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# Construction and Application of Performance Prediction Model for Aerobics Athletes Based on Online-SVM

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***Abstract***

*Aerobics has been broadly adopted in colleges and universities in our country. For aerobics can be better able to carry out, the performance prediction is very important. Aiming at the problems that the predictive model is often mismatching and difficult to solve the nonlinear optimization function of nonlinear system model of predictive control, an online support vector machine (OSVM) modeling is proposed. This proposed method builds a nonlinear model for objects using OSVM. Furthermore, we apply this method to the performance prediction of the aerobics. The results show that the online-SVM applying to the aerobics performance prediction is feasible and effective.*

***Keywords:*** *Online-SVM, Performance Prediction, indexes fitting*

## 1. Introduction

In recent years, Chinese colleges and universities begin to popularize the aerobics education gradually. Aerobics education can strengthen the basic teaching to meet the increasing requirements of aerobics learning, further reform the sports curriculum and improve the students' physical quality. Aerobics ranges between dance and physical exercise. It neither belong to the pure dance nor different from the traditional sports. Aerobics exercise mainly relies on the musical accompaniment. The body moves greatly in aerobics. Aerobics has strong sense of rhythm, and the movements are smooth. Aerobics can be used not only for entertainment but also for exercising.

In past researches, many scholars studied the performance of the aerobics. Yin Hang studied the main factors that could affect the aerobics special sport achievement of the athletes in different levels [1]. Wang Fang established the multivariate linear equations of the aerobics performance, the body shape and the somatic function. The weight coefficients in the equation were obtained by adopting the expert questionnaires and the empirical evaluation [2]. This method has the strong subjectivity. Wang Ni established the evaluation model of the special aerobics performance based on the neural network [3]. In this paper, we established the prediction model of the aerobics athletes special performances based on the thought which is put forward by Bai Kaixiang [4]. The author adopts the multivariate regression method which uses the body shape, quality and the performance as the indexes to establish the model. The variables are selected from the 32 different indexes by correlation analysis and cluster analysis. The dependent variables are the special movement performances. They are scored by experts through analyzing the level of the movement difficulty.

The traditional data forecasting method is difficult to establish an accurate predictive model. Therefore, many scholars put forward a prediction method which is based on the

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intelligent model [3]. The intelligent model does not need to understand the controlled objects deeply. It only needs to study the historical data to establish a more accurate model. Therefore, intelligent model has a good applied prospect. Other literatures design the predictive control methods based on the different neural network models [4-6]. This method can handle the nonlinear and the constrained objects. However, the neural network is easy to fall into the local optimum and has poor generalization ability. Therefore, some other scholars studied MPC method which is based on the Support Vector Machine (SVM) [7-10]. SVM has the characteristic of global optimum, strong generalization and small sample training. It improves the efficiency of the prediction control effectively. The above prediction models are off-line training models. They could not revise these models online. But the nonlinear process generally has the characteristic of time-varying. So, the offline established model cannot adapt the change. The online support vector machine is a training method of SVM online [11]. OSVM saves the training parameters. When the model error is more than the setting value, we adjust the model parameters through online learning and make the parameters meet the setting accuracy. Therefore, OSVM can adapt the dynamic changes of the nonlinear objects.

This paper identifies the evaluation indexes and the standards. These indexes include accuracy, uniformity, flexibility, coordination, stability and control. In addition, this paper uses the OSVM to predict the aerobics performances. The test results show that the method has a pinpoint prediction accuracy and a good generalization ability. The structure of the article is as follows. The first part is the introduction. The second part is the SVR model. The third part is the types and selection of kernel function. The fourth part is the Online SVM algorithm. The fifth part is the numerical analysis and the last part is the conclusion.

## 2. The SVR Model

$LS-SVR$ expands standard $SVR$ by optimizing the square of relaxation factors and converting the constraints of inequality to equality, so the quadratic programming problem in traditional $SVR$ becomes linear simultaneous equations, thus the calculating difficulty reduces a lot in company with the solution high efficiency and convergence speeding up.

