Research on Young Females' Body Classification Based on SVM

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Abstract

Young females's data in Jiangsu and Zhejiang areas are acquired by using 3D Body Scanner made by American TC^2. Then according to the four parts of body shape character, we can classify human data into different kinds of women's body types. In the process, SVM(support vector machine) model is used to identify the young women's shape. The results show that SVM is an effective identified and classified method due to short time and high precision. The reference data can be provided for the garment pattern design of young females's apparel.

Keywords

SVM, Young female, Human classification.

1. Introduction

Nowadays, clothing fit has been widely regarded as an important indicator that affects the appearance and comfort of clothing. According to a survey by KSA (Kurt Salmon Associates): 50% of women complain about not being able to buy fit clothes. Another survey indicated that 50% of the reasons for the return of goods were caused by inappropriate clothing. [1] Body shape directly affects structural design. Therefore, the purpose of body classification is to provide basis for clothing style design and structural design. Therefore, the accuracy and timeliness of body classification algorithms are crucial.

Body type analysis plays an important role. It is not only one of the key technologies to realize MTM(Made to Measure), but also an important procedure to combine 3D body scanner with digital garment production. Body type analysis means to analyze the data in Anthropometrical Database, then acquire parameters by computing the data based on the statistical theories, finally classify human body characteristics using clustering analysis. It provides advantageous help to the mapping from body form to clothing size and other application of MTM [2].

But the description of body character involves the relationship between data and specific judgment, which is hard to depict by traditional mathematic methods because of the non-linear relation among parameters and the existence of multi influencing factors. So we adopt Support vector machine (SVM) which is the very method to resolve this kind of problems. By checking the model through actual body measurements, the method in this paper can fully satisfy the need of body type analysis in MTM.

SVM is a learning method proposed by Vapnik et al. based on statistical learning theory. In recent years, there have been many applications in pattern recognition, regression analysis and feature extraction [2]. According to Vapnik's principle of structural risk minimization, SVM selects a limited data set to provide the optimal model with the minimum expected risk. Moreover, SVM algorithm is a convex quadratic optimization problem, which can guarantee that the extreme value solution found is the global optimal solution. Some recent applications show that the SVM method shows better adaptability and popularization ability than traditional methods including neural network methods [3,4].

The rest of the paper organized as follows: Section 2 describes the general structure of the SVM model; Section 3 explains the data source and classification; finally some concluding remarks are drawn from section 4.

2. Theory and Arithmetic of SVM

SVM take the following advantages over conventional statistical learning algorithms: (1) High generalization performance even with high dimension feature vectors; (2) The ability to manage kernel functions that map input data to higher dimensional space without increasing computational complexity.

2.1 Optimal Hyperplane

The main idea of SVM is to create an optimal hyperplane to classify the data into two classes (positive and negative) and maximize distance between the hyperplane separating the two classes and the closest data points to the hyperplane[4,5],see Fig.1.

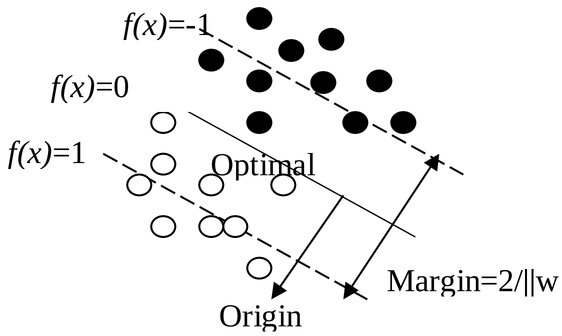

Fig.1 Optimal classifying line under linear classified condition

Fig.1 shows training examples linearly separated into two classes.

It starts with a set of l training data $(x_1,y_1),\ldots,(x_l.y_l)$, where $x_i \in R^n$ is an n-dimensiona vector and $y_i \in \{-1,+1\}$ is the class label of its data:

$$(x_1, y_1),\cdots,\ (x_1, y_1) \in R^n \times R \quad (1)$$

The basic idea of SVM is to maximize the margin between the positive and negative examples. Firstly, the training examples are mapped from original spaces Rn to feature spaces $\Psi(x)=(\varphi(x_1),\varphi(x_2),\cdots,\ \varphi(x_1))$ by a non-linear function ψ(□). Secondly, non-linear estimated function is changed into linear estimated function in hyperplane feature spaces by the most optimal decision function, as follows:

$$y(x) = w \cdot \varphi(x) + b \quad (2)$$

Finding w and b is just minimizing R:

$$\min R(w,\xi) = \frac{1}{2}\cdot \| w \|^2 + c\sum_{i=1}^{l}(\xi_i + \xi_i^*) \quad (3)$$

