

Smart Innovation, Systems and Technologies 394

About Ella Hassanien
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Proceedings of BIIT 2023

 Springer

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Preface

This volume constitutes the refereed proceedings of the 2023 International Conference on Business Intelligence and Information Technology (BIIT 2023) held in Harbin, China, during December 17–18, 2023. BIIT 2023 is organized by the School of Computer and Information Engineering, Harbin University of Commerce, and supported by Scientific Research School of Egypt (STSEG). BIIT is organized to provide an international forum that brings together those actively involved in the areas of interest, report on up-to-the-minute innovations and developments, summarize the state of the art, and exchange ideas and advances in all aspects of business intelligence and information technologies. The papers cover current research in business intelligence and decision making, digital economy and digital technology, electronic commerce technology and application, image analysis and processing, information technology and applications, machine learning and deep learning and their applications.

The conference proceedings has six main tracks:

Part I: Automatic Control Technique

Part II: Business Intelligence and Decision Making

Part III: Digital Economy and Digital Technology

Part IV: Image Analysis and Processing

Part V: Information Technology and Applications

Part VI: Machine Learning and Deep Learning and Their Applications

On average, all submissions were reviewed by at least two reviewers, with no distinction between papers submitted for all conference tracks. We are convinced that the quality and diversity of the topics covered will satisfy both the attendees and the readers of this conference proceedings. We express our sincere thanks to the plenary speakers, workshop/session chairs, and International Program Committee members for helping us to formulate a rich technical program. We want to extend our sincere appreciation for the outstanding work contributed over many months by the Organizing Committee: local organization chair and publicity chair. We also wish to express our appreciation to the SRSEG members for their assistance. We want to emphasize that the success of BITT 2023 would not have been possible

without the support of many committed volunteers who generously contributed their time, expertise, and resources toward making the conference an unqualified success. Finally, thanks to the Springer team for their support in all stages of the production of the proceedings. We hope that you will enjoy the conference contents.

Giza, Egypt
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About Ella Hassanien
Dequan Zheng
Zhijie Zhao
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About This Book

This book constitutes the refereed proceedings of the 2023 International Conference on Business Intelligence and Information Technology (BIIT 2023) held in Harbin, China, during December 16–17, 2023. BIIT 2022 is organized by the School of Computer and Information Engineering, Harbin University of Commerce, and supported by Scientific Research School of Egypt (SRSEG), Egypt. The papers cover current research in electronic commerce technology and application, business intelligence and decision making, digital economy, image processing and multimedia technology, signal detection and processing, and technology, information security, automatic control technique, data mining, software development, and design, blockchain technology, big data technology, and machine learning technology.

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Part I
Automatic Control Technique

Chapter 1

Extraction of Small Resonance Signals in Strong Same-Frequency Background



Xuena Han, Hui Li, and Qitao Zhang

Abstract In practical engineering applications, attenuated sinusoidal signals are very common, but in most practical scenarios, such signals will be submerged in a strong background. When the frequency of the background signal is the same as the signal to be measured, this signal extraction of the difficulty of the process will increase sharply. This paper compares the effects of short-time Fourier transform, continuous wavelet transforms, and shallow neural networks on this practical physical problem. In the end, the results of the shallow neural network are relatively good, achieving a demodulation error of one thousandth, which is an effective solution to this physical problem.

1.1 Introduction

After centuries of fundamental physics research, it is believed that applied physics has already got a solid foundation to build on. Since the last century, modern applied physics has been well developed with increasing acquisition bandwidth, faster measurement speed, and stronger signal processing capability. However, the shortcomings are also obvious, under the increasingly practical demand, noise reduction under strong noise and signal extraction under strong background has become imminent problems. Fortunately, the emergence of algorithms makes it possible to resolve some difficult physical problems. This paper compares and discusses the extraction of the same-frequency and different-attenuation time signals under the background of strong resonance under a specific physical problem. From the perspective of time–frequency analysis, the effects of short-time Fourier transform,

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continuous wavelet analysis, and shallow neural network in this specific physical problem are compared.

