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Extracting the Size from the Sizing System Table of the Humanbody Measurements

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Abstract: The paper presents the research's results in extracting the size from the sizing system table of the human body measurements, which has got 24 sizes with 5 kinds of different inside legs from the sample has got 542 men who are living in Southern Vietnam and from 18 to 25 years old. The Principal Component Analysis to choose of the best primary dimensions to design the target function with force conditions and edge conditions. This target function is the function of multiple linear regression models. The mathematical model with input are variables of primary dimensions that are the inside leg measurement and the neck size measurements, these variables values have in the sizing system table. The result is the size need. This model support to look for sizes in the shortest time. Extracting sizes are very useful in the manufacture of garments and business clothing by online, face to face. It will reduce the time to choose the size for fitting body measurements.

Index Terms: Sizing System, Primary Dimension, Extracting Size, Inside Leg, Neck Size.

I. INTRODUCTION

With the industrial rhythm and the standard of living, people have advanced, most people want to wear nice clothes. They will choose to buy at shop or order online to wear or give to relatives without having to measure new and have got it in a short time. However, these clothes will ensure to fit the body size. All most researchers related body dimensions to round up anthropometric measurements, primary dimensions in the clothing for children, women, such as standards [1],[2],[3],[4], [5]. Beside that, having got rules for body size designation such as standards, studies [6],[7],[8],[9],[10],[11],[12],[13],[14]. In the research[15], Ngoc Anh and Loan designed product's sizing system table on the basis of Vietnamese' anthropometric measurements from 18 to 55 years old by 3D body scanning. Another one[16], authors established sizing system for 7800 students from 6 to 18 years old, which divided two age group to analysis body shapes, which a body figure has one size chart for itself. The study on[17], authors developed a size chart for women, which the size chart has 11 sizes with primary dimensions are bust girth and waist girth. Measurement's problems in body shapes were presented in standards[18],[19] have got height dimensions for it. Otherside, choosing to optimal quantity sizes have got subjects[20],[21]. The research relative size labels have the study[22], which proposed a way to write size labels. General, studies rounded up standards methods of body measurements, looking for primary dimensions, made sizing system for men, women, and children with different age groups. Studies used method of the cross statistic, principal component analysis to choose primary dimensions and direct measurement method, indirect measurement method. Primary dimensions for men' upper garments are chest girth and waist girth. Primary dimensions for men' undergarments are height and waist girth. In the sizing system, one table has many sizes but not any studies made extracting sizes.

Aim study is introduced in this paper are made the mathematical model of extracting sizes which will reduce time to look for a fit size with body measurements. These study contents include coding of the sizing system table, looking for primary dimensions that have got high correlative to design two variables linear regression function[23], these two variables have must value in a range of the coding sizing system table. Furthermore, this model makes edge conditions, force conditions for variables and design a target function to find the fitting size. The odd number of results is a rounded integer that is the numerical order of body sizing system table which is coded from the number one to number twenty-four. Next, looking up at the table to havea suitable size.

II. MATERIALS AND METHODS

A. Methodology

The principal component analysis method uses this research to look for primary dimensions.

Analyzing of measurements will look for factors having the influence to develop sizing system table.

The linear regression model to build correlation functions.

On the base of the primary dimensions will make the first linear regression model having two variables. One variable is the primary dimensions of horizontal measurements. Another is the primary dimensions of vertical measurements. In this research, dependence variables have a correlation between independent variables and Sig's values under 0.05, so this linear regression model has meaning.

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Besides that, this model will use to extract sizes from the sizing system table but variables are chosen to put into the second model will be different from variables of the first model.

B. Softwares

There is four software to use for this research: MS. Word 97, MS. Excel 97, SPSS 4.2, Matlab R14[a].

C. Primary Dimensions Use to Establish the Linear Regression Program

In the size have many different dimensions such as waist girth, neck size, hip girth etc. So we need multiple variables linear regression model. Variables choose following of the principal component analysis from the coding sizing table and have the high coefficient correlation.

III. RESULTS AND DISCUSSION

A. Results of the Choosing Sample

Because this research's age group has two different body's development stages. Group 1, a primary dimension is height body and group 2 weigh body. Choosing percent of the reliability is 99%. The total sample of this study is 542 people. Designing for sizing system table will take 530 because of removing 1% sample of the waist making more concentrated measurements.

