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Time-synchronous-averaging-spectrum based on super-resolution analysis and application in bearing fault signal identification

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Comparsion between TSA-spectrum and DFT-spectrum

- **TSA-spectrum exhibits stronger features in the high-frequency region**

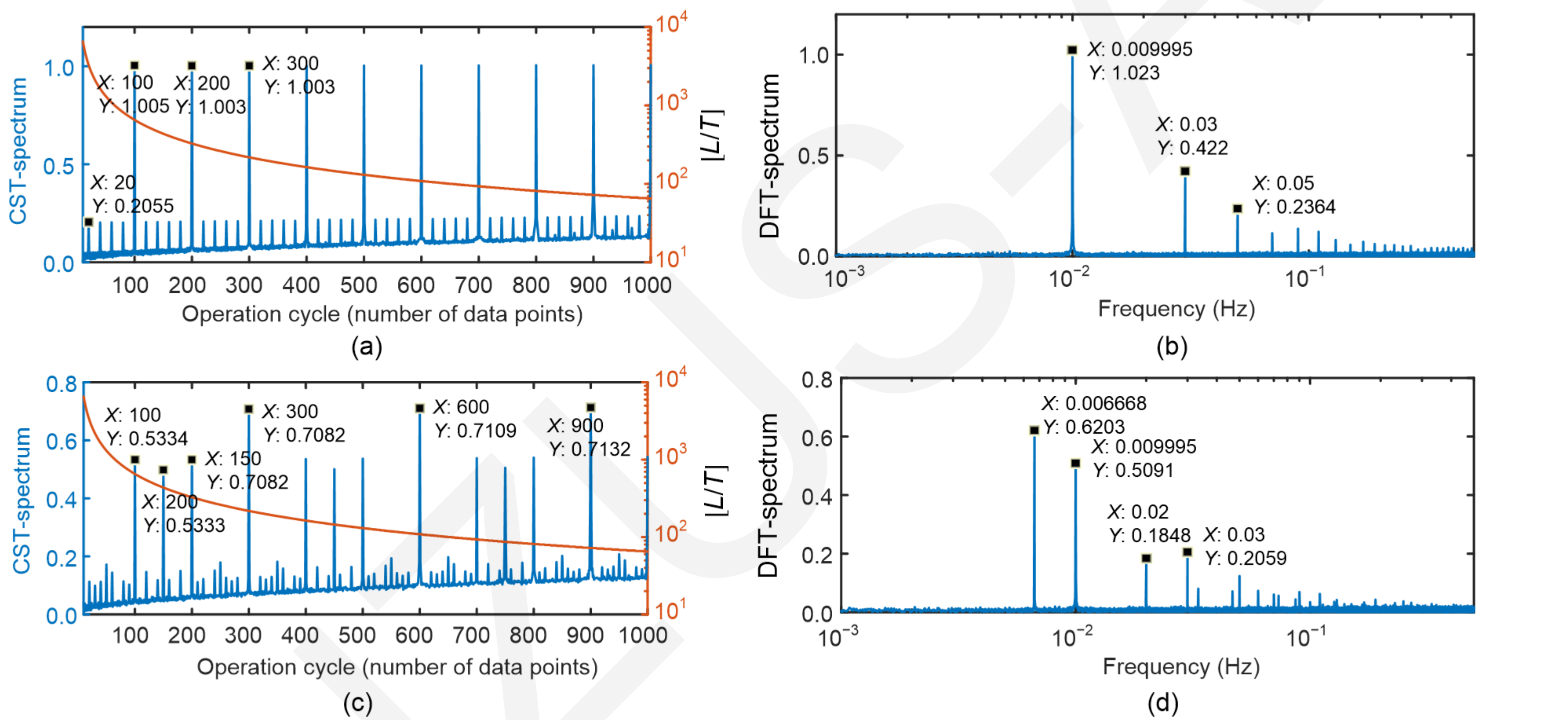


Fig. 2. Comparison between the TSA-spectrum and DFT-spectrum: (a)TSA-spectrum of Y1; (b) DFT-spectrum of Y1; (c) TSA-spectrum of Y2; (d) DFT-spectrum of Y2

Dataset Introduction

■ Listed the data content used in the article and the specific schematic diagram of the bearing structure