In applied physics, exponentially decaying sinusoidal signals are quite commonly obtained. This often corresponds to the dissipation of light waves and sound waves at homogeneous media and surfaces [1]. In some general practical cases, the frequency of the former is Terahertz (THz) [2], and the frequency of the latter generally does not exceed Megahertz (MHz) [3]. For example, in a uniform circle, the center of the circle seems like a source of the sound wave, which can be resonant in the circle [4, 5]. Such sound waves are reflected at the boundary to form standing waves, and the life of this sound wave resonance corresponds to the decay time of the sine wave [6]. However, in practical applications, such signals are often submerged in the large background signal, which makes the actual signal extraction a very difficult problem.

This paper systematically analyzes the optimal algorithm for signal processing in this practical physical problem. Starting from the time–frequency analysis, the signal is first disassembled from the time and frequency domains to transfer the signal processing into the difference between decay time and spectrum width, thereby obtaining the effective information of the signal. At this stage, the measurement results of the short-time Fourier transform, and continuous wavelet analysis are compared respectively, and the shallow neural network is used for the final signal disassembly. The results show that the shallow neural network has more advantages than traditional time–frequency analysis methods, can overcome the constraints of time and space resolution, and effectively invert signals.

1.2 Target Problem

1.2.1 Problem Description

Acoustic frequency spectrum analysis is considered a powerful tool for device health diagnostics and environmental analysis. When vibration with a specific frequency is imposed on, the device will be resonant with the activate frequency and some frequency multiplication, and the decay acoustic wave can be used to demodulate much useful information such as the health status, the overload situation, and even the external environment of some section of the device [6–9]. Imagine a situation like this, a uniform cylinder is used as a device under test, a short section of it is placed into liquid and the other sections are exposed to air. As shown in Fig. 1.1, the section in liquid is named Section B, the others are named Sections A and C.

Because the reflectivity of acoustic waves between solid and outside of Section B and others are different, acoustic waves get different lifetimes in Section B and others [10]. Therefore, the function between acoustic lifetime and acoustic reflectivity is:

$$1/\tau = 1/\tau_{\text{int}} - V_L/2r \ln(R) \quad (1.1)$$

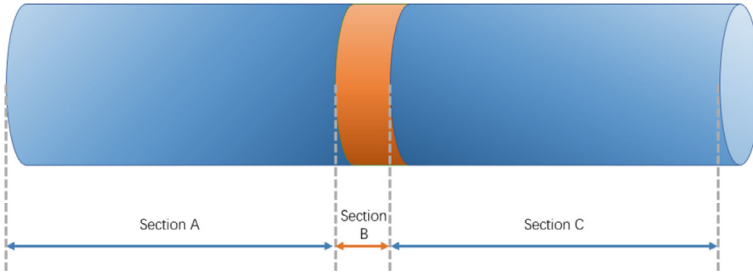


Fig. 1.1 Schematic diagram of the device under test

In which τ is the lifetime of the final acoustic wave, τ_{int} is the intrinsic acoustic lifetime, V_L is the longitudinal acoustic velocity, r is the radius of the cylinder, and R is the reflectivity. The lifetime of acoustic waves is equal to the full width at half maximum (FWHM) $\Delta\nu$, as shown in Eq. (1.2).

$$\Delta\nu = 1/\pi\tau \quad (1.2)$$

Therefore, the relationship between acoustic lifetime with reflectivity has been built up. The acoustic reflectivity is directly dominated by the kind of medium outside. However, the signal measured is summed by the signal from Section A, B, and C, to make matters worse, the amplitude of the signal from Section B is usually lower than the others, which induce the useful signal, that is the B signal, is usually submerged by the signal from Section A and C. The extraction of the B signal from the A and C signals is difficult.

