

COMPARISON OF SVM ALGORITHM AND BP ALGORITHM: STUDY ON THE EVALUATION INDEX SYSTEM OF SCIENTIFIC RESEARCH PERFORMANCE OF VOCATIONAL COLLEGES

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Abstract. As the education in China develops rapidly, the scientific research of higher vocational education has gradually drawn extensive attentions. In order to construct a reasonable evaluation model of scientific research performance to further enhance the research enthusiasm of teachers, this study constructed a model based on relevant theories of the support vector machine (SVM) algorithm and the back propagation (BP) algorithm. In addition, the simulation of the model was performed and the accuracy rate and errors of these two algorithms were compared and analyzed. Then the most appropriate algorithm was applied to the evaluation index system. The simulation results showed that, simplified data of scientific research evaluation could be applied as the input data of the SVM algorithm to accurately and effectively construct an evaluation index system of scientific research performances of vocational colleges. Thus a more reasonable and accurate evaluation system was constructed.

Keywords: SVM algorithm, BP algorithm, vocational colleges, scientific research, performance evaluation.

1. Introduction

The classification of industries refines day by day. The performance evaluation is not only the recognition to the achievements of bottom workers, but also a reflection of top managers' ability. Therefore, patents for invention of the comprehensive performance evaluation system of enterprises occur [1]. However, the corporate image can also be affected by safety problems, thus patents of the safety performance evaluation system of manufacturing enterprises come

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into being [2]. Medical institutions also have the same service performance evaluations [3].

Under the impetus of China's education, the higher vocational education also develops rapidly. Therefore, the evaluation of the performance of teachers in vocational colleges becomes very important [4]. As the reflection of the teaching level and educational quality of vocational colleges, the performance of teachers has become the competitive force of each college [5]. Current vocational colleges are transformed from secondary technical schools, thus their management systems and teaching models are still in old modes. Teachers are the main force of scientific researches, thus the correct evaluation of teachers' capacity for scientific research becomes the important issue of each vocational college [6]. Teachers with strong capacity for scientific researches are more likely to participate in scientific and research activities, thus the scientific research ability of colleges can be improved [7]. As the discipline classification increases, it has been unreasonable to evaluate teachers of different disciplines using the same evaluation standard [8]. Thus evaluation systems that are more accurate and fair are needed. Current evaluation methods include Delphi method, analytic hierarchy process (AHP), fuzzy comprehensive evaluation, etc. [9]. Heping Y et al. [10] formulated a new evaluation index system for scientific research achievements in universities by introducing value engineering and then analyzed the system using AHP method and multi-level fuzzy comprehensive evaluation method to obtain comprehensive and objective evaluation conclusions. Xiaoping W et al. [11] designed the framework of university teacher performance assessment indicators, established a hierarchical model of comprehensive quality evaluation using AHP to figure out the weight of each indicator, set up a fuzzy comprehensive evaluation model and provides the examples to suggest the feasibility and effectiveness of the method. Combining scientificity with systematicness, hierarchy with independence and maneuverability with easy quantization, this study established evaluation models of scientific research performance based on theories of the support vector machine (SVM) algorithm and the back propagation (BP) algorithm respectively. The simulation was performed after obtaining model results. The comparison showed that the SVM algorithm could establish the evaluation index system of scientific research performance more accurately and reasonably in vocational colleges.

2. Relevant theories

2.1 SVM and particle swarm optimization algorithms

The SVM keeps the balance of a small range of data samples in model training complexity and learning ability based on Vapnik-Chervonenkis (VC) dimension and theories of structural risk minimization [12]. The SVM can be linearly separable, linearly inseparable and multi-classification [13]. Its fitting function is

$$(1) \quad (g)_n = f_n(m) = \{\omega_n, \varphi_n(m)\} + \alpha_n.$$

In equation (1), ω_n shows the complexity of $f_n(m)$ and α_n is a constant. If

$$(2) \quad (f)_k - \{\omega_n, \varphi_n(n)\} - \alpha_n = (\xi_n)_k, (k = 1, 2, 3, \dots, d),$$

the minimum cost functional is

$$(3) \quad P_n = 0.5\{\omega_n, \omega_n\} + 0.5W \sum_{k=1}^d [(\xi_n)_k]^2$$

where W is the penalty factor and ξ refers to the slack variable. The constructed optimizing function is:

$$(4) \quad K_n(\omega_n, \alpha_n, \xi_n, \mu_n) = 0.5\{\omega_n, \omega_n\} + 0.5W \sum_{k=1}^d [(\xi_n)_k]^2 \\ + \sum_{k=1}^d (\mu_n)_k [\{\omega_n \varphi_n(t_k)\} + \alpha_n + (\xi_n) - (IMFn)_k].$$

