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Establishing the program to predict Shirt Sizes with Fuzzy Logic

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ABSTRACT: This paper presents a program for prediction shirt size with a fuzzy logic technique. The Mamdani model is applied to a MISO fuzzy system with two inputs and one output. Neck girth and sleeve length are chosen as the primary dimensions, serving as input variables for this simulation model. In this study, fuzzy logic is used to select the size of the Min-Max rule. The IF-THEN structure is applied to execute commands effectively within this model. The outcome is an appropriate size. The program's fuzzy rule matrix consists of 45 rows and 5 columns. Each row is a fuzzy rule. The first column represents the 9 sizes of necklaces. The second column represents the 5 groups of sleeve lengths. The third column represents the 9 predicted sizes in the output. The third column represents the 9 predicted output sizes. The fourth column is the weight coefficient. The last column represents the logical connection type. The fuzzy logic approaches significantly reduces the time required. This approach provides an alternative method for prediction sizes that more accurately align with individual body measurements, offering a personalized fit.

KEYWORDS: Fuzzy logic, Establishing, Prediction, Shirt, Size chart.

1. INTRODUCTION

Today, numerous studies have explored body size prediction using AI algorithms. For example, one study developed a back-propagation neural network model to predict body size by inputting key human body dimensions [1]. Another research employed Artificial Neural Networks to create a model for predicting the fit of virtual clothing in Optitex software, utilizing data from 50 women aged 18 to 35 years [2]. Other research has focused on using genetic algorithms to propose a 3D design method for polo shirts [3] and designing Kansei-style T-shirts with back-propagation neural networks [4]. Additional studies have examined clothing fit through various algorithms [5]. These intelligent algorithms are applied not only in garment design but also in other areas such as technology, sewing materials, and production management within the garment industry. For instance, several studies have investigated advancements in production technology [6], [7], [8], while others have explored intelligent algorithms in the context of sewing materials [9], [10], [11]. Another study proposed a new size chart, building upon existing market size charts, and linked secondary body measurements to primary measurements without relying on linear regression [12]. The research presented in this paper builds upon these previous studies, highlighting the importance of selecting the correct size for ready-to-wear clothing, which often requires significant time to ensure a proper fit. By integrating insights from these studies, the authors aim to develop a more accurate and practical model for predicting clothing sizes using advanced techniques. This model has the potential to greatly enhance the fit and comfort of ready-made clothing, addressing the ongoing challenge of achieving optimal sizing in the garment industry.

2. MATERIAL AND METHOD

2.1 Material

The size chart for men's shirts at Sanding Company includes five horizontal dimensions and three vertical dimensions, resulting in a total of nine distinct sizes. These sizes are denoted by numbers, with the smallest being size 36 and the largest size 44, each increasing by an interval of 1 unit [13].

2.2 Method

This research comprises six main components. Fuzzy logic is applied to develop the model for selecting the appropriate size and running the simulation program. This research employs the Mamdani model for a MISO (Multiple Input, Single Output) fuzzy system, which incorporates two inputs and one output. The foundation of the fuzzy logic rules is built on fuzzy sets, utilizing Max-Min rules. Fuzzy logic model uses two types of membership functions, which are triangular membership function. The Figure 1 is

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the triangular membership function. It has got three parameters: lower limit, top, upper limit, and it is calculated as in Equation (1). [14].

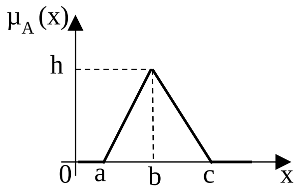

Figure 1. The triangular membership function

$$\mu_A(x) = \begin{cases} 0, & if\, x \leq a, or\ x \geq c \\ \dfrac{x-a}{b-a}, & if\ a < x < b \\ \dfrac{c-x}{c-b}, & if\ b < u < c \\ h, & if\ h \leq 1 \end{cases} \quad (1)$$

In this study, triangular fuzzy sets are used for the input variables. The model has structured IF-THEN to practice commands effectively in Mamdani. The program for predicting sizes is developed using Matlab software.