B. Results Principal Component Analysis for 530 Samples from Percentile 1% of the Waist Girth

There are 4 principal components. Among them, waist girth has hight index 0.905 for the first principal component, inside leg has index 0.789 that is top in the second principal component, scye depth' index is 0.844 that is represented for the third principal component and body rise has got index 0.807 that is the fourth principal component. All things show measurements data that is absolutely reasonable.

C. Determination of Optimal Sizes

Results calculate reply requires for clothing, which doesn't require about level ease according to the waist measurement and inside leg measurement has 28 sizes. They service 100% population, every size represents more than 2% population survey. Results have got 6 groups A, B, C, D, E, F. However, choosing a number of optimal sizes then shape F is failing because it has scale response lowly. Therefore, sizing system table has got 24 sizes with 5 shapes: A, B, C, D, E. Minimize size has got waist measurement that is 62cm and max size is 92cm and dividing optimal size by percentile 1% responses 97.7% population. Results establishing functions linear regression to determine secondary dimensions following 2 primary dimensions of the waist measurement and the inside leg measurement for the male from 18-25 years old (Table 1). In this table, X_1 is the waist girth measurement and X_2 is the sign of the inside leg measurement.

Table 1. Function Measurement's Linear Regression Model.

	Body's mean measurement	Correlation function
Height	169.05	$Z = 0.146 \times X_1 + 0.540 \times X_2 + 117.178$
Weight	60.69	$Z = 0.869 \times X_1 + 0.325 \times X_2 - 28.037$
Neck size	40.21	$Z = 0.156 \times X_1 + 0.104 \times X_2 + 20.825$
Chest girth	86.29	$Z = 0.673 \times X_1 - 0.034 \times X_2 + 39.324$
Top hip girth	77.09	$Z = 1.001 \times X_1 - 0.015 \times X_2 + 4.589$
Seat	91.74	$Z = 0.659 \times X_1 + 0.024 \times X_2 + 41.412$
Back neck to waist	41.12	$Z = 0.117 \times X_1 + 0.180 \times X_2 + 18.772$
Scye depth	21.25	$Z = 0.086 \times X_1 + 0.063 \times X_2 + 10.089$
Haft back	19.95	$Z = 0.083 \times X_1 + 0.060 \times X_2 + 9.255$
One piece sleeve	59.29	$Z = 0.144 \times X_1 + 0.325 \times X_2 + 23.902$
Two piece sleeve	75.24	$Z = 0.072 \times X_1 + 0.442 \times X_2 + 36.276$
Cuff size	16.51	$Z = 0.077 \times X_1 + 0.088 \times X_2 + 4.130$
Body rise	26.51	$Z = 0.112 \times X_1 + 0.015 \times X_2 + 17.170$

D. The Result of the Coding Sizing System Table

Sizing system table, each size has got more 4% with the interval is 6cm. Size information includes waist/inside leg, numerical order of the sizing system table. The waist measurement is itself and the inside leg looks up the size chart that is A, B, C, D, E. Example 65/A1 (waist: 65cm, group: A is the numerical order: 1). Coding sizing system table will be added two information columns that are coding size column and inside leg's measurement column. Coding size column will be numbered from 1-24 (Table 2; Table 3; Table 4; Table 5; Table 6). Inside leg's measurement is coded following of the group, group A is 65cm, group B is 70cm, group C is 75cm, group D is 80cm and group E is 85cm. In this table, every group has the range of the inside leg is different. This range is the standard deviation of the inside leg.

Table 2. Coding Sizing System Table of Groups A.

Group	A: Inside leg [62.5-67.5)			
Size chart	65/A1	71/A2	77/A3	83/A4
Coding size	1	2	3	4
Neck size	37.73	38.66	39.6	40.53
Chest	80.86	84.9	88.94	92.97

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Top hip girth	68.68	74.69	80.69	86.7
Seat	85.81	89.76	93.72	97.67
Back neck to waist	38.08	38.78	39.48	40.18
Scye depth	19.77	20.29	20.81	21.32
Half back	18.55	19.05	19.55	20.04
One piece sleeve	54.39	55.25	56.12	56.98
Two-piece sleeve	69.69	70.12	70.55	70.98
Cuff size	14.86	15.32	15.78	16.24
Inside Leg	65	65	65	65
Body rise	25.43	26.1	26.77	27.44

Table 3. Coding Sizing System Table of Groups B.