In equation (4), $(\mu_n)_k$ refers to the multiplier and final equation (1) is

$$(5) \quad f_n(m) = \sum_{k=1}^d (\mu_n)_k K_n(m, m_k) + \alpha_n.$$

If the $K_n(m, m_k)$ in equation (5) is the SVM function, then

$$(6) \quad K_n(m, m_k) = \exp\left[-\frac{\|m - m_k\|^2}{2\vartheta_n^2}\right],$$

which is the most common kernel function. In equation (6), ϑ_n is the standard deviation of f_n in the n^{th} group.

In particle swarm optimization (PSO), each individual is a particle and each particle is a potential solution [14]. The initial particle is expressed by position (Q), speed (V) and adaptive value (F). The adaptive value determines the performance of the particle. There is an optimal particle position in all particles, which is called the population extremum F_{best} . Meanwhile, there is an individual extremum G_{best} at the optimal position of individual fitness value. Suppose the X -dimensional solution space is composed of h populations composed of particles, $Y = (Y1, Y2, \dots, Yh)$. The n^{th} particle represents a vector quantity as well as the search location in the X -dimensional solution space. After obtaining the fitness value, the speed of the n^{th} particle is solved: $V_n = (V_{n1}, V_{n2}, \dots, V_{nX})^T$. The individual extremum is $G_n = (G_{n1}, G_{n2}, \dots, G_{nX})^T$; the population extremum is $F = (G_{\sigma 1}, G_{\sigma 2}, \dots, G_{\sigma X})^T$. Through the iteration, particles can adjust and update by themselves according to the speed and the position of individual extremum and population extremum. The result is $V_{nx}^{i+1} = \tau V_{nx}^i + l_1 r_1 (D_{nx}^i - X_{nd}^i) + l_2 r_2 (D_{\alpha x}^i - X_{\sigma x}^i)$, $V_{nd}^{i+1} = Y_{nx}^i + V_{nd}^{i+1}$, in which i refers to the times of iteration and τ is the inertia weight; $x = 1, 2, \dots, X$; $n = 1, 2, \dots, h$; V_{nx} is the particle speed; l_1 and l_2 are accelerated factors; r_1 and r_2 are random values in $[0, 1]$.

2.2 BP algorithm

BP algorithm is used to estimate errors of the leading layer based on errors of the output layer; then based on this, errors of the upper layer were estimated, until errors of all layers were estimated [15]. The specific algorithm is as follows. Random values are given to the weight matrix and the threshold vector and the error is designed as 0; the accuracy value is E and the maximum times of learning is U. Then sample data are input for calculation of the output results of each layer. The actual network output and neuron partial derivative are calculated. Then based on this, the neuron partial derivative of the hidden layer is calculated. The overall errors of network and error signals of each layer are calculated, and the weight of each layer is adjusted. Finally, it is checked whether all samples are tested and whether the overall errors of network reach the requirements.

3. Simulation experiment

3.1 Data collection

3.1.1 Index selection for the evaluation system of scientific research

As shown in table 1, the system is composed of 5 level-I indexes and 28 level-II indexes. Due to the lack of unified assessment criteria, this study took the engineering higher vocational schools as examples to establish a system for evaluation of scientific research performance of teachers.

3.1.2 Data acquirement

Data were collected from representative scientific research data of teachers. Taking the performance scoring of scientific researches formulated by vocational colleges as the standard, we calculated the scientific research activities of teachers. Teachers' capacity for scientific research was expressed as Z ; one to four points was used to represent the capability, 1 point for weak capacity, 2 for moderate capacity, 3 for good capacity and 4 for strong capacity. As shown in table 2, $P1 \sim P11$, $P12 \sim P18$, $P19 \sim P23$ and $P24 \sim P28$ were data of teachers with strong capacity, good capacity, moderate capacity and weak capacity respectively.