3. RESULTS AND DISCUSSION

3.1 Primary dimensions in the size chart

The size chart for Sanding shirts, utilized in this study, consists of 9 sizes, each represented by a number. The chart includes two types of size labels and covers 8 dimensions (as outlined in Table 1). Of these dimensions, three are considered primary: neck girth, bust girth, and sleeve length. Two of these primary dimensions are used as input variables in the fuzzy model, with one serving as the horizontal dimension and the other as the vertical dimension. Most shirt size labels are based on neck girth, which is logical since the collar should fit comfortably when buttoned. As a result, neck girth is the first primary dimension, and sleeve length is the second.

Table 1. The men's long shirt size chart

Dimension (cm)	36	37	38	39	40	41	42	43	44
Shirt length	76	76	76	78	80	80	82	82	82
Shoulder width	46	47	47	48	49	49	51	51	53
Bust girth	103	106	106	112	118	118	124	124	130
Sleeve length	55	57	57	58	60	60	62	62	62
Cuff	24.5	24.5	24.5	24.5	26.5	26.5	26.5	26.5	26.5
Neck girth	36	37	38	39	40	41	42	43	44
The first button	6.5	6.5	6.5	7.5	7.5	7.5	7.5	7.5	7.5
Disstance between buttons	8.5	8.5	8.5	9	9	9	9.5	9.5	9.5

3.2 The boundary conditions for input's two variables

The first variable (x_1) is the neck girth measurement, and the second variable (x_2) is the sleeve length measurement. These variables are subject to the following boundary conditions: $35 \leq x_1 \leq 45$ (cm); $54 \leq x_2 \leq 64$ (cm).

3.3 The input – output variables

The fuzzy logic system features two input variables and one output variable (as shown in Figure 2). Each input variable is associated with several membership functions. For example, the first input variable has 9 triangular membership functions, while the second input variable has 5 triangular membership functions, as detailed in Table 2. The program is designed with two input variables, with the first input having 9 triangular membership functions.

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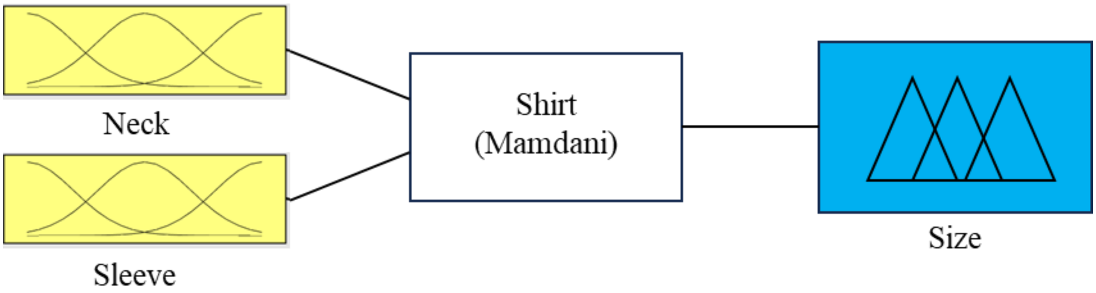

Figure 2. The fuzzy logic system of looking for the men's shirt sizes

Table 2. The range of membership functions' parameters for the first input (Neck girth)

The first input (Neck)				The second input (Sleeve)	
MF	Parameter (cm)	MF	Parameter (cm)	MF	Parameter (cm)
N36	[35 35 36 36.8]	N41	[40.2 41 41.8]	Sl55	[54 54 55 56.8]
N37	[36.2 37 37.8]	N42	[41.2 42 42.8]	Sl57	[56.2 57 57.8]
N38	[37.2 38 38.8]	N43	[42.2 43 43.8]	Sl58	[57.2 58 58.8]
N39	[38.2 39 39.7]	N44	[43.2 44 45 45]	Sl60	[58.3 60 61.7]
N40	[39.2 40 40.8]			Sl62	[60.7 62 64 64]