$$s.t.\ y_i - w\cdot\varphi(x_i) - b \le \varepsilon + \xi_i$$

$$w\cdot\varphi(x_i) + b - y_i \le \varepsilon + \xi_i^*, \xi_i^*, \xi_i \ \ge 0, i = 1,\cdots,\ l$$

in Eq(1): $\|w\|$——Controlling the complication of models

C ——Const

ε —— Misclassification errors

The answer of Eq(1) can be got by Lagrang Function:

$$L(w,\xi^*,\xi,\alpha,\alpha^*,c,\beta,\beta^*) = \frac{1}{2} w \times w + c\sum_{i=1}^{l}(\xi_i + \xi_i^*) - \sum_{i=1}^{l} a_i((w\times j(x_i)) - y_i + b + \varepsilon + \xi_i) - \sum_{i=1}^{l}\alpha_i^*(y_i - (w\times j(x_i)) - b + \varepsilon + \xi_i^*) - \sum_{i=1}^{l}(\beta_i\xi_i + \beta_i^*\xi_i^*) \quad (4)$$

According to optimal conditions:

$$\frac{\partial L}{\partial w}=0,\frac{\partial L}{\partial b}=0,\frac{\partial L}{\partial \xi_i}=0,\frac{\partial L}{\partial \xi_i^*}=0$$

The results are :

$$w=\sum_{i=1}^{l}(\alpha_i-\alpha_i^*)\varphi(x_i),\sum_{i=1}^{l}(\alpha_i-\alpha_i^*)=0,$$
$$c-\alpha_i-\beta_i=0,c-\alpha_i^*-\beta_i^*=0,i=1,\cdots,\ l \tag{5}$$

Defining the Kernel Function based on Mercer's conditions:

$$k(x_i,x_j)=\varphi(x_i)\cdot\varphi(x_j) \tag{6}$$

Through Eq(2),Eq(3) and Eq(4), the optimization problem is exchanged as follows:

$$\max W(\alpha,\ \alpha^*)=-\frac{1}{2}\sum_{i,j=1}^{l}(\alpha_i-\alpha_i^*)(\alpha_j-\alpha_j^*)K(x_i,x_j)+$$
$$\sum_{i=1}^{l}(\alpha_i-\alpha_i^*)y_i-\sum_{i=1}^{l}(\alpha_i-\alpha_i^*)\varepsilon \tag{7}$$

$$\text{s.t.}\quad \sum(\alpha_i-\alpha_i^*)=0$$
$$0\le\alpha_i\le c,0\le\alpha_i^*\le c,i=1,\cdots,1$$

So the final non-linear estimated function is:

$$f(x)=\sum(\alpha_i-\alpha_j^*)K(x_i,x_j)+b \tag{8}$$

2.2 Kernel Function

We choose different Kernel functions that can construct variable support vector products. In general, Kernel function including:

1)Polynomial Kernel Function: $K(x_i,x_j)=[(x_i,x_j)+1]^d$;

2)Radial Machine Kernel Function: $K(x_i,x_j)=e^{-\frac{\|x_i-x_j\|^2}{2\sigma^2}}$;

3)Neural Network Kernel Function:

$$K(x_i,x_j)=S(v(x_i,x_j)+c)$$

In this paper, we use radial machine Kernel functions that have been very effective.

2.3 SVM Network Structure

The realization of SVM in this paper due to the structure as Fig.2 shows:

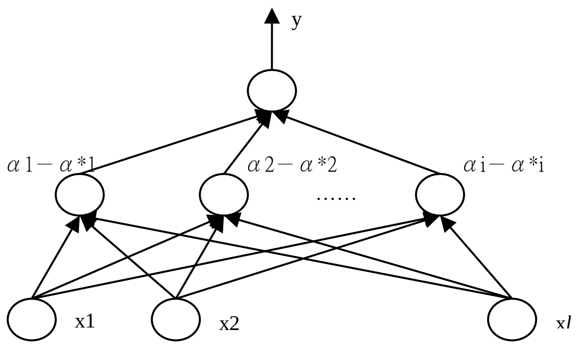

Fig.2 SVM network structure diagram

Where αi－α*i is the weight of network, variable x1,x2,…,x*l* is introduced for input numbers and y is output number.

Systematic identification based on SVM steps as follows:

1) Choosing the training examples, modifying and pre-computing the data;

2) Using the function of SVM to train the chosen data: input a set of *l* training data x1,x2,…,x*l*, then output variable y;

3) Constructing the modeling of SVM and predicting the unknown examples.

3. Experiment

3.1 Analysis on Body Characteristic Parts

According to garment pattern design and the experience of fashion designers, there are more than 80 geometric characteristic sizes [6,7]. Among them the following four parts, flank shape, bust shape, hips shape and abdomen shape can reflect the most of the information about the body form, and are also the most important geometric characters of human body model [8,9,10].

