A Customer Satisfaction Degree Evaluation Model Based on Support Vector Machine

Wang Ting, Hua Zhiwu
Department of Economy Management, North China Electric Power University, Baoding , Hebei, China
abcde-20015@163.com

Abstract: An efficient classification algorithm is proposed for evaluating the customer satisfaction degree. The algorithm is based on the RBF-Kernel support vector machine and multilevel binary tree classifier. Fuzzy membership function was used to quantify the evaluation indices. The evaluation indices and the SVM algorithm were used to design a customer satisfaction degree evaluation model. The novel evaluation method has higher accuracy in comparison with the traditional fuzzy comprehensive evaluation method and BP evaluation method.

Keywords: customer satisfaction degree, support vector machine, multilevel binary tree classifier, evaluation model

1. INTRODUCTION

Support vector machine (SVM) were developed from the machine learning theory of small samples based on statistical learning theory by Vapnik et al, which were originally designed for binary classification problems. It can solve small-sample learning problem better by using structural risk minimization in place of experiential risk minimization. Moreover, SVM can convert a nonlinear learning problem into a linear learning problem in order to reduce the algorithm complexity by using the kernel function concept.

With market competition gradually fierce, more and more enterprises adopt "customer-centered" enterprise strategy and marking strategy. There was some study of customer satisfaction degree at home and abroad, but current index system and comprehensive analysis method was seldom which have stronger directivity and practical. Therefore, the customer satisfaction degree evaluation was converted to multivariate classification in this paper, on the basis of deeply surveying and studying of correlative concept and theory. The customer satisfaction degree evaluation model was built with the algorithm which is based on the SVM multivariate classification.

e-Forensics 2008, January 21-23, 2008, Adelaide, Australia.

2. SUPPORT VECTOR MACHINE

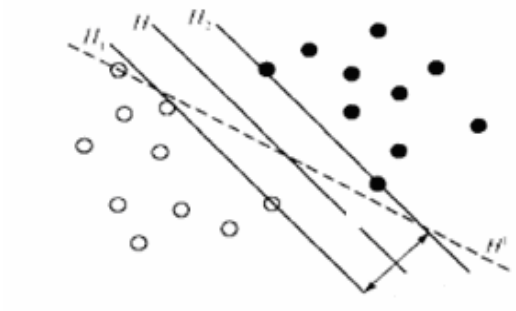

Figure1 Linearly separable SVM

The idea behind training an SVM classifier, in case of linearly separable classes, is to find two hyperplanes in the feature space. The elementary theory of SVM can be simply described as (figure 1) follows: searching an optimal hyperplane satisfies the request of classification, then using a certain algorithm to make the margin of the separation beside the optimal hyperplane maximum while ensuring the accuracy of correct classification. According to the theory, we can classify the separable data into two classes effectively. The following is the brief introduction of SVM in two cases: the linear case and the nonlinear case. [1][2]

2.1 THE LINEAR CASE

Suppose we are given a set of training data

$x_i \in R^n$ (i=1,2, ⋯ ,n) with the desired output $y_i \in \{+1,-1\}$ corresponding to the two classes. And suppose there exists a separating hyperplane with the target functions $w \bullet x_i + b = 0$. w represents the weight vector and b the bias. To ensure all training data can be classified, we must make the margin of separation ($\frac{1}{\|w\|}$) maximum. To generalize the problem to the non-separable case, slack variable $\xi_i \geq 0$, i=1,2,⋯,n is introduced. So, the constraint condition is:

$$y_i[w \bullet x_i + b - 1] + \xi_i \geq 0 \qquad (1)$$

Then, in the case of linear separation, the linear SVM for optimal separating hyperplane has the following optimization problem,

$$\min(\frac{1}{2}\|w\|^2 + c\sum_i \xi_i)$$

$$\text{s.t} \qquad y_i[w \bullet x_i + b] - 1 + \xi_i \geq 0 \qquad (2)$$

The solution to above optimization problem can be converted into its dual problem. We can search the nonnegative Lagrange multipliers by solving the following optimization problem,

$$\max w_{(a)} = \sum_i a_i - \frac{1}{2}\sum_{i,j} a_i a_j y_i y_j (x_i \bullet x_j)$$

$$\text{s.t} \quad \sum_i y_i a_i = 0 , \quad 0 \leq a_i \leq C , \quad \text{i=1,2,⋯,n} \qquad (3)$$

C is the nonnegative parameter chosen by users. Solving the problem is similar to the problem of the case of linear separation.

