

# Analysis of Yong Men’s Neck Morphology Classification based on 3D body measurement

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**Abstract.** Human’s body shape classification is the basis apparel digital processing and manufacturing. Human neck’s morphology is a critical factor that influences the fitness and comfort of apparel’s collar. In this paper, 300 young men, aged from 20 to 25, are measured by means of the 3D Interactive Body Scanning Instrument (TecMath).The Statistic data of the measurements are processed and analyzed, and according to the characteristic indexes, the male neck morphology is subdivided into 9 types. This result will provide technological parameter for designing the apparel’s collar and made-to-measure (MTM) apparels.

## Introduction

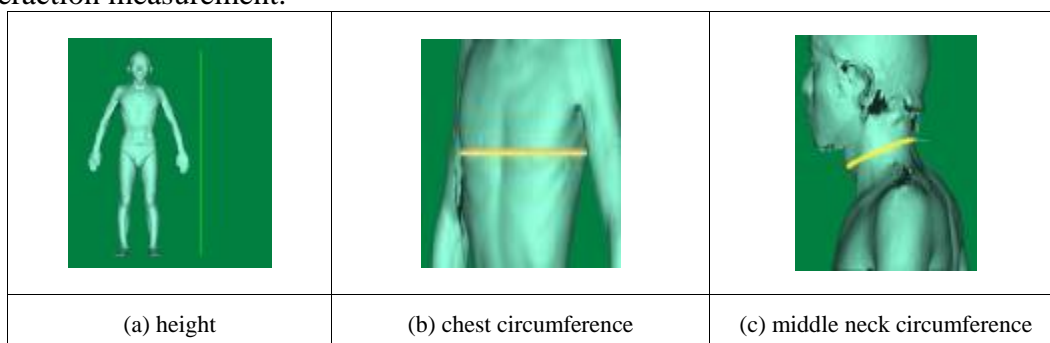
The apparel industrial production has begun to change to digital production mode with the rapid development of information technology and computer science. The appearance of high quality, personalized clothing consumption mode has promoted the development of industrialized MTM (made-to-measure), the quick achievement of the production mode requires enough sectionalization of human specifications data base, then matches with pattern database [1]. While the segment of human neck is one of the very important parts of human body segments, it can provides technological parameter for collar design, at the same time it also can provide reasonable theoretical basis for garment industrial production[2].

## Experiment on anthropometric measurement of 3D

**Experiment equipment.**This experiment utilizes non-touched 3D human body laser scanner made by German TecMath Corporation to carry on human body data acquisition, this scanner can scan the 2.1m high region in 8~10 seconds, the resolution may reach 5mm, measuring accuracy for  $\pm 2$ mm.

**Experiment scope.** The survey scope is 300 aged from 20 ~25 years old male university students.

**The establishment of body measurement Project.** Referring to the correlative measurements of collar pattern design, this research withdraws data of 10 measurements (2 human bodies foundation measurement: height and chest circumference; 8 neck related detail sizes), the detail items can be seen in Fig.1. The positions demonstrated in Chart (a) to chart (d) are the sizes that scanner system reports, the positions from chart (e) to chart (i) are obtained by the three dimensional digitized human body interaction measurement.