1.2.2 Modeling

The resonance frequency of the cylinder can be obtained by finite element simulation. The material of the cylinder is set as aluminum, and the radius is 5 cm. The radial acoustic modes can be solved, and the frequency of these modes can be calculated, as shown in Fig. 1.2.

According to the actual scene, the mode $R_{0,6}$ with frequency 177.3 kHz is selected as activate frequency. Set the amplitude of the background to 1, and the signal to be around 0.05, the decay time of the background is 0.05 ms, and the signal decay time is higher than the background one. The measured, background, and signal in the time domain are shown in Fig. 1.3.

Fortunately, although the frequency of the signal and background is the same, and the amplitude of the signal is much smaller than the background, the spectrum width is different. Impose Fourier transform on the signal above, the spectrum can be obtained in the frequency domain (Fig. 1.4).

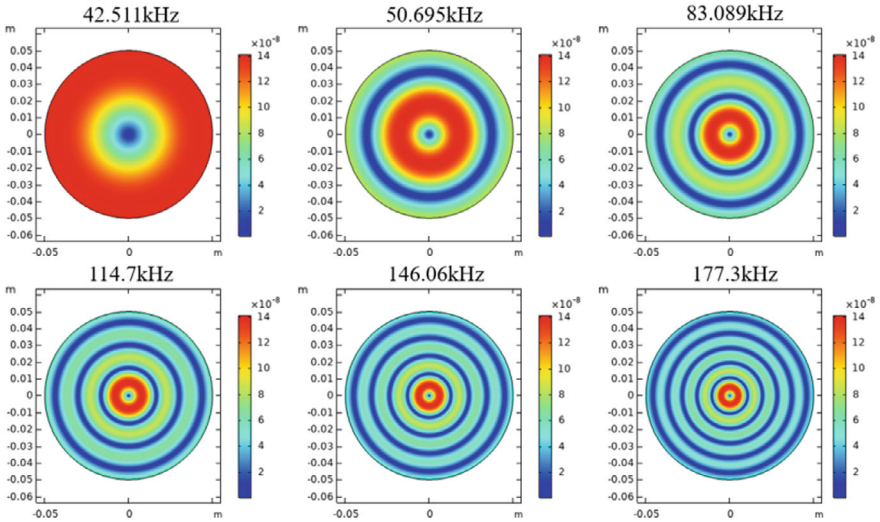


Fig. 1.2 Simulated radial acoustic modes of $R_{0,1}$ to $R_{0,6}$, the resonance frequencies are marked above

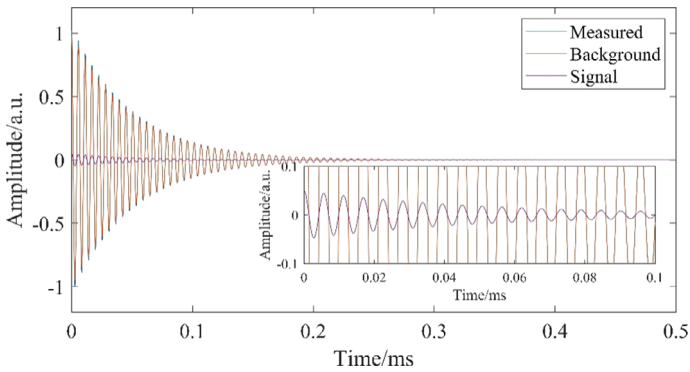


Fig. 1.3 Schematic diagram of the modeled measured, background, and signal

Notably, the frequency spectrum of the signal cannot be obtained by Fourier transform directly because of the Background, but, due to the longer duration of the signal compared to the background, it is believed feasible to use time–frequency analysis to get the signal information.

