

ORIGINAL RESEARCH

# The design, simulation, and adjustment of the Vietnam men's Ao dai on the CLO3D software

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The study presents the results of the design, simulation, and adjustment of middle-aged men's Ao Dai from 30 to 60 years old in Ho Chi Minh City. This research combines two methods of 2D design on the Gerber software and 3D design on the CLO3D software, of which the main simulated patterns' material is cotton sateen fabric. An avatar is used to simulate men's Ao Dai which has the average measurements of the 378 measurement samples. There are three steps to simulate and edit. At first, the patterns are draped on the avatar. The sample does not achieve a smooth, flat fit in the side seam and waist area when they drape on the avatar. After patterns are adjusted at the side seam, finally, these patterns are draped again to meet the standard of smooth and flat appearance on the simulated model's front, back, and side faces. The study was conducted on one model that has suitable dimensions for Vietnamese men, so there will be additional avatar data in the CLO3D software database. This is very useful for fashion and technique designers in garment businesses.

**Keywords:** pattern, design, simulation, adjustment, men's Ao Dai, CLO3D

## 1. Introduction

Body measurements are an important basis for the determination of the size of pieces in costume design. There has been a vast majority of studies related to body measurements on various devices, such as experiments on body measurements from the Kinect v2 Depth Camera (1). The authors measured 129 males aged from 18 to 29 years. After extraction, the highest error was in waist circumference compared to other dimensions. The authors of another research extracted body measurements from 2D scanned images in order to adapt to clothing design (2). The researchers used a camera to take a frontal image and measured the bust, waist, and hip girth dimensions. The outcomes show that the size errors measured by 2D images were 10% less than those in manual measurements. Inferring body shapes through captured photographs is also the same experimental direction (3). The authors photographed the body's front and sides and subsequently

applied the regression method to estimate the body shape and dimensions. Currently, the utilization of 3D human body scanner technology is one of the most modern methods to get the fastest and most accurate parameters. In many developed countries, the indirect measurement of the human body from the 3D scanner method is commonly used. There are many studies on the extraction of measurements from 3D body scanners in the textile field (4–8). Regarding the study of shape analysis, the author has compiled many references to make statistics on common shapes. Take a study (9) as an example. It simulated overweight and obese body shapes, and the study group's size was also measured using the ASTM standard. Also related to the classification of physique, there is a research topic to classify the sample body shapes of 37 men aged 20–30 years living in Bangladesh. These experimental shapes are triangles, trapezoids, and inverted triangles (10). In addition, there are studies to classify shapes according to the principal component analysis and factor analysis. With the topic (9), the authors classified body shape,

analyzed the main components with varimax rotation, and analyzed the K-mean cluster to identify different body shape groups. Connected to the style classification is a costume display's design according to the flat experience method (2D), the pattern draping method on the avatar (3D), and the combination of the 2D with the 3D method (11). For example, in studies (12–14), costumes were designed by the researchers on the CLO3D software so as to simulate and evaluate clothes' fit through color charts. With this design direction, it will save more time and materials for a final finished model because it does not require sewing and testing samples many times. This is the motivation for the authors to research the study *The Design, Simulation and Adjustment of the Vietnam Men's Ao Dai on CLO3D Software*.

## 2. Materials and methods

### 2.1. Sample

The authors use the direct measurement method to survey measured data. Subjects were 30–60-year-old male civil servants in Ho Chi Minh City. According to the laws



FIGURE 1 | Size stream 3D body scanner includes 14 sensors.



