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Aviation safety evaluation by wavelet kernel-based support vector machine

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Abstract

In order to obtain the excellent evaluation effects, the wavelet kernel function is used as the kernel function of support vector machine, and the model is defined as wavelet kernel-based support vector machine. Thus, wavelet kernel-based support vector machine is applied to aviation safety evaluation. The two dimensional input vector of the training samples is employed to construct the training samples. The traditional radial basis function kernel-based support vector machine is used to compare with the wavelet kernel-based support vector machine. The testing results show that the evaluation error of the wavelet kernel-based support vector machine belongs to the range from 0.015 to 0.04, and the evaluation error of the traditional radial basis function kernel-based support vector machine belongs to the range from 0.02 to 0.07. Then, we can conclude that aviation accidents evaluation accuracy of wavelet kernel-based support vector machine is higher than those of traditional radial basis function kernel-based support vector machine.

Keywords: *wavelet kernel; evaluation; aviation safety; support vector machine*

1. Introduction

Recently, artificial neural networks have been used less in engineering field. Instead of artificial neural networks, support vector machine has been applied for various domains, due to its excellent generalization ability[1-6]. Support vector machine proposed by Vapnik is a novel machine learning algorithm based on statistical learning theory[7,8]. Originally, support vector machine was developed to solve the classification problems. Recently, the method has been extended to solve the regression and evaluation problems. The choice of kernel function of support vector machine has a certain influence on the evaluation effects. In order to obtain the excellent evaluation effects, the wavelet kernel function is used as the kernel function of support vector machine, and the model is defined as wavelet kernel-based support vector machine. Thus, wavelet kernel-based support vector machine is applied to aviation safety evaluation. Aviation accidents from 1995 to 2003 in China are employed as our experimental data to test and analysis for aviation accidents[9] evaluation by using the proposed method. The two dimensional input vector of the training samples is employed to construct the training samples. The traditional radial basis function kernel-based support vector machine is used to compare with the wavelet kernel-based support vector machine. The testing results show that the evaluation error of the wavelet kernel-based support vector machine belongs to the range from 0.015 to 0.04, and the evaluation error of the traditional radial basis function kernel-based support vector machine belongs to the range from 0.02 to 0.07. Then, we can conclude that aviation accidents evaluation accuracy of wavelet kernel-based support vector machine is higher than those of traditional radial basis function kernel-based support vector machine.

2. Wavelet Kernel-based Support Vector Machine

Support vector machine proposed by Vapnik is a novel machine learning algorithm based on statistical learning theory. Recently, the method has been extended to solve the regression and evaluation problems [10,11].

Given a set of the training samples $\{(x_i, y_i)\}_{i=1}^n$, where $x_i \in R^m$ denotes the input vector and $y_i \in R$ denote the corresponding output. The evaluation function of support vector machine employs the following formula:

$$y(x) = \omega \cdot \phi(x) + b \quad (1)$$

where ω denotes the weight vector and b denotes the bias.

In order to gain the values of the weight vector ω and the bias b , two positive slack variables ξ, ξ^* are introduced, and infeasible constraint of the optimization problem is given as follows:

Minimize

$$\frac{1}{2} \|\omega\|^2 + C \sum_{i=1}^n (\xi_i + \xi_i^*) \quad (2)$$

Subject to

$$\begin{cases} y_i - \langle \omega, \phi(x_i) \rangle - b \leq \varepsilon + \xi_i & \xi_i \geq 0 \\ \langle \omega, \phi(x_i) \rangle + b - y_i \leq \varepsilon + \xi_i^* & \xi_i^* \geq 0 \end{cases}$$

where C denotes the penalty.

Then, the Lagrangian multipliers a_i, a_i^* are introduced to obtain the constrained optimization problem:

Maximize

$$\sum_{i=1}^n y_i (a_i - a_i^*) - \varepsilon \sum_{i=1}^n (a_i + a_i^*) - \frac{1}{2} \sum_{i,j=1}^n (a_i - a_i^*) (a_j - a_j^*) K(x_i, x_j) \quad (3)$$

Subject to

$$\begin{cases} \sum_{i=1}^n (a_i - a_i^*) = 0 \\ 0 \leq a, a^* \leq C \end{cases}$$

where $K(x_i, x_j)$ ($K(x_i, x_j) = \phi(x_i) \phi(x_j)$) denotes the kernel function.

Finally, the evaluation function of support vector machine is given as follows:

$$y(x) = \sum_{i=1}^n (a_i - a_i^*) K(x_i, x) + b \quad (4)$$

In this study, the wavelet kernel function is used as the kernel function of support vector machine, the wavelet kernel function can be shown as follows:

$$k(x, x') = \prod_{i=1}^M H\left(\frac{x_i - b}{a_i}\right) H\left(\frac{x'_i - b'}{a_i}\right) \quad (5)$$

where x_i denotes the variable vector.