The basic method of $SVR$ :

Define $x \in R^n$ and $y \in R$ , let $R^n$ be the input space, by nonlinear transformation $\phi(\cdot)$ , we let in the input space $x$ map into a high dimensional characteristic space where we use the linear function to fit sample data while making sure the generalization.

In the characteristic space, the linear estimation function is defined as:

$$y = f(x,\omega) = \omega^T \phi(x) + b \tag{1}$$

Where $\omega$ is the weight and $b$ is the skewness.

The aim function is:

$$\min_{\omega,b,\xi} J(\omega,b,\xi) = \frac{1}{2}\omega^T\omega + \frac{1}{2}C\sum_{i=1}^{N}\xi_i^2 \tag{2}$$

s.t.

$$y_i = \phi(x_i)\omega + b + \xi_i \quad i = 1,\cdots,N \tag{3}$$

Where $\omega \in R^h$ is the weight vector and $\phi(\cdot)$ is non-linear mapping function, $\xi_i \in R^{N\times 1}$ is relaxation factor, $b \in R$ is the skewness while $C > 0$ is penalty factor.

Importing factors, $\alpha_i \in R^{N\times 1}$ , we can easily get the function as:

 

$$L(\omega, b, \xi_i, \alpha_i) = \frac{1}{2}\|\omega\|^2 + \frac{1}{2}C\sum_{i=1}^{N}\xi_i^2 - \sum_{i=1}^{N}\alpha_i[\phi(x_i)\omega + b + \xi_i - y_i] \tag{4}$$

According to the KTT we get

$$\begin{cases} \frac{\partial L}{\partial \omega} = \omega - \sum_{i=1}^{N}\alpha_i\phi(x_i) = 0 \\ \frac{\partial L}{\partial b} = \sum_{i=1}^{N}\alpha_i = 0 \\ \frac{\partial L}{\partial \xi_i} = \alpha_i - C\xi_i = 0 \\ \frac{\partial L}{\partial \alpha_i} = \phi(x_i) + b + \xi_i - y_i = 0 \end{cases} \tag{5}$$

$$\begin{bmatrix} 0 & E^T \\ E & \phi\phi^T + C^{-1}I \end{bmatrix}\begin{bmatrix} b \\ \alpha \end{bmatrix} = \begin{bmatrix} 0 \\ y \end{bmatrix} \tag{6}$$

Where $E$ is the matrix whose elements are all 1, $I$ is a $N \times N$ identity matrix.

Inner product of regression in non-linear function can be replaced by kernel function satisfied $Mercer$. Let $\Omega_{ij} = \phi\phi^T$,

Then

$$\Omega_{ij} = \phi(x_i)^T\phi(x_j) = K(x_i, x_j) \tag{7}$$

We then have the $LS - SVR$ regression function model

$$f(x) = \sum_{i=1}^{N}\alpha_i K(x_i, x_j) + b \tag{8}$$

The basic thought can be showed as Figure 1.

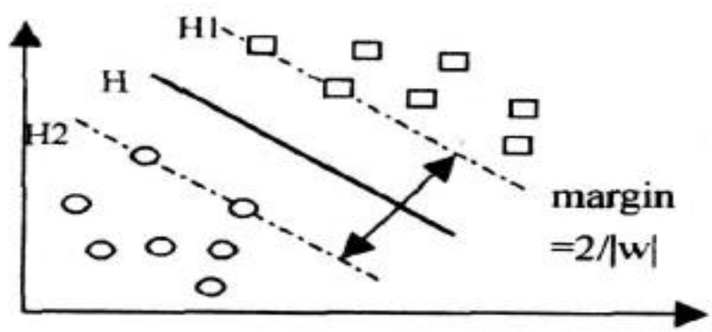


**Figure 1. The Optimal Hyperplane**

## 3. The Types and Selection of Kernel Function

In general, the kernel function is commonly used as the linear kernel function, polynomial kernel function, the radial basis kernel function, and sigmoid kernel function. The functions are as follows:

(1) Linear kernel function

$$K(x, x_i) = x * x_i$$

(2) Polynomial kernel function

$$K(x, x_i) = [(x * x_i) + 1]^d$$

Where the d is the order of the polynomial

(3) Radial basis kernel function

$$K(x, x_i) = \exp(-\|x - x_i\|^2 / 2\sigma^2)$$

Where the $\sigma$ is width of the kernel function

(4) Sigmoid kernel function

$$K(x, x_i) = \tanh(\gamma(x * x_i) + c)$$

Commonly used kernel function can be divided into two categories: one category is the global kernel function, the other is local kernel functions: The linear kernel function, polynomial kernel function, and Sigmoid kernel function is a global common kernel function.

## 4. The Online SVM Algorithm

In this paper, we present an online SVM model whose primary distinction from the conventional SVM model focuses on the manner of data provided. The data are provided in sequence for the presented online SVM model, while they are supplied in batch for the conventional SVM model. In our model, suppose that the initial training data set with l samples. Then we select the optimal kernel function with the optimal parameter. As we know, for any orthogonal basis $(\rho_1, \rho_2, \cdots, \rho_k)$

In this paper, we present an online SVM model whose primary distinction from the conventional SVM model focuses on the manner of data provided, *i.e.*. The data are provided in sequence for the presented online SVM model, while they are supplied in batch for the conventional SVM model. In our model, without loss of generality, suppose that the initial training data set with $l$ samples. Then we select the optimal kernel function with the optimal parameter (say, the optimal model is established based on the current $l$ data). As we know, for any orthogonal basis $(\rho_1, \cdots, \rho_k)$ in Hilbert space $H$, if $\theta \in H$, then $\sum_{i=1}^{k} \cos^2(\rho_i, \theta) = 1$ holds. $(cos(x, y))$ refers to the cosine function of the includes angle between vector $x$ and $y$, and $cos(x, y) = x^T y / (\|x\|\|y\|)$. In the presented approach, a vector sequence $\{\alpha_1, \cdots, \alpha_k\}, \alpha_k = \phi(x_i) y_j - \phi(x_j) y_i, k = 1, \cdots, l(l-1)/2$ is firstly constructed, and then an orthogonal vector sequence $\{\beta_1, \cdots, \beta_d\}$

 

$$\beta_i = \frac{\alpha_i - \sum_{j=1}^{d} \beta_j (\beta_j \cdot \alpha_i)}{\left\| \alpha_i - \sum_{j=1}^{d} \beta_j (\beta_j \cdot \alpha_i) \right\|}$$

With $d = rand(\alpha_1, \cdots, \alpha_k)$ can be obtained by the well-known Schmidt's orthogonalization procedure. Because $\{W, \beta_1, \cdots, \beta_k\}$ ,( $W$ is the normal vector of the regression hyperplane) is an orthogonal basis in $H$ and each $\phi(x_i)$ belongs to $H$ , we have

$$\sum_{j=1}^{d} \cos^2(\beta_j, \phi(x_i)) + \cos^2(W, \phi(x_i)) = 1$$

Hence,

$$\|W\| = \frac{y_i}{\|\phi(x_i)\| \sqrt{1 - \sum_{j=1}^{d} \cos^2(\beta_j, \phi(x_i))}}$$

The main ideal of the online-SVM can be as the following:

Step 1 (Initialization)

(1) Let the initial training data set $G$ has summarized $l$ samples
(2) Let the class of kernel function

$$Ker(\sum) = \{K_1(\sum) K_2(\sum), \cdots, K_p(\sum)\}$$

Where $K_i(\sum)$ is the $ith$ type kernel function with continuously adjustable kernel parameters $\sum$ .