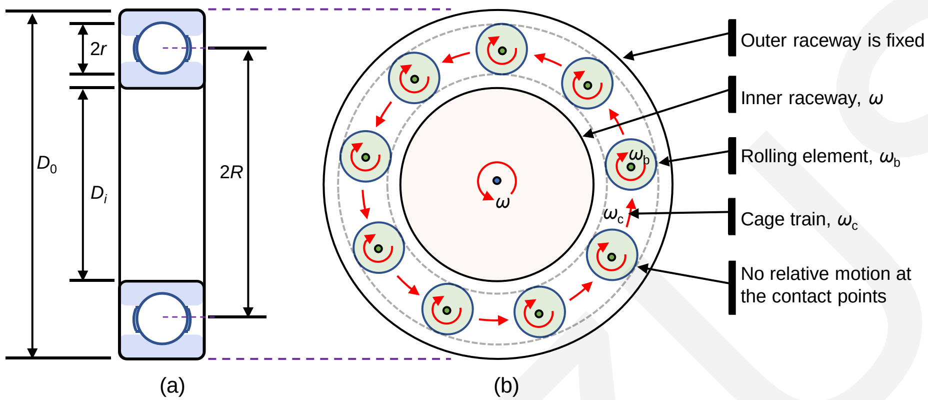
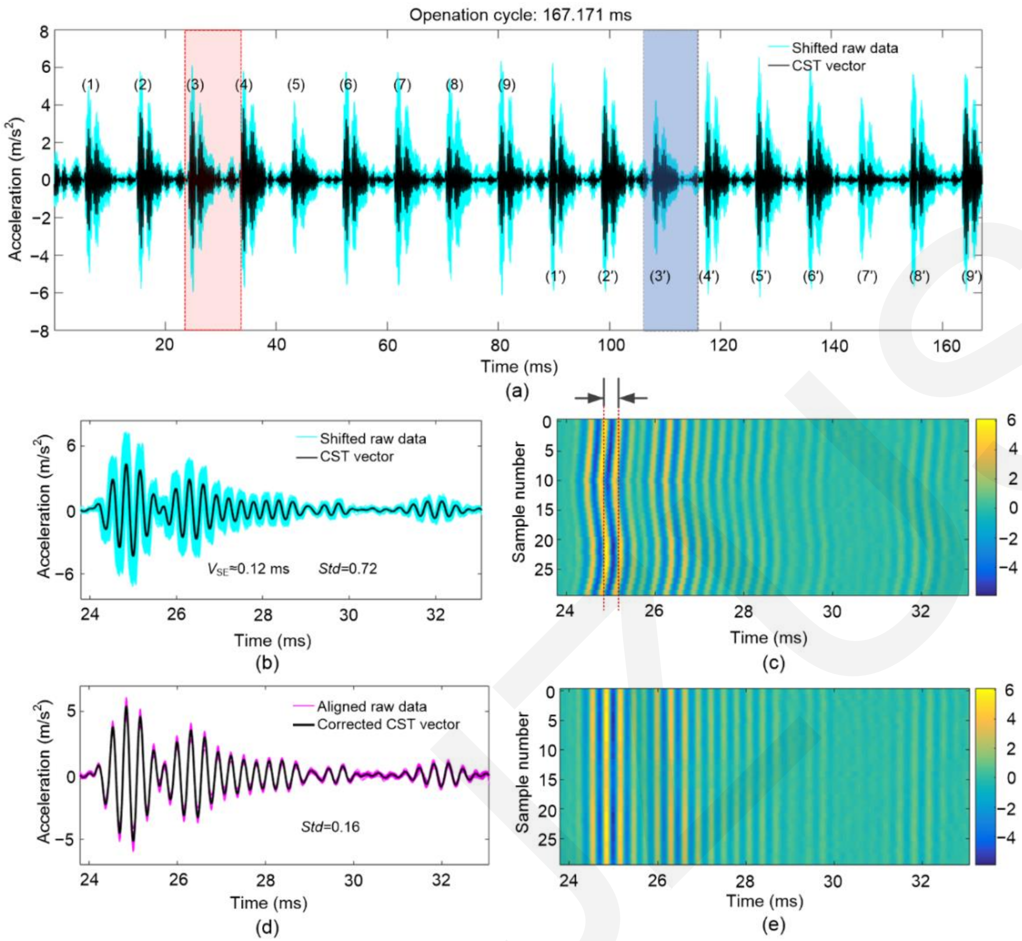


Fig. 4 Illustration of the structure of Bearing 6205-2RS JEM SKF. 2R=39.03 mm, 2r=7.94 mm, D0=52 mm, Di=25 mm. There are 9 rolling elements

File ID	Sample number	Fault type	Operating condition	Fault size
1	100	Normal	1725 r/min, 0 HP	
2	122	Ball failure	1796 r/min, 0 HP	
3	109	Inner raceway failure	1796 r/min, 0 HP	0.007 inches
4	135	Outer raceway failure centered to load	1797 r/min, 0 HP	

Table 1 Four data samples from the Seeded Fault Test Data published by CWRU

Effect of fault signal feature extraction under speed fluctuation of TSA



■ The first 9 pulses in Fig. 7a, are the first time the 9 rolling elements run across the defect area on the outer race, while the other 9 pulses relate to the second time the rolling elements run across the defect area. Note that the pulses (i) and (i′) are actually the signals of the same rolling ball running across the defect area.