The code for sleeve:

```
fis = addvar(fis, 'input', 'Neck', [35 45]);
fis = addmf(fis, 'input', 1, '36', 'trimf', [35 36 36.8]);
fis = addmf(fis, 'input', 1, '37', 'trimf', [36.2 37 37.8]);
fis = addmf(fis, 'input', 1, '38', 'trimf', [37.2 38 38.8]);
fis = addmf(fis, 'input', 1, '39', 'trimf', [38.2 39 39.7]);
fis = addmf(fis, 'input', 1, '40', 'trimf', [39.2 40 40.8]);
fis = addmf(fis, 'input', 1, '41', 'trimf', [40.2 41 41.8]);
fis = addmf(fis, 'input', 1, '42', 'trimf', [41.2 42 42.8]);
fis = addmf(fis, 'input', 1, '43', 'trimf', [42.2 43 43.8]);
fis = addmf(fis, 'input', 1, '44', 'trimf', [43.2 44 45]);
```

The second input has 5 membership functions with the type triangular. The code for sleeve:

```
fis = addvar(fis, 'input', 'Sleeves', [54 64]);
fis = addmf(fis, 'input', 2, '56', 'trimf', [54 55 56.12]);
fis = addmf(fis, 'input', 2, '57', 'trimf', [55.7 57 57.94]);
fis = addmf(fis, 'input', 2, '58', 'trimf', [57.2 58 58.8]);
fis = addmf(fis, 'input', 2, '60', 'trimf', [58.3 60 61.7]);
fis = addmf(fis, 'input', 2, '62', 'trimf', [60.7 62 64]);
```

There are 9 sizes in total, meaning there are 9 output membership functions for the system's output values. These output membership functions correspond to sizes S36, S37, S38, S39, S40, S41, S42, S43, and S44. The range for the output values is also presented in Table 3.

Table 3. The range of membership functions' parameters for output.

MF	Parameter	MF	Parameter	MF	Parameter
S36	[35 36 37]	S39	[38 39 40]	S42	[41 42 43]
S37	[36 37 38]	S40	[39 40 41]	S43	[42 43 44]
S38	[37 3839]	S41	[40 41 42]	S44	[43 44 45]

The output result is a number. This number is the size which needs looking for. The code for the output:

```
fis = addvar(fis, 'output', 'Size', [35 45]);
fis = addmf(fis, 'output', 1, 'S36', 'trimf', [35 36 37]);
fis = addmf(fis, 'output', 1, 'S37', 'trimf', [36 37 38]);
fis = addmf(fis, 'output', 1, 'S38', 'trimf', [37 38 39]);
fis = addmf(fis, 'output', 1, 'S39', 'trimf', [38 39 40]);
fis = addmf(fis, 'output', 1, 'S40', 'trimf', [39 40 41]);
fis = addmf(fis, 'output', 1, 'S41', 'trimf', [40 41 42]);
fis = addmf(fis, 'output', 1, 'S42', 'trimf', [41 42 43]);
fis = addmf(fis, 'output', 1, 'S43', 'trimf', [42 43 44]);
fis = addmf(fis, 'output', 1, 'S44', 'trimf', [43 44 45]);;
```

3.4 The matrix of fuzzy logic rules

With the pair of a variable will show the fit is integrated rules by CoM-Center of the Maximum method:

$$x^* = \frac{\sum x_{i\epsilon M} x_i}{|\mathrm{M}|}$$

M= $\{x_i|\mu_A(x_i)$ is equal to the height of the fuzzy set A$\}$ and |M| is the cardinality of the set M.

The output values for any combination of the two input variables. Because there are 9 membership functions for the first input variable and 5 membership functions for the second input variable, so the total number of fuzzy rules in the study is 45. The size notation is numbered according to the neck girth measurement. Values of model's set parameters are results having from the establishing the size chart. The fuzzy rule set of the study is presented in Table 4. This table, the number 1, 2, 3, 4, 5, 6, 7, 8, 9 represents the order in which the member functions were defined as follows:

Neck: N36 = 1; N37 = 2; N38 = 3; N39 = 4; N40 = 5; N41 = 6; N42 = 7; N43 = 8; N44 = 9.

Sleeve: Sl55 = 1; Sl57 = 2; Sl58 = 3; Sl60 = 4; Sl62 = 5.

