

Dynamic Signal Processing Based on Morphological Filter

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Abstract. In order to filter out all kinds of interference noises in batching control and improve the precision of the ingredients, a morphology filtering method was used in data processing which is the combination of morphological open-closing and close-opening. When the morphology filter is used to de-noise the interference noise, it doesn't need to consider the dynamic signal spectrum characteristics. After data processing and application in practical production, it is proved that the random noise, pulse noise and mixture noise can be removed effectively. The experiment shows that the simple and realized easily algorithm can be used in facilitate industrial fields and real-time signal processing.

Introduction

On the scene of mixing control, there exists various of peak pulse interference generated by the starting and stopping of high-power inductive loads, electromagnetic interference produced by relay and random noise created by the other equipments. These above noises have a serious affection when obtaining precise weighing signal. Many methods have been used in filtering noise in engineering fields, such as amplitude limiting filter, wavelet transformation and so on. And a good filtering effect have been achieved. However, with Amplitude limiting filter, the choice of the threshold value and corresponding replacement value of data points after removing pulse can produce a great deal of error and reduce the accuracy of the weighing signal. Wavelet transformation, when used in de-noising random noise, have a great deal of disadvantage such as band aliasing, phase shift and amplitude attenuation calculation amount. Taken everything into consideration, it is not suitable for acquisition of weighing signal on the scene of mixing control. For the special requirements of data collection and increasing accuracy on batching scene morphological filtering method is adopted in this paper, selecting the cosine structural elements. In this way, the noise in the weighing signal is eliminated, effectively, the accuracy of weighing signal in the process of the mixing control scene is also improved obviously.

Principle of mathematical morphological filtering and its construction

Mathematical morphological filtering principle

Mathematical morphology is a filtering method to describe the input signal based on mathematics set theory, which is non-linear analytic method different from those based on time domain or frequency domain. Mathematical morphology is widely used in image processing, shape analysis, pattern recognition, power systems, computer vision and medical aspects. However, it is much less popular in the field of industrial control. Morphological filtering based on characteristics of the input signal collect information of the signal by selecting the probe of the appropriate collection of information, which is also known as "structural elements". It matches the signal by moving the

structural elements in the input signal in this way, useful information of the signal can be extracted and noise can be suppressed. Noisy signal are often superimposed on the signal in the form of peak and the bottom, therefore, open – closing cascading combination should be used to eliminate noise in practice.

Construction of mathematical morphological filtering

The signal is one-dimensional signal in the mixing control scene, It is very important to design the morphological filter in this paper. The input signal that is $f(n)$ and the structure element is $g(n)$. $f(n)$ and $g(n)$ are both discrete function, and their definition domain are $F = \{0, 1, \dots, N-1\}$ and $G = \{0, 1, \dots, M-1\}$ and also the condition $N > M$ is required. The basic morphological operations are erosion \ominus and dilation \oplus , two other operations that derived from the basic ones are opening \circ and closing \bullet , and their definition such as equation (1) and (2).

$$(f \circ g)(n) = [(f \ominus g) \oplus g](n) \quad (1)$$

$$(f \bullet g)(n) = [(f \oplus g) \ominus g](n) \quad (2)$$

So the basic filter can be designed such as equation (5) and (6) follows.

$$OC(f(n)) = (f \circ g \bullet g)(n) \quad (3)$$

$$CO(f(n)) = (f \bullet g \circ g)(n) \quad (4)$$

OC and CO represent open-closing and close-opening.

Alternately mixed filter

$$y(n) = \frac{[OC(f(n)) + CO(f(n))]}{2} \quad (5)$$

In the formula, $y(n)$ is output of morphological filter.

Morphological filter applying to signal processing

Ideally, the weighing signal is a linear in the mixing control system, however, it can be changed by the factor such as various noises, and interference which is engendered by the amplifier and regulate circuit, meanwhile the quality is also effected. The signal that is obtained in the batching scene includes noises such as random noise, sinusoid noise which is engendered by control value and pulse noise that is generated by large power equipment and relay. In order to filter out the noises, the type of cosine structure element is used to filter out the random noise, pulse noise, sinusoid noise which are superposed to the weighing signal in this paper. The result can be measured by root mean square and correlation coefficient, the smaller the root mean square and the larger correlation coefficient is, the better the result is. The equation as follows.

