An Improved Digital Filtering Method Based on Weighted Average of Input and Output Data

Qiang Zhou[1, a], Huali Wu[2, b], Yong Liu[3], Junwei Lei[2]

[1]Department of Scientific Research, Naval Aeronautical and Astronautical University, Yantai, 264001,China

[2]Department of Control, Naval Aeronautical and Astronautical University, Yantai, 264001,China

[3]Department of Navigation, Naval University of Engineering, Wuhan, 430033, China

[a]email: zhouqiang1024@126.com, [b]email: tom_linhuali@126.com

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Abstract. Digitalization of low-pass filter produced from first-order inertia link is carried out firstly in this paper. Then an improved algorithm is proposed to achieve better low-pass characteristics by weighted smoothing the first n-part of the input and output data and using the smoothed data instead of n-1 based on the first step. At last, through the detailed numerical simulation analysis, the correctness and validity of the proposed improved filter design method are verified.

Introduction

Digital filter is a digital device that processes signal by a certain algorithm, and it is usually used to inhibit a band of the signal to get a new signal, making the measurement or display more accurate and more reliable [1-3]. Many scholars have proposed many effective algorithms. Such as median digital filtering method to overcome the large pulse limiting [4-5], the average filtering method to suppress the small high-frequency noise [6], and the compound filtering method with the above two method combined [7]. However, at present, the classical filtering methods are more or less to increase the fuzzy information [8]. Therefore, it is difficult to find a filtering method which can remove the signal distortion and noise at the same time. Based on the principle of average filtering, this paper presents a filtering method based on the weighted average of input and output data, which preserves the details of the signal while filtering the noise.

Model Description of Traditional Low-pass Filter

The traditional low-pass filter is generally designed as the following first-order system, which can be described by differential equation 1as follows [9].

$$\dot{y} = -\frac{1}{T}y + \frac{1}{T}u \tag{1}$$

The transfer function can also be described as following formula 2 [10].

$$\frac{y}{u} = \frac{1}{Ts+1} \tag{2}$$

The following numerical equation 3 is discretized using computer programming.

$$[y(n) - y(n-1)]/\Delta T = [-y(n-1) + u(n-1)]/T \tag{3}$$

Where ΔT is the sampling interval. The formula 3 can be organized as formula 4.

$$y(n) = y(n-1) - \frac{\Delta T}{T}y(n-1) + \frac{\Delta T}{T}u(n-1) \tag{4}$$

Simulation Analysis of Traditional Low-pass Filter

Set $T = 0.1s$, assuming that the input signal is $u = u_a + u_b, u_a = \sin(5t), u_b = 2\sin(10^5 t)$, and $0.2\sin(10^5 t)$ is the noise signal. The performance of the designed filter is verified by comparing the signal before the filter with that after the filter [11]. The simulation results are shown from figure1 to figure 3.