Group	B: Inside leg [67.5-72.5]				
Size chart	65/B5	71/B6	77/B7	83/B8	89/B9
Coding size	5	6	7	8	9
Neck size	38.25	39.18	40.12	41.05	41.99
Chest	80.69	84.73	88.77	92.8	96.84
Top hip girth	68.6	74.61	80.62	86.62	92.63
Seat	85.93	89.88	93.84	97.79	101.7
Back neck to waist	38.98	39.68	40.38	41.08	41.79
Scye depth	20.09	20.61	21.12	21.64	22.15
Half back	18.85	19.35	19.85	20.34	20.84
One piece sleeve	56.01	56.88	57.74	58.6	59.47
Two-piece sleeve	71.9	72.33	72.76	73.19	73.62
Cuff size	15.3	15.76	16.22	16.68	17.14
Inside Leg	70	70	70	70	70
Body rise	25.5	26.17	26.84	27.52	28.19

Table 4. Coding Sizing System Table of Groups C.

Group	C: Inside leg [72.5-77.5]				
Size chart	65/C10	71/C11	77/C12	83/C13	89/C14
Coding size	10	11	12	13	14
Neck size	38.77	39.7	40.64	41.57	42.51
Chest	80.52	84.56	88.6	92.63	96.67
Top hip girth	68.53	74.54	80.54	86.55	92.55
Seat	86.06	90	93.96	97.91	101.86
Back neck to waist	39.88	40.58	41.28	41.98	42.69
Scye depth	20.4	20.92	21.44	21.95	22.47
Half back	19.15	19.65	20.15	20.64	21.14
One piece sleeve	57.64	58.5	59.37	60.23	61.09
Two-piece sleeve	74.11	74.54	74.97	75.4	75.83
Cuff size	15.74	16.2	16.66	17.12	17.58
Inside Leg	75	75	75	75	75
Body rise	25.58	26.25	26.92	27.59	28.26

Table 5. Coding Sizing System Table of Groups D.

Group	D: Inside leg [77.5-82.5]				
Size chart	65/D15	71/D16	77/D17	83/D18	89/D19
Coding size	15	16	17	18	19
Neck size	39.29	40.22	41.16	42.09	43.03
Chest	80.35	84.39	88.43	92.46	96.50
Top hip girth	68.45	74.46	80.47	86.47	92.48
Seat	86.17	90.12	94.08	98.03	101.98
Back neck to waist	40.78	41.48	42.18	42.88	43.59
Scye depth	20.72	21.24	21.75	22.27	22.78
Half back	19.45	19.95	20.45	20.94	21.44
One piece sleeve	59.26	6013	60.99	61.85	62.72
Two-piece sleeve	76.32	76.75	77.18	77.61	78.04
Cuff size	16.18	16.64	17.1	17.56	18.02
Inside Leg	80	80	80	80	80
Body rise	25.65	26.32	26.99	27.67	28.34

Table 6. Coding Sizing System Table of the Group E.

Group	E: Inside leg [82.5-85]				
Size chart	65/E20	71/E21	77/E22	83/E23	89/E24
Coding size	20	21	22	23	24
Neck size	39.81	40.74	41.68	42.61	43.55
Chest	80.18	84.22	88.26	92.29	96.33
Top hip girth	68.38	74.39	80.39	86.4	92.40
Seat	86.29	90.24	94.2	98.15	102.10
Back neck to waist	41.68	42.38	43.08	43.78	44.49
Scye depth	21.03	21.55	22.07	22.58	23.10
Half back	19.75	20.25	20.75	21.24	21.74

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One piece sleeve	60.89	61.75	62.62	63.48	64.34
Two-piece sleeve	78.53	78.96	79.39	79.82	80.25
Cuff size	16.62	17.08	17.54	18	18.46
Inside leg	85	85	85	85	85
Body rise	25.73	26.4	27.07	27.74	28.41

E. Results of Choosing Primary Dimensions

Through results of the table principal component analysis present having two components have greater individual value 1 and cumulative value is 92.262%.