Step 2 (optimal kernel select)

(1) For each $K\sum := K(\sum) \in Ker(\sum)$ , solving the following optimization problem.

$$A^* = agr\min_{\Lambda \in \sum} \{F(K_\Lambda)\}$$

Where

$$F(K) = \|W\|^2 = \frac{y_{j*}^2}{K(x_{j*}, x_{i*}) - \sum_{j=1}^{d} \gamma_j^2}$$

(2) Then the optimal kernel is

$$K^*(\sum *) = K_{O*}(\Lambda)$$

Where

$$O^* = \arg\min_{1 \le i \le P}(K_i(\Lambda^*))$$

Step 3 (Online learning loop)
When a new sample, $(l+1)th$ , arrives

(1) If $\alpha_{l+1} \neq \sum_{i=1}^{d} \beta_i \alpha_{l+1}^T \beta_i$ , then calculate $\{A(d+1,i,j), B(d+1,\gamma_{d+!}), C(d+1,i,j), \beta_{d+1}\}$ and then go to step 2.
(2) Otherwise, the optimal kernel and corresponding online SVM model are not changed.

The objective function can be written as follows:

$$L = \frac{1}{2}\beta^T K \beta - \left\langle c, \beta \right\rangle \tag{9}$$

Where $c$ is an $l \cdot 1$ vector, $\beta = \{\beta_1, \cdots, \beta_d\}$ .

At the initial stage of the online training, suppose one example is given for each class. The hyperplane with a maxi-mum margin for these two examples can be found by solving the quadratic programming problem (10). In this case, both examples are SVs. The new hyperlane can be found by minimizing Eq.(9) with the SVs obtained from the current hyperplane and the new example.

Similarly, at the $kth$ step, we denote the set of SVs as $SV_k$ and the example corresponding to the SVs as

$$\{Sx_i^k, Sy_i^k\}_{i=1}^{|SV_k|}$$

The hyperplane is

$$f_k(x) = \mathrm{sgn}\left(\sum_{1}^{|SV_k|} \beta_i^k Sy_i^k K(X, Sx_i^k) + b_k\right) \tag{10}$$

The algorithm is summarized as follows.

Algorithm (Online support vector classifier algorithm)
Set $G_1 = \{x_k, y_k\}$ ,for $k = 1, 2$ ,and $|E_2| = 0$ .
Minimize (9) with $w_1$ to obtain an optimal
Boundary $f_1$ .
For $k = 3, \cdots, l$ do
  Obtain a new example $S_k = \{x_k, y_k\}$ .
  If $y_k f_{k-1}(x_k)$ violate the KKT conditions
    Or $|E_{K-1}| > 0$ then
    if $y_k f_{k-1}(x_k)$ violate the KKT conditions
      and $|E_{K-1}| = 0$ then
      $G_k = \{Sx_i^k, Sy_i^{k-1}\}_{i=1}^{|SV_{k-1}|} \cup S_k$ .
    end if

 

if $y_k f_{k-1}(x_k)$ satisfy the KKT conditions
and $|E_{K-1}| > 0$ then
$G_k = \{Sx_i^k, Sy_i^{k-1}\}_{i=1}^{|SV_{k-1}|} \cup E_{k-1} \cup S_k$.
end if
Minimize (9) to obtain an optimal boundary
$f_k$ with $G_k$.
$E_k = \{x_i, y_i \mid y_i f_k(x_i)$ violates the KKT
conditions$\}_{i=1}^{k}$.
end if
end for
while $E_l > 0$ do
$G_l = SV_l \cup E_l$.
Minimize (9) to obtain an optima boundary $f_l$.
$E_l = \{x_i, y_i \mid y_i f_l(x_i)$ violates the KKT
conditions$\}_{i=1}^{l}$.
end while

The prediction process figure of improved support vector machine model is showed as Figure 2.