3. Experimental Testing and Analysis

As shown in Fig.1, aviation accidents from 1995 to 2003 in China are employed as our experimental data to test and analysis for aviation accidents evaluation by using the proposed method. The two dimensional input vector of the training samples is employed to construct the training samples. The traditional radial basis function kernel-based support vector machine is used to compare with the wavelet kernel-based support vector machine. As shown in Fig.2, the evaluation curve of the wavelet kernel-based support vector machine is given, the evaluation curve of the wavelet kernel-based support vector machine is near to the curve composed of the actual values. As shown in Fig.3, the evaluation error of the wavelet kernel-based support vector machine belongs to the range from 0.015 to 0.04.

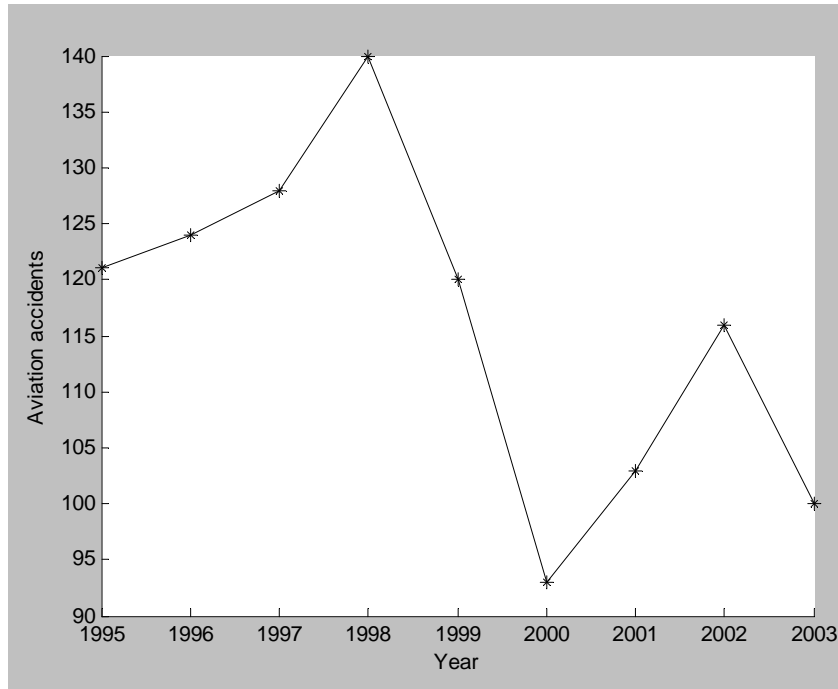


Figure 1. Aviation accidents from 1995 to 2003 in China

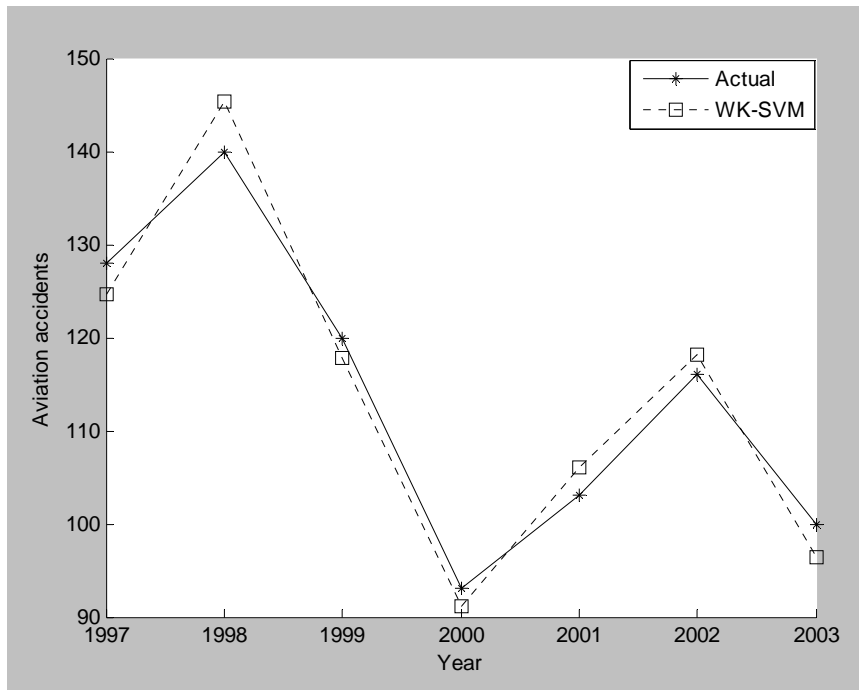


Figure 2. The evaluation curve of the wavelet kernel-based support vector machine