This result has got two principal components of measurements and is the basis to choose primary measurements. Results of table 7 about component analysis show the correlation between variables or correlation in the variables matrix. The first principal component has 9 components having value over 0.8. The second principal component has 3 components having value over 0.8. Table 8 shows the values of the linear regression' analysis. There are 7 components having meaning statistic (Sig <0.05). From these 7 components will analyze multiple variable linear regression to find suitable values. This analyzes results have 2 variables that have the correlation coefficient with sizes and having the meaning statistic that is neck size and inside leg showing in table 9. Besides that, table 8 shows these variables having Sig's value upper 0.05, so they will be not correlated together with. One variable represents dimensions of the upper body and represents horizontal primary dimensions. Another will represents dimensions of the underbody and represents vertical dimensions. Through this analysis are sure that choosing neck size and inside leg variables to design two variables linear regression model to choose the size is the perfect fit.

Table 7. Loading Explanations Results of the Principal Component Analysis.

Component Matrix		
	Component	
	1	2
Neck size	1.000	.003
Halfback	.999	.035
Scye depth	.999	.040
Cuff size	.972	.233
Back neck to waist	.933	.358
Body rise	.931	-.360
Seat	.899	-.432
Top hip girth	.880	-.470
Chest	.865	-.495
Inside Leg	.543	.831
Two-piece sleeve	.691	.716
One piece sleeve	-.056	.340
Extraction Method: Principal Component Analysis.		
a. 2 components extracted.		

Table 8. Correlation Coefficient and Meaning Statistic.

	R	R2	Sig
Neck size	0.697	0.486	0.000
Half back	0.720	0.519	0.000
Scye depth	0.724	0.524	0.000
Cuff size	0845	0.713	0.000
Back neck to waist	0.908	0.824	0.000
Body rise	0.386	0.149	0.062
Seat	0.312	0.097	0.138
Top hip girth	0.271	0.074	0.200
chest	0.243	0.059	0.253
Inside Leg	0.980	0.960	0.000
Two-piece sleeve	0.999	0.998	0.000
One piece sleeve	0.108	0.012	0.617

Table 9. Correlational Coefficient between Neck Size and Inside Leg.

Model Summary									
Model	R	R Square	Adjusted R Square	Std. An error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.999[a]	.998	.998	.29295	.998	6689.437	2	21	.000
a. Predictors: (Constant),Inside leg, Neck size									

Table 10. Correlations of Neck Size and Inside Leg.

Correlations			
		neck size	inside leg
neck size	Pearson Correlation	1	.545**
	Sig. (2-tailed)		.006
	N	24	24
Inside leg	Pearson Correlation	.545**	1
	Sig. (2-tailed)	.006	
	N	24	24
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 11. ANOVA Analysis.

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1148.198	2	574.099	6689.437	.000[b]
	Residual	1.802	21	.086		
	Total	1150.000	23			
a. Dependent Variable: coding size						
b. Predictors: (Constant).Inside leg. neck size						

Table 12. Values of the Linear Regression Analysis.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-94.540	1.603		-58.974	.000

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	Neck size	1.048	.046	.232	22.553	.000
	Inside Leg	.855	.010	.853	82.833	.000
a. Dependent Variable: coding size						

F. The Mathematical Model

In the mathematical model (Fig.1) has the input, output, function and edge conditions and force conditions. Input is neck size's and inside leg's measurements. Edge conditions are a value of the neck size measurement ranging in tables 2. 3. 4. 5. 6, and values are made the positive integer. Force is inside leg's measurement swill convert to follow measurement in table 10. The output is the size needing to look for. Target function in this study is written by two variables linear regression with the result is made a positive integer and looking for tables to have needing size.

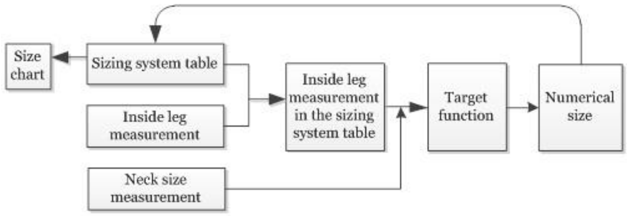

Fig.1. The Mathematical Model to Choose the Size.

G. Target Function

From table 11,Sig is 0.000 < 0.005 so linear regression which is fit total. Residual of the sum of squares is 1.802 and mean square is 0.086 which show relative between two variables with size is large. From analysis of table 12, target function is $Z = -94.540 + 1.048 \times X_1 + 0.855 \times X_2 + 0.086$. The first variable is the neck size variable ($X_1 = X_{neck\ size}$).The second variable is the inside leg measurement ($X_2 = X_{inside\ leg}$). Regression coefficients of X_1. X_2 have got results of measurements analysis in table 2. 3. 4. 5. 6.