FIGURE 2 | The cotton sateen cloth.

of anthropometric development, this age range will be divided into two stages: the middle-aged stage and the adulthood stage (15). Therefore, there will be two age groups in the measured samples: the 30–45 years old and the 46–60 years old. In each group, 30 samples will be randomly measured and selected primary dimensions for height, weight, bust, waist, and hip girth, which leads to being able to choose the highest standard deviation dimension. The results of both groups are analyzed by the statistical method (16). It showed that weight had the highest standard deviation, followed by the waist dimension. The abdomen dimension will show the difference in body shapes clearer than those of weight. Because of this reason, abdomen girth is chosen as the primary dimension to calculate the number of measured samples for research purposes. As a result, groups 1 and group 2 have abdomen girths with a standard deviation of 7.53 cm for the former and 7.52 cm for the latter. The middle-aged participants were almost office workers in Ho Chi Minh City, so they had similar living conditions in terms of geography and had a notably stable height. One or more unified sets were grouped to process measured data and establish the sizing system table. The standard deviation of the abdomen girth is 7.53 cm. The number of samples to be measured is calculated according to formula (1):

$$m = \frac{t \times \sigma}{\sqrt{n}} \rightarrow n = \frac{t^2 \times \sigma^2}{m^2} \quad (1)$$

where:

- Research chooses 99% accuracy, so the value of t is 2.58.
- The value of  $\sigma$  standard deviation is 7.53cm, which is the abdomen girth's standard deviation.
- The n is the sample.
- The value of m is 1.



FIGURE 3 | The front body and the back body of men Ao dai.

**TABLE 1** | Average body dimensions for men in Ho Chi Minh City from 30 to 60 years old.

Dimension (cm)	N Sample (people)	Min (cm)	Max (cm)	Medium (cm)	Standard deviation (cm)
1. Height	378	154.76	181.35	167.88	5.35
2. Weight	378	49.50	92.50	68.11	7.99
3. Neck height to floor	378	131.22	156.54	141.73	4.70
4. Shoulder height to floor	378	125.65	149.61	136.91	4.73
5. Chest height to floor	378	111.24	133.58	121.64	4.39
6. Waist height to floor	378	91.96	111.13	101.09	3.73
7. Hip height to floor	378	63.86	90.88	82.42	3.47
8. Seat fold height to floor	378	67.05	82.26	74.45	3.29
9. Outside leg length	378	83.08	100.39	91.67	3.63
10. Inseam leg length	378	66.49	81.93	74.20	3.25
11. Crotch height to floor	378	62.90	80.18	72.62	3.36
12. Thigh height to floor	378	60.07	74.91	67.45	3.33
13. Knee height to floor	378	37.59	50.47	43.94	2.24
14. Neck to front waist	378	40.03	55.29	47.47	2.76
15. Neck to back waist	378	41.76	56.93	49.04	2.60
16. Crotch girth	378	45.01	88.87	62.36	7.39
17. Neck girth	378	37.21	48.86	41.43	1.93
18. Upper bust girth	378	85.62	114.01	99.42	4.81
19. Bust girth	378	74.63	114.04	96.12	5.70
20. Abdomen girth	378	73.65	103.77	88.08	6.09
21. Hip girth	378	84.51	111.81	96.75	4.84
22. Thigh girth	378	44.95	65.48	54.28	3.96
23. Knee girth	378	30.67	44.84	36.48	2.47
24. Calf girth	378	30.69	44.26	36.92	2.53
25. Min lower leg girth	378	18.29	28.59	22.73	1.74
26. Arm hole girth	378	37.49	53.90	45.33	3.06
27. Bicep girth	378	24.50	35.63	29.65	2.16
28. Elbow girth	378	22.65	31.74	26.96	1.53
29. Forearm girth	378	22.64	30.99	26.71	1.42
30. Wrist girth	378	14.21	20.99	17.00	1.03
31. Shoulder slope	378	3.13	6.84	4.82	0.82
32. Shoulder width	378	28.00	53.96	43.73	3.51
33. Shoulder length	378	10.53	18.09	14.14	1.29
34. Arm length	378	50.06	63.88	56.78	2.62
35. Elbow length	378	28.15	37.68	32.56	1.96
36. Across chest arm to arm	378	32.52	40.21	36.35	1.52
37. Across back arm to arm	378	34.74	43.23	38.73	1.66
38. Bust to bust length	378	16.82	23.98	19.96	1.24
39. Chest width	378	29.45	39.23	34.30	1.68
40. Chest thickness	378	19.68	28.19	23.81	1.64
41. Waist width	378	25.93	35.55	30.59	1.95
42. Waist thickness	378	18.66	28.12	23.26	2.11
43. Hip width	378	30.44	38.16	34.30	1.49
44. Hip thickness	378	20.37	28.85	24.50	1.62
45. Neck height	378	4.25	11.77	7.88	1.47
Sample N (people)	378				

