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An Algorithm to Extract the Costume's Size by Fuzzy Logic

Mong Hien Thi Nguyen[1,*] **and Minh Hieu Tran**[2]

[1]*Faculty of Mechanical Engineering, University of Technology-VNU–HCM, Ho Chi Minh City, Vietnam*
[2]*Department of Electric-Telecommunication Electronic Technologies in Ho Chi MInh City Technical and Economic College, Vietnam*
[*]*Corresponding author: ntmhien14719@hcmut.edu.vn*

Abstract. This study presents an algorithm to extract the size of the ready-to-wear clothing, which is men's T-shirts with front house branding. The table has four sizes, and the size labels are signed by S, M, L, and XL. Authors use fuzzy logic to establish the algorithm model. In this model, the input variables have three inputs, which are the body height, weight, and bust girth measurements. In the output variables are the results of size coding. From this size chart table, the authors choose the primary dimensions to be the input variables of the algorithm. The first dimension is a vertical dimension, and the other two dimensions are horizontal dimensions. The vertical dimension is height. The two horizontal dimensions are weight and bust girth. The sizes in the table are encoded to be used for the algorithm results, and the output is the encoded sequence number, which is also the size to be searched. After running this simulation program, measurements of three primary dimensions in size are tested on customers using two methods for two objects. An algorithm for extracting the size of ready-to-wear clothes by the fuzzy logic method reduces the time it takes to choose the size that fits body measurements. In addition, this research direction is consistent with the trend of digital development.

Keywords: algorithm, fuzzy logic, ready-to-wear, size, sizing system

INTRODUCTION

Each measurement method has its advantages and disadvantages, and the parameters after the measurements will be used in different fields in the garment industry. In Vietnam, having a sizing system table was establishment in 2009. This size chart table has been 12 years old by now [1]. For men's sizes, there are a total of 26 sizes, of which 14 are for boys and 12 are for adult men. According to the research [2], fuzzy clustering data mining may be used to create a size system using the anthropometric data of girls between the ages of 20 and 30. Every form of apparel comes in a variety of sizes, such as the shirt-dress in Technical Reference [3], which includes 15 sizes and 5 main measurements. Technical Reference JML 3247 women's pants [5] have 11 sizes and 4 primary dimensions, whereas Technical Reference CERVO pants [4] have 11 sizes and 5 primary dimensions. The size chart of the Novelty shirt has 10 sizes and 4 primary dimensions. Novelty trousers have 9 sizes and 5 primary dimensions. The Sanding shirt has 9 sizes and 5 primary dimensions. The symbol for each size number has four information about height, bust, waist circumference, and buttock circumference, and each height group has three size groups: A, B, and C. The new sizing standards in the world also show that there are many sizes for each group of objects, such as ISO 8959-3: 2017 with 16 sizes for three kinds of body groups [6]. In recent years, there have been many studies on the establishment of the size chart, such as in the study [7]. The authors measured a sample of 500 men ranging from 18 to 35 years old with 30 measurement parameters. The size chart for the Vietnam People's Army includes 52 sizes [8]. In Japan, Jis L4004: 1997 men's clothing sizing system, has 10 body shapes [9]. Another study correlates the classification of body shapes, which is the size chart developed in Korea after scanning on a three-dimensional (3D) human body scanner. There are four body types, in which the body shape is classified based on the one-drop of bust circumference [10, 11]. The authors of the research [12] developed a sizing method for 7800 kids, aged 6 to 18, who were separated into two age groups for the investigation of body forms. The authors of the study on [13] created an 11-size

women's size chart with the major measurements of breast girth and waist girth. The sizing systems and tables of each country were different. For example, the American size chart has 43 dimensions [14], the UK size chart has 20 dimensions [15], and the Australian size chart has 17 dimensions. It shows that each sizing system table has different sizes, so choosing the right size for your body shape will take a long time, causing fatigue as well as damage to the product because of full testing. Until now, choosing the size of ready-to-wear clothes was still based on the parameters printed on the product packaging. On this basis, the research of an algorithm to extract the size of the costume to choose the fit size in a short time from the size chart table is very urgent in the field of clothing trading and is in line with the development trend of 4.0 today.

