

# Research on the Method of Optimal Estimation of Net Body Size

Chen Chong

*Fashion Institute, Shanghai University of Engineering Science, Shanghai, China*

## **Abstract:**

*The 3D scan technology is fast and accurate, but require the subjects to wear tights or naked measurement. Many people give up for privacy, which affect the popularity of 3D scanner in the world. In this paper, 100 young men aged 18 to 26 years old were taken as samples and 8 young man were taken as verified samples for study, and the size of the net body and the size of the fit clothing were measured using 3d scanning, and the accurate clothing and the size data of the net body were obtained, and then import the model into the 3D measurement system Vitus Smart, get precise size of dressed and net data. Factor analysis was performed the data by SPSS. And then uses Matlab to establish the neural network model, and enter the data of dressed body, you can get precise results. Experimental results reveal that the method can quickly and effectively according to the 3D scan obtained by the body of the data, calculate the net size, the error value can be controlled in 1.5cm.*

**Keywords:** *Component; Optimal estimation; Virtual fitting; Human body mathematical model*

## **I. INTRODUCTION**

Modern consumer pursue independent and individual consumption pattern, so that customization has become a production trend. In order to attract more consumers and get the best benefit, tailored must be more convenient. So 3D body scanning measurement technology has become an important issue in the apparel industry. The 3D scanning measurement system is mainly composed of light source, imaging device, image data storage and processing system. Only a short period of time, you can draw most of the human body data, and high accuracy[1]. However, in order to achieve the required accuracy, 3D scanning measurement often requires the subject to take off the coat, only wearing tight clothing or not wearing clothes at all[2]. Otherwise the measured value may have a greater error. The majority of subjects are not willing to scan the body, which has become an important factor restricting the development and popularization of 3D body scanning. The relationship between the net size and the size of the dressing is taken as the starting point of the study, and it is very practical to forecast the data of the net body based on the related data of the body.

## **II. DATA ACQUISITION**

This paper, uses the Germanic advanced 3D body scanning system, Vitus Smart and its own software Scan WorX to obtain 3D anthropometric data. First step is to measure the size of the human body by manual measurement. Then using virtual clothing software CLO 3D, according to the design of human size, we built virtual mannequins, and for each virtual human model "wear" on their fit shirt. The second is to obtain the virtual model and the model when wearing the shirt and the output of the virtual human form of the net body and the object OBJ file[3], then introduce 3D body scanning system Vitus Smart, get accurate dress and net size data. Last step is to analyze the dimensional data of the dressing body by the software SPSS and factor analysis. Then we use the neural network tool of Matlab to extract the factor as the input, select the net size data as the output, the neural network model of establishment, can be more accurate net size data effect.

In addition, six human volunteers were scanned by Vitus Smart system. They dressed in the same style with the virtual dressing men's shirts for three-dimensional body scan, nearly five groups of body and body size dress data, used to verify whether the neural network model is consistent with the real situation or not.

## **III. OPTIMAL ESTIMATION OF NET SIZE**

### **A. Technology Implementation**

South Korea's CLO 3D software includes a virtual avatar and sample two windows, it can be flexible to achieve the freedom of conversion between two-dimensional and three-dimensional. In the process of design modification, the two window data can be linked in real time. Compared with the traditional graphic design method, the new method is more rapid, convenient and environmentally friendly. In this paper, the CLO 3D plate making and the human body dress data are extracted and applied to the human body fit 3D scanning data model.

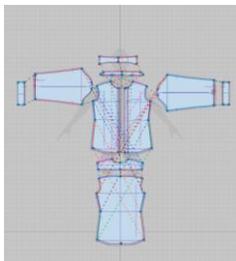
In this paper, we use a non-contact three-dimensional human body laser scanner Vitus Smart measuring instrument. The image obtained by this scanner has high resolution and the error range of measurement accuracy is  $\pm 2\text{mm}$ . It can avoid the error caused by human factors in manual measurement[4]. The method used in Scan WorX is based on the measurement of human body feature points. Compared

with the direct measurement method, Scan WorX method is more independent. The measurement method based on the feature points of the human body will not change because of the change of the measuring object and the measuring rule. Based on the characteristics of the human body measurement method, it is the most suitable for three-dimensional measurement of clothing, and applied to Scan WorX.

