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An Improved Wide-band Noise Signal Analysis Method

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Abstract

The representation form of most signals in practice is non-stationary signal, and the main analysis methods for these signals are centralized in the field of time frequency (or time scale), and a series of results have been acquired. A reversible transformation method based on time sequence bit is proposed from another angle, and this method can be used to analyze non-stationary wide-band noise signals according to the difference of some characters of noises and speech signals (such as the randomness degree). The experiment result indicates that this method can reversibly convert random sequences with unordered time sequence into approximately ordered time sequences, and the difference between the wide-band noise character and the speech character is relatively obvious. The method and the principle are simple, and the algorithm can be easily realized real time.

Keywords: Non-stationary signals, Reversible transformation, Wide-band noise

1. Introduction

Noises come from actual application environment, so their characters change largely. Noises can be additive or non-additive. For non-additive noises, some of them can be transformed as additive noises. For example, the multiplicative noises or convolution noises can be changed to additive noises by the isomorphic transformation. The noises concerned in the article can approximately include the voice interference and periodic noises, the impulse noise and the wide-band noise.

The speech interference is mainly induced by other speeches acquired by the mikes or the overhearing in the transfer.

The character of the periodic noise is that it contains many discrete narrow pecks which always come from the periodic rotation of the mechanisms such as engine. Electric interference, especially 50 or 60 Hz AC noises, also will induce periodic noises. Problems induced by periodic noises may be less, because they can be found by the power spectrum or removed by the filtering technology or the transformation technology. However, it is difficult to restrain the AC noise, because its frequency component is not the fundamental tone (it is blow the effective frequency of speech signals), but the harmonic wave component (it may cover the whole audio frequency spectrum by the pulse form).

The impulse noise is embodied as the narrow pulse suddenly occurring in the time domain wave, and it generally is the result of discharge. To eliminate this noise can be implemented in the time domain, i.e. the threshold value can be confirmed according to the average value of extents with speech noise signals. When the extent of noise exceeds this threshold value, the noise signal is judged as the pulse noise which can be depressed and even eliminated completely. If the interference pulses are not too close, they can be simply eliminated in the time function by the interpolation method according to neighboring sample values of signals.

The wide-band noise generally can be supposed as the Gauss noise and white noise. It comes from wind, breathing noise and common random noise source. The quantizing noise generally can be treated as white noise, and it also can be regarded as the wide-band noise. Because the wide-band noise completely superposed with speech signal in time domain and frequency domain, it is very difficult to eliminate it (Hu, 2000).

For the non-stationary signals such as wide-band noise, the traditional analysis measure is not sufficient in time domain or frequency domain, so it needs to develop the united time frequency analysis method which can optimize the non-stationary signals in the time domain and the frequency domain simultaneously. At present, the time frequency analysis has been a very active and important research task in modern signal processing domain.

The wide-band noise signal analysis is to reflect certain character of the noise signals differentiating with other signals by above various methods. With the development of the research of non-stationary signals, new signal analysis processing methods need to be developed continually, and these methods are making us more really cognize the essentials of the nature step by step.

A new reversible transformation method based on time sequence bit is proposed in the article, and this method can be used to analyze the wide-band noises. By the noise experiment, this method can reversibly convert random sequences with unordered time sequence into approximately ordered time sequences, and the difference between the wide-band noise character and the speech character is relatively obvious. The method principle is simple, and the algorithm can be easily realized real time.

2. The reversible transformation based on time sequence bits

The reversible translation method based on the time sequence bit can be described as follows.

(1) Quantify the sampling analog signals as the "binary time sequence A";

(2) Supposed that the length of "unprocessed binary sequence B" is N, inquire whether the binary sequence represented by former n bits (n=1-N) in the sequence B occurs in the "processed binary sequence set C". And if it doesn't occur, stop the inquiry, and add the former n binary sequence into the sequence set C;

(3) Circulate step 2 until traverse the sequence A to end;

(4) Treat the final sequence (the final sequence may be same with certain sequence in the sequence set C);

(5) Transform each sequence X in the sequence set C into the decimal number x, and store it into the sequence set D in turn.