Size: S36 = 1; S37 = 2; S38 = 3; S39 = 4; S40 = 5; S41 = 6; S42 = 7; S43 = 8; S44 = 9.

Table 4. The matrix of fuzzy rule set

Fuzzy rules	Neck	Sleeves	Size	Fuzzy rules	Neck	Sleeves	Size	Fuzzy rules	Neck	Sleeves	Size
1	1	1	1	16	4	1	4	31	7	1	7
2		2		17		2		32		2	
3		3		18		3		33		3	
4		4		19		4		34		4	
5		5		20		5		35		5	
6	2	1	2	21	5	1	5	36	8	1	8
7		2		22		2		37		2	
8		3		23		3		38		3	
9		4		24		4		39		4	
10		5		25		5		40		5	
11	3	1	3	26	6	1	6	41	9	1	9
12		2		27		2		42		2	

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13	3	28	3	43	3
14	4	29	4	44	4
15	5	30	5	45	5

Through Table 4, a rule list is established, consisting of 45 rows and 5 columns. Each row represents a rule, while each column in the rule matrix corresponds to the following: the first input variable (Neck), the second input variable (Sleeve), the output variable (Size), the weight factor, and the logic connection type. The matrix is presented below:

```
ruleList = [1 1 1 1 1; % If (neck is N36) and (sleeve is Sl1) then (size is S36)
            1 2 1 1 1; % If (neck is N36) and (sleeve is Sl2) then (size is S36)
            1 3 1 1 1; % If (neck is N36) and (sleeve is Sl3) then (size is S36)
            1 4 1 1 1; % If (neck is N36) and (sleeve is Sl4) then (size is S36)
            1 5 1 1 1; % If (neck is N36) and (sleeve is Sl5) then (size is S36)
                ⋮
            9 1 9 1 1; % If (neck is N44) and (sleeve is Sl1) then (size is S44)
             9 2 9 1 1; % If (neck is N44) and (sleeve is Sl2) then (size is S44)
            9 3 9 1 1; % If (neck is N44) and (sleeve is Sl3) then (size is S44)
            9 4 9 1 1; % If (neck is N44) and (sleeve is Sl4) then (size is S44)
            9 5 9 1 1]; % If (neck is N44) and (sleeve is Sl5) then (size is S44)
```

3.5 The result of prediction for the men's shirt sizes

In the program's command window, start by entering the file name. Then, input the neck measurement, followed by the sleeve length. The program will process these values and provide the corresponding size (refer to Figure...). For instance, if the neck measurement is 42 cm and the sleeve length is 63 cm, the resulting size will be 42.

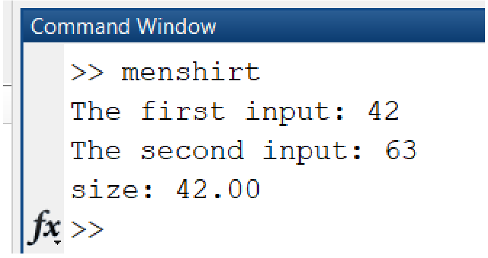

Figure 3. Input measurements

3.6 Testing of the choosing size model

The size selection process is evaluated using two methods. In the first method, measurements from Table 1 are entered into the program, followed by a comparison of the results with the sizes in the corresponding tables. In the second method, the neck girth and sleeve length measurements of 30 customers are input into the program, and the results are again compared with the sizes in the tables. In both methods, the results are appropriate and consistent.

4. CONCLUSION

This paper presents a study on using fuzzy logic to simulate the selection of appropriate shirt sizes for men. The model uses neck girth and sleeve length as input variables, with shirt size as the output. It incorporates 9 membership functions for neck girth, 5 for sleeve length, and follows the Max-Min composition rule with 45 fuzzy rules. The program allows users to quickly determine their size, improving the selection of well-fitting clothing. Results show that fuzzy logic is effective for size prediction. Future work will validate the model against real data and explore methods to further improve accuracy. This research offers a promising approach to size selection and has potential applications in garment technology.

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Conflict of interest

The author confirms that there is no conflict of interest to declare for this publication.

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