

The Research of Power plant Operating Data Based on Real-time Digital filtration technology

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Abstract

Real-time monitoring of the data of the thermal power plant is the basis of accurate analyzing thermal economy and accurate reconstruction of the operating state. Due to noise is inevitable, we need real-time monitoring data filtering to get accurate information of units and equipment in the operating data of thermal power plant. Real-time filtering algorithm can't be used to correct the current data with future data. Compared with traditional filtering algorithm, there are a lot of constraints. First-order lag filtering method and weighted recursive average filtering method can be used for real-time filtering. This paper analyzes the characteristics of the two filtering methods and applications for real-time processing of the positive spin simulation data, and the thermal power plant operating data. The analysis revealed that the weighted recursive average filtering method applied to the simulation and real-time plant data filtering achieved very good results.

Keywords: real-time filtering, power plant, operating data, simulation

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1. Introduction

The real-time optimization technique of thermal power units operating parameters is one of the key technologies for the power industry development. Unit modeling is the basis for real-time optimization of operating parameters. The operating parameters of the thermal system are associated with a variety of different strength relationship. Accurate construction of the operating state of the system can reduce the impact of a variety of uncertainties. Typically, Unit modeling rely on the operating mechanism. This method is often difficult to be effective for the complex thermal system. A large number of information reflecting the characteristics of systems and related equipment are hidden in massive operating data. Therefore, the use of data mining methods, correction mechanism model, can greatly improve the modeling accuracy and modeling efficiency [1] [2].

In order to extract the plant operation data, we need to achieve real-time monitoring of the data of the thermal power plant. But in the input signal of the measuring system contains a variety of noise and interference. The noise and interference is fled or superimposed on the electrical signal, which has nothing to do with the signal, on the system power supply and signal cables. It may cause measurement error and the serious interference can cause damage to the equipment [3]. The generated signal interference by computer in the process of electricity production occurs mainly in the following components:

- (1) The interference caused by AC electromagnetic induction.
- (2) The spatial radiation interference generated by the electromagnetic wave.
- (3) The interference caused by improper grounding.
- (4) The interference caused by common impedance [4]
- (5) Mutual interference caused by the multiplexed signals wells column transfer

2. Real-Time Filtering Algorithm

The digital filtering reduces or weakens the influence of noise through the procedure of calculation or judgment. The advantage of digital filtering does not require investment in hardware, and high reliability, good stability, and there is no impedance matching problem.

Digital filtering can also, depending on the actual input signal, using different filtering methods or filtering parameters, with flexible, convenient and functional characteristics. There are many commonly used methods of digital filtering, but mostly for bulk filtering process of offline data. Using the point of time before and after the value to correct the current value, that is not suitable for real-time filtering.

Some real-time filtering algorithm, such as the wavelet real filtering algorithm is an improvement on offline wavelet filter. For slowly varying time-domain signal, it can achieve the effect of the real-time filtering. But in terms of run-time data of the thermal power plant, Signal's time-varying is strong. With wavelet filtering algorithm, Filtered signal lag and boundary effects cause the poor filtering effects [5-11]

After analysis, first-order lag filter method and average weighted recursive filtering method can fulfill the real-time operation of the thermal power plant data filtering.

A. First-order lag filter method

First-order lag filter method is simple and practical, only one parameter a in the range between 0 and 1. The advantages of the first order lag filter method are that it has good inhibition for periodic interference and it is applicable to the higher frequency fluctuations. The disadvantage is that the Phase lag, low sensitivity and the hysteresis level all depend on the values of a . But it can't eliminate the interference signal of the filtering frequencies which is higher than 1/2 of the sampling frequency.

The first order lag filter method can be described as follows: the filtering result = $(1-a) \cdot$ the sample values + $a \cdot$ last filtering results [6].

B. average weighted recursive filtering method

Recursive average filtering is a kind of smoothing filter. Its principle is that measured values are temporarily stored in a queue and the length of the queue is a fixed value N . After getting a new measurement data, the first data of the first queue will be discarded and the queue is moved forward. New measurement data is then placed in the tail, seeking the arithmetic average of the N pieces of sampling values in the queue.

Average weighted recursive filtering method is a recursive average filtering method to improve the data for different time multiplied by a different coefficient. Generally when it is close to the data of the present time, it is multiplied by a large coefficient. The advantage is that the greater of new sampled value of the coefficient is, the higher of sensitivity is. The disadvantage is that the signal smoothing degree will be reduced [7]. This is the average weighted recursive filtering method.

