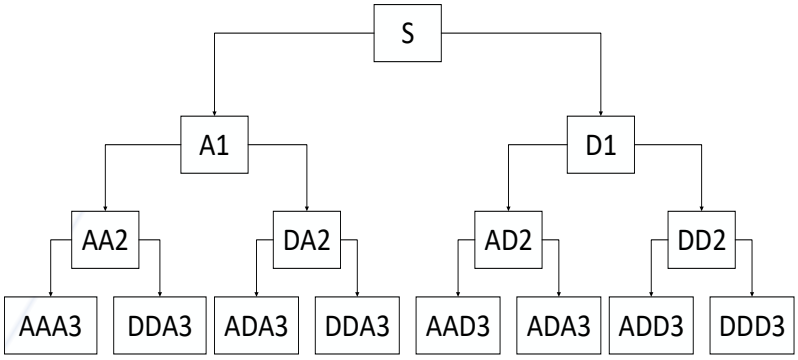

Fig1. Wavelet packet three layer decomposition tree structure diagram

In Fig1 A stands for low frequency, D stands for high frequency, and the ordinal number at the end indicates the number of layers of wavelet decomposition (i.e. degree of scale). Decomposition has relations: S=AAA3+DDA3+ADA3+DDA3+AAD3+ADA3+ADD3+DDD3.

2.1 Wavelet packet decomposition algorithm

$$c_{j+1,2m}(k) = \sum_n c_{j,m}(n)h(n-2k)$$

$$c_{j+1,2m+1}(k) = \sum_n c_{j,m}(n)g(n-2k)$$

2.2 Wavelet packet reconstruction algorithm

$$c_{j,m}(k) = \sum_n c_{j+1,2m}(n)\overline{h(k-2n)} + \sum_n c_{j+1,2m+1}(n)\overline{g(k-2n)}$$

III. Wavelet packet threshold de-noising principle

Wavelet packet de-noising principle based on multi-resolution analysis theory, the first audio signal with noise by the threshold processing in the wavelet domain, then the audio signal is processed by wavelet transform the audio signal after de-noising.

3.1 Wavelet packet de-noising step

the general procedure for de-noising the noisy audio signals using wavelet packets is as follows[5-6]:

(1) Wavelet packet decomposition of signal: select a wavelet base, and determine a hierarchical wavelet decomposition N, and then N wavelet packet decomposition of the signal.

(2) Calculation of the best tree (determine the best wavelet packet base): for a given entropy criterion, the best wavelet packet decomposition tree is calculated.

(3) The threshold quantization of wavelet packet decomposition high frequency coefficients: an appropriate threshold is chosen to quantify the high-frequency coefficients at each decomposition scale. Generally speaking, in order to obtain the optimal result to satisfy the specific analysis and information evaluation criteria, the threshold must be adjusted by repeated experiments.

(4) Wavelet packet reconstruction: wavelet reconstruction is based on wavelet packet decomposition, low frequency coefficients and quantization processing coefficients in layer N.

In these four steps, the most critical is how to select the threshold and how to quantify the threshold. To some extent, it is directly related to the quality of signal de-noising.

IV. Wavelet packet que algorithm

4.1 Selection of threshold function

Wavelet packet usually adopts two methods, hard threshold method and soft threshold method, to de-noise.

4.1.1 Hard threshold function

$$D_n^j = \begin{cases} d_n^j & \left|d_n^j\right| \geq T \\ 0 & \left|d_n^j\right| < T \end{cases}$$

Represents the layer J wavelet transform coefficients, and T represents the threshold. It is proved by the continuity theorem of function that the function is discontinuous at the point of discontinuity, so the wavelet coefficients in the hard threshold method are discontinuous at the threshold and cause the oscillation of the reconstructed signal.

4.1.2 Soft thresholding function

$$D_n^j = \begin{cases} \mathrm{sgn}(d_n^j)(\left|d_n^j\right| - T) & \left|d_n^j\right| \geq T \\ 0 & \left|d_n^j\right| < T \end{cases}$$

Represents the layer J wavelet transform coefficients, and T represents the threshold. By continuous function theorem, the function is a continuous function, although the soft threshold method has good continuity, but the constant deviation between the wavelet coefficients and processing after threshold processing, the constant deviation will result in the reconstruction of the signal amplitude of the small wave attenuation coefficient is large[7].

V. MATLAB of experimental results and analysis

In the MATLAB software platform, the wavelet packet threshold method is used to analyze the de-noising effect of audio signals in tool wear, and compare it with the simulation results of wavelet hard threshold and soft threshold de-noising method.