MATERIAL AND METHODOLOGY

Material

There are five main topics for this study. Firstly, choose the primary dimensions in the sizing system table. Secondly, create a simulation model for selecting the fit size. Thirdly, establish a simulation model of selecting the fit size. Fourthly, a test of the simulation model's results. Finally, draw the flowchart to extract the size.

Methodology

The study uses the fuzzy logic method, which is used in the design of the algorithm to extract the size. There is one output and three inputs in this model. Fuzzy sets serve as the foundation for fuzzy logic's rules. In this study, a triangular fuzzy set is a particular kind of fuzzy set that is utilized for input variables. The Simulink simulation method is used in the design of the size extraction model. The experimental method is applied in checking the results of size extraction through customers who buy new clothes and who are wearing these clothes.

RESULTS AND DISCUSSIONS

CHOOSING PRIMARY DIMENSIONS IN THE SIZING SYSTEM TABLE

The research database is extracted from the technical document T-Shirt brand front house of Phuong Dong Garment Joint Stock Company. This is an oversize T-shirt (Figure 1). The measurement parameters (Table 1) have been coded and the measurement positions are presented according to Table 5.24. This table has four sizes, and the size labels are signed by S, M, L, and XL. From the dimensions of the table, it shows that there are two primary horizontal dimensions (the weight dimension and the bust dimension). Vertical primary dimensions are not available for this product group. Therefore, an additional vertical primary dimension is required; the body height is chosen based on standards [16–20]. The height dimension comes from the size chart [1], and it is divided into three groups. Group 1 sets up from 150 cm to 160 cm, Group 2 sets up from 160 cm to 170 cm, and Group 3 sets up from 170 cm to 179 cm.

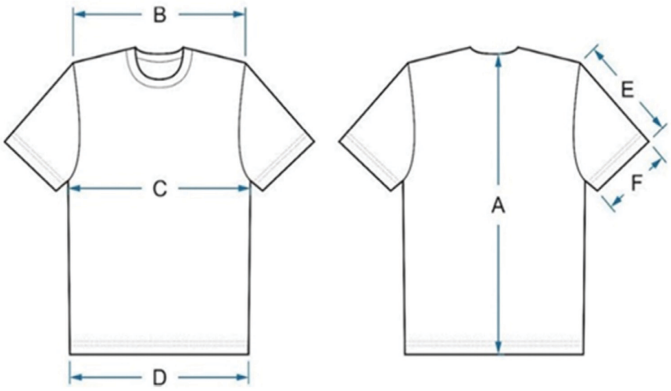


Figure 1. T-shirt's measurement dimension positions.

Table 1. The size chart of the T-shirt for front house branding.

Measurement Dimensions (kg; cm)	Positions	S	M	L	XL
Weight		<65	65–73	73–81	81–90
Length	A	70	72	74	76
Shoulder	B	47	48	49	50
Width bust	C	50	52	54	56
Width hem	D	48	50	52	54
Sleeve length	E	24	24.5	25	25.5
Bicep	F	17	17.5	18	18.5

Table 2. The code table of the T-shirt for front house branding.

Size	S	M	L	XL
Coding size	1	2	3	4
Shape A (150–160) (cm)				
Weight	<65	65–73	73–81	81–90
Bust girth	80	84	88	92
Shape B (160–170) (cm)				
Weight	<65	65–73	73–81	81–90
Bust girth	80	84	88	92
Shape C (170–180) (cm)				
Weight	<65	65–73	73–81	81–90
Bust girth	80	84	88	92

Designing the Algorithm to Extract the Size Ready-to-Wear

The size chart table has three different height groups, each of which has four sizes (Table 2).