The missing data were recorded as 0 to reduce experimental errors.

3.1.3 Pretreatment of experimental data

The data in table 2 were pretreated and the equation was:

$$a_{n\gamma} = \frac{a_{n\gamma} - \text{Min } a_{\kappa\gamma}}{\text{Max } a_{\kappa\gamma} - \text{Min } a_{\kappa\gamma}}, \quad n = 1, 2, 3, \dots, t, \quad \gamma = 1, 2, 3, \dots, \rho, \quad 1 \leq \kappa \leq t.$$

In the equation, $\text{Min } a_{\kappa\gamma}$ refers to the minimum value of the column where the attribute of variate a_{γ} locates and $\text{Max } a_{\kappa\gamma} - \text{Min } a_{\kappa\gamma}$ refers to the range

Target layer	Grade-I index	Grade-II index
Indexes of teachers' capacity for scientific research	Scientific research project	State-level major project study L1
		State-level key project study L2
		State-level general project study L3
		Provincial major project study L4
		Provincial key project study L5
		Provincial general project study L6
		Bureau-level project study L7
		Cross-sectional project study L8
		School-level project study L9
	Research paper	Retrieval paper L10
		A-level journal article L11
		B1-level journal article L12
		B2-level journal article L13
		C2-level Chinese core journal L14
		C3-level foreign language periodical and international conference L15
	Work	C4-level published papers and national conference L16
		Monograph national press L17
		Monograph other levels of press L18
		Non-monograph national press L19
		Non-monograph other levels of press L20
	Award grade	National award L21
		Provincial award L22
		Bureau-level award L23
		Social force establishment L24
	Patent grade	International patent for invention L25
		National patent for invention L26
		Patent for utility models L27
		Design patent L28

Table 1. Index system of teachers' capacity for scientific research

value of variate a_γ . However, these two values might be 0, thus the index was eliminated to guarantee the accuracy of the experiment. L1~L11 were selected as the experimental sample data and the obtained sample data are as shown in table 3.

3.2 Construction of the evaluation model based on SVM algorithm

In order to achieve the balance between the tolerance degree and the complexity of sample classification errors, this study adopted penalty factor W to define the degree of misclassification of penalty samples. The model included the training function and the forecasting function. The scientific research evaluation model after training was SVMtrain (labels, research, $-w8g0.02t2$), in which the labels represented teachers' capacity for scientific research (1~4 points); research was the sample data; $-w, g$ and t were the penalty factor, kernel parameter and

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
P1	56 9.7	64	31 2.4	0	422	13 .9	0	11 14.2	0	0	0
P2	26 0.5	31	12 4.6	0	95	95 .2	0	12 40.3	0	0	0
P3	0	113 0.5	14 4.7	0	991 .3	1. 4	0	27	0	13 5.7	2 8
P4	0	597	11 7.1	0	102 2.9	10 .8	0	48 22.2	0	0	5 5.4
P5	0	239	8	2 2	285	65	0	48 22.2	0	0	0
P6	0	421 .8	16 5.3	0	10	10 .8	0	12. 4	0	9.8	8 .2
P7	0	197 .3	26 4.7	0	99	4	0	1.3	0	97	5 0.5
P8	0	237	51 .9	0	252 .1	16 5	5	28 7	0	0	0
P9	0	138 .1	47 4	0	187	11 7.5	3	52. 4	0	0	0
P10	21 1	23. 8	12 4	0	50	56 .8	0	96 6.3	0	0	0
P11	0	0	14 2.6	2 3.9	157 .3	96 .2	0	33 5.5	0	10 42.1	8 86
P12	0	0	37 .2	0	0	44 .7	0	22 4.8	0	0	0
P13	0	0	0	0	0	0	3 4	34 6.7	0	0	0
P14	0	0	33	0	9.4	30 .3	0	50 2.6	0	0	0
P15	0	0	82 .8	0	0	0	0	44 8.3	3 .7	0	0
P16	0	0	0	0	0	20 0	0	14 8	0	0	0
P17	0	0	63 .9	0	0	51 .7	0	17 3	0	0	0
P18	0	0	63 .9	0	0	52 .9	0	17 3	0	0	0
P19	0	0	0	0	0	1. 4	0	86. 1	8 .7	0	0
P20	0	0	0	0	0	9. 3	0	56. 7	3 .3	0	0
P21	0	0	0	0	0	0	5	76	0	0	0

