Development of Rotating Machinery Fault Diagnosis Using Order Tracking and Wavelet Techniques

陳錦城、林志哲 吳建達

E-mail: 9419893@mail.dyu.edu.tw

ABSTRACT

Two applications of adaptive order tracking and wavelet transform technique for engine fault diagnosis are adopted in this study. In the first part, an application of adaptive order tracking fault diagnosis technique based on Recursive Least-Square algorithm and variable step-size affine projection algorithm (VSS APA) are presented. In the second part, an application of fault diagnosis technique for internal combustion engines using continuous wavelet transform algorithm is presented. Order tracking fault diagnosis technique is one of the important tools for fault diagnosis of rotating machinery. Conventional methods of order tracking are primarily based on Fourier analysis with reference to shaft speed. In this study, a high-resolution order tracking method with RLS algorithm or VSS APA is used to diagnose the fault in engine cooling fan. The RLS algorithm and VSS APA can overcome the problems encountered in conventional methods. The problem is treated as the tracking of frequency-varying bandpass signals. Ordered amplitudes can be calculated with high resolution after experimental implementation. Experiments are also carried out to evaluate the proposed system in engine cooling fan defect diagnosis. The experimental results indicated that the proposed algorithms are effective in engine cooling fan fault diagnosis. In section 2, the concept of wavelet is introduced and review of wavelet transform is given. Wavelet analysis is one such powerful tool. It is more suitable for extracting mechanical fault information. In this study, the concept of time-frequency wavelet spectrum based on continuous wavelet transform is proposed.

Keywords : Fault diagnosis; Order tracking; RLS algorithm; VSS APA; Continuous wavelet transform.

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REFERENCES

[1] J. D. Wu, C. W. Huang and J. C. Chen, 2005, " An order-tracking technique for the diagnosis of faults in rotating machineries using variable step-size affine projection algorithm, " NDT & E International, Vol. 38, pp. 119-127.

[2] E. Y. Chow and A. S. Willsky, 1984, " Analytical redundancy and the design of robust failure detection systems, " IEEE Transaction on Automatic Control, Vol. 29(9), pp. 603-614.

[3] P. M. Frank, 1990, " Fault diagnosis in dynamic system using analytical and knowledge-based redundancy: A survey and some new results, "