Supposed the length of sequence X is n, and X_j is the number denoted by the j'th number in the sequence X (0 or 1). So the transformation function is

$$x = \sum_{i=1}^{n} 2^i + \sum_{j=0}^{i} X_{j+1} \times 2^j$$

3. The analysis method of non-stationary wide-band noise signals

Apply above reversible transformation method based on the time sequence bit in the wide-band noise analysis.

Experiment environment: Windows 2008, Matlab 2008a, Cooledit2.1.

Experiment data: Sampling rate 22050 Hz, 16 bits quantification.

(1) Respectively generate 1s white noise and 1s brown noise by the Cooledit2.1 software, and the format is the Windows wave voice file (.wav). The time domain figure and the transformed time domain are respectively seen in Figure 1 and Figure 5.

(2) Record 1s fan noise, and the format is the Windows wave voice file (.wav). The time domain figure and the transformed time domain are respectively seen in Figure 2 and Figure 6.

(3) Record 1s flute music signals, and the format is the Windows wave voice file (.wav). The time domain figure and the transformed time domain are respectively seen in Figure 3 and Figure 7.

(4) Record 1s male voice of "twelve" and the format is the Windows wave voice file (.wav). The time domain figure and the transformed time domain are respectively seen in Figure 4 and Figure 8.1 and Figure 8.2.

Experiment method: Use Matlab 2008a to realize the programming of new method. Test the sampling data by the Matlab 2008a Simulation Platform. And the experiment figures are seen in Figure 1 to Figure 8.

4. Result analysis and theoretical analysis

In short time, the speech signals can be approximately regarded as time domain stationary signals. In practice, wide-band noise mainly includes white noise and color noises (pink noise and brown noise), and both of them are representative non-stationary random signals, and even in the time domain analysis of signals in short time, the wide-band noise still shows unpredictable random character, i.e. the randomness degree of wide-band noise is higher than the speech signals. The new transformation method in the article just can accord with this character. By large numerous of experiment, after new reversible transformation, the voice signal, the music signal and the wide-band noise could present completely different characters, and the random noise in unordered time sequence could show the character of rule.

Being similar with the ergodicity of random signals, in the wide-band noise analysis, the new method also embodies the tendency of "ergodicity" that the transformed sequence set data increase approximately and gradually.

5. Conclusions

For non-stationary signals, the most widely analysis methods are all based on the time frequency domain (or time scale) at present, and a series of result has been acquired. With the development of the research of non-stationary signals, new signal analysis processing methods should be developed continually. The non-stationary signals can be transformed from another angle in the article, and the reversible transformation method based on the time sequence bit is proposed. Though relative theories have not been studied deeply, but many experiments have showed that this method can transform more unordered wide-band noise signals in time sequence into ordered sequences. The deeper research in the application of normal speech signal processing is been implemented.

References

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Zhang, Xianda & Bao, Zheng. (2001). *Non-stationary Signal Analysis and Processing.* National Defense Industry Press. July of 2001.