Table 2. Partial original data of the evaluation index system of teachers scientific research

kernel function respectively. The range of the penalty factor and the kernel parameter was $[2^{-10}, 2^{10}]$.

The classification model of the predicted function was (New label, accuracy)=SVMpredict(labels, research, model), in which “New label” refers to the new capacity score, “accuracy” was the accurate rate of classification; “labels” represented the forecasting of the capacity for scientific research, “research” refers to the predicted sample data and “model” refers to the scientific research evaluation model after training.

	L 1	L 2	L 3	L 4	L5	L6	L 7	L8	L 9	L 10	L 11
P 1	1	0. 054	0. 651	0	0.41 1	0.05 1	0	0.1 87	0	0	0
P 2	0. 468	0. 021	0. 259	0	0.08 9	0.47 6	0	0.2 55	0	0	0
P 3	0	1	0. 308	0	0.94 3	0.00 8	0	0.0 06	0	0. 122	0. .03 1
P 4	0	0. 512	0. 241	0	1	0.04 4	0	1	0	0	0. .05 7
P 5	0	0. 216	0. 018	0. 847	0.26 8	0.32 8	0	1	0	0	0
P 6	0	0. 364	0. 374	0	0.03 3	0.05 9	0	0.0 07	0	0. 012	0. .00 9
P 7	0	0. 221	0. 571	0	0.09 2	0.01 8	0	0.0 11	0	0. 108	0. .04 8
P 8	0	0. 221	0. 108	0	0.23 1	0.84 3	0 .122	0.6 21	0	0	0
P 9	0	0. 124	1	0	0.17 9	0.64 1	0 .009	0.0 17	0	0	0
P 10	0. 372	0. 031	0. 207	0	0.03 7	0.28 1	0	0.2 02	0	0	0
P 11	0	0	0. 347	1	0.14 8	0.49 3	0	0.0 71	0	1	1
P 12	0	0	0. 084	0	0	0.23 8	0	0.0 46	0	0	0
P 13	0	0	0	0	0	0	1	0.0 71	0	0	0
P 14	0	0	0. 074	0	0.07 9	0.15 1	0	0.1 12	0	0	0
P 15	0	0	0. 168	0	0	0	0	0.1 20	0. .06 0	0	0
P 16	0	0	0	0	0	1	0	0.0 27	0	0	0
P 17	0	0	0. 134	0	0	0.23 5	0	0.0 29	0	0	0
P 18	0	0	0. 134	0	0	0.23 5	0	0.0 29	0	0	0
P	0	0	0	0	0	0.00	0	0.0	1	0	0

Table 3. Experimental sample data after pretreatment

3.3 Construction of the evaluation model based on BP algorithm

During the training process, the corresponding weight of the neuron was constantly adjusted to narrow the gap between the forecasting output results and the actual results. The number of samples, input nodes and output layers was 11, 11 and 4 respectively. The learning rate was set as 0.01, the maximum training times was as 200, and the training accuracy was $E - 3$. The model was `net=new ff(research, labels, 2); net=train(net, research, labels); sim=sim(net, labels)`, in which research represented sample data and labels represented the network predicting capacity for scientific research.