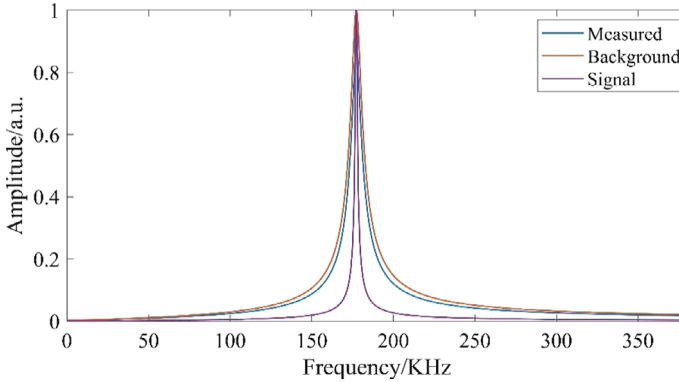


Fig. 1.4 Frequency spectrum of the model measured, background, and signal

1.3 Demodulation

1.3.1 Short-Time Fourier Transform

Short-time Fourier transform is considered a powerful tool for time–frequency analysis. How short-time Fourier transform works is that segment the signal and pan the window so that the frequency mapping on time can be calculated.

The spectrum of the measured signal is regarded as the overlay of the spectrums of the signal and background. However, the amplitudes of the signal and background do not show the same decay trend due to the different lifetimes. Therefore, for a signal with a lifetime much longer than the background, the spectrum located away from time 0 is considered less affected by the background. This gives us the possibility to distinguish the signal.

The crucial factor of the short-time Fourier transform is the determination of window parameters. There is a very important contradiction, between the time resolution and frequency resolution. The windows act as units for the Fourier transform, which means when the window is wide, the time corresponding will be wasted, and the information near time 0 cannot be obtained, when the window is narrow, that is, there are fewer points for Fourier transform, the spectrum resolution will serious loss. To obtain the fine spectrum away from time 0, a wider window should be chosen for a higher spectrum resolution. The sample rate is 5,000,000, and the width of the window is 1024, corresponding to a time resolution is 0.205 ms, and a frequency resolution is 4.88 kHz.

However, the information from 0 to 0.102 ms is wasted due to the wide window used. The spectrums of 0.102 and 0.8 ms are shown in Fig. 1.5 with the measured, background, and signal spectrum correspondingly.

As seen, although the frequency resolution is higher enough, the spectrum obtained by short-time Fourier is not narrow than the signal spectrum. That is because, although the amplitude of the background has decayed a lot, it is still not negligible at

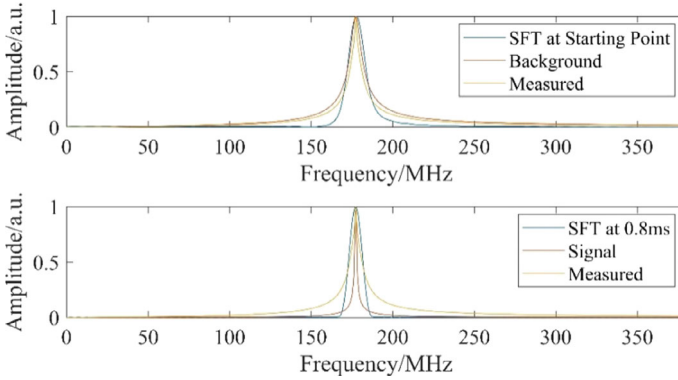


Fig. 1.5 Spectrums obtained by short-time Fourier transform and Fourier transform

0.8 ms, which is far away from the starting point. It is inevitable when the amplitude of the signal is much less than the background, both with the contradiction between time and frequency resolution.

1.3.2 *Continuous Wavelet Transform*

As we discussed in the last subsection, the short-time Fourier transform is powerful; however, the contradiction between time resolution with frequency spectrum resolution is unconquered. Continuous wavelet transform is usually considered the alternative. In the process of the continuous wavelet transform, the width of the window is not fixed but flexible, a short wavelet is used to act with the signal; therefore the contradiction between the time and frequency spectrum can be conquered to a certain extent. The CMOR wavelet with narrow bandwidth and corresponding frequency is used here.

The spectrum comparison is shown in Fig. 1.6. The spectrums of 0.03 and 0.8 ms are shown with the measured, background, and signal spectrum correspondingly.