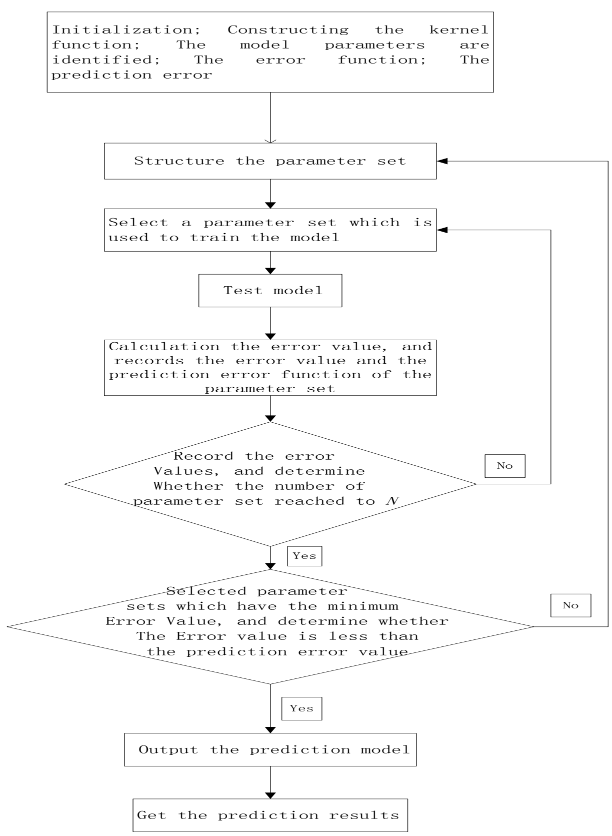


**Figure 2. The Prediction Process Figure of Improved Support Vector Machine Model**

## 5. Numerical Analysis

### 5.1. The Choice of the Indexes

There are six indexes according to the public aerobics competition rules. They are the veracity, the regularity, the elasticity, the harmony, the stability and the control. Requirement derails are shown as Table 1.

**Table 1. The Indexes and the Requirements**

| Index | Requirement |
|---|---|
| Veracity | accuracy of action and the precise position |
| Regularity | consistent degree to accomplish the actions |
| Elasticity | the light pace |
| harmony | coordination of action and music |
| stability | the ability to dominate the body continuously |
| control | the ability to control and regulate the body |

### 5.2. The Choice the Training Samples

We choose 20 students who take part in the aerobics curriculum as the training samples. The scores are given by Delphi Technique. The results are showed in Table 2.

**Table 2. The Results of the Scores for the Samples**

| N20 | X1 | X2 | X3 | X4 | X5 | X6 | Y |
|---|---|---|---|---|---|---|---|
| 1 | 8.7 | 8.8 | 8.5 | 8.9 | 9.2 | 9.1 | 8.87 |
| 2 | 7.5 | 7.9 | 7.5 | 8.1 | 8.0 | 7.7 | 7.78 |
| 3 | 9.2 | 9.1 | 8.9 | 8.8 | 8.9 | 8.7 | 8.93 |
| 4 | 7.4 | 7.4 | 7.9 | 8.1 | 8.4 | 7.9 | 7.85 |
| 5 | 8.0 | 8.3 | 8.1 | 7.9 | 7.3 | 7.7 | 7.88 |
| 6 | 6.9 | 6.6 | 6.7 | 7.2 | 7.0 | 6.9 | 6.88 |
| 7 | 8.8 | 8.1 | 8.2 | 8.3 | 8.6 | 8.8 | 8.47 |
| 8 | 7.1 | 7.2 | 6.8 | 6.7 | 7.0 | 7.6 | 7.07 |
| 9 | 9.4 | 9.1 | 9.4 | 9.6 | 9.2 | 9.2 | 9.32 |
| 10 | 8.5 | 7.9 | 7.5 | 8.1 | 8.6 | 8.4 | 8.17 |
| 11 | 9.1 | 9.3 | 9.6 | 9.5 | 9.6 | 9.1 | 9.37 |
| 12 | 6.2 | 6.6 | 6.7 | 6.2 | 5.8 | 6.7 | 6.37 |
| 13 | 6.6 | 6.1 | 6.8 | 6.4 | 6.0 | 6.9 | 6.47 |
| 14 | 7.8 | 7.9 | 8.1 | 7.4 | 7.8 | 7.7 | 7.78 |
| 15 | 8.1 | 8.4 | 7.8 | 7.9 | 8.1 | 8.4 | 8.12 |
| 16 | 8.2 | 8.8 | 8.2 | 8.5 | 8.4 | 8.3 | 8.40 |
| 17 | 6.9 | 6.2 | 6.8 | 7.2 | 6.1 | 6.9 | 6.68 |
| 18 | 8.7 | 9.2 | 8.9 | 8.4 | 8.1 | 8.5 | 8.63 |
| 19 | 8.4 | 8.3 | 8.1 | 8.0 | 8.4 | 8.9 | 8.35 |
| 20 | 7.9 | 7.0 | 7.1 | 7.1 | 7.2 | 6.8 | 7.18 |

X1 is the veracity, X2 is the regularity, X3 is the elasticity, X4 is the harmony, X5 is the stability and X6is the control.