Then, the optimal equation for classification is

$$f(x) = \text{sgn}\{\sum_i y_i a_i (x_i \bullet x_j) + b\} \qquad (4)$$

2.2 THE NONLINEAR CASE

As to the non-linear separable data, the data can be mapped into a high dimensional feature space with a nonlinear mapping in which we can search the optimal hyperplane. The linear classification after mapping is performed by selecting the appropriate inner-product kernel satisfies the Mercer's condition. Then the problem is converted into searching the nonnegative Lagrange multipliers $\{a_i\}_{i=1}^n$ by solving the following optimization problem,

$$\max w_{(a)} = \sum_i a_i - \frac{1}{2}\sum_{i,j} a_i a_j y_i y_j k(x_i, x_j) \qquad (5)$$

$$\text{s.t} \quad \sum_i y_i a_i = 0 , \quad 0 \leq a_i \leq C , \quad \text{i=1,2,⋯,n} \qquad (6)$$

Hence, the classification function is

$$f(x) = \text{sgn}\{\sum_{x_i \in w} y_i a_i k(x_i, x_j) + b\} \qquad (7)$$

The common used kernel function is RBF kernel function

$$k(x_i, x_j) = \exp(-\frac{\|x_i - x_j\|^2}{2\sigma^2}) \qquad (8)$$

2.3 MULTIVARIATE CLASSIFICATION

There was certain corresponding relationship between the multivariate classification and the binary classification. If the samples have n classes, a multilevel binary tree classifier which combines SVM and binary tree is established. For n classes training samples, $n-1$ SVMs should be trained. The first SVM use the first-class sample as -1and the second-class, third-class⋯*n*th-class samples as +1 and then train SVM1. The *i*th SVM use the *i*th-class as -1and the (*i*+1)th-class, (*i*+2)th-class⋯*n*th-class samples as +1 and then train SVM*i*. Until SVM(n－1) is is trained, training samples of *n* classes will be classified. [3]

3. CUSTOMER SATISFACTION DEGREE EVALUATION MODEL BASED ON SVM

In order to evaluate the customer satisfaction degree based on support vector machine, we should do the following steps. [4] [5]

(1) Confirm the influence factor of the customer satisfaction degree;
(2) Establish the index system;
(3) Establish the model based on multilevel binary tree classifier;
(4) Collect the training data;
(5) Train the network and classify the testing samples.

3.1 The customer satisfaction index system

The customer satisfaction index system is composed of seven variables. Each index is used as one input in the model. The index system is shown in Table 1.

Table 1 Customer satisfaction index system.

Number	Index
U_1	Customer expect
U_2	Brand Image
U_3	Customers' Perception of quality
U_4	Customers' Perception of value
U_5	Customer satisfaction
U_6	Customer complain
U_7	Customer Loyalty

Customer satisfaction can be divided into several levels in the view of psychology. There are five levels here. That is, V={V_1，V_2，V_3，V_4，V_5}={ V_1（Excellent），V_2（Good），V_3（Fair），V_4（Poor），V_5（None）}。[6][7][8]

3.2 the customer satisfaction evaluation model

Support we are given a set of training data （x_1，y_1），（x_2，y_2），…，（x_n，y_n）. According to the degree of customer satisfaction, four SVMs are established to classify the five grades. The following are the detailed steps.（figure 2）

(1) SVM1 classify the $V_1$and the other classes. If the output of SVM1 is -1, the satisfaction degree is V_1; if the output if +1, the satisfaction degree is the other four classes(V_2，V_3，V_4，V_5）.
(2) SVM2 classify the V_2 and the other classes. If the output of SVM1 is -1, the satisfaction degree is V_2; if the output if +1, the satisfaction degree is the other three classes(V_3，V_4，V_5）.
(3) SVM3 classify the V_3 and the other classes. If the output of SVM1 is -1, the satisfaction degree is V_3; if the output if +1, the satisfaction degree is the other three classes(V_4，V_5）.
(4) SVM4 classify the V_4 and the V_5. If the output of SVM1 is -1, the satisfaction degree is V_4; if the output if +1, the satisfaction degree is V_5.