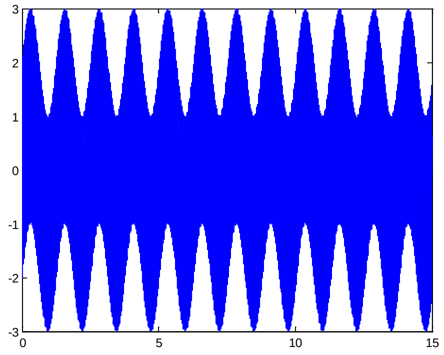

Figure 1 Source signal mixed with noise signal

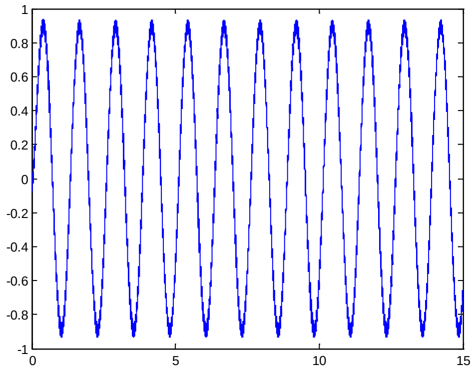

Figure 2 Filtered signal

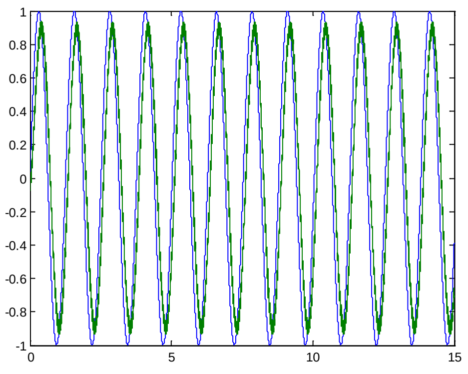

Figure 3 Comparison of filtered signal with useful signal

Improvement Design by Weighted Smoothing

The following improvement design is proposed as formula 5.

$$y(n)=\sum_{i=0}^{j}a_i y(n-1-i)+\sum_{i=1}^{k}b_i\frac{\Delta T}{T}y(n-1-i)-\sum_{i=1}^{l}c_i\frac{\Delta T}{T}u(n-1) \tag{5}$$

And it satisfies the formula 6.

$$\sum_{i=0}^{l}c_i=1,\ \ \sum_{i=0}^{l}b_i=1,\ \ \sum_{i=0}^{j}a_i=1 \tag{6}$$

Simulation results are shown from figure 4 to figure 6.

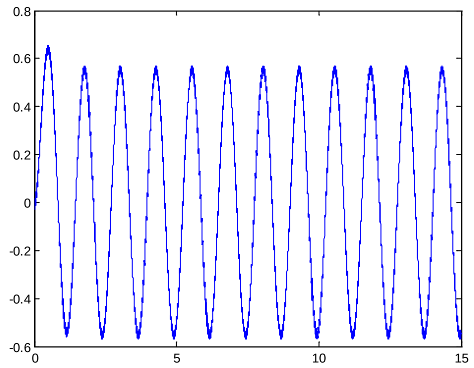

Figure 4 Signal of the improved digital filtering

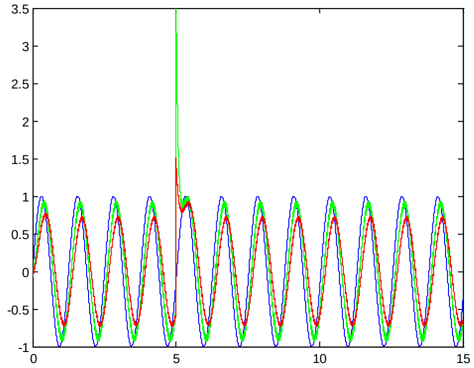

Figure 5 Comparison of the filter signal with the original signal

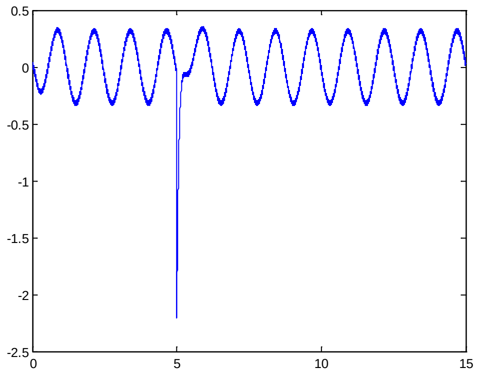

Figure 6 Error Curves of Two Methods

Figure 1 shows the curve of original signal mixed with noise signal, and figure 2 shows the signal from filter designed according the traditional low pass filter, and figure 3 shows the comparison between the useful signal and signal from filter. Figure 4 shows filter result of the improved filter method, Figure 5 shows the difference of the two methods. and figure 5 shows comparison of filter signal with the original signal. And at 5 s, we set a singular point, so the improved method can response to that quickly and error is smaller than the traditional method.

Conclusions

Low-pass filter is designed based on first-order model in this paper. Then an improved algorithm is proposed by weighed average smoothing of the first n-part of input and output data and using the smoothed data instead of n-1. Simulation results show that the improve algorithm has better low-pass performance, which can effectively remove the noise and filter the desired signal. .

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