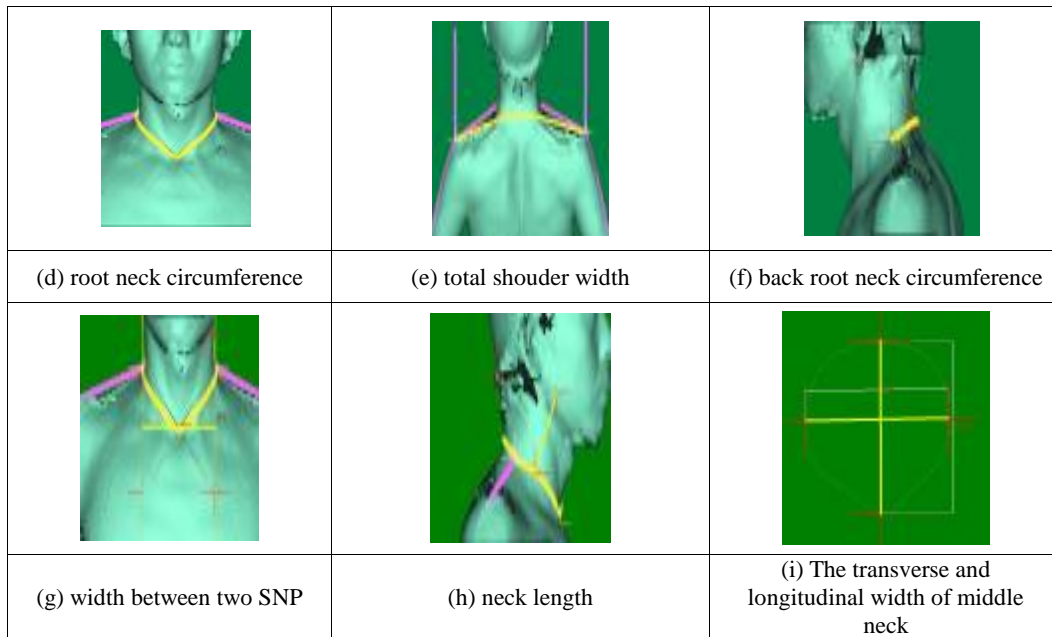


Figure 1 Digital human measured positions.

### Characteristic indices extraction

**Cluster Analysis.** Cluster analysis is also called group analysis. It is a common mathematical method which studies on how to make reasonable classification to objective things [3].

There are many items can reflect body neck's characteristics, and in order to find out the representative items which can reflect body neck's most important characteristics from so many items, and enable them to serve to apparel MTM, it's necessary to carry on cluster analysis to these measured items. This research uses SPSS statistics software R type clustering to the variables.

Table 1 shows variables cluster Agglomeration Schedule; we can see from table 1 the process of the items cluster. Firstly, item 5 merges with item 10, their correlation coefficient is 0.812; Secondly, item 2 merges with item 4, their correlation coefficient is 0.759;.....Seventhly, the merged item which contain with item 4 merges with the merged item which contain with item 5, their correlation coefficient is  $0.385 < 0.5$ , so we consider the first 6 merging steps are effective.

After clustering, 8 variables (not include height and chest circumference) in this research are divided into 3 categories. First category: root neck circumference, mid neck circumference, width between two SNP, The transverse and longitudinal width of middle neck. Second category: total shoulder width, small shoulder width. Third category: neck length.

Table 1 Cluster Agglomeration Schedule

stage	Cluster combined		coefficients	Stage Cluster First Appears		
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	Next Stage
1	5	10	0.812	0	0	3
2	2	4	0.759	0	0	4
3	3	5	0.700	0	1	6
4	1	2	0.607	2	0	6
5	6	7	0.579	0	0	7
6	1	3	0.520	4	3	7
7	1	6	0.358	5	6	8
8	1	8	0.131	7	0	9
9	1	9	-0.292	8	0	0

### Characteristic indices extraction.

**The extraction of the basic parts of young guy's neck.** Fully considering, we take national standard which takes three basic positions for the classification of the human body into account, and finally concluded that two basic parts are selected for human neck is feasible. Select which two basic measurements? We have to comply with the following principles.

- A. Matching the objective laws of body neck's shape transformation and actual experience of clothing production and conditions.
- B. To meet the needs of the people; making as many people as possible found in the classification of the neck similar type; keeping other major measurements of the body neck derived from the basic measurements in the scope of permissible error.
- C. As closes as possible with the national standards.
- D. Selecting with scientific methods.