H. Force Conditions Andedge Conditions

Force conditions show limit accepting two variables'. Every variable has ranged from minimizing to maximizing in tables 2. 3. 4. 5. 6.

$X_2 = 65 \cup 70 \cup 75 \cup 80 \cup 85$;

$36.95 \le X1 \le 44.29$;

$62.5 \le X_2 \le 87.5$

$1 \le Z \le 24$

I. Program of the Extracting Sizes by Matlab Software

There is differential calculus to declare X_1 variable by Matlab software. This variable will input real measurement into the function (Fig.2). However, nothing look up table to look for fit value, which is program will practice. After inputting two variables' value, the program shows sizes. When running the program, results are the size chart. This is optimal in the technical extracting sizes in the software. This technique is different from extracting sizes by common calculation, which doesn't need to look up the sizing system table to look for the size chart through the coding size. Examples check results in table 2. Fig.3(a) is an example of the result to look for fit size when input variables of table 2. The result shows the size 65/A1. Testing again, it true with numerical in the sizing system table such as Fig.3(b) is the result to look for fit size when input variables following real values. The result shows the size 77/C12. Comparison it with sizes chart in table 2 showing it is completely suitable. Fig.3(c) is the result to look for fit size when input variables following real values. Among them, one variable of the neck size measurement is outside of the edge conditions, so program shows the error in the result. Fig.3(d) similar to Fig.3(c) that is inside leg measurement is outside of the edge conditions, so it hasn'tany size.

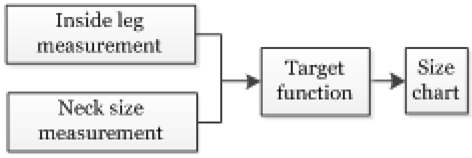

Fig. 2. The Mathematical Model to Choose the Size in the Software.

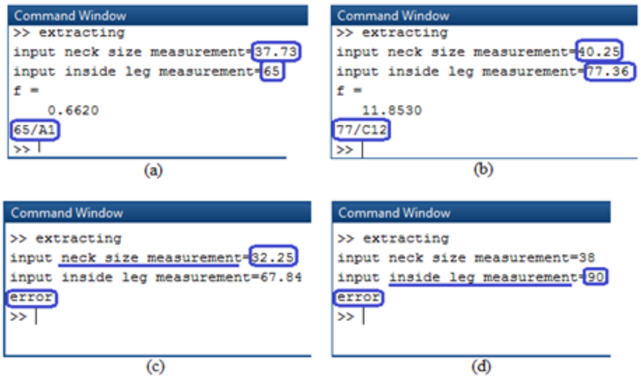

Fig.3. Examples Choose the Size.

J. Test The Feasibility of the Mathematical Model

Test the choosing sizes and comparison with values in tables 2. 3. 4 has resulted in many odd numbers. They are made of a rounded positive integer for results similar to the values of coding sizes that show the test is true 100%.

Test with real measurements by software: Customers input real values of the neck size and inside leg following their body measurements. Results will show odd numbers, which will change integer numbers, and they change suitable sizes chart. All results are sure with body's measurements.

IV. CONCLUSION

The study on extracting size from body sizing system table for 542 men has 24 sizes with 5 groups A. B. C. D and E. The inside leg's interval is 5cm and the waist girth is 6cm. Next, making the mathematical model to choose fit sizes through the linear regression model in the SPSS software. This method has got the target function that is two variables are neck size and inside leg. The neck size variable is the real value which will input to function, and the inside leg variable will look up the tables 2. 3. 4. 5. 6 to get the corresponding value which input to function. The target function's result is rounded positive integer. Next, looking up the table 10 will have the fit size. However, the extracting size in the function with Matlab software helps customers or producers who input real values of two variables then the program shows the fit size.

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If the calculation by the common method will show the result is the number that is the coding size in tables but if the calculation in the program by support Matlab software will show the result is the size chart which includes the alphanumeric and the alphabetical. This subject's results attend research targets that are establishing of the sizing system and the making of the mathematical model to choose the size in a short time. This research is useful in the practical production of industrial garment and business of the sale by online or from far away. The model extracting size extends to multiple users as women, children of various ages and other research are about body shape which will be useful in advisory choosing clothing to fit body.

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