### **B. The Establishment of Virtual Human Model**

The research data in this experiment are the 3D scanning data and it comes from the human body model using virtual fitting software to simulate the data. Virtual fitting technology can according to the different human body model shape, modify the clothing directly on a computer size. This technique does not require to using a large number of real shirts. You can get more reliable experimental data. Due to the need to simulate the real use of virtual fitting technology of human dress state[5], must first establish a virtual people all die. Then I prepare all models of the human body to fit the shirt model. In this paper, according to the data of the tailored database, the net body size of 80 virtual human models is designed, and the model of the corresponding shirt is designed. The size of each virtual human model is unique, and the size of each individual model is different, which ensures the integrity of the shirt. In addition, this paper designed 6 groups of human experiments to verify the accuracy and authenticity of the model.

In the human model editor, by adjusting the size of each part of the virtual human model, we design the net body size. We will be each of the design of a good version of the shirt, into the CLO 3D software, the film will be dragged to the appropriate location. Use the virtual stitching tool to sew the pieces together, is shown in Figure 1. Suture after fitting, and check the suture leaks and joint method is correct. To add fabric information to the shirt, the physical property is defined as "cotton", adjusted after the effect shown in Figure 2..



**Figure 1. Suture clothing.**



**Figure 2. Effect of wearing**

In order to the Scan WorX software to recognize and face the screen, the virtual model is exported in OBJ file format. The garment body retains garment and body contour information, and the net body retains only the contour information of the body and

allows the X axis Y axis to be interchanged. Before importing the Scan WorX software, you also need to import the OBJ file into the "Could Compare" software and rotate it to the horizontal flat state. After successful import, Scan WorX automatically calculates the size of each part of virtual mannequin.

In order to be able to identify and face the screen, we set the Scan WorX software export format is OBJ file format. The body retains the clothing and body contour information, the body retains only the body profile information, and allows the X axis Y axis swap. Before the introduction of Scan WorX software, we also need to import the OBJ file into the Could Compare software and become flat state level rotation. After importing successfully, Scan WorX automatically calculates the size of each part of the virtual human model.

## **IV. DATA ANALYSIS AND BUILD THE MODEL**

### **A. Data Preprocessing**

Scan WorX software can get 88 key dimensions and details of the size of the human body. In the experiment, 80 virtual human models were designed to obtain the experimental data of the 80 groups. However, in the 12 virtual human modeling body data, it lacks important size information. For example, I measure the length of the left arm and the left and right wrists circumference, because of the lack of information, so that some data can not be used. The actual experimental data for the 68 groups, each group contains a set of net body size data and a set of body size data. There are 60 groups of virtual human model data set for the neural network training data. The 8 group is the validation data.

The purpose of this paper is to find out the relationship between the net body and the body through the control variable method. The main body size for the upper body, do not consider the change of the lower body. So I did not keep the lower body size. In this paper, the normal human body is taken as the research object. Some parts of a local dimension and information are negligible. There are 44 parts after treatment.

### **B. Data Analysis**

In this paper, factor analysis is used as the method of mathematical data, and the obtained data are analyzed. For neural networks, however, 44 data we input are still too large and must be analyzed to find out which dimensions are correlated with which data, and combine them into a factor. The analysis is as follows:

1. Before doing the factor analysis, KMO and Bartlett's tests are needed to verify that the data are appropriate for factor analysis. The test results of 60 test data are shown in Table 1, the KMO measure is 0.691 close to 0.7, the significance level is 0.000, which is suitable for factor analysis.

**Table 1. Kmo and bartlett's test**

Sampling length Kaiser-Meyer-Olkin .	.691
Bartlett sphericity test	Chi-squared approximations 7623.91
	0
	df 946
	Sig. .000

2. From the "total variance explained", partial screenshots are shown in Figure 3. We can see that when factor analysis divides the information of 60 size parts into 8 components, the characteristic value is 1.074, which is greater than 1, and the variance cumulative rate at this time reaches 86.398 %, more than 85%. This indicates that it is more appropriate to divide the factors into eight groups.

