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Pressure vessel state investigation based upon the least squares support vector machine

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ABSTRACT

In view of the remarkable time–frequency property obtained from wavelet packets and the excellent generalization ability derived from the least squares support vector machine (LS SVM), a novel approach is proposed, which focuses on the research on state detection for pressure vessels. The minimum entropy criterion is adopted to realize the optimal wavelet packet decomposition, the feature vectors being established according to the percentage of single-band signal energy in the total energy. In addition, the LS SVM is introduced to accomplish classification, for judging the states of pressure vessels. The test results show that high classification accuracy is achieved compared with the cases for the original SVM and BP neural networks under the same conditions. The scheme proposed is proved to be an accurate one for identifying the various states, which can be adapted to wide practical applications.

1. Introduction

The state of a pressure vessel is an essential factor affecting the safety of the working environment, especially in cases with vessels under high pressure; the identification of the state of pressure vessels, therefore, has become one of the crucial factors guaranteeing reliable production. The core technical problems, however, consist in how to get the characteristics of a particular pressure vessel and how to realize the pattern recognition. Fortunately, the analysis techniques using the packet wavelet and least squares support vector machine (LS SVM) provide us with feasible solutions.

The SVM is in nature a machine learning approach based on data, derived from the statistical learning theory of the minimum structural risk inductive principle, and it is free of the phenomenon of overlearning [1]. Moreover, the SVM itself provides a practical method for solving the small sample problems with nonlinearity and the pattern recognition problems with high dimension. However, SVM training is a constrained quadratic programming problem and the constraint number equals the number of samples, and this results in too much time being taken for training. Just due to this consideration, in 1999, J.A.K. Suykens put forward the least squares support vector machine (LS SVM) based upon the standard SVM [2].

The LS SVM provides improvements by invoking regularization theory; quadratic loss functions are adopted, replacing the insensitive loss functions in the SVM, and linear equations are obtained, substituting for the quadratic programming problems in the SVM, which then decreases the complexity of the computation, accelerating the solution process.

A novel identification method based on the LS SVM is proposed in this work, and it is achieved by means of optimal wavelet packet decomposition for acoustic emission signals and energy extraction of each band as an eigenvector. The final results show that the proposed scheme can realize accurate classification of the states of pressure vessels.

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