The MISO model was selected for the fuzzy controller in this study. The input has three variables (body height,

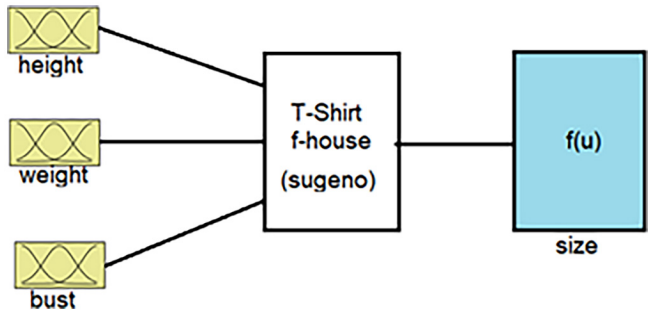
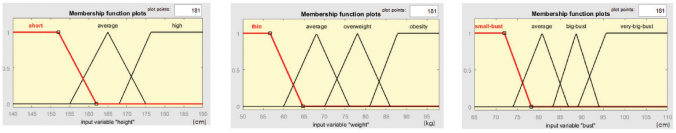


Figure 2. The fuzzy logic model for extracting the T-shirt size.



(a) (b) (c)

Figure 3. The graph of membership functions for input variables: (a) The first input, (b) The second input, and (c) The third input.

Table 3. Measurement arrange of sizes for two output variables.

Input 1 (Height) (cm)		Input 2 (Weight) (kg)		Input 3 (Bust) (cm)	
MF	Measurement	MF	Measurement	MF	Measurement
Shape A	[145 155 165]	weight 64	[52 60 68]	Bust 50	[72 80 88]
Shape B	[155 165 175]	weight 69	[61 69 77]	bust 52	[76 84 92]
Shape C	[165 175 185]	weight 78	[70 78 86]	bust 54	[80 88 96]
		weight 85	[77 85 93]	bust 56	[84 92 100]

Table 4. The value of the output for the size to look for.

MF	Coding Size
S	1
M	2
L	3
XL	4

weight, and chest circumference), one output (size to find), and is passed through the fuzzy logic controller (Figure 2). The size chart has three heights corresponding to four sizes. The first input variable has three membership functions, the second input variable has four membership functions, and the third input variable has four membership functions corresponding to Figure 3. All three use triangular fuzzy sets and parameter intervals for each membership function of each variable as shown in Table 3.

The output is the size of a lookup table. There are four sizes in total in the size chart; so, there will be four membership functions for the output variable (Table 4).

The matrix of fuzzy logic rules is built based on the "max-min" inference method (Table 5). This fuzzy logic model has 48 rules. In there, there are 16 rules for size S, 8 rules for size M, 12 rules for size L, and 12 rules for size XL.

The structure to extract the size is shown in Figure 4. There are three inputs, each of which has three

Table 5. The matrix of fuzzy logic rules.

Shape	Shape A				Shape B				Shape C			
Size	S	M	L	XL	S	M	L	XL	S	M	L	XL
Weight (<65)	x				x				x			
Weight (65–73)		x				x				x		
Weight (73–81)			x				x				x	
Weight (81–90)				x				x				x
Bust girth (50)	x	x	x	x	x	x	x	x	x	x	x	x
Bust girth (52)	x	x	x	x	x	x	x	x	x	x	x	x
Bust girth (54)	x	x	x	x	x	x	x	x	x	x	x	x
Bust girth (56)	x	x	x	x	x	x	x	x	x	x	x	x

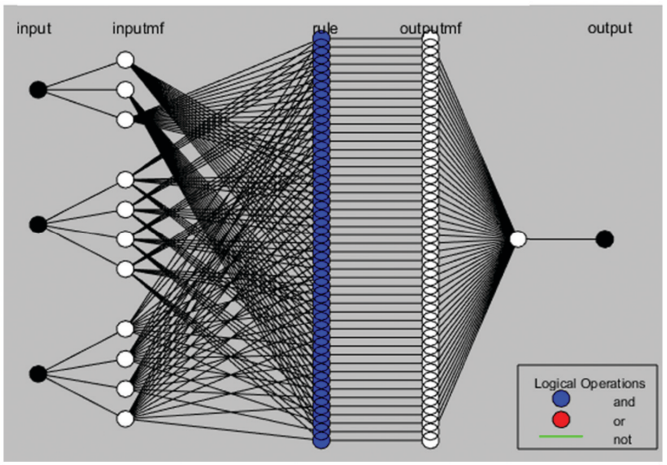


Figure 4. The anfis model structure.