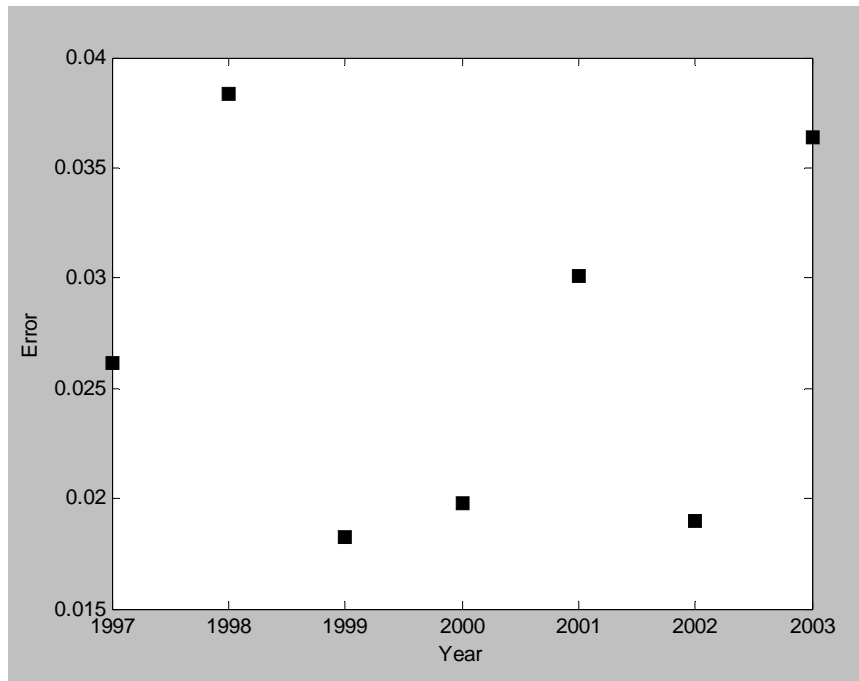


Figure 3. The evaluation error of the wavelet kernel-based support vector machine

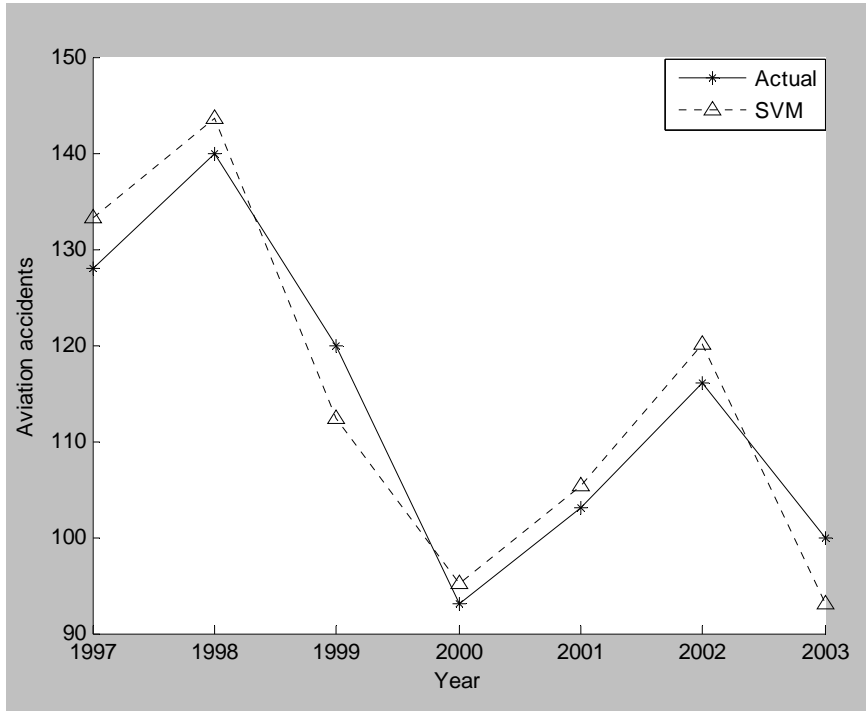


Figure 4. The evaluation curve of the traditional radial basis function kernel-based support vector machine