As seen, although the frequency resolution is higher enough, the spectrum obtained by continuous wavelets transform is not narrow than the signal spectrum, too, because of the unignored amplitude difference between the background and signal. Nonetheless, the results show better performance than the short-time Fourier transform, because of the variable size of the window.

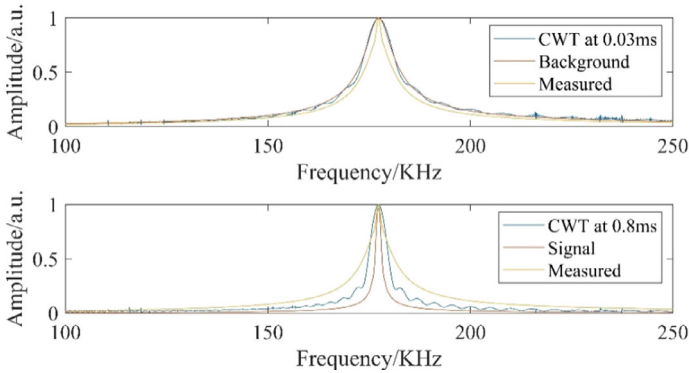


Fig. 1.6 Spectrums obtained by continuous wavelets transform and Fourier transform

1.3.3 Shallow Neural Network

Strictly, the shallow neural network is not a time–frequency analysis tool in the conventional sense. When the traditional tool is disabled, the neural network is usually miraculous. According to the target problem, a corresponding shallow neural network is built up, with 2 hidden layers and 10 neurons. The measured time trace is used as input, with the signal decay time as the output variable from 50 to 500 μs , with the unit of 1 μs . 1400 samples are used to train the neural network, 300 were used for validation, and 300 were used to test. The regression of the neural network is shown in Fig. 1.7.

As shown, the performance of the neural network is much better than the methods above. The applied performance of the neural network is proved by a new database with 2000 samples, the result is shown in Fig. 1.8, with the red line meaning the decay time of the signal, and the blue line means the error between the real decay time and the solution demodulated by the neural network. The total error is less than 0.5 μs .

1.4 Discussion

To demodulate the decay time of the signal which is hidden in a strong background signal with the same frequency. Both short-time Fourier transform and wavelet analysis were attempted on this signal for time–frequency analysis. However, due to the contradiction between frequency resolution and time resolution and the particularity of the signal, these two methods cannot achieve accurate demodulation. Shallow neural networks show excellent adaptability to this problem, which is in line with its research properties for practical physics. Taking this problem as a black-box problem, using the measured signal as input and the decay time as the output to train the neural