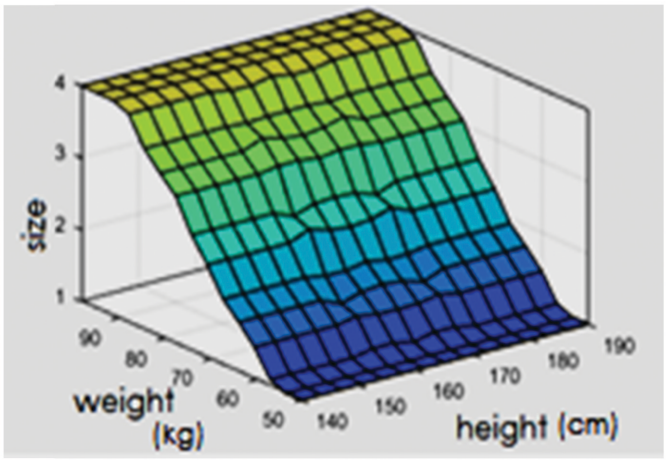


Figure 5. Testing controller rules in surface.

membership functions: for input 1, four for input 2, and four for input 3. According to the rule, one input membership function will be linked to one output membership function, producing one output that is the desired size.

To see fuzzy logic rules in the space, choose "Surface" in the menu View shown Figure 5.

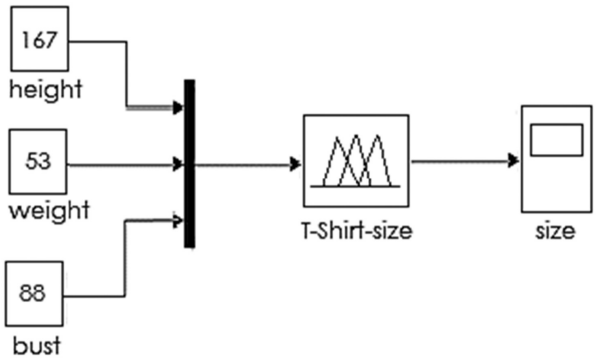


Figure 6. The simulink simulation for T-shirt-front House.

Table 6. The result of testing for extracting the size by the first method.

Size	S (1)	M (2)	L (3)	XL (4)
Bust girth (cm)	88	92	96	100
Weight (kg)	62	70.5	76	85.5
Traditional method	S	M	L	XL
Fuzzy logic method	1	2	3	4

Establishing the Simulink Simulation Model

The model has three inputs (the height, the weight, and the bust measurement) and one input (the size), as shown in Figure 6. The height measurement range is 145–185 cm. The weight measurement range is 52–93 kg. The bust measurement range is 72–100 cm.

Testing the Result to Extract the T-Shirt's Size

Testing is done in two ways. The first way is to take the correct measurements from the size chart and input them into the model, see the results after running, and then compare them with the size in the table (Table 6).

The results show that they are true to the coding size in the table. The second way, testing the objectivity by two methods of extracting the size: the traditional method and the fuzzy logic method, by inputting measurements of three dimensions of height, weight, and bust. In there, seven men are using T-shirts (f. house) and three people are trying on new products. The fit of products is evaluated scientifically according to the analysis of product appearance when T-shirts are worn on three customers (Figure 7). The images shown Figure 7 have the following serial numbers in Table 7. The sample (a-XL) is sample 10. These people's primary dimensions are similar to the primary dimensions of the size XL in the size chart. The sample (b-L) is sample 9. The primary dimensions are similar to the primary dimensions of the size L in the size chart. The sample (c-S) is sample 8. The primary dimensions are similar to the primary dimensions of the size S in the size chart. Besides that, it is evaluated through the comments of 10 people about the fit of 5 levels (very tight, tight, medium, wide, and very broad) and is analyzed with the results of an algorithm simulation.