Fig. 7 TSA of ORF_CE sample '135_1796.csv'. The result is given at an operation cycle of 167.171 ms. The smoothing effect Vse≈0.12 ms

Fault characteristics of different signal modes

1）Normal bearing: stable cycle signal
2）ball fault: Stacked spin and impact
3）inner and outer ring faults: clear pulse mode

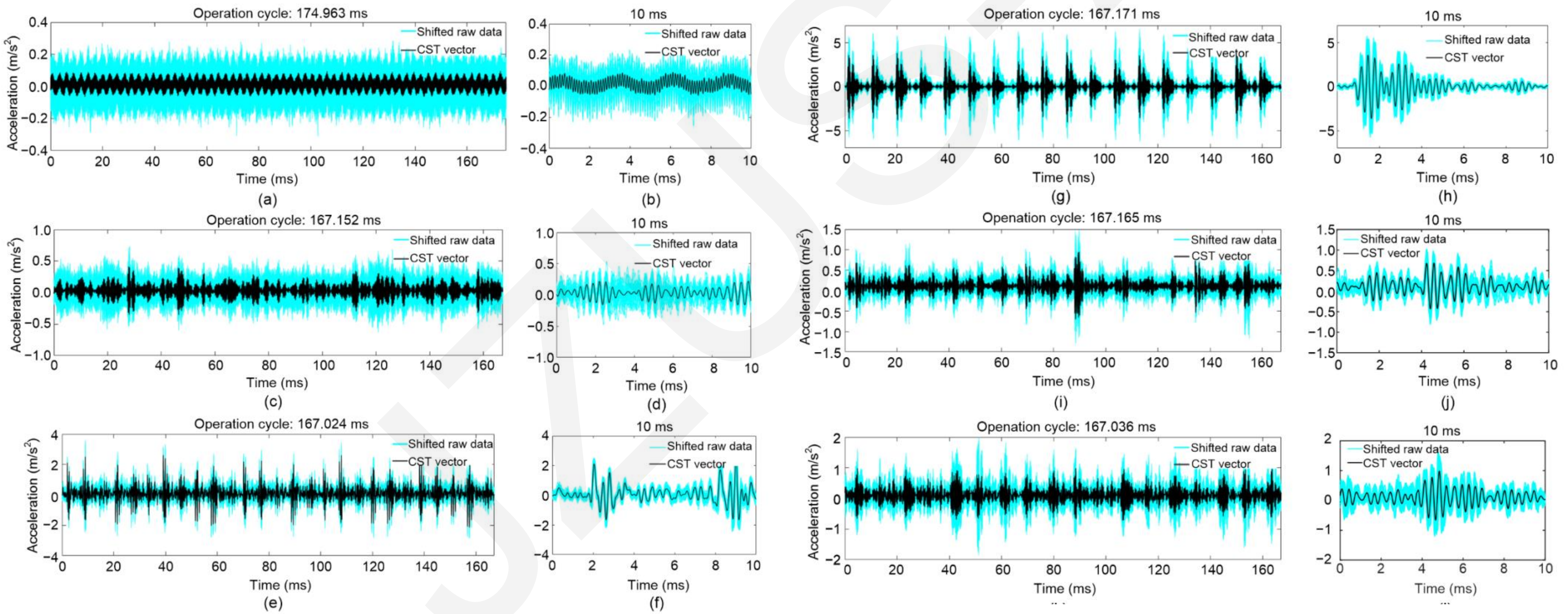


Fig. 8 Extracted waveforms of different fault types: (a), (c), (e), and (g) relate to file ID 1 to 4 in Table 1. (b), (d), (f), and (h) are enlarged views of the first 10 ms of the waveform

Conclusions

- (1) The theoretical framework of TSA, en-hanced by super-resolution analysis, effectively ana-lyzes periodic components in quasiperiodic signals.
- (2) TSA provides more detailed information on cross-effects between periodic components com-pared to DFT, making it a valuable supplement in the long-period range.
- (3) The case study showed TSA's superiority in processing vibration signals from defective bearings, illustrating its practical diagnostic benefits.
- (4) TSA has potential for further exploration in revealing the period aliasing phenomenon (PAP) and its applications in quasiperiodic signal processing.
- In summary, TSA-spectrum and su-per-resolution analysis significantly enhance the precision and reliability of bearing-fault diagnosis, contributing to improved predictive maintenance and machinery reliability. This study lays the groundwork for more efficient fault diagnosis in bearing health monitoring.