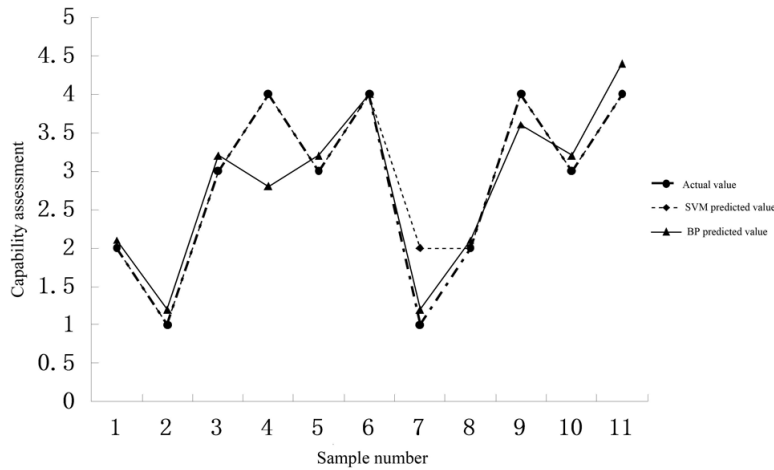


Figure 1. Comparison of the predicted results and the actual results.

4. Simulation results

Figure 1 shows the comparison between predicted values obtained from the above two models and the actual values. It can be noted from the figure that most of BP predicted values were basically similar to the actual values, but some of them had large error, and the error value of the maximum capability assessment reached 1.5 approximately; SVM predicted values had higher accuracy and smaller error compared to the predicted values; except sample 7, the errors of other samples could be ignored. Therefore, the SVM algorithm could evaluate the scientific research performance of teachers more accurately.

5. Improvement of the evaluation system based on SVM algorithm

The SVM model was optimized and improved by combining the SVM algorithm with PSO. It was obtained by the proof method that w was 8 and g was 0.25. In iterative solution, w was 11.5 and g was 1.5 under the optimal accuracy. The obtained predicted values are shown in figure 2.

Compared to the SVM algorithm, the accuracy of the PSO optimized SVM algorithm reached 100%, indicating the penalty factor and kernel parameter of the PSO optimized SVP algorithm ensured the accuracy of prediction, avoid errors caused by individual samples, and effectively improved the accuracy of predicted results.

The optimized SVM algorithm was applied to the computer system, and the detection results were the same as the actual results. Its application in the evaluation indicator system for the research performance in higher vocational colleges had a 100% accuracy.

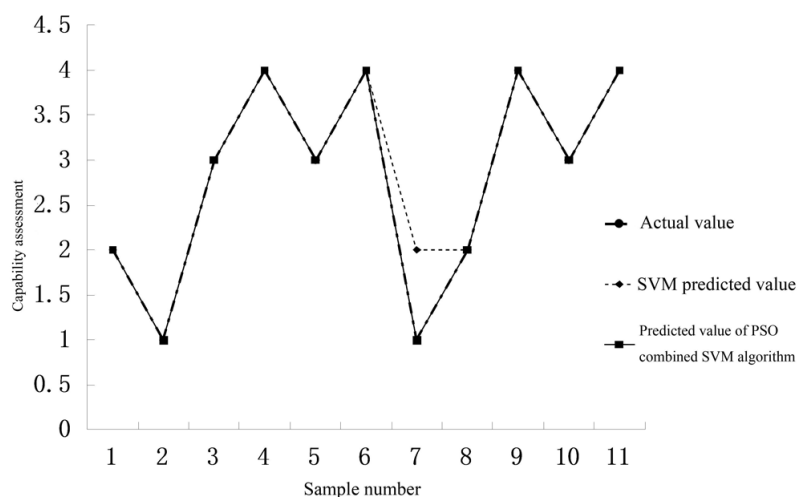


Figure 2. Comparison between predicted values of the PSO optimized SVM algorithm, predicted values of the SVM algorithm and actual values.