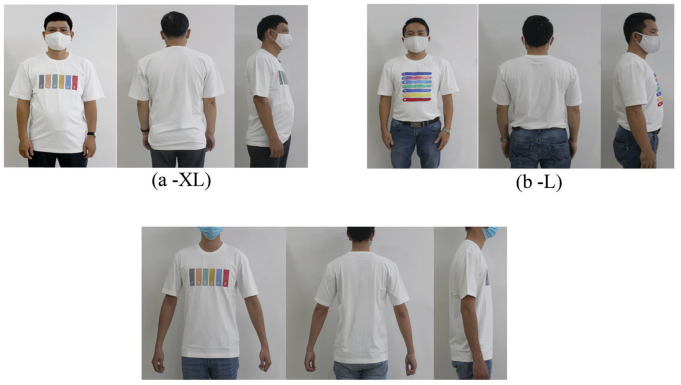


Figure 7. Images try on T-shirt, front house branding: size L (a), size M (b), and size S (c).

Table 7. The result of testing for extracting sizes of the T-shirt for front-house branding.

Samples	Heights (cm)	Weights (kg)	Bust (cm)	Sizes	Fit Levels	Coding Sizes	Comments
1	173	61	80	XL	4	1 (S)	The sample is wide. The result is true with the fuzzy logic method (size S).
2	168	70	90	M	3	2 (M)	The result is true.
3	169	58	78	L	4	1 (S)	The sample is wide. The result is true with the fuzzy logic method (size S).
4	165	72	91	L	3	3 (L)	The result is true.
5	168	56	80	L	4	1 (S)	The sample is wide. The result is true with the fuzzy logic method (size S).
6	178	75	90	XL	4	3 (L)	The result is true.
7	167	52	87	M	4	1 (S)	The sample is wide. The result is true with the fuzzy logic method (size S).
8 (new)	169	56	83	S	3	1 (S)	The result is true.
9 (new)	167	75	92	L	3	3 (L)	The result is true.
10 (new)	172	78.5	97.5	XL	3	4 (XL)	The result is true.

The Flowchart for Extracting the Ready-to-Wear

The flowchart to extract the ready-to-wear size needs three input variables (height, weight, and bust dimensions). The three variables must be in the range of values in the size

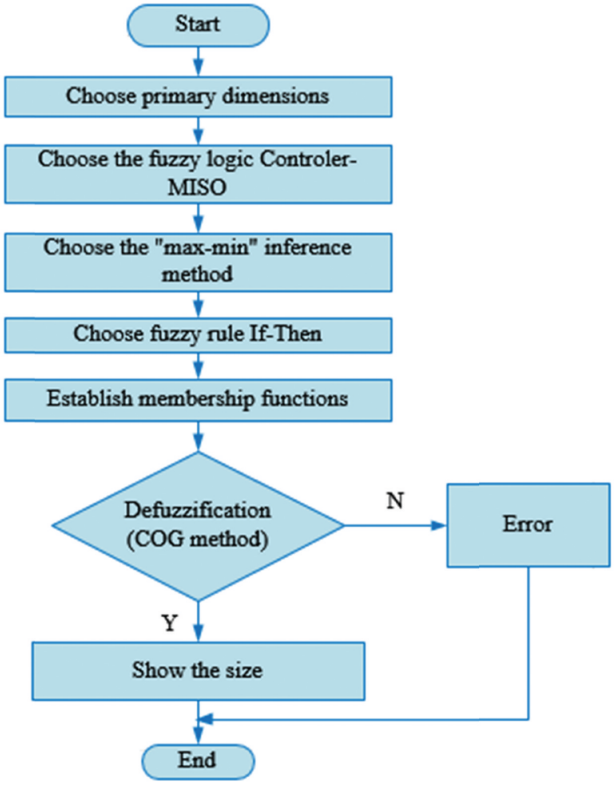


Figure 8. The flowchart to extract the ready-to-wear size.

chart, then the program shows the output of the fit size (Figure 8).

