ADAPTIVE ALGORITHMS IN VIBRATION DIAGNOSIS

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Abstract – This paper considers modern rolling bearing fault classification methods in the field of vibration diagnosis. The concept of adoptive algorithms is introduced. Literature survey allows highlighting and selecting the most effective algorithms for further research application.

Industrial equipment includes many moving parts and elements. Some of them, such as rolling bearings are heavy loaded, highly worn and often fail. During the work moving parts of the equipment produce vibration noise. The noise of healthy and fault equipment differ, so it can be used for fault diagnosis. Vibration diagnosis allows estimating the health of equipment using vibration noise of working process. Health estimation, in its turn, allows timely equipment maintenance and replacement. The most common research field and application of vibration diagnosis is rolling bearing fault diagnosis because of widespread, importance and short lifespan of bearings in industry.

Vibration diagnosis process includes five sequential phases: theoretical model development, empirical data obtaining, diagnostic feature extraction, fault state classification, fault progress prediction and decisions. The first phase implies kinematic models development and mathematic estimation of possible rotating machinery faults and its features. The second phase consists of raw data obtaining, accumulating and preprocessing using suitable sensors like accelerometers and computers. The third phase means raw data conversion to most important information about system state. The fourth phase is to make a decision on the actual system state by a machine. The fifth phase is the most pragmatic and the least explored, it serves to estimate equipment lifespan and plan maintenance and replacement.

Since vibration diagnosis work with noise, regular and individual features of any fault, it has to be adaptive. Monitored signals and processes nature, numerous combinations of defects with different levels and their continuous degradation requires to use methods with high adaptability to input data variations. Such methods are united in the concept of adaptive algorithms. Adaptive algorithm means the ability of hardware or software to adapt to uncertain input data and circumstances of work.

In modern vibration analysis adaptation to input data is mainly provided by the methods of classification of the fourth diagnosis phase. The best fault classification performance is provided by different machine learning techniques namely artificial neural networks, multi-layer perceptrons, support vector machines and others. Machine learning is the field of information technologies, including methods of information processing in which adaptation to further work is based on training (learning) process of classifier. Training process can be held in different ways for example by collecting training data corresponding to all various cases and further tuning of neural network reaction to each case.

The most common and effective classification technique is multilayer perceptron neural networks with back propagation training algorithm [1 - 5], which allows achieving 90% – 100% classification accuracy. Another technique is support vector machines [6] which have the same effectiveness but less common. Moreover, interesting opportunities are provided by fuzzy neural network [3, 7], sequential [7] and combined [1, 8] systems. It is worth noting that the best results are achieved not only by machine learning based classification techniques but with elaborated feature extraction methods. However, they are generally not adaptive, except some new developing methods as empirical mode decomposition and adaptive wavelet transform.

In conclusion, vibration analysis widely uses adaptive algorithms such as machine learning methods in fault classification problems. Practical advancement may be achieved by the combination of these methods. Moreover, it is a trend to the development of adaptive feature extraction methods with good effectiveness. Finally, such an important problem as automatic equipment lifetime prediction is not explored enough and still waits for its researchers.

Bibliography:

1. Sulochana Wadhwani. Fault Classification for rolling element bearing in electric machines / Sulochana Wadhwani, S. P. Gupta, Vinod Kumar // IETE journal of research. – 2008. – vol. 51, issue 4. – P. 262 – 273.
2. Manish Yadav. Automatic fault classification of rolling element bearing using wavelet packet decomposition and artificial neural network / Manish Yadav, Sulochana Wadhwani // International joutnal of engineering and technology. – 2011. – vol. 3, issue 4. – P. 270 – 276.
3. Khalid F. Al-Raheem. Rolling bearing fault diagnostics using artificial neural networks based on Laplace wavelet analysis / Khalid F. Al-Raheem, Waleed Abdul-Karem // International Journal of Engineering, Science and Technology. – 2010. – vol. 2, issue 6. – P. 278 – 290.
4. D.H. Pandya. ANN Based Fault Diagnosis Of Rolling Element Bearing Using Time-Frequency Domain Feature / D.H. Pandya, S.H. Upadhyay, S.P. Harsha // International Journal of Engineering Science and Technology. – 2012. – vol. 4, issue 6. – P. 2878 – 2886.
5. Kalyan M. Bhavaraju. A Comparative Study on Bearings Faults Classification by Artificial Neural Networks and Self-Organizing Maps using Wavelets / Kalyan M. Bhavaraju, ; P. K. Kankar; Satish C. Sharma ; S. P. Harsha // International Journal of Engineering Science and Technology. – 2010. – vol. 2, issue 5. – P. 1001 – 1008.
6. Shuen-De Wu. Multi-Scale Analysis Based Ball Bearing Defect Diagnostics Using Mahalanobis Distance and Support Vector Machine / Shuen-De Wu, Chiu-Wen Wu, Tian-Yau Wu, Chun-Chieh Wang // Entropy. – 2013. – vol. 15, issue 2. – P. 416 – 433.
7. Ke Li. An intelligent method for rotating machinery using least squares mapping and fuzzy neural network / Ke Li, Peng Chen, Shiming Wang // Sensors journal. – 2012. – vol. 12, issue 5. – P. 5919 – 5939.
8. A. Tanoh. A Neural Network Application for Diagnosis of the Asynchronous Machine / A. Tanoh, D.K. Konan, M. Koffi, Z. Yeo, M.A. Kouacou, B.K. Koffi, K.R. N`guessan // Journal of Applied Sciences.– 2008.– vol. 8, issue 19.– P.3528 – 3531.