Components	Initial eigenvalues			Extraction sum of squares			Rotation sum of squares		
	Summarize	Percentage of variance	Percentage of accumulation	Summarize	Percentage of variance	Percentage of accumulation	Summarize	Percentage of variance	Percentage of accumulation
1	12.784	29.054	29.054	12.784	29.054	29.054	11.544	26.238	26.238
2	10.319	23.452	52.507	10.319	23.452	52.507	8.897	20.221	46.457
3	4.438	10.087	62.594	4.438	10.087	62.594	4.277	9.721	56.178
4	3.928	8.928	71.522	3.928	8.928	71.522	3.693	8.393	64.571
5	2.712	6.164	77.686	2.712	6.164	77.686	3.278	7.451	72.022
6	1.593	3.621	81.307	1.593	3.621	81.307	2.491	5.662	77.684
7	1.166	2.651	83.958	1.166	2.651	83.958	2.211	5.025	82.709
8	1.074	2.441	86.398	1.074	2.441	86.398	1.624	3.690	86.398
9	.870	1.977	88.376						

**Figure 3. "Total Variance of Interpretation" Partial Screenshots**

### C. Build the Model

I was established the output data[7]. The neck, shoulder, waist, hip circumference, arm length, arm circumference and wrist circumference were selected from 60 groups of three-dimensional human body scans. Established the neural network model. First, the matrix y was used as the input data, the matrix n as the output data, and the samples were set as the matrix rows. Next, the training set, confirmation set, and validation set was set at 80%, 15%, and 5%, respectively. The hidden layer of the neural network model was acquiescent 10 levels. This experiment was done by default.

**Table 2. Validation Sample Error**

NO.	neck	acromion	chest	waist	hip	right arm	right upper arm	Right wrist
Verify the sample 1	1.42	1.04	0.12	0.88	0.68	0.22	0.68	0.04
Verify the sample 2	0.03	0.06	1.53	1.18	1.26	0.63	0.46	0.18
Verify the sample 3	0.62	0.4	0.79	0.37	0.83	0.33	1.28	0.63
Verify the sample 4	1.21	1.56	2.32	0.44	0.25	0.04	0.51	0.42
Verify the sample 5	0.16	0.31	0.46	0.63	1.02	0.2	0.13	0.19
Verify the sample 6	0.2	0.33	1.03	0.09	1.14	0.66	0.75	0.08
Verify the sample 7	1.19	0.18	0.47	1.15	0.32	0.17	0.05	0.51
Verify the sample 8	0.97	0.35	0.36	0.16	0.64	0.57	0.3	0.07
Average error	0.72	0.53	0.88	0.61	0.77	0.35	0.52	0.27

3. The rotation component matrix, which represents the specific situation of the variables contained in each factor. In each row, the variable has the largest number of factors in the list of factors. The maximum size of the 60 parts in each row is indicated by the bold typeface, and the position is the largest value for each component column.

4. The component score matrix is calculated by summing the weights of all 60 parts in each factor so that the size information for each part in each component group can be multiplied by its weight, then all the results. Then, we can get the specific coefficient values of the eight input items of the neural network.

### V. VERIFY THE MODEL

#### A. Virtual Model 3D Scan Data Validation

1. The validation data in the form of a matrix, entered in Matlab, the matrix A, 8 rows and 44 columns matrix.

2. The matrix A is multiplied by the matrix M to obtain a matrix C, which is a matrix of 8 rows and 8 columns.

3. The matrix C is substituted into the neural network to obtain the calculated net body data y0.

4. The net data y1 of the actual three-dimensional scan of the verification data is input into Matlab, and the matrix of 8 rows and 8 columns is obtained, as shown in Table 2.

As can be seen from the results in Table 2, the net body size data predicted by the neural network model is generally small in error. The total average error is less than 1 cm. The reason of the abnormal value appears may be that the number of samples is not enough, and the neural network model is still inadequate in some aspects. Because of training the neural network model, the number of samples needs to reach a certain amount to be able to train the model. When the number of samples is sufficient, the result of the model can be relatively accurate. If we want to correct the deficiencies of the existing neural network, we must correct the model by obtaining a large number of samples in succession.