Based on the n th data, for example: it continuously collect the L data and average the m x_i which behind the L data, the average result is y_n .

$$y_n = \frac{1}{m} \sum_{i=L-m+1}^L x_i \quad (1)$$

Y_n is average of m times measured values, x_1 is the 1st sample, For different situations, the value of m may be different, in the above formula is continuously fed into a length of N in the data window. The N data within the filter window as weighted mean movement operation and the output of average weighted recursive filtering method is Z_n .

$$Z_n = \frac{1}{N} \sum_{i=0}^{N-1} W_i y_{n-i} \quad (2)$$

W_0, W_1, \dots, W_{N-1} are constants and satisfy the following conditions:

$$W_0 > W_1 > \dots > W_{N-1} > 0$$

$$W_0 + W_1 + \dots + W_{N-1} = 1$$

Weighted coefficient method which weights are W_0, W_1, \dots, W_{N-1} . Let δ is the delay time, and

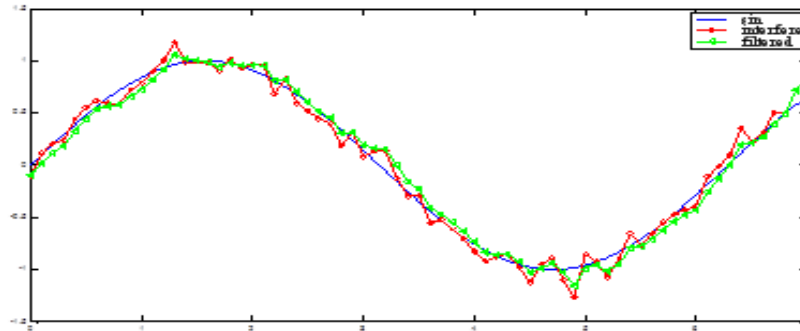
$$\delta = 1 + e^{-\tau} + e^{-2\tau} + \dots + e^{-(N-1)\tau};$$

Then:

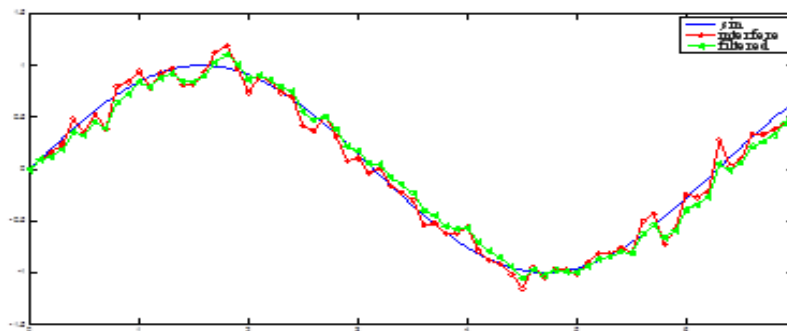
$$W_0 = 1/\delta, W_1 = e^{-\tau}/\delta, \dots, W_{N-1} = e^{-(N-1)\tau}/\delta \quad (3)$$

3. Real-Time Filtering Simulation

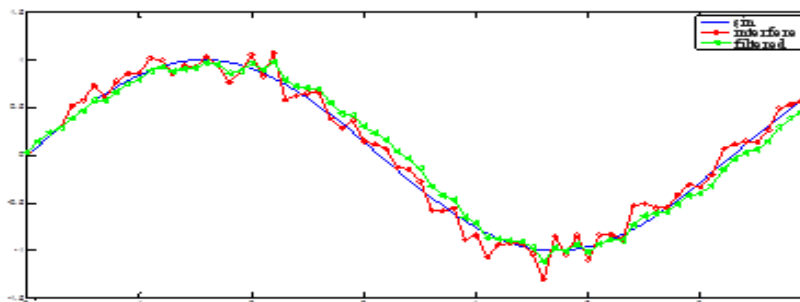
In order to verify the effect of these two real-time filtering algorithms, this article use positive spin signal plus white noise signal as simulation signal at first. Simulated signals in real-time filtering through two filtering algorithm [8], the filtering effect shown in Figure 1.