When testing the samples, at first, from the root-node sub-classifier SVM_1, justify its output is positive or negative (show as +1, and -1), and then, according to the output result to testing samples by using the second sub-classifier SVM_2 , following this rule, till the last sub-classifier, so that, get out the classification that the samples belong.

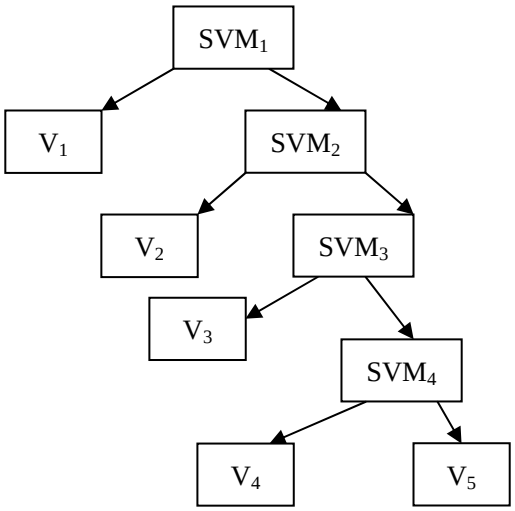

Figure2 The frame of multilevel binary tree

4. EMULATIONAL EXPERIMENT

The samples of 150 are obtained from some enterprise in this study. Fuzzy membership function was used to quantify the data. 100 samples of them are used as training samples, and the rest 50 samples are used as testing samples. Multilevel binary tree classifiers are established to train the network, and then Four SVMs are gotten. Evaluate the same samples with BP and the fuzzy comprehensive evaluation method. The results are shown in Table 2.

From Table 2, we can know that the multilevel binary tree classifier can classify the testing samples of five classes in a high accuracy of classification. The

classification correct rate of testing samples is 94% which is higher in comparison with the traditional fuzzy comprehensive evaluation method and BP evaluation method.

Table 2 Classification results of SVM \BP and fuzzy comprehensive evaluation method.

CSD	Original number	SVM	BP	fuzzy comprehensive evaluation
V_1	9	9	8	9
V_2	6	6	6	5
V_3	15	15	14	11
V_4	13	11	10	9
V_5	7	6	6	5
Accuracy		94%	88%	74%

5. CONCLUSIONS

SVM is a successful use of statistical Learning Theory. It is built on the theory of VC dimension and the minimization of structural risk. It uses limited information to make complication and learning ability best. This paper gives a set of index system of customer satisfaction. Then establish a model to evaluate the customer satisfaction degree which based on multilevel binary tree classifier and the index system. In order to prove the effectiveness of the method, a case is used and the experimental results show that the method is effective and classified the testing samples in a high accuracy. And the method shows higher classification correct rate than BP algorithm and fuzzy comprehensive evaluation method. The method has great use value in the customer satisfaction degree evaluation.

REFERENCES

[1] Vapnik V, The nature of statistical learning theory [M], NewYork, Spring-Verlag, 1995

[2] Vapnik V, Nature of statistical learning theory [M], NewYork, John Willey and sons, Inc, 2000

[3] Cortes C,Vapnik V, Support vector networks [J], Machine Learning,1995,(2):273-297

[4] ZHANG Xue-gong, Introduction to statistical learning theory and support vector machines [J], Act Automatics Sinica, 2000, (1):32-42

[5] HU Yong-hong, HE Si-hui, Comprehensive assessment methods [M], Beijing, Science Press,2000

[6] TANG Xiaofen, The measure and evaluation of customer satisfaction [M], Shanghai, Shanghai Science and Technology Press, 2002

[7] WANG Yongqing, YAN Haoren, The measure and evaluation of customer satisfaction [J], Economic Management, 2000, (8):36-38

[8] Jim Jubelirer, Customer Satisfaction Numbers do tell the whole story Quirk’s Marketing Research Review, 1999, (10):23-45