$$d = \left[\frac{1}{N} * \sum_{n=1}^N (y(n) - f(n))^2 \right]^{1/2} \quad (10)$$

$$R_{xy} = \frac{\sum_{i=1}^N (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^N (X_i - \bar{X})^2} \sqrt{\sum_{i=1}^N (Y_i - \bar{Y})^2}} \quad (11)$$

X and Y represent input signal $f(n)$ and output signal $y(n)$

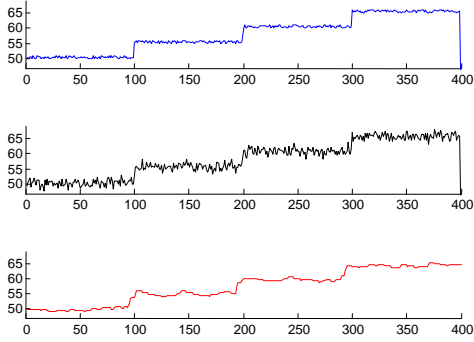


Figure 1 Superposed random noise

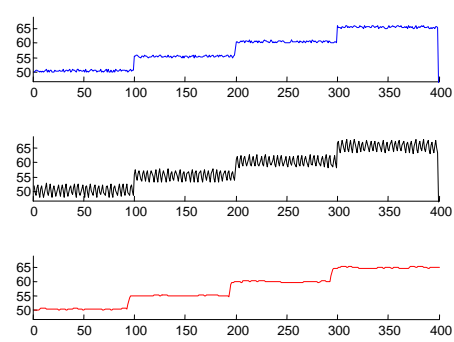


Figure 2 Superposed sinusoid noise

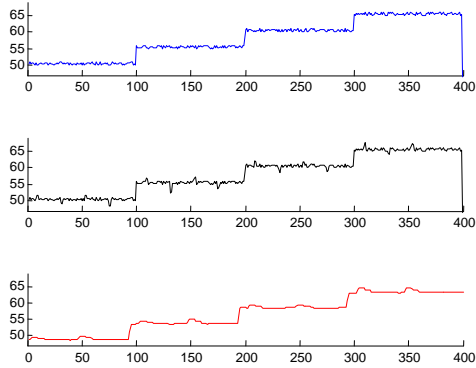


Figure 3 Superposed pulse noise

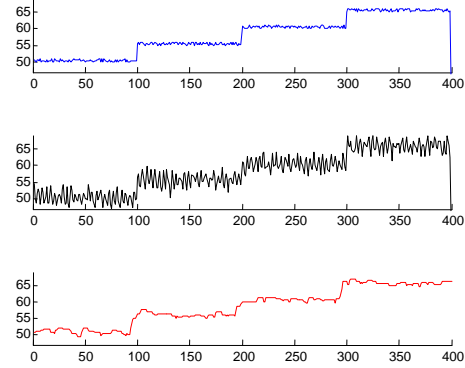


Figure 4 Superposed mixed noise

According to the figure 1,figure 2,figure 3,figure 4,the conclusion shows that:random noise ,sinusoid noise and pulse noise can be effectively removed ,and the filtering result is ideal.The root mean square and correlation coefficient shown as table (1)and (2).

Table 1 The value of the root mean square

Kinds of superposition	Before the filtering	After the filtering
Random noise	3.2768	5.2031e-26
Sinusoid noise	8.6192	1.7772e-26
Pule noise	0.3208	1.9117e-24
Mixed noise	3.2850	3.7328e-25

Table 2 The value of the correlation coefficient

Kinds of superposition	correlation before and after filtering
Random noise	$R=0.8408$
Sinusoid noise	$R=0.8352$
Pule noise	$R=0.8421$
Mixed noise	$R=0.8381$

The conclusion can be found in the table 1and table 2,the weighing signal feature can be retained after filtering

Summary

Morphological filter is a kind of non-linear digital signal processing technology, it is widely used in two-dimensional image processing and shape analysis.The morphological filter is applied in the industrial control field in this paper,pulse noise and random noise can be removed effectively by constructing one filter that based on morphological opening and closing operation cascade combination,a new approach is provided for industrial field signal processing.Various noises can be effectively restrained with morphological filter , the result is much better than one of the methods

such as limiting filtering, median filtering, moving filtering ,and its processing speed and the simple algorithm are obviously superior to the commonly used wavelet transform .

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