IEEE Transaction on Automatic Control, Vol. 26(5), pp. 459-474.
[4] R. Isermann, 1991, “ Process fault diagnosis based on process model knowledge – part I: Principles for fault diagnosis with parameter estimation, ” ASME Journal of Dynamics Systems, Measurement and Control, Vol. 113, pp. 620-626.
[5] R. Isermann, 1991, “ Process fault diagnosis based on process model knowledge – part II: Case study experiments, ” ASME Journal of Dynamics Systems, Measurement and Control, Vol. 113, pp. 627-633.
[6] M. Biswas, A. K. Pandey, S. A. Bluni and M. M. Samman, 1994, “ Modified chain-code computer vision techniques for interrogation of vibration signatures for structural fault detection, ” Journal of Sound and Vibration, Vol. 175, pp. 89-104.
[7] K. Shibata, A. Takahashi and T. Shirai, 2000, “ Fault diagnosis of rotating machinery through visualization of sound signals, ” Mechanical System and Signal Processing, Vol. 14, pp. 229-241.
[8] Y. D. Chen, R. Du and L. S. Qu, 1995, “ Fault features of large rotating machinery and diagnosis using sensor fusion, ” Journal of Sound and Vibration, Vol. 188, pp. 227-242.
[9] G. Gelle, M. Colas and C. Serviere, 2001, “ Blind source separation: a tool for rotating machine monitoring by vibration analysis, ” Journal of Sound and Vibration, Vol. 248, pp. 865-885.
[10] S. Haykin, 1996, “ Adaptive filter theory, ” Prentice-Hall, New Jersey.
[11] M. R. Bai, J. Jeng and C. Chen, 2002, “ Adaptive order tracking technique using recursive least-square algorithm, ” Transaction ASME, Journal of Vibration and Acoustics, Vol. 124, pp. 502-511.
[12] P. W. Tse, W. X. Yang and H. Y. Tam, 2004, “ Machine fault diagnosis through an effective exact wavelet analysis, ” Journal of Sound and Vibration, Vol. 227, pp. 1005-1024.
[13] J. Lin and M. J. Zuo, 2003, “ Gearbox fault diagnosis using adaptive wavelet filter, ” Mechanical Systems and Signal Processing, Vol. 17(6), pp. 1259-1269.
[14] A. Yoshida, Y. Ohue and H. Ishikawa, 2000, “ Diagnosis of tooth surface failure by wavelet transform of dynamic characteristics, ” Tribology International, Vol. 33, pp. 273-279.
[15] R. Rubini and U. Meneghetti, 2001, “ Application of the envelope and wavelet transform analyses for the diagnosis of incipient faults in ball bearings, ” Mechanical Systems and Signal Processing, Vol. 15(2), pp. 287-302.
[16] F. Kong and R. Chen, 2004, “ A combined method for triplex pump fault diagnosis based on wavelet transform, fuzzy logic and neuro-networks, ” Mechanical Systems and Signal Processing, Vol. 18, pp. 161-168.
[17] W. J. Wang and P. D. McFadden, 1995, “ Application of orthogonal wavelets to early gear damage detection, ” Mechanical Systems and Signal Processing, Vol. 9, pp. 497-507.
[18] W. J. Staszewski and G. R. Tomlinson, 1994, “ Application of the wavelet transform to fault detection in a spur gear, ” Mechanical Systems and Signal Processing, Vol. 8, pp. 289-307.
[19] Q. Meng and L. Qu, 1991, “ Rotating machinery fault diagnosis using Wigner distribution, ” Mechanical Systems and Signal Processing, Vol. 3, pp. 155-166.
[20] O. Riou and M. Vetterli, 1991, “ Wavelets and signal processing, ” IEEE Signal Processing Magazine, Vol. 10, pp. 14-18.
[21] H. Zheng, Z. Li and X. Chen, 2002, “ Gear fault diagnosis based on continuous wavelet transform, ” Mechanical Systems and Signal Processing, Vol. 16, pp. 447-457.
[22] A. Swami, G. B. Giannakis and G. Zhou, 1997, “ Bibliography on higher-order statistics, ” Signal Processing, Vol. 60, pp. 65-126.
[23] A. V. Oppenheim, R. W. Schafer, 1999, “ Discrete-time signal processing, ” Prentice-Hall.
[24] P. Denbigh, 1998, “ System analysis and signal processing, ” Addison Wesley.
[25] S. G. Sankaran and A. A. Beex, 2000, “ Convergence behavior of affine projection algorithms, ” IEEE Transaction on Signal Processing, Vol. 48, pp. 1086-1096.
[26] R. W. Harris, D. Chabries, and F. Bishop, 1986, “ A variable step (VS) adaptive filter algorithm, ” IEEE Transaction on Acoustics, Speech, and Signal Processing, Vol.34, pp. 309-316.
[27] T. Aboulnasr and K. Mayyas, 1997, “ A robust step-size LMS-type algorithm: analysis simulations, ” IEEE Transaction on Signal Processing, Vol.45, pp. 631-639.
[28] R. H. Kwong and E. W. Johnston, 1992, “ A variable step size LMS algorithm, ” IEEE Transaction on Signal Processing, Vol. 40, pp. 1633-1641.
[29] J. Lin and L. Qu, 2000, “ Feature extraction based on morlet wavelet and its application for mechanical fault diagnosis, ” Journal of Sound and Vibration, Vol. 234(1), pp. 135-148.
[30] W. H. Crouse, 1993, “ Automotive mechanics, ” New York: McGraw-Hill.