Under the guidance of the above principles, and combining with the distribution of statistical selection theory, we conclude that in order to accurately reflect changes in the human neck, the basic measurements of the neck with the biggest change should be selected. That is selecting the measurements which have the largest standard deviation expressed by statistical language. After analysis, the "root neck circumference" and the "middle neck circumference" get the largest standard deviations, so we choose these two measurements as the basic measurements of neck. And the basic parts are undoubtedly the characteristic parts also [4].

**The extraction of other characteristics indices of young guy's neck.** From cluster analysis, it's necessary to choose one or more important items as characteristic indices from each category. There are two basic ways for choosing the indices, (1) choose the indices which are easier to obtain. (2) if hard to choose, we have to according to the formula based on statistics:

$$\bar{R}^2_j = (\sum r^2) / (m_j - 1) \quad (1)$$

In this formula  $r$  is the correlation coefficient between item  $x_j$  and other similar item,  $m_j$  is the items number of the category which item  $x_j$  in, and we have to find out which characteristic index has the biggest  $\bar{R}^2$  [5].

Take Pearson correlation analysis. Take the first category for example, we carry on correlation analysis to the items in first category, and get the correlation matrix table, Table 2 shows Pearson correlation coefficients inspection results with two-tailed, and effective participation amount  $N$ .

Calculate correlation coefficients between each designated item and all other items in this category, then calculate the average value of these correlation coefficients.

$$\begin{aligned} \bar{R}^2_{\text{root neck circumference}} &= \\ & (0.7672 + 0.6572 + 0.6482 + 0.5872 + 0.7472) / 5 = 0.469 \end{aligned}$$

$$\begin{aligned} \bar{R}^2_{\text{back root neck circumference}} &= \\ & (0.7472 + 0.5992 + 0.6282 + 0.5372 + 0.7122) / 5 = 0.421 \end{aligned}$$

$$\begin{aligned} \bar{R}^2_{\text{mid-neck horizontal width}} &= \\ & (0.6572 + 0.6822 + 0.4872 + 0.6732 + 0.6282) / 5 = 0.396 \end{aligned}$$

$$\begin{aligned} \bar{R}^2_{\text{mid neck circumference}} &= \\ & (0.7672 + 0.6822 + 0.5192 + 0.4682 + 0.5992) / 5 = 0.308 \end{aligned}$$

$$\begin{aligned} \bar{R}^2_{\text{mid-neck vertical width}} &= \\ & (0.6482 + 0.5192 + 0.4872 + 0.3402 + 0.5372) / 5 = 0.267 \end{aligned}$$

$$\begin{aligned} \bar{R}^2_{\text{width between two SNP}} &= \\ & (0.5872 + 0.4682 + 0.6732 + 0.3402 + 0.7122) / 5 = 0.328 \end{aligned}$$

Compare six average values in this group,  $\bar{R}^2_{\text{root neck circumference}} = 0.469$ , it's the biggest value in this category, so we choose root neck circumference as the characteristic index of body neck.

Apply the same analysis method to the other categories if the items are more than one, finally we obtain 3 characteristic indices of body neck. They are: root neck circumference, total shoulder width and neck length. Comprehensively consider the basic parts and the characteristics parts of human neck and the use in apparel industry, we finally have 3 characteristic indices, they are: root neck circumference, middle neck circumference, and neck length.