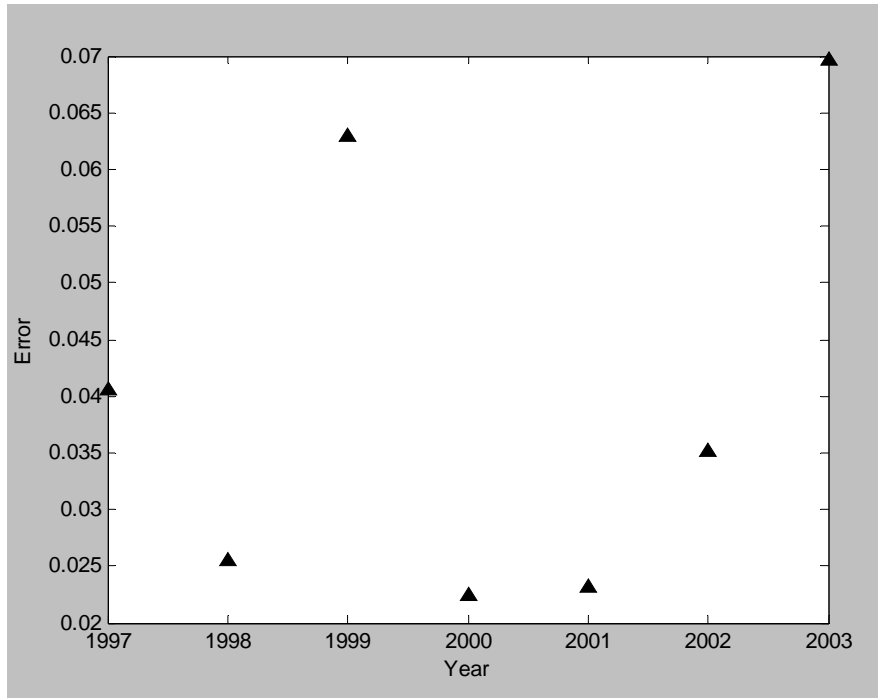


Figure 5. The evaluation error of the traditional radial basis function kernel-based support vector machine

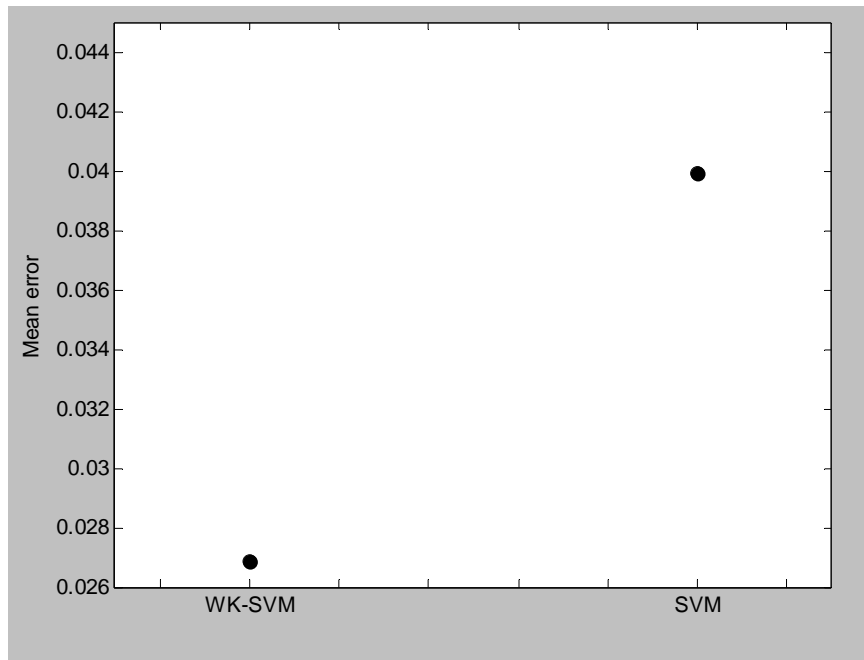


Figure 6. The comparison of the mean error between traditional radial basis function kernel-based support vector machine and wavelet kernel-based support vector machine

As shown in Fig.4,the evaluation curve of the traditional radial basis function kernel-based support vector machine is given,the evaluation curve of the traditional radial basis function kernel-based support vector machine is near to the curve composed of the actual values. As shown in Fig.5,the evaluation error of the traditional radial basis function kernel-based support vector machine belongs to the range from 0.02 to 0.07.

As shown in Fig.6,the comparison of the mean error between traditional radial basis function kernel-based support vector machine and wavelet kernel-based support vector machine is given,which indicates that aviation accidents evaluation accuracy of wavelet kernel-based support vector machine is higher than those of traditional radial basis function kernel-based support vector machine.

4.Conclusion

Wavelet kernel-based support vector machine is applied to aviation safety evaluation. The wavelet kernel function is used as the kernel function of support vector machine,and the two dimensional input vector of the training samples is employed to construct the training samples.The traditional radial basis function kernel-based support vector machine is used to compare with the wavelet kernel-based support vector machine.The testing results indicate that aviation accidents evaluation accuracy of wavelet kernel-based support vector machine is higher than those of traditional radial basis function kernel-based support vector machine.

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