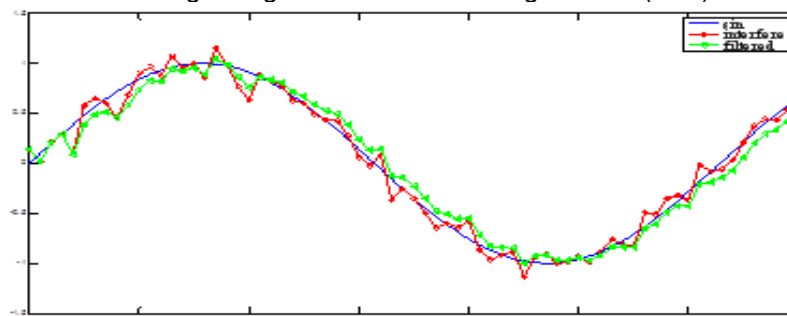
a. First-order lag filter method



b. Average weighted recursive filtering method (N=3)



c. Average weighted recursive filtering method (N=5)



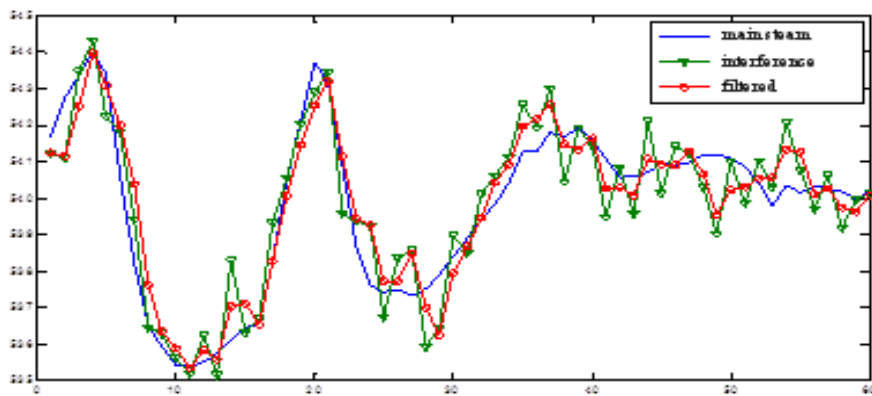
d. Average weighted recursive filtering method (N=6)

Figure 1. A variety of real-time filtering algorithms to handle real-time sine wave signal

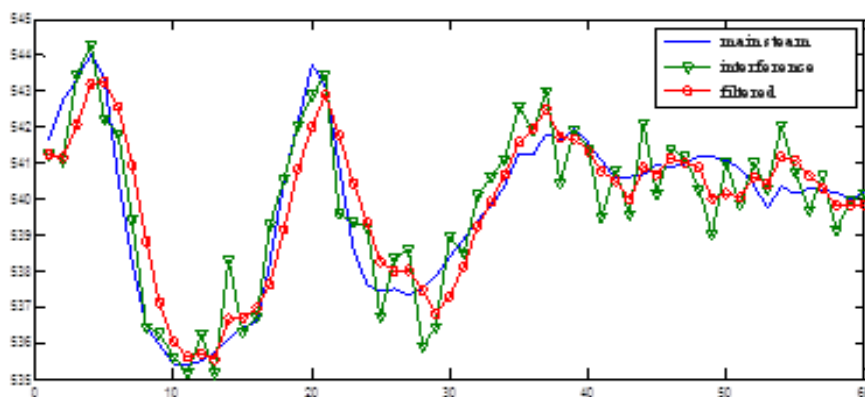
From the above figures it can be seen. With the first-order lag filter method, Real-time sine wave signals are a little different before processing. Smoothness is poor, and compared to the true sine wave, the deviation value is large. With average weighted recursive filtering processed, Real-time sine wave signal's smoothness is generally better and its true sine deviation value is smaller. Therefore, we can say, in terms of real-time signal processing, the average weighted recursive filtering method is superior to the first-order lag filter method.