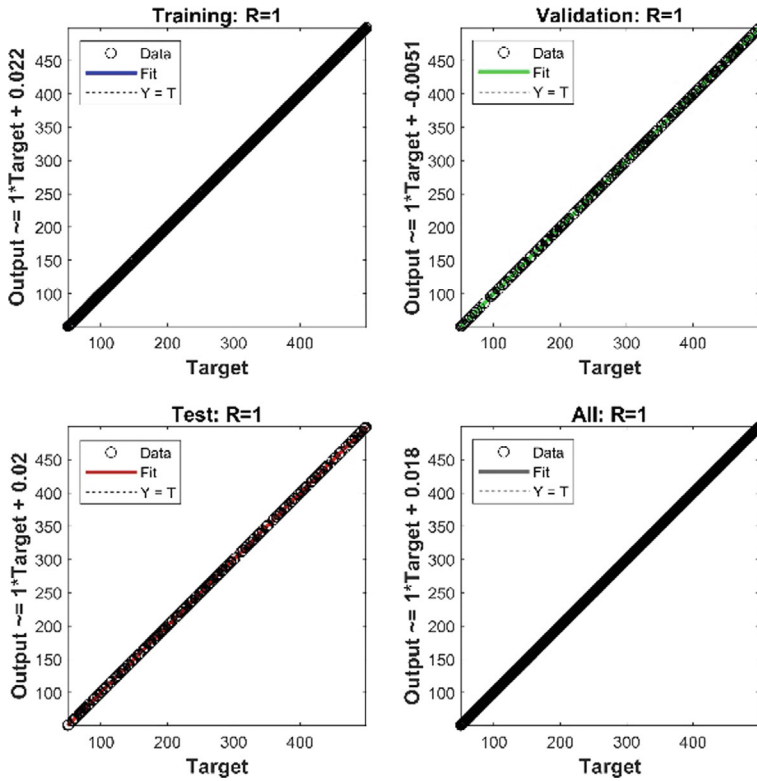


Fig. 1.7 Regression of the neural network

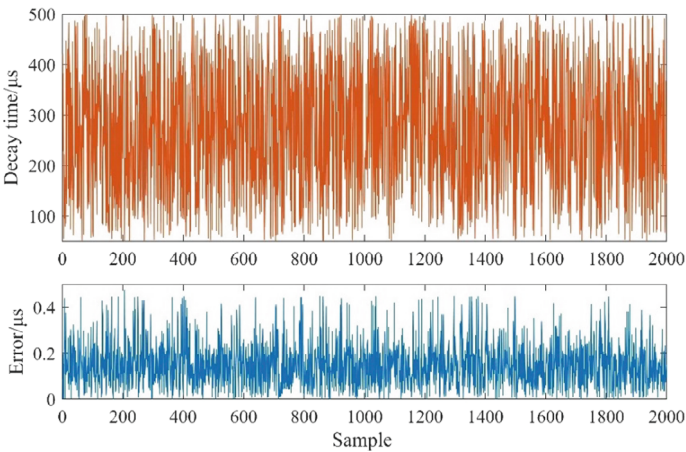


Fig. 1.8 Comparison between the real decay time and the demodulation error of the neural network. The red line is the real decay time, with a unit of μs , and the blue one means the error

network, we get quite good results. The solution provides new processing ideas and stronger solutions.

1.5 Conclusion

In this paper, short-time Fourier transform, continuous wavelet analysis and shallow neural network are used to deal with the same physical problem, small signal extraction in strong co-frequency background. In this process, continuous wavelet analysis shows stronger processing capability than short-time Fourier transform, but it is still difficult to reproduce small signals individually from the perspective of time–frequency analysis. In this regard, the shallow neural network showed more processing performance and finally achieved a demodulation error of fewer than 0.5 μ s.

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Chapter 2

Coverage Optimization of WSN Based Upon Improved Salp Swarm Algorithm



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Abstract In line with the problem of caused by high aggregation in random deployment of wireless sensor networks, a new coverage strategy because of improved salp swarm algorithm is proposed. Firstly, logistic mapping is used to initialize, which makes the population well-distributed in the search space, and improves the diversity of its initial individuals and the convergence speed of its prophase; Secondly, the sine cosine strategy is introduced in the leader stage to boost the global and local exploration capability of this algorithm; finally, Gaussian mutation operators and greedy selection strategies are added to the follower stage, and the optimal individual parameter evolution results are selected, which improves the algorithm development ability. The experimental consequence demonstrates that under the same scenario, the improved algorithm can availably reduce the redundancy of sensor nodes and greatly improve the convergence speed and coverage.

2.1 Introduction

Wireless sensor network (WSN) consists of a great quantity of densely distributed terminal network nodes, which has the ability of communication, compute and sensing. The wireless sensor network formed by its large-scale deployment can monitor the monitoring area and is widely used in the fields of auxiliary agricultural production, environmental monitoring, and intelligent home appliances. In the application process, the sensor nodes are primarily deployed by random sprinkling. Because of the random deployment location, there is a coverage blind area, which is difficult to effectively cover the area to be monitored, thus affecting the monitoring ability of the network. Changes in the environment of the monitoring area and changes in the mobility of sensor nodes will reduce the network coverage and thus affect its monitoring ability. Therefore, it is necessary to adjust and deploy the sensor

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