Substituting the parameters into the sample calculation formula (1) will have the number of samples to be measured from 378 men. The 3D Size Stream body scanner is used to

scan the full size of a person's body (17). Its 3D scanning consequences are extracted into PDF and Excel files that are used for data analysis on the SPSS software.

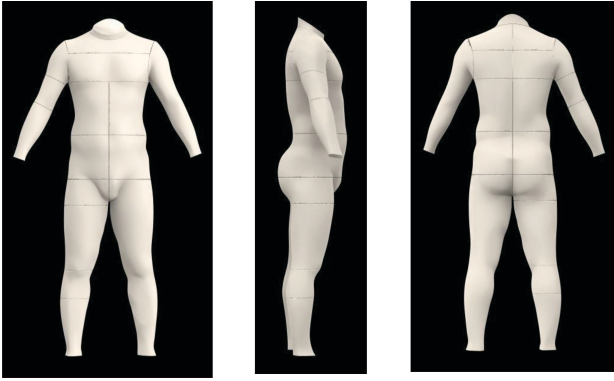


FIGURE 4 | Smooth surface 3D model.

## 2.2. Materials

American Size Stream 3D body scanner is a machine with a 3D scanning system designed to capture three dimensions of the entire person's body, including 14 infrared sensors, placed at different heights. Sensors connected via UBS ports to a computer control the scanner and load data (Figure 1).

The sample measurement procedure is as follows:

Step 1: Prepare to measure—declare and enter the measurement information into the 3D machine to store the data on the computer. The person being measured changes to the measuring clothes and wears tight underwear to prepare for the measurement.

Step 2: Take measurement—the person being measured enters the 3D scanner chamber and stands naturally.

Hold the handle with both hands, breathe gently, and look straight ahead. They should strictly follow the instructions of the measuring operator.

Step 3: Finish measurement. The measured data obtained allow for storing the body image file in the computer.

Ao dai fabric is made up of cotton sateen, with a weight of 137.8792 g/m<sup>2</sup> and a thickness of 0.32 mm (Figure 2).

Men's Ao dai sketch image is shown in Figure 3.

## 2.3. Methods

The cross-sectional statistical method is used in a survey of 378 databases on men from 30 to 60 years old living in HCMC. Moreover, the K-mean cluster method is used to provide body shape grouping options. The 2D pattern design method is used to design pieces of the men's Ao dai in the Gerber software, while the sample draping 3D method uses the flat patterns transfer to the avatar.

## 3. Results and discussions

### 3.1. Description of anthropometric data

The results of the analysis of anthropometric dimensions of 378 men aged 30–60 years living in the southern region of Vietnam are presented in Table 1. Values such as standard deviation, mean, maximum value, minimum value, and