 

We calculate the average value of the six indexes for each sample and get the row Y. Then, we draw the histogram of the six indexes for each sample and the curve of the average value Y in one picture. The results are as shown in Figure 3.

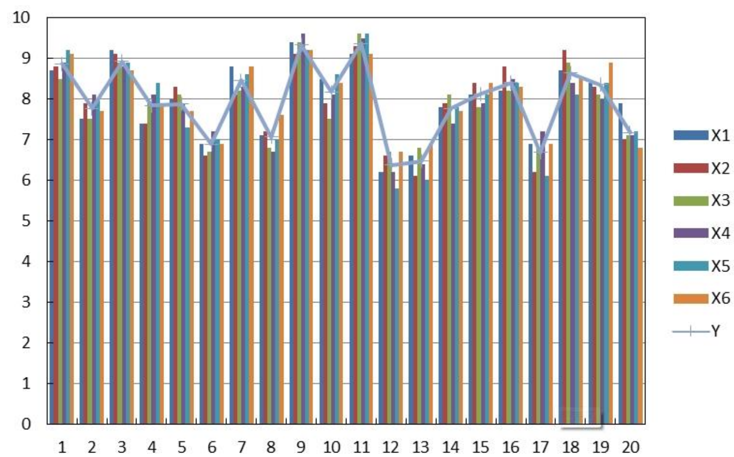


**Figure 3. The Six Indexes and the Average Value Y**

### 5.3. Indexes Fitting

We fit the indexes and get the fitted values. Then we calculate the error of the two columns of the values. The results are as shown in Table 3.

**Table 3. The Error of the Actual Values and the Fitted Values**

| N20 | Actual values | Fitted values | Error |
|---|---|---|---|
| 1 | 8.87 | 8.94 | 0.0079 |
| 2 | 7.78 | 7.89 | 0.0141 |
| 3 | 8.93 | 8.79 | -0.0157 |
| 4 | 7.85 | 7.79 | -0.0076 |
| 5 | 7.88 | 7.95 | 0.0089 |
| 6 | 6.88 | 6.92 | 0.0058 |
| 7 | 8.47 | 8.55 | 0.0094 |
| 8 | 7.07 | 6.99 | -0.0113 |
| 9 | 9.32 | 9.18 | -0.0150 |
| 10 | 8.17 | 8.27 | 0.0122 |
| 11 | 9.37 | 9.30 | -0.0075 |
| 12 | 6.37 | 6.25 | -0.0188 |
| 13 | 6.47 | 6.60 | 0.0201 |
| 14 | 7.78 | 7.84 | 0.0077 |
| 15 | 8.12 | 8.22 | 0.0123 |
| 16 | 8.40 | 8.29 | -0.0131 |
| 17 | 6.68 | 6.78 | 0.0150 |
| 18 | 8.63 | 8.69 | 0.0070 |
| 19 | 8.35 | 8.21 | -0.0168 |
| 20 | 7.18 | 7.33 | 0.0209 |

We compare the actual values and the fitted values. The two values are drawn in one picture. The results are showed in Figure 4.

