

Comparing SVM with BP to Identify the Young Females' Body Type

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Abstract: Nowadays, from mass production to mass customization has occupying the domain of apparel industry. And new techniques that provide fitting apparel are needed to satisfy individual demands. In the paper, a math arithmetic using SVM(Support Vector Machine) is introduced. Firstly, a new strategy of dependency analysis is proposed. Secondly, the paper compares the approach ability of SVM and BP. Finally, some chosen feature types are used for learning and for creating the modification matrix using SVM and BP. Two model is established to identify body type. The result, which realizes auto-mapping from body data to specific estimation, has increase accuracy highly by using SVM.

Keywords: Match conversion, Pattern conversion, BP, SVM.

1. Introduction

The introduction should provide background information (including relevant references) and should indicate the purpose of the manuscript. Cite relevant work by others, including research outside your company. Place your work in perspective by referring to other research papers. Inclusion of statements at the end of the introduction regarding the organization of the manuscript can be helpful to the reader. By far, customers are longing for customized garments and individualized garments that fit for their body shape and satisfy their aesthetic needs. However, there are limited information about the body shape, most of which are the length and circumference measurements. At the same time, there are few differences in size label. Therefore, who are lack of apparel knowledge, or haven't "standard" body shape, need to spend a lot of time and vigor trying on. The developmental trend of garment industry is fashion and customization, and the require for comfort and high quality makes MTM(Made to Measure) a necessity, which make it possible to apply MTM in garment industry [1]. Fortunately, new manufacturing technologies such as 3D body scanners, CAD/CAM, have begun to play a key role in increasing the effectiveness, flexibility, and precision of production [2].

Body type analysis plays an important role. It is not only one of the key technologies to realize MTM, 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 [3].

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 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.

The rest of the paper organized as follows: Section 2

describes the general structure of the SVM model; Section 3 depicts the BP network model in brief; Section 4 explains the data source and classification, contrast the results between SVM and BP; finally some concluding remarks are drawn from section 5.

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.(Figure 1)[4]

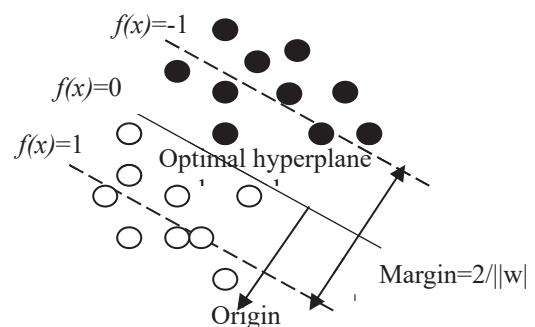


Figure 1. Optimal classifying line under linear classified condition

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

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

$$(x_1, y_1), \dots, (x_l, y_l) \in R^n \times R$$

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 R^n to feature spaces $\Psi(x) = (\varphi(x_1), \varphi(x_2), \dots, \varphi(x_l))$ by a non-linear function $\psi(\bullet)$. Secondly, non-linear estimated function is changed into linear estimated function in hyperplane feature spaces by the most optimal decision function, as follows:

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

Finding w and b is just minimizing R :

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

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

$$w \cdot \varphi(x_i) + b - y_i \leq \varepsilon + \xi_i^*, \xi_i^*, \xi_i \geq 0, i = 1, \dots, l$$

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:

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

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 :

$$w = \sum_{i=1}^l (\alpha_i - \alpha_i^*) \varphi(x_i), \sum_{i=1}^l (\alpha_i - \alpha_i^*) = 0, \quad (3)$$

$$c - \alpha_i - \beta_i = 0, c - \alpha_i^* - \beta_i^* = 0, i = 1, \dots, l$$

Defining the Kernel Function based on Mercer's conditions:

$$k(x_i, x_j) = \varphi(x_i) \cdot \varphi(x_j) \quad (4)$$

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

$$\max W(\alpha, \alpha^*) = -\frac{1}{2} \sum_{i,j=1}^l (\alpha_i - \alpha_i^*) (\alpha_j - \alpha_j^*) K(x_i, x_j) + \quad (5)$$

$$\sum_{i=1}^l (\alpha_i - \alpha_i^*) y_i - \sum_{i=1}^l (\alpha_i - \alpha_i^*) \varepsilon$$

$$s.t. \sum_{i=1}^l (\alpha_i - \alpha_i^*) = 0$$

$$0 \leq \alpha_i \leq c, 0 \leq \alpha_i^* \leq c, i = 1, \dots, l$$

So the final non-linear estimated function is:

$$f(x) = \sum (\alpha_i - \alpha_i^*) K(x_i, x_j) + b \quad (6)$$

2.2. Kernel Function

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

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

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

$$3) \text{Neural Network Kernel Function:}$$

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

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 Figure 2 shows:

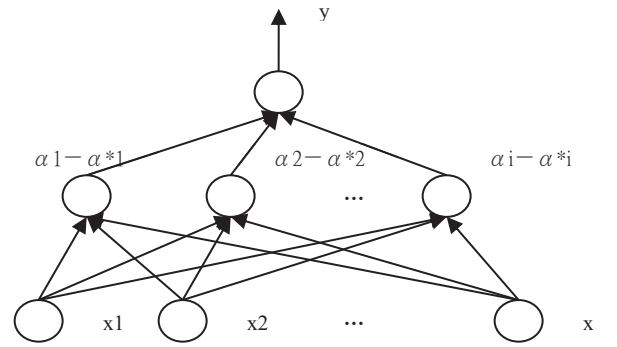


Figure 2. SVM network structure diagram

Where $\alpha_i - \alpha^*_i$ is the weight of network, variable x_1, x_2, \dots, 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 x_1, x_2, \dots, x_l , then output variable y ;
- 3) Constructing the modeling of SVM and predicting the unknown examples.

3. Artificial Neural Network

Artificial neural network BP is made up of forward propagate and back propagation two parts, its structure as Figure 3 shows.

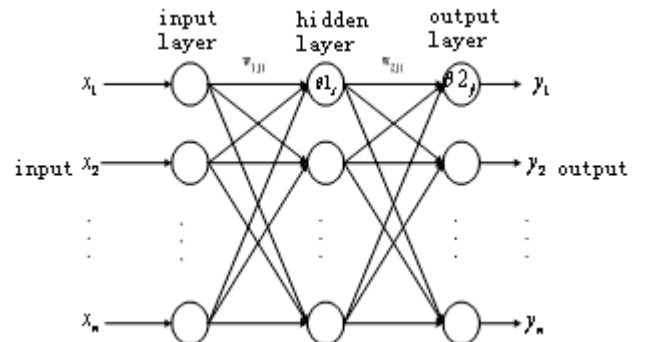


Figure 3. Structure of BP network

The output y can be obtained by the equation:

$$a = f(wp + b) \quad (7)$$

Variable w and b are decided through the produce of training. Otherwise, we use logical sigmoid function as transmitting function:

$$a = sig(x) = \frac{1}{1 + e^{-x}} \quad (8)$$

There is one layer or more layers besides the inputting node in the network, the same layer nodes do not have any coupling. That means the network with deviation and at least one S type imply layer adding one linear output layer can approach any rational function [5], [6].

4. Experiment

4.1. Analysis on Body Characteristic Parts

According to garment pattern design and the experience of fashion designers, there are more than 80 geometric characteristic sizes [7], [8]. 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 [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].

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

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)

4.2. 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 Tab.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 Tab.1) are regarded as output vectors.

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

$$x_i' = 2 \cdot \frac{x_i - \min\{x_i\}}{\max\{x_i\} - \min\{x_i\}} - 1 \quad (9)$$

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.

4.3. Comparing SVM and BP

By testing every parameter, we know when Learning ration (Lr)=0.05, the maximal iterative steps (epochs)=100000, goal precision (goal)=le-2, the error index get to its optimization. Therefore, the model structure of Flank shape is 5:3. This structure refers to there are 5 input parameters, and 3 output data.

According to the above method, there are 350 samples every single part. 300 of them are made as training samples and 50 of them as testing samples. After repeated tests, we select the models whose structures fit the producing in clothing factories most, and the models have been applied to garment producing and the result shows the model works well. The comparison between SVM and BP see Table 2.[12]

Table 2. The comparison between SVM and BP

parts	structure	Success rate in training sample (%)		Success rate in testing sample (%)	
		SVM	BP	SVM	BP
Flank	5: 3	99.1	97.9	98.5	85.7
Bust	6: 3	99.6	97.6	99.3	92.0
Hip	3: 3	99.4	98.7	99.4	92.0
Abdomen	4: 2	99.7	98.2	98.8	91.9

From Table 2 we can see clearly that the average precisions of training sample are above 99% by using SVM algorithm which also indicates fine prediction. It is better than the BP that Former researchers provided. Besides, the following two aspects may cause the errors: First, the 3D body scanner often makes mistakes when looking for the neck back, and the flank shape is reflected by Neck to Waist-Front and Neck to Waist-Back, these cause the input samples incorrect relatively. Second, the training samples are not adequate.

5. Conclusions and Future Works

5.1. Conclusions

1) The research in this paper demonstrates the feasibility of SVM applied to body type classification and prediction. The more important is that the models of SVM take superior over BP. 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.

5.2. 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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