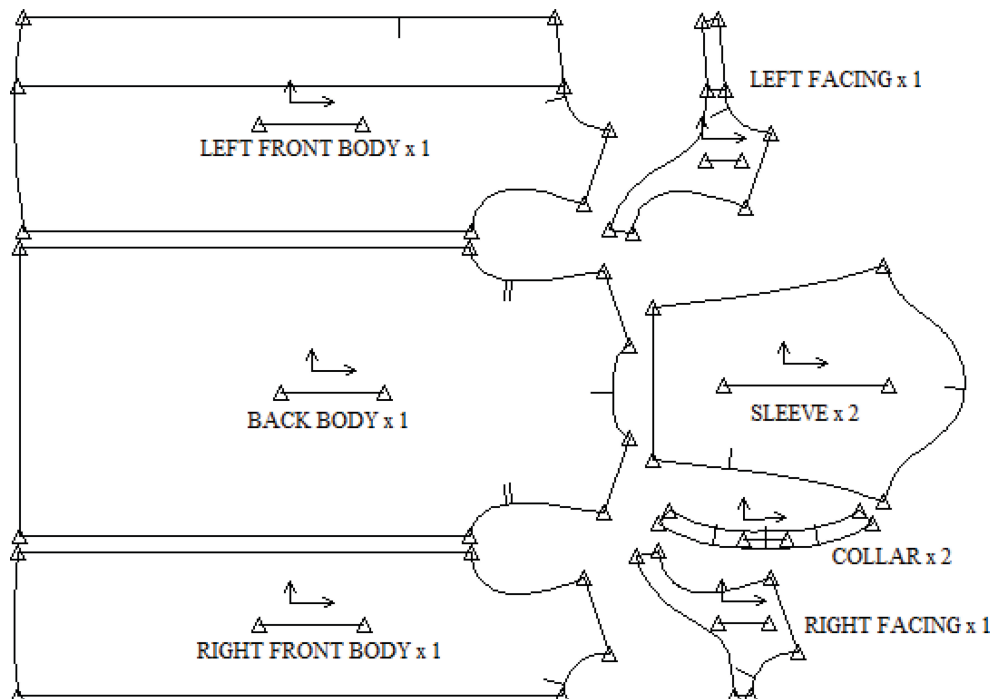


FIGURE 5 | The patterns of the Vietnam men's Ao dai.



**FIGURE 6** | Simulation of men's Ao Dai on the model. Patterns before adjusting.

range of variation are statistical and used in the process of classifying the human body shape. There are a total of 45 measured dimensions.

### 3.2. The 3D model of the avatar

The avatar in the study is made according to the average measurements of [Table 1](#). Combined with the results of avatar construction in the study (18), a 3D model has been created to simulate shape and structure as shown in [Figure 4](#).

### 3.3. Patterns design of the men Ao dai

The men's Ao Dai is designed by the 2D method on the Gerber software with patterns as shown in [Figure 5](#). The measurements are used to design patterns that have medium measurements in [Table 1](#).

### 3.4. Simulation of men's Ao dai on the avatar

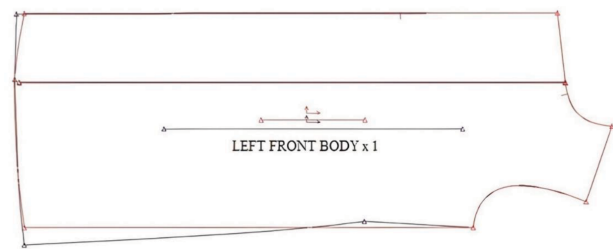
[Figure 6](#) is a sample image of a shirt surface simulation on the CLO3D software with avatars built by anthropometric scan datasets of 378 middle-aged men in Ho Chi Minh City.

### 3.5. Simulation of men's Ao dai on the avatar

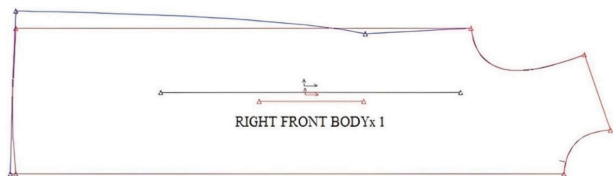
Testing and assessing the fit of samples in the CLO3D software are determined by Strain Map color distribution maps. Each color will describe the state of the product. The color of the graph represents the contact position of the garment with the wide to the tight body surface.



**FIGURE 7** | The color chart of the men's Ao dai model before adjusting the pattern.



**FIGURE 8** | Adjustment of the left front body pattern (red color: the back body pattern; black color: the first pattern of the back body).

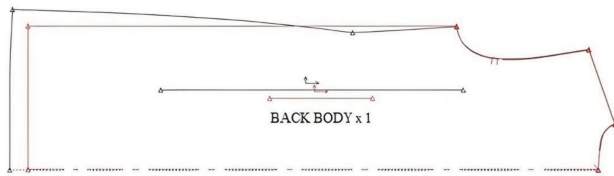


**FIGURE 9** | Adjustment of the right front body pattern (red color: the back body pattern; black color: the first pattern of the back body).