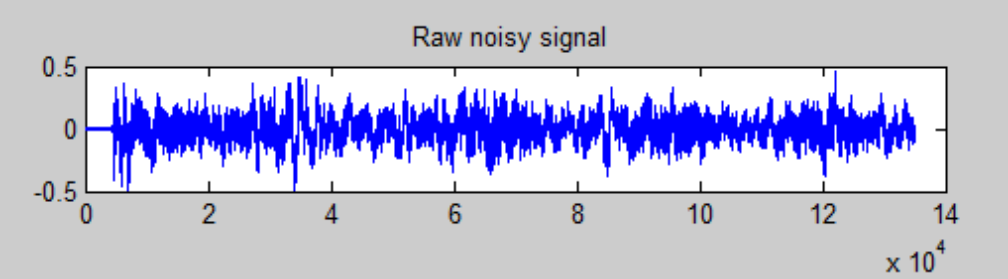

Fig2. Raw noisy signal

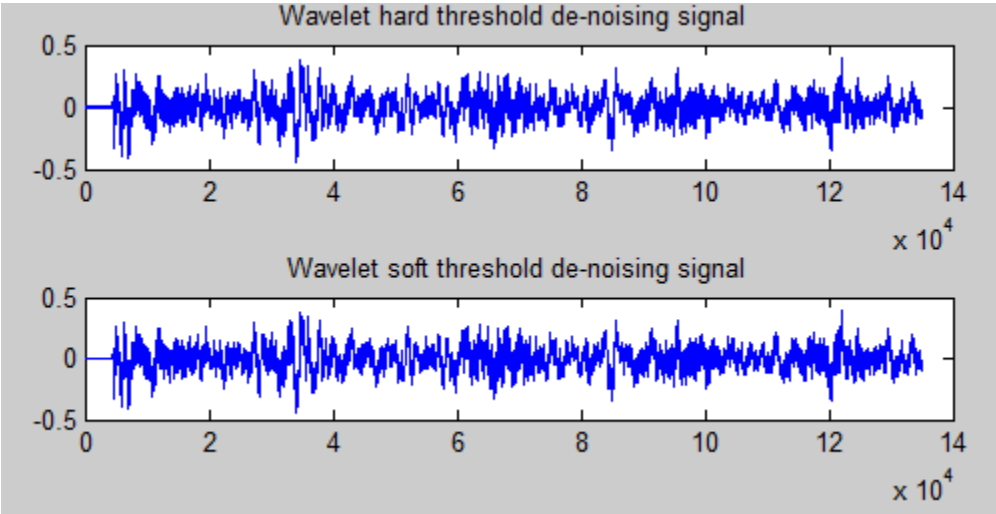

Fig3. Wavelet hard and soft threshold de-noising signal

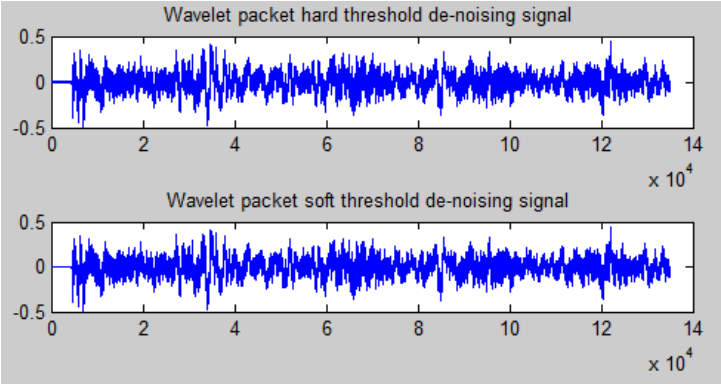

Fig4. Wavelet packet hard and soft threshold de-noising signal

In order to further evaluate the de-noising effect, the mean square error (MSE) and the signal to noise ratio (SNR) evaluation index are introduced[8]:

$$MSE(\%) = \sqrt{\frac{\sum_{n=0}^{N-1}(f - \hat{f})^2}{N}} \times 100\%$$

$$SNR(dB) = 10\lg\left(\frac{\sum_{n=0}^{N-1} f^2}{\sum_{n=0}^{N-1}\left(f - \hat{f}\right)^2}\right)$$

Table1. Mean square error (MSE) and signal to noise ratio (SNR) of various methods

Method	MSE (%)	SNR (dB)
Wavelet threshold method	19.32	11.4471
Wavelet packet thresholding	9.25	17.8490

VI. Conclusion

In traditional signal processing, the no-load condition, the low frequency sound signal, filter the noise signal by filtering, but in the actual cutting process due to human reason there will be a lot of other noise, such as talking and some shop workers from machines crash and so on, these noise bands often not in the low frequency, if these interference noise signal is removed, the processing and analysis of the useful signal which will seriously affect the. Other methods can be used to further deal with the noise signal, so that the useful information in the audio signal can be better preserved, so that the analysis of the audio signal is more accurate. This paper uses wavelet and Wavelet Packet Threshold De-noising Method in de-noising, and to determine their de-noising effect by SNR and RMSE, SNR is higher than the original SNR, the original signal and estimate the signal RMS error of RMSE is small, it is more close to the estimated signal the original signal de-noising effect is better, the simulation can determine the de-noising effect of the wavelet packet threshold is far better than the wavelet de-noising effect.

Reference

[1]. Ren Zhong. Advanced manufacturing technology. *Wuhan: Huazhong University of Science and Technology press*, 2013.
[2]. Miao Zhen. Research on tool wear monitoring based on surface texture of workpiece. *Zhejiang: Zhejiang University of Technology*, 2003.3.
[3]. Hai Tao Fang, Deshuang Huang , Yong Hua Wu. Anti-noise approximation of the lidar signal with wavelet neural networks . *Appl .Opt* , 2005, 44(6):1077-1083.
[4]. Hu Changhua, Li Guo Hua, Liu Tao et al .Wavelet Analysis of System Analysis and Design Based on MatLab 6.0 . *Xi ′ an: Xi Dian University Press* , 2004.1.
[5]. Xu Fei, Shi Xiao Hong, et al. Matlab Application of image processing. *Xi'an: Xi'an Electronic and Science University press*, 2002.
[6]. Kim W. Wavelet packet based optimal sub-band coder . *IEEE Proc. ICASSP* , 1995.
[7]. RELJIN I, SRELJIN B D, PAPIC V. Extremely flattop windows for harmonic analysis. *IEEE Transactions on Instrument and Measurement* , 2007 , 56(3): 1025-1041.
[8]. Yu Wen Xin, Zhang Qian. Wavelet packet de-noising based on improved threshold de-noising algorithm. *communication technology*. Vol.43, No.062010.

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