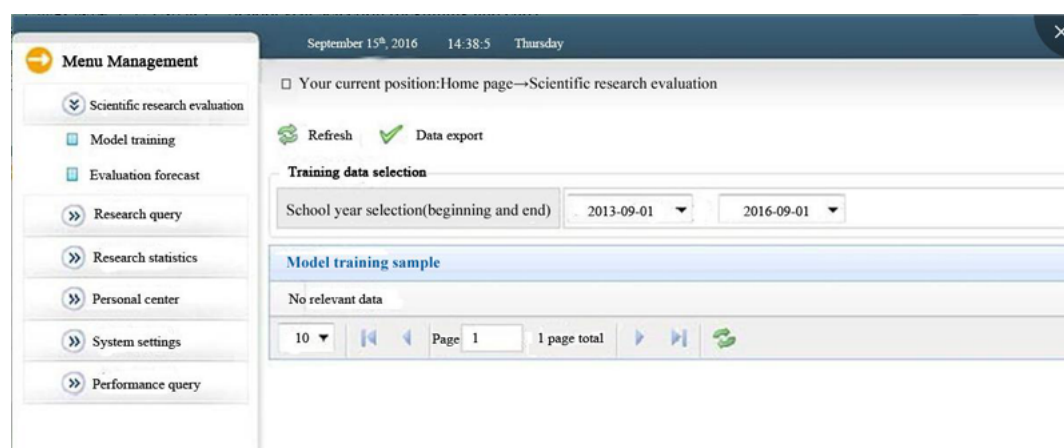


Figure 3. Computer interface.

6. Discussion and conclusion

Currently, the evaluation of the scientific research performance of vocational colleges is still at the starting stage. There are plenty of theoretical researches concerning core factors, evaluation indexes and methods that can affect the evaluation of the scientific research performance; however, there are still some deficiencies. Compared with universities, the vocational colleges still need to further improve their evaluation on the scientific research performance. Current evaluation methods in vocational colleges focus more on quantized evaluations instead of qualitative evaluations. This study compared the BP algorithm and

» Research statistics

» Personal center

» System settings

» Performance query

Model training sample											
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
P1	1	0.054	0.651	0	0.411	0.051	0	0.187	0	0	0
P2	0.468	0.021	0.259	0	0.089	0.476	0	0.255	0	0	0
P3	0	1	0.308	0	0.943	0.008	0	0.006	0	0.122	0.031
P4	0	0.512	0.241	0	1	0.044	0	1	0	0	0.057
P5	0	0.216	0.018	0.847	0.268	0.328	0	1	0	0	0
P6	0	0.364	0.374	0	0.033	0.059	0	0.007	0	0.012	0.009
P7	0	0.221	0.571	0	0.092	0.018	0	0.011	0	0.108	0.048
P8	0	0.221	0.108	0	0.231	0.843	0.122	0.621	0	0	0
P9	0	0.124	1	0	0.179	0.641	0.009	0.017	0	0	0
P10	0	0.031	0.207	0	0.037	0.281	0	0.202	0	0	1

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Figure 4. Pretreatment data.

» Research statistics

» Personal center

» System settings

» Performance query

Model training sample										
	L1	L2	L3					L9	L10	L11
P1	1	0.054	0.651					0	0	0
P2	0.468	0.021	0.259					0	0	0
P3	0	1	0.308					0	0.122	0.031
P4	0	0.512	0.241					0	0	0.057
P5	0	0.216	0.018					0	0	0
P6	0	0.364	0.374					0	0.012	0.009
P7	0	0.221	0.571					0	0.108	0.048
P8	0	0.221	0.108	0	0.231	0.843	0.122	0.621	0	0
P9	0	0.124	1	0	0.179	0.641	0.009	0.017	0	0
P10	0	0.031	0.207	0	0.037	0.281	0	0.202	0	1

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Figure 5. Assessment after the improvement of SVM algorithm.

the SVM algorithm, established evaluation models, and made simulation. The results demonstrated that the SVM algorithm was more accurately in processing small samples and multiple indexes than the BP algorithm. Currently, the BP algorithm develops well in related fields, but there were some deficiencies. The SVM algorithm tactfully avoids those deficiencies and moreover achieves global optimization. Therefore, the evaluation of SVM algorithm is more scientific and accurate in this study. Based on it, the SVM algorithm was further optimized and improved and combined with PSO. Then the accuracy of the experimental results reached 100%. However, only one vocational college was selected for study; the research performance was evaluated using the optimized SVM algorithm to further prove the accuracy of the experimental results. Due to the diversity of different vocational colleges, further studies are required in the future. In conclusion, the application of SVM algorithm to the evaluation of scientific research performance in vocational colleges should be promoted.

This study is supported by Study on the new method of practical teaching in SSH course,(JYZD201606).

Acknowledgements

Research project on the development of social science in Hebei province 2018
The people's livelihood project No.201803040106.

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Accepted: 29.06.2017