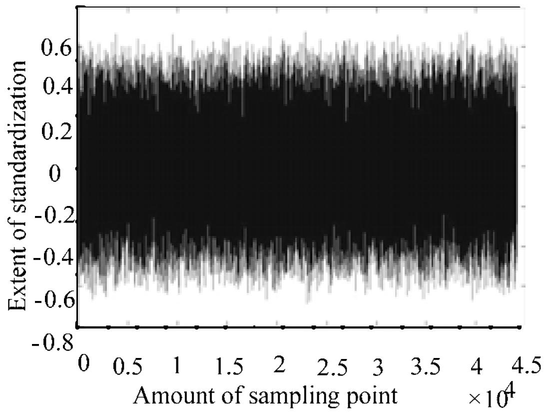

Figure 1.1 Second White Noise in Time Domain

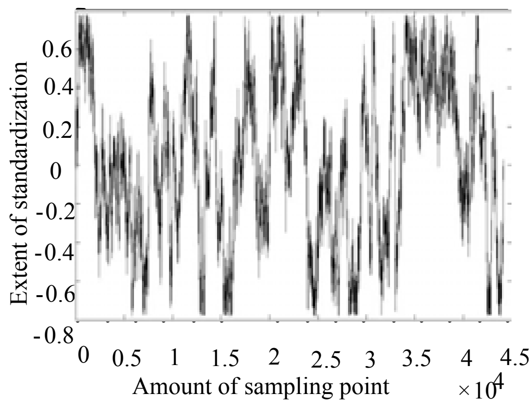

Figure 2.1 Second Brown Noise in Time Domain

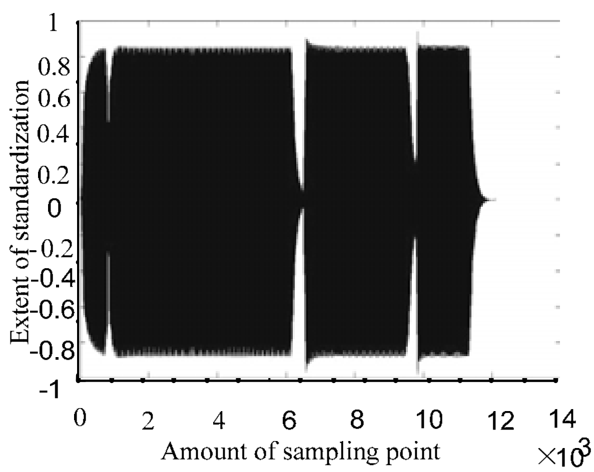

Figure 3.1 Second Flute Music in Time Domain

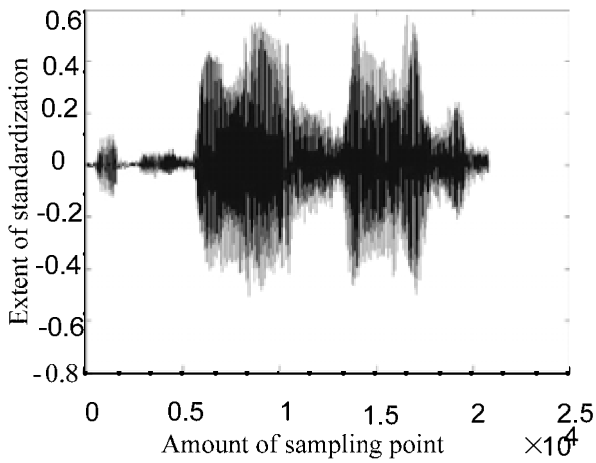

Figure 4.1 Second Male Voice "Twelve" in Time Domain

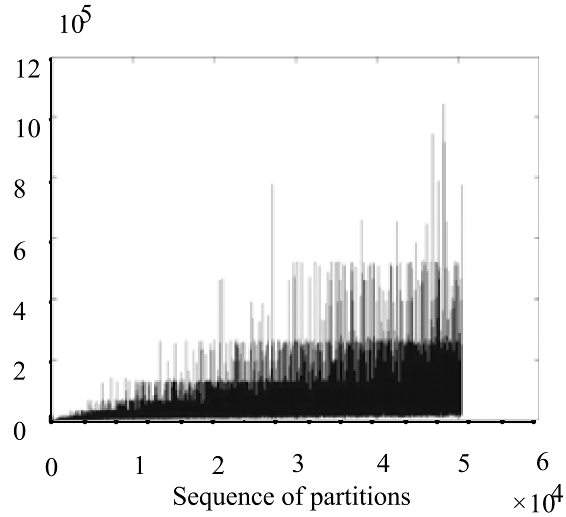

Figure 5.1 Second White Noise after New Transformation