**B. Live 3D Scan Data Validation**

1. The 6 groups of real people dress data b input Matlab, b 6 rows and 44 columns of the matrix.

2. Get the real dress data input y3,  $y_3 = b * m$ .

3. Substituting y3 into the neural network, the predictive value matrix of the net body size of the neural network y4 is obtained. In Matlab, the real body dimensional data y5 of the three-dimensional scan of the human body is input.

4. The error y5-y4 is obtained, as shown in Figure 5.

Compare the average error of Table 2 with the figure can be found. The error of the model in predicting the net body size of the live sample is greater than the error of the net body size prediction of the phantom. This phenomenon may be due to virtual fitting technology and dress caused. Although the virtual dressing technology can more accurately simulate the state of human clothing, but there are still some differences with the real situation. When experimental conditions permit, a large amount of live-body data and net-body data needs to be collected to make the model more accurate for predicting the size of a net body in a real-life state

**Table 3. Man Sample Error**

NO.	neck	acromion	chest	waist	hip	right arm	right upper arm	Right wrist
Actual 1	0.52	0.04	1.11	1.22	1.32	1.79	1.17	1.54
Actual 2	0.62	1.43	1.10	1.27	1.29	0.79	1.93	1.02
Actual 3	0.39	1.46	2.28	1.41	1.34	0.54	1.05	1.93
Actual 4	1.34	0.49	0.35	1.16	1.78	1.35	1.54	1.80
Actual 5	1.09	1.09	0.80	1.44	1.90	0.25	1.29	0.76
Actual 6	1.59	1.78	1.03	1.34	1.93	0.90	0.44	1.33
average error	0.92	1.05	1.11	1.31	1.59	0.94	1.24	1.40

**VI. CONCLUSIONS**

In this paper, we start from the relationship between the net body and the dress body, was studied by using advanced virtual fitting technology and 3D body scanning system. We use CLO software 3D to establish virtual fitting model, simulation of men wearing the fit shirt. Using the 3D body measurement system Vitus

Smart system, calculated the shirt and no shirt size data, using the SPSS of 3D body data obtained by factor analysis, the factor analysis results as an important parameter to establish and validate the final use of MatLab neural network.

Now in the garment industry to study and use of computer technology, 3D body measurement technology and virtual technology is one of the more advanced technology. They are out of contact with the human body, can give people the desired data and results. They are one of the technical support for the future development of intelligent clothing. In this paper, these two techniques are combined with the data analysis method, and the model which can be used to predict the net body size data is successfully developed. The research on the relationship between the body and the body is less, and it is a new research topic. Although my model is still not perfect, but it provides a way to study the net body and body. This paper begins from the relationship between the net body and the dress body, was studied by using advanced virtual fitting technology and 3D body scanning system, the input data size by virtue of dress will be able to predict Net - net size dress model.

**REFERENCES**

- [1] Zhou Zhu. Research on 3D human body information acquisition and virtual clothing try technology [D]. Huazhong University of Science and Technology, 2004.
- [2] Lizhen Chen. Research and implementation of 3D garment modeling technology[D].Wuhan Textile University ,2013.
- [3] Liqian Dong . Research on the application of CLO3D technology in the rapid structural design of clothing[J]. Journal of Zhejiang Textile and Fashion College,2014,02:26-30.
- [4] Shuhua Mu,Wei qun Cao. Virtual garment design based on CLO3D[J]. Electronic Science and technology,2015, 03:366-371.
- [5] Hong Liu. Study on the pressure comfort of elastic sports vest[D].Jiangnan University,2012
- [6] Yan Zhen, Xin Zhang. Application evaluation of Tec math 3D body scanning system[C]. 2005 Seminar on the development of modern apparel textile technology, BeiJing: 2005, 28-30.
- [7] Cmenzind ma , Daledj , Rossirm . Manikintest for flame engulfment evaluation of protective clothing: historical review and development of a new ISO standard[J].Fire and Materials,2007,31(5): 285-295.
- [8] CUI Fangfang, ZHANG Xin, WANG Lingshan. Study of the relationship between jacket-business wear fitness and fabric drape[C].Textile Bioengineering and Informatics Symposium Proceedings. 2010