4. Instance Analysis

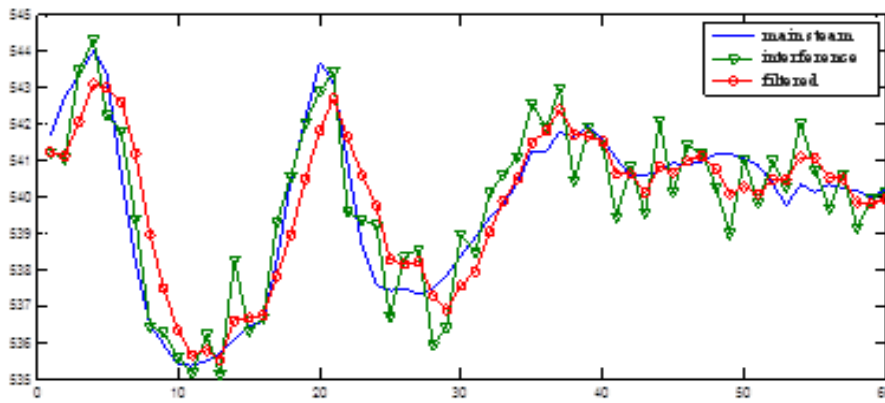
Consider the main steam's temperature signal in real-time of a 600MW power plant Unit as processing objects. Processing the objects with the average weighted recursive filtering method and the first-order lag filter method respectively. As for the actual signal, we can't know its precise value. Therefore, in the program, the object is no longer only the original real-time data of the thermal power plant, but with the white noise process, Then artificially modify certain data. Adding some dead pixels form data deliberately, so that according to the two filtering methods, we can use the effect of processing white noise and bad points to infer the original data processing effect is good or bad. The real-time filtering effect as shown in Figure 2.



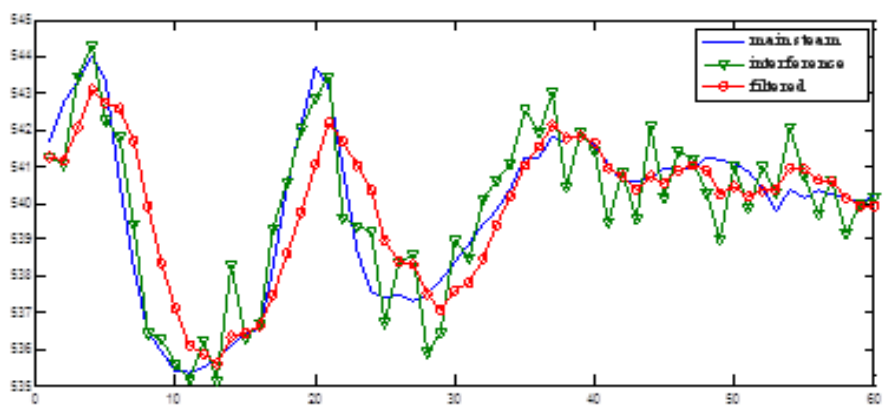
a. First -order lag filter method



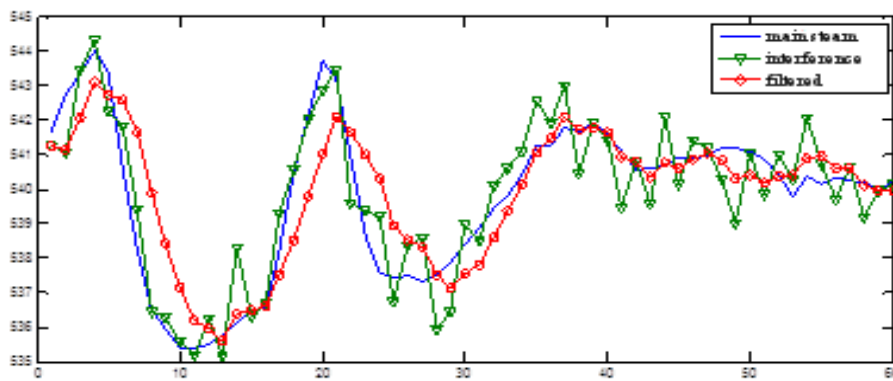
b. Average weighted recursive filtering method (N=3)



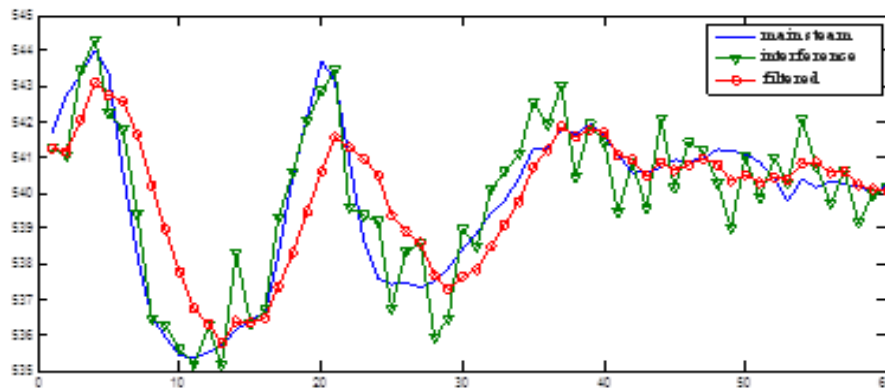
c. Average weighted recursive filtering method (N=4)