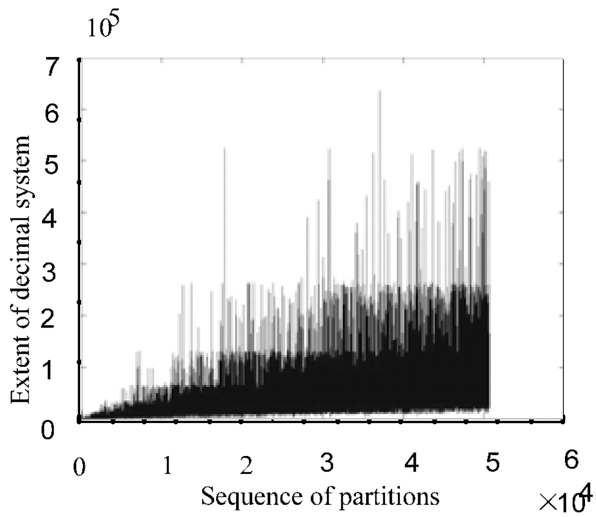

Figure 6.1 Second Brown Noise after New Transformation

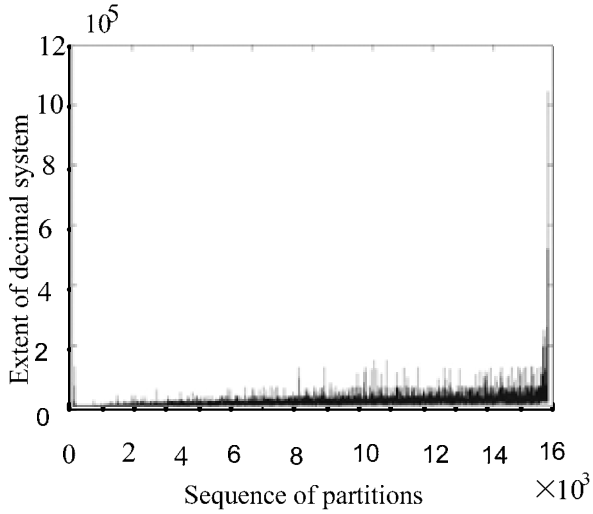

Figure 7.1 Second Flute Music after New Transformation

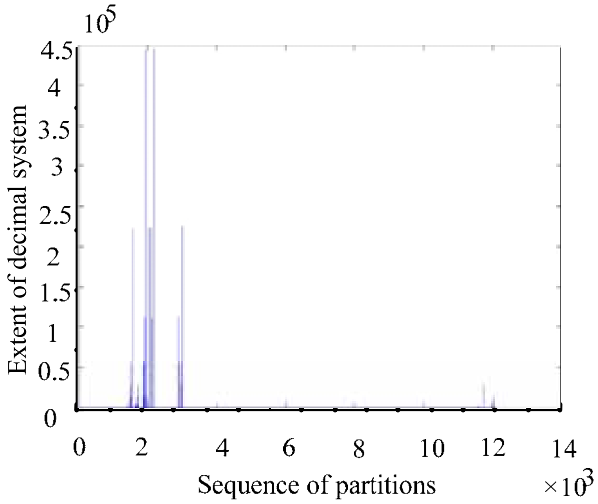

Figure 8.1.1 Second Male Voice "Twelve" after New Transformation (Overall View)

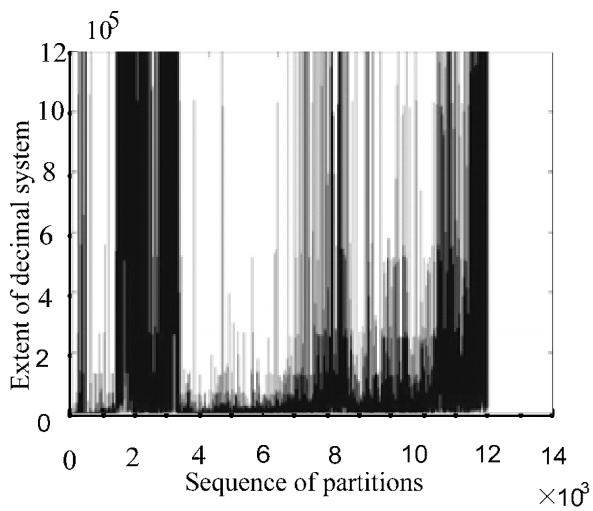

Figure 8.2.1 Second Male Voice "Twelve" after New Transformation (Local View)