As can be seen, fit positions are blue, and easy locations are white. [Figure 7](#) shows that there are wrinkles in the back waist and side. The neck and armhole area reaches the fit of Ao dai. Thereby, the authors give the direction of adjustment in the front and back body according to the straight form of the body, chest across, waist across, and hip across ([Figures 8–10](#)). Other locations keep the same design.

### 3.6. The result of draping men's Ao dai after editing patterns

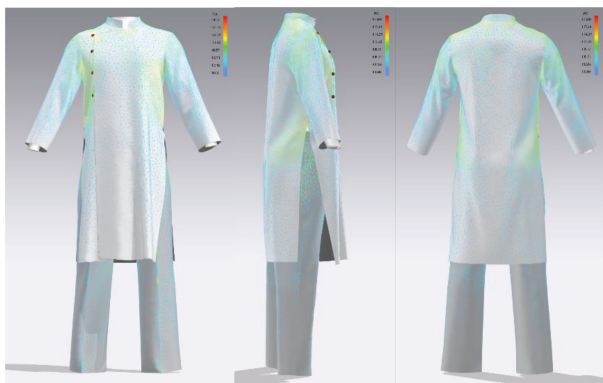
The images of patterns after adjusting describe the smooth and flat, not wrinkles, and it fits the avatar ([Figure 11](#)). A comparison from the color chart shows that the front body, back body, and sides are fit, with no wrinkles in the waist area ([Figure 12](#)).



**FIGURE 10 |** Adjustment of the back body pattern (red color: the back body pattern; black color: the first pattern of the back body).



**FIGURE 11 |** Simulation of men's Ao dai on the model. Patterns after adjusting.



**FIGURE 12 |** The color chart of the men's Ao dai model after adjusting the pattern.

### 3.7. Discussions

The dimensions of samples built in the study were compared with the male measurements in the TCVN 2009 table, showing that the primary dimension in this study was larger than that standard. The height is 154.46–181.35 cm, while the standard is from 150 to 179 cm. The bust dimension of the incline is 85.62–114.01 cm, while that in the standard is from 74 to 95 cm. Although the abdomen girth is 73.65–103.77 cm, the standard is 64–85 cm. Similarly, the hip girth is also larger with 84.51–111.81 cm in the study and 80–97 cm in the standard. Thereby, the body dimensions of Vietnamese men from 30 to 60 years old are now taller than that in the standard table 5782:2009. As for the avatar dimensions, the height of  $167.88 \pm 5.35$  cm belongs to the standard measurement range, and the avatar's bust, waist, and hip girth

are larger than the standard measurement range. The original pattern details have a tight waist girth and a wrinkled back waist, but the neck girth and armhole fit the avatar. After adjustment, the patterns of the Ao dai front and back body are not tied at the waist, and the images of the simulation of men Ao dai are flat, with no wrinkles.

## 4. Conclusion

The authors make statistics and analyses of the anthropometric dimensions of 378 men aged 30–60 years living in the southern region of Vietnam. It shows the standard deviation, mean, maximum value, and minimum value to design patterns. There are a total of 45 measured dimensions. An avatar used to design patterns and simulate samples has the average database measurement from the database. Men's Ao dai is designed according to the 2D design method and then is simulated on the avatar by the CLO3D software to check the fit of the model. Cotton sateen fabric is used for the design. After the first time simulation, the sample does not have a smooth, flat appearance and is checked through the color chart. After being edited to a straight shape, the pattern is not hugging at the side, and the fit has been achieved through visual assessment, a color histogram of the simulated model. The research makes one avatar be suitable dimension for Vietnamese men. It will be additional avatar data in the database of the CLO3D software. The authors applied technology development, specifically the CLO3D software to design and evaluate the men's Ao dai model. In addition, the research results also serve as the basis for designing and implementing production, ensuring the fit, comfort, and comfort in costume design.

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## Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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