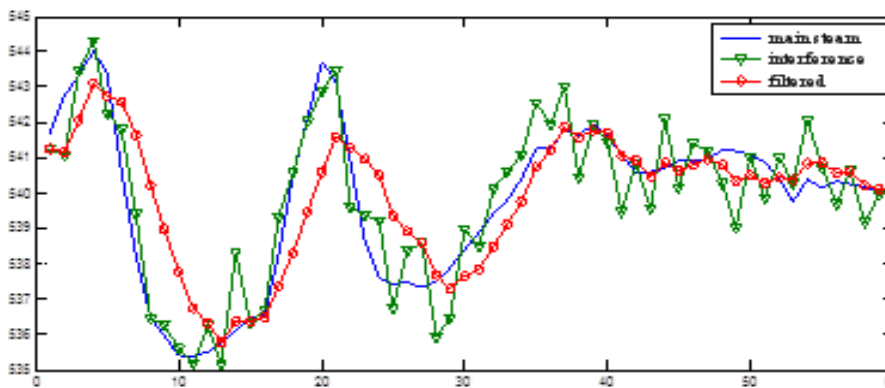
d. Average weighted recursive filtering method (N=5)



e. Average weighted recursive filtering method (N=6)



f. Average weighted recursive filtering method (N=7)



g. Average weighted recursive filtering method (N=8)

Figure 2. Filtering algorithm for processing real-time power plant data

From the group of pictures above, we can say: With the first order lag filter method, the thermal power plant operating data and real data maintained uniform error. Processing data curve's smoothness is poor. While, with average weighted recursive filtering method, the error between thermal power plant operating data and the real data is not very uniform. The two curves in the preferred case (N=5) can be partially overlapped. And we can see the difference between processed data and real data with average weighted recursive filtering method is also less than the difference with first-order lag filter method. From the principle of the filtering method, we can see that the first order lag filter method process data in the next moment with different weights, considering the impact of the previous moment. Recursive average filtering method process data with different weights in a certain moment (the more front moment, the smaller the weight given), considering the impact of the first few moments. Thus, as the reason of different weights, the random interference signal of the first few moments get some elimination. In terms of degree of eliminating the random interference, first order lag filter method is less favorable than the average weighted recursive filtering method. Thus we can see that, dealing with the thermal power plant operating data, compared to the first-order lag filter method, the average weighted recursive filtering method can achieve better results.

From the comparison of average weighted recursive filtering images we know that at the process of filtering different number (N) of recursive data, the impact of the first few moments is different with the moment behind. Thus, we can say the results are obviously different. When recursive data number increased from 3 to 5, the smoothness of the data curve is getting better and better after the filtering process. Results after the filtering process are getting closer and closer to the real data. It means when the number of recursive data increased gradually from 3 to 5, White noise signal added to the real data are increasingly being

eliminated. When recursive data number increased from 5 to 8, the smoothness of the data curve is getting worse,

Results after the filtering process are increasingly far from the real data. With comprehensive comparison, when the number of data is 5, average recursive filtering method can obtain the best results.

5. Conclusion

As the actual signal contain noise and interference, for extracting the valid data reflects the characteristics of the systems and equipment from the scene ,improving the unit model and achieving the purpose of real-time optimization of operating parameters, interference and noise in the real-time monitoring data must be removed. This article discusses two filtering algorithm can be used for real-time filtering, And by positive spin simulation function and the actual operating data analysis, we draw the conclusion: The weighted recursive average filtering method is better than the first-order lag filter method. When the number of recursive average number is 4, the best real-time filtering effect can be applied to the plant real-time data analysis. Thus, it provides a basis for precise analysis of economy of thermal power plants and accurate reconstruction unit operation status. Through the verification of unit modeling, the accuracy of unit reconstructed in real-time filtering is higher than unit reconstructed with direct application of the measurement signal, and more in line with the law of changing with different conditions

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