CONCLUSION

The study presents the results of the algorithm to extract the size of a ready-to-wear T-shirt with front house branding from the sizing system table and give suggestions on choosing the right size for the customer. Each of the four sizes in this table includes three distinct metrics for body height. The three most important parameters for choosing input variables for the fuzzy simulation model are waist circumference, bust, and body height. This outcome demonstrates the viability of using fuzzy logic to select the fit size. We may use the experimental measurement data to determine a good size for males based on the fuzzy. In addition, the study analyzed the experimental results in each research area as well as discussed the experimental data of the study. Measurements of height, weight, and bust are selected as the three input variables of the fuzzy model. The output variable is the required size. The study expanded the size selection range when extracting the size and body shape according to the fuzzy logic method and created a basis for businesses to easily calculate the number of sizes chosen by customers to balance production. Furthermore, it can be applied to other fields in garment technology as well.

REFERENCES

[1] TCVN 5782. (2009). *Standard sizing systems for clothes*, Hanoi.
[2] HSU, Chih-Hung, LEE, Tzu-Yuan, KUO, Hui-Ming. Mining the body features to develop sizing systems to improve business logistics and marketing using fuzzy clustering data mining. *Wseas TRANSACTIONS on COMPUTERS*. (2009), **8**, 1215–1224.
[3] *Technical document of reference J. CREW 113425.* (2016).
[4] *Technical document of reference CERVO trousers*. (2014).
[5] *Technical document of reference JML trousers 3427*. (2015).
[6] ISO 8559-3:2017. *Size designation of clothes — Part 3: Anthropometric definitions for body measurement*, Switzerland. (2017).
[7] NGA, Bui Thi. (2011). Researching and application of 3D measuring equipment in building a standard pattern for men's pants and shirts. *Institute of Textile Garment, Hanoi*.
[8] CHAU, N.T.H. (2001). Researching of establishing sizing system table of the military by an anthropometric method. *Institute of Textile Garment. Hanoi*.
[9] Jis L 4004. (1997). *Sizing system for men's garments*. Japan.
[10] KS 0050. (2001). *Sizing Systems for Men's and Boy's Garments*. Korean Standards Association, Seoul.
[11] KS K 0050. (2004). *Sizing System for Male Adult's Garments*. Korean Standards Association. Seoul.
[12] CHUNG, Meng-Jung, LIN, Hai-Fen, J. WANG, Mao-Jiun. (2007). The development of sizing system for school students. International Journal of Industrial Ergonomics. **37** (8), 707–716.
[13] GUPTA, D. and GANGADHAR, B. R. (2004). A statistical model for development body size charts for garment. *International Journal of clothing Science and Technology*. **16**(5), 458–469.
[14] AMTRONG, Helen Joesph. (2010). *Patternmarking for Fashion Design. Fith Edition*. New York.
[15] ALRICH, Winifred. (2011). *Metric Pattern Cutting, Four Edition*. Wiley.
[16] ISO: 4415. (1981). *Size designation of clothes – Men's and boys' underwear. nightwear and shirts*. Switzerland.
[17] ISO/TC 133. (1991). *Clothing sizing systems – size designation, size measurement methods and digital fittings*. Switzerland.
[18] ISO 8559-1. (2017). *Size designation of clothes – Part 1: Anthropometric definitions for body measurement*. Switzerland.
[19] KS K 0050. (2001). *Sizing Systems for Men's and Boy's Garments*. Korean Standards Association. Seoul.
[20] KS K 0050. (2004). *Sizing System for Male Adult's Garments*, Korean Standards Association. Seoul.