**Table 2 Pearson correlation analysis**

		root neck circumference	mid neck circumference	mid-neck horizontal width	mid-nec k vertical width	width between two SNP	back root neck circumference
root neck circumference	Pearson	1	0.76	0.65	0.64	0.58	0.74
	Correlation	.	0.00	0.00	0.00	0.00	0.00
	Sig.(2-tailed)						
	N	300	300	300	300	300	300
mid neck circumference	Pearson	0.76	1	0.68	0.51	0.46	0.59
	Correlation	0.00	.	0.00	0.00	0.00	0.00
	Sig.(2-tailed)						
	N	300	300	300	300	300	300
mid-neck horizontal width	Pearson	.065	0.68	1	0.48	0.67	0.62
	Correlation	0.00	0.00	.	0.00	0.00	0.00
	Sig.(2-tailed)						
	N	300	300	300	300	300	300
mid-neck vertical width	Pearson	0.64	0.51	0.48	1	0.34	0.53
	Correlation	0.00	0.00	0.00	.	0.00	0.00
	Sig.(2-tailed)						
	N	300	300	300	300	300	300
width between two SNP	Pearson	0.58	0.46	0.67	0.34	1	0.71
	Correlation	0.00	0.00	0.00	0.00	.	0.00
	Sig.(2-tailed)						
	N	300	300	300	300	300	300
back root neck circumference	Pearson	0.74	0.59	0.62	0.53	0.71	1
	Correlation	0.00	0.00	0.00	0.00	0.00	.
	Sig.(2-tailed)						
	N	300	300	300	300	300	300

**Neck morphology classification.** Considering the extracted characteristic indices, root neck circumference and neck length are main reference dimensions in fashion design, and also are main variables reflecting the stereo morphology of human body neck.

This research uses the Quick sample clustering method through SPSS statistical software, Quick sample clustering is also called system clustering, the advantage of quick sample clustering is it can be applied to cluster large samples, and it can quickly assign various types of variables to different clusters. This research uses quick sample clustering method, and takes clustering analysis on middle neck circumference, then according to the production of clothing collar and practical classification purposes, and taking into account the relevant national researches about body types, finally, the result of 3 types after clustering is more satisfactory, which we consider will match the new National Standard well.

By comparison, the result of dividing root neck circumference and neck length into 3 categories is more suitable. Considering both factors the root neck circumference and neck length comprehensively, and also considering the visual factors, we can through an absolute numerical size of root neck circumference and a relative value neck length / root neck circumference to judge the type of neck.

The analysis results show, young men's neck can be subdivided into 9 categories namely: thin short type (A1), thin and medium (A2), slender type (A3), medium and short type (B1), moderate type (B2), medium long type(B3), thick and short type (C1), thick and medium type(C2),thick long type(C3)

Figure 2 shows the neck subdivision graph, in the graph abscissa (root neck circumference) indicates the neck's thickness degree, and the ordinate (neck length / neck root circumference) indicates neck's length degree. Table 4 shows the proportion of tested population in different neck type.

Table 3 the proportion of tested population in different neck type

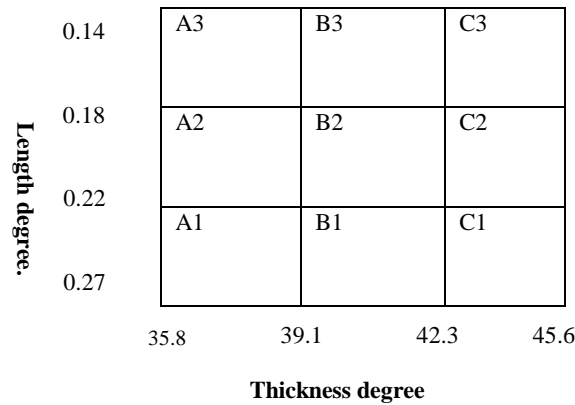


Figure2 Neck subdivision graph

Table 4 The proportion of tested population in different neck type

Neck type	A1	A2	A3	B1	B2	B3	C1	C2	C3
number of people	7	21	13	32	71	19	12	16	9
proportion	3.5%	10.5%	6.5%	18.5	35.5%	9.5%	6%	8%	4.5%

## Conclusion

Classification of body shape is the foundation for realization of clothing MTM, garment size making, apparel CAD / CAM and other basic research. Neck's classification results have positive reference value for reflecting the target body model of the human, clothing modeling, the collar shape design, pattern design and research, improving garment fitness and comfort.

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