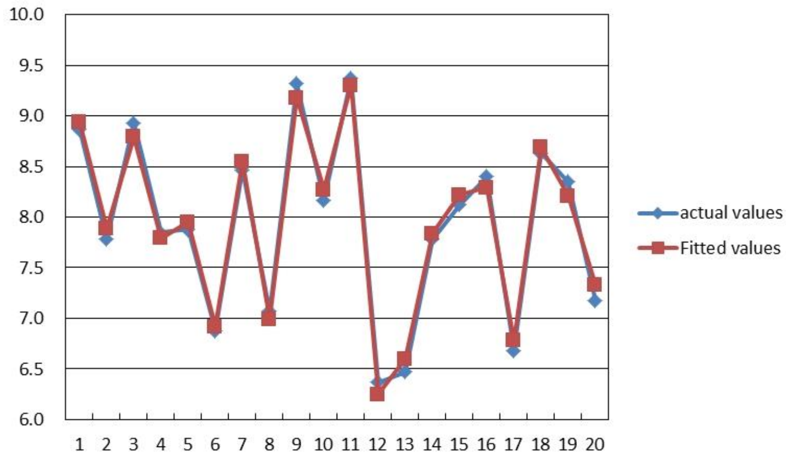


**Figure 4. The Actual Values and the Fitted Values**

From the Figure 4, we can find that the actual values and the fitted values are almost the same. The cures are little different at the point 12, 13, 16 and 19. And the curves at the other points are almost perfect. The fitting of the indexes achieves a good result.

### 5.4. Performance Prediction

As the good result of fitting curve, we predict the values for next ten samples by online-SVM. Then, we calculate the error between the actual values and the predicted values. The results are shown as the Table 4.

**Table 4. The Predicted Values and the Error**

| N10 | Actual values | Predicted values | Error |
|---|---|---|---|
| 21 | 8.2 | 8.25 | 0.0061 |
| 22 | 8.4 | 8.43 | 0.0036 |
| 23 | 7.9 | 8.11 | 0.0266 |
| 24 | 6.5 | 6.61 | 0.0169 |
| 25 | 7.7 | 7.59 | -0.0143 |
| 26 | 8.1 | 8.17 | 0.0086 |
| 27 | 9.1 | 8.92 | -0.0198 |
| 28 | 8.8 | 8.93 | 0.0148 |
| 29 | 6.9 | 7.01 | 0.0159 |
| 30 | 7.0 | 7.13 | 0.0186 |

We draw the actual values and the predicted values in one picture. The results are shown as the Figure 5.

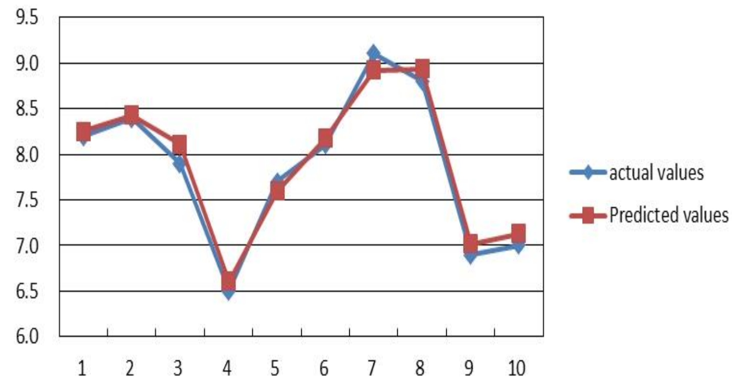


**Figure 5. The Actual Values and the Predicted Values**

From the Figure 5 we can see that the curve of the actual values and exactly similar with the curve of the predicted values. This means that the prediction has obtained the good effect. The online-SVM applying to the aerobics performance prediction is feasible and effective.

## 6. Conclusion

Aerobics has been broadly adopted in colleges and universities in China. As the characteristics of ornamental value and easily accepted, Aerobics is very popular among the students.

In this paper, we choose six indexes as the judgment criteria to evaluate the performance of the aerobics. We apply Delphi Technique to get the scores for 20 samples. Then, we calculate the average values of each sample. At the same time, we fit the samples and get the fitting curve. With the comparison of the actual curve, we find that the fitting curve achieves a good result. At the basic of the fitting curve, we predict the next 10 samples by online-SVM. The results show that the predicting outcome has obtained a good effect. This result means that the online-SVM applying to the aerobics performance prediction is feasible and effective.

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