The flank part can reflect information which the front part and back part can not reflect. For example, vertical section body form curve can clearly reflect whether the body is prominent bust, bend back or not. Bust and back will influence the length of front centerline and back length, and then result in the changes of patterns.

The breast is the main factor influencing bust shape. Its size, shape and height directly affect breast dart design of the front piece.

The hip part is an important part in the research on the fitting of the lower part. The angle from back waist to back hips is a parameter to design back rise. It can reflect the raise shape of hips, the fuller the hips, the larger the angle, and the thinner the hips, the smaller the angle.

The abdomen part influences the waist dart. It is shown that the abdomen shape plays a more important part in the body form. It is easy to accumulate fat for abdomen, which will cause the change of the front of the lower part [11,12].

Summing up, we get the parameters depicting women's body form as Table 1 shows. And this demonstrates the multi-dimension of human body.

Table 1 Parameters and Description of the Parts

	Parameters	Description
Flank	back bend index, the angle from shoulder blade to back neck, the angle from shoulder blade to back waist, Under bust slope angle, Front neck to breast angle	back bend(C1) medium(C2) bust prominent (C3)
Bust	under bust slope angle, front neck to breast angle, side neck to breast/ breast to waist, bust to bust /bust front, bust width/bust thickness, bust full	flat(R1) medium (R2) full(R3)
Hip	The angle from back waist to back hips, hips full, hips thickness/hips length	flat (T1) medium (T2) full (T3)
Abdomen	the angle of abdomen prominence, waist full, abdomen full, waist length	medium(F1) prominent (F2)

3.2 Body Type Identification Method Based on SVM Algorithm

Because garments enterprises haven't analyzed the target's body form, they always produce "safe" garments, which results that customers can not buy garments fitting their body form. Fully analysis on body form enables people to acquire more information when they are tailoring and transfer sensibility recognition to logos evaluation. This rationalizes the formulation of data. Therefore, if we can simulate and reconstruct the fashion designers' experience and arrange the proportion of every body form by computer, the designers' burden will be lessened. As the SVM is able to approximate the complicated non-linear relation of human body and simulate designers' non-linear experience. In this way, we can determine the system category to be developed and garment production using the results of body form analysis.

In this research, four machines are constituted on the basis of flank shape, bust shape, hips shape and abdomen shape and their optimal structures are acquired. we take the classification of flank shape as an example.

1) Ascertain the collection of training samples: In this experiment, we choose 350 young women age from 18 to 35, average height 160.55cm, average weight 50.5kg and average age 23. Equipment: TC^2 3D body scanner made in American, the revised altimeter and weight scale and so on. First, the 350 young women's bodies are scanned by 3D body scanner. Then, 10 experts score the parts. The data of the 350 individuals' bodies are made as input and the corresponding description as output, so the training sample collection is got.

2) Pre-computing the data: Based on the analysis on human body form character and fully considering the need of garment pattern design, we can use the parameters which in Table 1 as the input of the SVM, they are: back bend index, the angle from shoulder blade to back neck, the angle from shoulder blade to back waist, Under bust slope angle, Front neck to breast angle. 10 experts are asked to give semantic description of the body form and their judgments "back bend ", "medium" and "bust prominent" (the "description" in Table 1) are regarded as output vectors.

The data are normalized in [-1 ,1].The normalization formula is

$$x_i' = 2 \cdot \frac{x_i - \min\{x_i\}}{\max\{x_i\} - \min\{x_i\}} - 1 \tag{9}$$

x_i—— the original data of index variables.

max { x_i }—— the maximum of the same index data.

min { x_i }——the minimum of the same index data.).

3) Constructing the modeling of SVM: In the process of training, there are 5 parameters of input and 3 categories of output in every training sample, which are 1, 2, 3. Accordingly, their goal outputs are [+1,-1,-1], [-1,+1,-1], [-1,-1,+1]. And we make the category corresponding to the maximal output as the category for classifying. Finally, 300 of young women's bodies are regarded as training samples and 50 as testing samples.

4. Conclusions and Future Works

4.1 Conclusions

1) The research in this paper demonstrates the feasibility of SVM applied to body type classification and prediction. It can avoid the partial minimal point and improve the precisions of results. The models have been applied to garment producing and the result shows the models have a good effect on the garment producing.

2) As long as we find out the factors influencing figure characteristic and enough samples to be learned by the network, we can make accurate and applied evaluation on body type, and optimize the index. This is significant to garment enterprises because it provides them with basis to arrange producing garment size reasonably.

3) This paper provides powerful data support to the mapping between body form and garment size and solves one of the key technologies to realize MTM. The body type analysis algorithm in this paper satisfies the need of body type analysis; it will promote the realization of MTM in our country.

4.2 Future Works

First, we can make software to realize the identify methods. Second, more samples are need to make the model have more extensive applications and to reduce errors. Third, we can combine SVM with BP, or study on the parameter setting further.

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